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ສຶກສາ ພຶດຕິກຳ ຂອງ ສ່ວນປະສົມແອສຟັລຕຄອນກຣີດທີ່ໃຊ້ AC 60/70 ແລະ PMA ສຳຫຼັບ ຊັ້ນຜິວທາງ

ພອນໄຊ ດວງມະຈັນ* ແລະ ວິໄຊ ຈັນສະຫວ່າງ
ພາກວິຊາ ວິສະວະກຳໂຍທາ, ຄະນະວິສະວະກຳສາດ, ມະຫາວິທະຍາໄລສຸພານຸວົງ

ບົດຄັດຫຍໍ້

ການປູໜ້າທາງ ດ້ວຍ ແອສຟັລຕຄອນກຣີດ ຊ່ວຍໃຫ້ຄຸນນະພາບການປູ ໄດ້ຢ່າງມີປະສິດທິພາບຫຼາຍ ທາງດ້ານເສດຖະກິດ ແລະ ອາຍຸການໃຊ້ງານ ດີກວ່າຮູບແບບການປູໜ້າທາງປະເພດອື່ນໆ ໃນການກໍ່ສ້າງທາງ ສຳຫຼັບໜ້າທາງ. ຈຸດປະສົງຂອງການສຶກສາຄັ້ງນີ້ ແມ່ນເພື່ອຫາຄຸນລັກສະນະ ຂອງ ວັດສະດຸທາງດ້ານວິສະວະກຳ ຂອງ ແອສຟັລຕຄອນກຣີດ, ການທົດລອງປະກອບດ້ວຍ ດັ່ງນີ້: ການທົດລອງຫາຄຸນສົມບັດ ຂອງ ວັດສະດຸມວນລວມຫີນປູນ, ຄ່າສະເຖຍລະພາບ ແລະ ຄ່າການໄຫຼ ແລະ ດັດສະນີຄວາມແຂງແກ່ນ. ວັດສະດຸເຊື່ອມປະສານທີ່ໃຊ້ເກຣດ 60/70 (AC 60/70) ແລະ Polymer Modified Asphalt (PMA) ສຳຫຼັບ ໜ້າທາງທີ່ມີປະລິມານຈາລະຈອນຫຼາຍ ໂດຍໃຊ້ວິທີການທົດລອງຂອງ Marshall ສຳຫຼັບຊັ້ນໜ້າທາງ. ຜົນການທົດລອງຂອງວັດສະດຸມວນລວມ ເຊັ່ນ: ຄວາມແຂງແກ່ນ, ຄວາມທົນທານ, ຄວາມຖ່ວງຈຳເພາະ, ຄວາມແບນ, ຄວາມຍາວ ແລະ ປະລິມານຊາຍ ແມ່ນຜ່ານມາດຕະຖານການທົດລອງ. ຄຸນລັກສະນະທາງວິສະວະກຳ ຂອງສ່ວນປະສົມແອສຟັລຕຄອນກຣີດ ທີ່ໃຊ້ວັດສະດຸເຊື່ອມປະສານ AC 60/70 ແລະ PMA ພົບວ່າ: ຄວາມໜາແໜ້ນ, ປະລິມານວັດສະດຸເຊື່ອມປະສານທີ່ແຊກເຊື່ອມວັດສະດຸ (% VFB), ຄ່າສະເຖຍລະພາບ ແລະ ຄ່າການໄຫຼເພີ່ມຂຶ້ນໃນຂະນະປະລິມານວັດສະດຸເຊື່ອມປະສານເພີ່ມຂຶ້ນ. ໃນຂະນະທີ່ປະລິມານຊ່ອງຫວ່າງອາກາດ ແລະ ປະລິມານຊ່ອງຫວ່າງຂອງວັດສະດຸມວນລວມລຸດລົງ ໃນຂະນະທີ່ປະລິມານວັດສະດຸເຊື່ອມປະສານເພີ່ມຂຶ້ນ. ດັດສະນີຄວາມແຂງແກ່ນທີ່ໃຊ້AC 60/70ແລະ PMA ເຫັນວ່າ 79.72% ແລະ 86,05% ຕາມລຳດັບ. ສາມາດສະຫຼຸບໄດ້ວ່າ ວັດສະດຸແອສຟັລຕຄອນກຣີດ ທີ່ໃຊ້ PMA ມີຄຸນນະພາບ ດີກວ່າວັດສະດຸແອສຟັລຕຄອນກຣີດ ທີ່ໃຊ້ AC 60/70.

ຄຳສຳຄັນ: ຫີນປູນ, ຄຸນລັກສະນະທາງດ້ານວິສະວະກຳ, ດັດສະນະຄວາມແຂງແກ່ນ.

