Using Marchshall Mix Design to Develop A Repairing Material Package for Colored Pavement Under the Subtropical Climate of Taiwan

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Abstract: Colored asphalt concrete refers to asphalt concrete pavement that pigments are added in or colorful stones are mixed with, pigments added de-colored petroleum resin asphalt pavement, or modified asphalt pavement with water permeability sprayed with colorful resin coating. It is indispensable to develop traffic safety and embellish street environment. Taiwan is an island under subtropical climate. In summer, black pavement absorbs heat and produces greenhouse effect, which is called the ‘heat island effect. Due to the weather factors or outer forces, it is difficult to refill or repair the pits or holes on colored asphalt pavement. The aim of this study is to develop a repairing material package by using Marchshall Mix Design to solve the problem of colored pavement repairing. Furthermore, the repairing material package is packed in 40 kg package and this is convenient for operation by using simple tools. Ultimately, life quality will be improved as well.

Key-Words: colored asphalt concrete, normal-temperature asphalt concrete, marshall mix design, repairing material

1 Introduction

The colored Normal-temperature asphalt concrete is produced by mixing Normal-temperature asphalt, aggregates and colored pigments at an optimal proportion at appropriate temperature, in which the aggregates, asphalt and additives are all newly rising products. However, Taiwan locates in the rainy area of Asia and the government won’t afford the expenses of renovating the whole road temporarily in order to save public expenditure, thus the repairing policy is adopted. In addition, the manufacturing of conventional colored asphalt concrete requires high temperature heating, so it can’t be produced in rainy climates. Hence, it can be replaced by the colored Normal-temperature concrete and the constructions carried out immediately while in emergency, which avoids the condition that repairing can’t be conducted due to not knowing the construction approaches. Although there are a few asphalt concrete mixing plants with the ability to produce colored asphalt concrete in Taiwan currently, the colored Normal-temperature asphalt concrete can still be the most popular and convenient materials applied in pavements in Taiwan, since it can be stored at room temperature and easy to transport.

The primary purpose of this paper is to develop the colored Normal-temperature asphalt concrete, which can repair the pits or holes on colored asphalt pavement at any time for the common asphalt concrete repairing kit in Taiwan. Starting from the Normal-temperature asphalt concrete manufactured by asphalt concrete mixing plants, the paper utilizes Marshall Mix Test to study the main structure material for the colored concrete repairing package. In addition, it also provides the related references for both the industrial and academic circles in the purchase and application of new Green building materials. The research of this study extends to colored Normal-temperature asphalt concrete based on the mix tests of Normal-temperature asphalt concrete. The materials and mix proportion in this study are the actual cases employed by an asphalt plants in Pingtung [1]. The materials are all obtained locally with the same nature but differ according to specific products, which are combined with pigments of different ratios used in this study to qualify the data in graph with mix data. The study is mainly to explore the production process of colored Normal-temperature asphalt concrete mixing plants via Marshall Mix Test, mend the problems of difficulty in repairing
the damages on colored AC pavements, and also propose feasible suggestions for promoting the work strategies of colored asphalt concrete mixing plants in Taiwan in the future.

1.1 Normal-temperature Asphalt Concrete
Normal-temperature asphalt concrete is a new-type mixture produced by manual processing and mechanical agitation with Normal-temperature asphalt oil and aggregates. The key technique is the processes in preparing the Normal-temperature asphalt concrete by adding additives of different dosages into common petroleum asphalt corresponding to certain construction conditions. Through a lot of indoor and road proposes to determine and prepare the specific additives which meet various. The technique is convenient and simple to operate in construction. The primary technical contents of the proposed technique are as follows [7].

It eliminates the low-temperature brittleness of asphalt materials. Such asphalt mixture can be paved and shaped easily at a low temperature (-15°C), which can be compacted to meet the pavement performance, thus it completely dissolve the problems of difficulty in repairing the hot-mix bituminous concrete in winter completely, which can be selected as the best material to maintain the asphalt pavements in winter.