Study Asphalt Concrete Behavior Mixtures Using AC 60/70 and PMA for Wearing Course

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Abstract:

Paving with asphalt concrete allows you to pave a surface more efficiently, more economically, faster and with greater serviceability than with any other paving material in road construction. This study was conducted to determine the engineering properties of the asphalt concrete material. The following tests were conducted in this research: aggregate properties of lime stone, stability, flow, and strength index tests: Asphalt cement penetration grade 60/70 (AC 60/70) and polymer modified asphalt (PMA) for heavy volume roads (herein, the equivalent standard axle load number is heavy), for wearing course. Results of aggregate tests such as abrasion, soundness, specific gravity, flakiness and elongation and sand equivalent were passed specification tests. The engineering properties of asphalt concrete mixtures using AC 60/70 and PMA found that density bulk, percent of VFB, stability and flow values increasedas the asphalt content increased. While the percentage of air voids and percent of VMA values decreases as the asphalt content increases.

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Strength index with AC 60/70 and PMA the compressive strength were 79.72 % and 86.05 %, respectively. We could be said that mixtures of asphalt concrete materials with PMA have superior properties more than with AC 60/70.

Keywords: Limestone, Engineering properties, Strength index.

1. Introduction

The increase in the number of vehicles combined with the rapid growth of cities in recent years has resulted in an increase in the volume of traffic on the roads. Road surfaces have experienced a significant increase in traffic flow and vehicles carrying loads. The normal temperature in summer softens the asphalt material. This reduces the service life of the road which is easily damaged due to the hot climate. The deterioration of road surface is defined by the damage to the condition of the surface over time. The discrete, for example, from cracking, permanent deformation and disintegration are classified as pavement surface defects. Flexible pavement distress modes normally considered in the flexible pavement analysis and design as low temperature cracking, rutting and fatigue cracking (Thomson and Nauman, 1993). Asphalt modifiers have been used over 60 years. They are more commonly used in Europe compared to the United Stated in the 20th century. (Baker, 1998),(Isaacson and Lu,1999) tested the various properties of modified binders and showed that elastomeric binders increase both rut resistance and fatigue life. They observed that styrene butadiene styrene (SBS) modified bituminous mixes have longer life than conventional mixes. Modification of virgin bitumen with synthetic polymer binder is considered as a solution to overcome the problems which happen because of the increase in wheel load and changing climatic conditions. Polymer modification is considered as one of the solutions to improve fatigue life, reduce rutting and thermal cracking in the pavement.

This research focuses on the use of conventional bitumen (AC 60/70) and polymer modified asphalt (PMA) by use of the Marshall method to determine the properties of the asphalt concrete mixtures, bulk density, stability, voids in mineral aggregate (VMA), voids filled with bitumen (VFB) and strength index for heavy volume roads (herein the equivalent standard axle load number is heavy).

2. Materials and Methods

2.1. Asphalt cement (Grade AC 60/70)

Grade AC 60/70 supplied by TIPCO Asphalt Company Limited, Bangkok, Thailand was used for this research.

2.2 Polymer modified asphalt (PMA)

Polymers used to modify the physical and rheological properties of bitumen are styrene butadiene styrene copolymer (SBS), styrene butadiene rubber (SBR).

2.3. Aggregates

To ascertain the fundamental and engineering properties of the aggregates (ASTM, 1986), the aggregate specification tests below were followed:

1) Standard method of testing for sieve analysis of fine and coarse aggregates ASTM C136-05.
2) Standard method of testing for specific gravity and absorption of fine/coarse aggregates AASHTO T-84-00 and AASHTO T-85-08.
3) Standard method of testing for resistance to degradation of large size coarse aggregate by abrasion and impact in the Los Angeles machine ASTM C535.
4) Standard method of test for soundness of Aggregates by use of sodium sulfate ASTM C88-13.
5) Flat particles, elongated particles, or flat and elongated particles in coarse aggregates ASTM 4791.
6) Sand equivalent value of soils and fine aggregates by use of calcium chloride solution ASTM D2419-02.

2.4. Marshall test

This test procedure is used in designing and evaluating bituminous paving mixes for the job mix. There are two major features of the Marshall method of designing mixes namely, density – voids analysis and stability – flow test.

The Marshall Stability and flow test provides the performance prediction measure for the Marshall Mix design method. The stability portion of the test measures the maximum load supported by the test specimen at loading rate of 50.8 mm/minute. Load is applied to the specimen till failure, and the maximum load is designated as stability. During the loading, an attached dial gauge measures the specimen's plastic flow (deformation) as a result of the loading. The flow value is recorded in 0.25 mm (0.01 inch) increments at the same time when the maximum load is recorded.