The production and construction methods of Normal-temperature asphalt concrete are simple and easy to master, which is quite suitable for road gang to use. Particularly, such concrete can be mixed centrally, stored in bags and taken for use when needed, which has a vast market and a promising future.

The Normal-temperature asphalt concrete can be cemented with original pavements tightly when repairing the potholes. The stability and durability after being compacted is equivalent to that of hot-mix bituminous concrete in summer.

With this technique to repair the potholes on asphalt pavements, it can realize that repair immediately once a pothole is founded, which avoid the expanding of potholes, ensures the safety, comfort and speed of moving vehicles, and greatly reduces the occurrence of traffic accidents. The production process of Normal-temperature concrete is shown in the following Fig.1 [1].

![Fig.1 Production process of Normal-temperature concrete][1]

2 Materials and Methods
[2,3,7,12,13] Marshall Mix design method is the most common design method for asphalt concrete, which requires the specimen diameter to be at least four times the maximum aggregate size. However, the standard Marshall Specimen diameter is only 4 inches, thus the method is only applicable to the mixture with its nominal maximum aggregate size is equal to or less than 1 inch, while for those
larger, it should adopt the Marshall Method modified for 6-inch specimen or other methods.

2.1 Materials
Steps of Marshall Mix Design
1. Assess the nature of selected aggregate.
2. Assess the nature of asphalt grout.
5. Analysis of density and porosity.
6. Determine the optimal asphalt content.

2.2 Methods
Through Marshall Mix method, the data of colored Normal-temperature asphalt concrete required during each experiment process can be quantified to be reference for manufacturers’ in future material application, mix procedures, and mass production. In the actual cases, the paper modifies the mix requirements based on the common Normal-temperature asphalt concrete that is widely used in Taiwan. The obtained data in Marshall Mix test are analyzed and compared by using the mathematical computation mode in Microsoft Excel.

3 Research Results
Based on the mix design for colored Normal-temperature concrete obtained from an asphalt plant in Pingtung and this research, the products are divided according to different proportions and are tested in graph with the methods specified in AIMS-2.[14] The physical properties of the AC are as follows: 1. 5% 3/4" aggregates; 2.10% 3/8" aggregate; 3. 50% 1/4" aggregate; 4. 35% fine aggregate (≦4.75 mm). The void gravity of mixture is 2.581 and gravity of asphalt is 1.031, while the valid gravity of mixture is of 2.602 and the absorption rate \(P_{ba}\) of asphalt by aggregates runs up to 0.33. Besides, the asphalt mixture are compacted in a Marshall test 4-inch mould at a temperature of 140 °C, with both the top and bottom sides being hammered for 50 times respectively. The hammer ram weighs 10 pounds with a drop height of 18 inches. It uses discolored asphalt mixtures or transparent resin mixtures for integration, which meet requirements of CNS 14184—Polymer Modified Asphalt Type III[8]. The colored pigments, which is ferric oxide, is used at a percentage of 40–60% in this study, in which a pure powder material that won’t be singed at the mix temperature of 185 °C is also adopted. The Normal-temperature asphalt oil used in the study is provided by the selected asphalt plant in Pingtung.

3.1 Drawing the Performance Curves of the Test
Taking the relevant data obtained previously as the Y-axis and the asphalt content (to mixture) as the X-axis, six linear regression graphs of relation are drawn in this study, in which ‘•’ refers to the average values of experimental data, ‘—’ the trend-line obtained by calculating with formulas via Microsoft Excel. According to the figure shown below:

The higher oil content leads to a higher unit weight (Fig.2) the higher oil content leads to a higher unit weight accordingly. The stable values start rising when the oil content reaches 4.0, which get the highest value when the oil content is 4.8 and then go down with the increase of oil content. (Fig.3). The higher oil content leads to a higher unit weight accordingly(Fig.4). The W.M.A starts dropping when the oil content reaches 3.5, which gets the lowest value when the oil content is 4.8 and then goes up with the increase of oil content.(Fig.5) The higher oil content leads to a lower unit weight accordingly.(Fig.6).The higher oil content leads to a higher V.F.A accordingly(Fig.7).