- **Specimen preparation**

Approximately 1200gm of aggregates and filler is heated to a temperature of 175^{o}C to 190^{o}C. Bitumen is heated to a temperature of 121 - 125^{o}C with the first trial percentage of bitumen (say 4% by weight of the material aggregates) to the heated aggregates and thoroughly mixed at a temperature of 154degrees Celsius to 160degrees Celsius. The mix is placed in a preheated mould and compacted by a rammer with 75 blows on either side at a temperature of 138 degrees Celsius to 149 degrees Celsius. The weight of mixed aggregates taken for the preparation of the specimen may be suitably altered to obtain a compacted thickness of 63.5+/-3 mm. The bitumen content in the next trial was varied by +0:5% and the above procedure were repeated.

2.5. Strength index

This test method is useful as an indicator of the susceptibility to moisture of compacted bitumen-aggregate mixtures. Generally, test specimens, at least six 101.6 by 101.6-mm (4 by 4-in.) cylindrical specimens are made for each test. The procedures described in test method ASTM D 1074, are followed in preparing the loose mixtures and in molding and curing the test specimens.

- **Specimen preparation**

1) Bring the test specimens to the test temperature 25±1°C, by storing them in an air bath maintained at the test temperature for not less than 4 hours and determine their compressive strengths in accordance with Test Method D 1074.
2) Immerse the test specimens in water for24 hours at 60±1°C. Transfer them to the second water bath maintained at 25±1°C and store them there for 2 hours. Determine the compressive strength of the specimens in accordance with test method D 1074.
3) Alternative procedure: Immerse the test specimens in water for four days at 49±1°C. Transfer them to the second water bath maintained at 25±1°C and store them there for 2 hours determine the compressive strength of the specimens in accordance with test method ASTM D 1074.

3. Results

3.1. Aggregate tests

A summary of all the aggregate specification tests on limestone and the results are shown in Table 3.2. The abrasion aggregate to resist crushing, degradation and disintegration of limestone used was 23.9, passing the specification value of 40.

Table 1. Results of aggregate gradation

Sieve size (in.)	Sieve size (mm)	% Passing		Specification
		Coarse	Fine	
1	25.4	100		100 – 100
3/4	19	100		100 – 100
1/2	12.5	92.31		80 – 100
3/8	9.5	82.34		65 – 95
#4	4.75		61.77	44 – 74
# 8	2.36		41.83	28 – 58
# 16	1.18		30.74	18 – 47
# 30	0.6		18.11	8 – 35
# 50	0.3		13.12	5 – 21
# 100	0.15		7.94	4 – 15
# 200	0.075		5.02	2 – 10

Table 2. Results of aggregate specification tests

physical property	Test result	Specification
Abrasion	23.9	Maximum of 40
Soundness		Maximum of 9
Coarse	0.93	
Fine	0.83	
Combined GSB		
Dry	2.690	From 2.400 to 3.000
SSD	2.706	
GSAFlankiness index	2.718	
Elongation index	14.7	Maximum of 30
Sand equivalent	17.4	Maximum of 30
	80.89	Minimum of 50

Table 3. Marshall stability test results for mixtures with AC 60/70

Binder type	Average specimen No.	Density bulk (g/ml)	Air voids (%)	VMA (%)	VFB (%)	Stability (lbs)	Flow 0.25 in)	Asphalt content
AC 60/70	1	2.371	6.78	15.14	55.22	2535	12.0	4.00
	2	2.389	5.40	14.90	63.76	2708	12.0	4.50
	3	2.404	4.07	14.77	72.43	2842	13.0	5.00
	4	2.415	3.02	14.78	79.59	2700	13.7	5.50
	5	4.422	1.58	15.25	89.61	2566	15.7	6.00
Criteria		-	3-5	14 - 20	65 - 80	≥1800	8-16	3-7

Table 4. Marshall stability test results for mixtures with PMA

Binder type	Average specimen No.	Density bulk (g/ml)	Air voids (%)	VMA (%)	VFB (%)	Stability (lbs)	Flow (0.25 in.)	Asphalt content
PMA	1	2.374	6.63	15.01	55.83	3245	12.7	4.00
	2	2.400	4.96	14.50	65.80	3432	14.0	4.50
	3	2.406	4.02	14.71	72.68	3868	14.7	5.00
	4	2.415	3.04	14.77	79.44	3672	15.0	5.50
	5	2.431	1.25	14.92	91.65	3581	16.7	6.00
Criteria		-	3-5	14-20	65-80	≥1800	8-16	3-7

Table 5. Strength index test results for mixtures with AC 60/70 and PMA

Binder type	Strength index (%)	Specification (%)
AC 60/70	79.72	> 75
PMA	86.05	> 75

The resistance of coarse and fine aggregates to weathering action and to judge the durability of the coarse aggregate, sodium sulfate was used. 0.83 and 0.93 are the fine and coarse aggregates respectively. The results are the combined specific gravity of aggregates under three different sample conditions: Apparent specific gravity (GSA), (bulk dry specific gravity) (Dry) and bulk saturated surface specific gravity (SSD) were between about 2.400 and 3.000 with 2.700 being fairly typical of limestone. To prevent the excessive flakiness and elongation aggregates in the HMA, the Marshall method was used, where specification requires a maximum 35 % of the aggregates to be flat and elongated. The 14.7 flakiness and 17.4 elongation values obtained satisfied the specification. The portions of clay-like or plastic particles and dust in granular fine aggregates passed through the 4.75 mm (No. 4) sieve. The 80.89 sand equivalent value passed specifications.

3.2. Marshall properties

3.2.1. AC 60/70

The results of all the Marshall stability tests using, AC 60-70, show the design asphalt contents vary from 4 to 6 of total weight aggregate which are summarized in Table 3 for mixtures. All results shown for each specimen are the average value of three tests.

The average values of bulk specific gravity, air voids, flow, MA, VFB, Flow and stability obtained above are plotted separately against the bitumen content and a smooth curve drawn through the plotted values. The average of the binder content corresponding to air void of 4% are considered as the optimum binder content is e 5.10% (by weight of total mix) tolerance ± 0.3%, bulk specific gravity of 2.398 g/ml, VMA of 14.70%, VFB of 72%, stability of 2840 lbs and flow of 13 mm.

From Table 3, the engineering properties of asphalt concrete mixtures using AC 60/70 was found that density bulk, percent of VFB, stability and flow values increases as the asphalt content increases. While, percent of air voids and percent of VMA values decreases as the asphalt content increases.

3.2.2. Polymer modified asphalt (PMA)

The results of all Marshall stability tests using, PMA, show the design asphalt contents vary from 4 to 6 of total weight aggregate which are summarized in Table 4, for mixtures. All results shown for each specimen are the average value of three tests.

The average values of bulk specific gravity, air voids, flow, MA, VFB, flow and stability obtained above are plotted separately against the bitumen content and a smooth curve drawn through the plotted values. The average of the binder content corresponding to air void of 4% are considered as the optimum binder content is 5.10% (by weight of total mix) tolerance ± 0.3%., with bulk specific gravity of 2.415 g/ml, VMA of 14.62%, VFB of 73%, stability of 3850 lbs and flow of 14 mm.

From Table 4, the engineering properties of asphalt concrete mixtures using PMA showed that density bulk, percentage of VFB, stability and flow values increase as the asphalt content increases. While the percentage of air voids and percentage of VMA values decreases as the asphalt content increases.

3.3. Strength index

A compressive strength test was performed to determine the compressive properties of mixtures. A compression load is applied on the circular face of the specimens and the load is increased until failure occurs.

An optimum bitumen content of 5.10% (by weight of total mix) as found from the Marshall Mix design was used in preparing the compressive strength test. The average compressive strength for AC 60/70 and PMA mixtures is listed in Table 5.

4. Discussion

The results from comparing the properties of asphalt concrete employing asphalt cement grade PMA and asphalt cement grade 60/70, showed that the air voids were decreased when the asphalt content increased. Density bulk, VMA (%), VFB (%) and flow values were increased while the asphalt content increased. A trend of higher stability or the rutting resistance of PMA was increased when asphalt content increased (Anantasaipong and Sornwong., 2010). The stability and strength index of PMA were higher than AC 60/70 of asphaltic concrete (Srichanin., 2001).It can be summarized that asphalt concrete materials with PMA have superior properties to asphalt concrete materials with AC 60/70 to resist rutting and fatigue life (Baker., 1998), (Isaacson and Lu., 1999).

5. Conclusion

In this research, extensive laboratory testing program was conducted to evaluate the engineering aggregate properties and behavior of asphalt concrete mixtures, AC 60/70 and PMA, as optimum asphalt content. Test results using the Marshall method to investigate the engineering properties of asphalt concrete mixtures with AC 60/70 found that density bulk, % of VFB, stability and flow values increase as the asphalt content increases. Mixtures using PMA, found that the percentage of air voids and the percentage of VMA values decreases as the asphalt content increases. Test results of t the compressive strength of mixtures e found that in the mixture with AC 60/70, the compressive strength was 79.72%, passing specification value of 75% and in the mixture with PMA, the compressive strength was 86.05%, passing specification value of 75%. It can be concluded that asphalt concrete materials with PMA have superior properties than asphalt concrete materials with AC 60/70.

6. Acknowledgment

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