![Fig.2 Unit weight of AC vs oil content of asphalt](image-url)
3.2 Suggested Asphalt Content

Lots of factors should be considered to select the Suggested Asphalt Content, including traffic volume, climate, economical efficiency, and durability. Therefore, the engineers can select and adjust the asphalt content based on their personal experiences, environmental, and design conditions, without deviating from the following principles:

Suggested Asphalt Content and the corresponding traits of various asphalt mixtures shall meet the specifications and requirements in design principles or criteria.

If adopting the Marshall Mix Design, the latest design method of asphalt concrete AI MS-2 [14] publicized by Asphalt Institute of USA, the key points for determining the Suggested Asphalt Content in terms of close-graded of surface and bottom courses on road and pavement are as follows:

Asphalt content with a porosity (Va) of 4.0% shall be selected preferentially. In case that all natures of such asphalt mixture meet the requirements defined in mix design criteria and specifications, it shall be determined as the Suggested Asphalt Content.

If parts of natures of asphalt mixture with a porosity of 4.0% fail to meet the requirements defined in mix design criteria and specifications, adjustment shall be conducted to make it satisfy all requirements, which is then determined as Suggested Asphalt Content. For the asphalt content adjusted according to the methods described in (2), the principles shall be followed that the corresponding porosity shall not exceed 0.5%, (i.e. porosity shall fall between 3.5~4.5%). Among the nature analysis of the experimental tests, if the asphalt content with its all natures failed to meet the requirements defined in mix design criteria and specifications, mix formula (i.e. graduation of mixture aggregates) shall be adjusted to conduct the testing procedures of mix design again. According to the research results, it can be learned that the optimal oil content of asphalt is 4.8% when the porosity is 4.0%, with its corresponding stable values, V.M.A, V.F.A and fluidity value meeting the specifications.

In accordance with the common government pavement in Taiwan, the Acceptance Standards for Normal-temperature asphalt concrete defines that the stable value should be more than 350 kg, fluidity value more than 18-30, and oil content of asphalt should be 5-7%. Although the optimal result in this study suggests that the oil content is 4.8%, it is
adjusted to 5.2% considering the practical application in plants in the future; thus all the experimental results meet the acceptance standards.

4 Results and Conclusions

According to the previous results and discussion, the conclusions and suggestions are as follows:

Based on the research results, it is feasible both in theory and experiment procedures to further develop the colored Normal-temperature asphalt concrete by utilizing the test data of common Normal-temperature asphalt concrete. However, more practical tests are necessary to verify whether it can be used for mass production.

If the porosity is 4.0%, the optimal asphalt content would be 4.8%, and the corresponding stable value, VMA, VFA and flow value all meet the requirements. But considering the future practical application in factory, it is suggested that the optimal content be 5.2%.

It is difficult to repair the pits or holes on the colored asphalt pavements, thus the colored asphalt concrete is hard to be promoted in Taiwan currently. However, the concrete proposed in this paper can effectively solve the problem, prolonging the service life of colored asphalt concrete.

Moreover, the proposed colored asphalt concrete can also be used in small-sized projects without considering the factors such as environment and climate, thus it can offer a favorable caution in the dangerous road section.

The largest challenge during the mix design in this research is that the temperature of aggregate changes greatly. The extremely high temperature will result in that the Normal-temperature chemical oil evaporates; on the contrary, extremely low temperature will bring about a defective asphalt concrete package which will further reduce the storage period. Besides, as the temperature of the aggregate is not controlled well, the color difference of Normal-temperature asphalt concrete will be uneven. Consequently, how to reduce the heat loss during mixing is the key point that asphalt industries and researchers should work on. In the process of colored asphalt concrete mixing, it must avoid the color contaminated, so it requires quite complicated procedures to clean the mixing machine, which is quite troublesome. Study can efficiently improve the situation and be convenient during construction.

References:


