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Effect of Asphalt Concrete Mix Remolding on Mix Stability and Density

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ABSTRACT

Marshall Mix Design is the most widely method used for flexible pavement mix design. The main objective of this method is to identify the optimum asphalt cement content to be used in the asphalt mix. One of the main parameters that control the asphalt cement content is the mix stability. Stability is considered as an empirical measure for the strength of the asphalt concrete mixes. It is defined as the resistance to deformation of an asphalt concrete mix when subjected to traffic loadings under a variety of environmental conditions. The characteristics of the asphalt cement and its content in the asphalt mix is one of the main parameters affecting the mix stability. It is well known that the characteristics of the asphalt cement can be affected to a large extent by remolding. The main objective of this paper is to investigate the effect of the mix remolding on its stability. It should be indicated that the mix remolding can also affect, in addition to the asphalt cement characteristics, the mix density. The main objective of this paper is to investigate the effect of the asphalt concrete mix remolding on its stability and density. A comprehensive laboratory program has been designed to achieve the objective of this paper. The output results can help the highway engineers evaluating the mix properties based on the mix stability and density more precisely.

Key words: Asphalt Concrete, Marshall Mix Design, Stability, Density, Asphalt Content

Introduction

Asphalt Concrete pavement is the most common type of pavement used around the world. It represents main element of highway infrastructure (Yoder et al. 1974). A typical ACP structure consists of bituminous layer(s), granular base, and granular subbase constructed over the compacted subgrade. The selection of the material properties and thickness of each pavement layer depends on the traffic loading and the environmental conditions throughout the pavement service life as well as the subgrade condition (Garber et al. 2001).

Construction quality affects to a large extent the pavement long-term performance (Huang 2003). In order to evaluate the construction quality, specifications define the required tests, rates, limits, and tolerances. For asphalt layers, specification requires the preparation of a mix design before construction. The main purpose of the mix design is to define the aggregate combinations and optimum percentage of asphalt cement that can satisfy the required mix properties (aggregate gradation, stability, flows, % of air voids, and voids in mineral aggregates). During construction, and to guarantee the construction quality, mix samples are obtained to check the aggregate gradation, asphalt content against the mix design. Moreover, cores specimens are also taken to check the layer thickness and mix density (HBRC 2007).

In case of the contractor started working without the preparation of the mix design, there is no standard method that can be used to evaluate the constructed asphalt mix. The main objective of this paper is to investigate the effect of the remoulding process (reheating and recompaction) on the mix density and stability of the asphalt concrete mixes. This paper consists of three parts, the first one is the introduction, the second part deals with the experimental works and test results, and finally the summary and conclusions

Experimental Work:

The main objective of this research as mentioned before is to investigate the effect of asphalt concrete mix remoulding (reheating and recompacting) on its density and stability. To achieve this objective, two standard Egyptian hot-laid mixes for heavy traffic roads, namely 4C and 3D, were used. The experimental work was divided into two main parts. The first part is to examine the effect of the remoulding process on the density and stability of asphalt core specimens taken from the field. On the other hand, the second part is to examine the effect of the remoulding process on asphalt mix specimens taken from asphalt plant. In the first part the mix type 4C was used, while in the second part the mix type 3D was used. The aggregate gradations and binder content along with the specification limits for the two mixes 4C and 3D are shown in Tables 1 and 2 respectively.

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Table 1: Aggregate gradation, binder content, and specification limits of 4C

Sieve Size (inch)	Specification Limits 4C	Gradation of 4C (% passing)
1"	100	100
0.75"	80-100	97.7
0.5"	-----	93.9
0.375"	60-80	70.5
No. 4	48-65	55.3
No. 8	35-50	42.6
No. 30	19-36	28.8
No. 50	13-23	19.8
No. 100	7-15	10.0
No. 200	3-8	7.0
Binder Content (%)	4-7.5	5.19

Table 2: Aggregate gradation, binder content, and specification limits of 3D

Sieve Size (mm)	Specification Limits 3D	Gradation of 3D (% passing)
1"	100	100
0.75"	75-100	100
0.5"	-----	74.9
0.375"	45-70	62.0
No. 4	30-50	38.7
No. 8	20-35	23.6
No. 30	5-20	13.6
No. 50	3-12	9.4
No. 80	2-8	6.2
No. 200	0-4	3.0
Binder Content (%)	3-6	4.72

For the mix type 4C, thirty core specimens were taken from the field, transported to the laboratory, and tested to determine the density and stability for each specimen. Table 3 summarizes the density and stability for each core specimen. Then, each specimen was reheated, recompacted using Marshall Compactor, and tested again to determine its density and stability. This process was repeated three times for each core specimen. The results of the density and stability of the core specimens after each remoulding process (heating and compaction) are indicated in Table 4 and Figure 1.

Table 3: Density and stability of cores specimens for mix 4C

Specimen number	Density (gm/cm3)	Stability (kg)	Specimen number	Density (gm/cm3)	Stability (kg)
1	2.269	683	16	2.171	217
2	2.256	627	17	2.236	288
3	2.195	456	18	2.218	249
4	2.209	553	19	2.273	430
5	2.243	523	20	2.184	220
6	2.215	498	21	2.248	347
7	2.257	610	22	2.229	368
8	2.249	556	23	2.240	377
9	2.221	790	24	2.182	197
10	2.271	625	25	2.174	293
11	2.068	429	26	2.204	380
12	2.277	295	27	2.267	384
13	2.236	307	28	2.288	309
14	2.078	276	29	2.082	242
15	2.269	352	30	2.166	329

Table 4: Density and stability of the cores specimen after the remoulding processes for mix 4C

Specimen number	Density (gm/cm3)			Stability (kg)		
	Remoulding Process No.			Remoulding Process No.		
	No. 1	No. 2	No. 3	No. 1	No. 2	No. 3
1	2.339	2.393	2.406	1334	2463	2766
2	2.322	2.371	2.392	1058	2256	2374
3	2.41	2.340	2.371	940	1496	1806
4	2.330	2.385	2.388	988	1765	1649
5	2.310	2.355	2.360	1042	2185	2271
6	2.316	2.356	2.372	1035	2099	2190
7	2.332	2.378	2.387	1105	2350	2695
8	2.328	2.368	2.375	1095	2296	2710
9	2.307	2.350	2.367	995	1815	1960
10	2.319	2.348	2.352	1195	2545	2430
11	2.319	2.328	2.385	969	1068	1535
12	2.333	2.366	2.373	990	1022	1210
13	2.347	2.375	2.378	1070	1094	1432

14	2.315	2.352	2.358	952	980	1418
15	2.332	2.361	2.354	967	990	1129
16	2.332	2.352	2.368	1116	1163	1540
17	2.335	2.365	2.372	1138	1166	1252
18	2.333	2.365	2.361	1264	1296	1366
19	2.335	2.369	2.369	1050	1127	1146
20	2.318	2.352	2.364	1147	1179	1380
21	2.324	2.360	2.355	997	1068	1468
22	2.332	2.369	2.398	1003	1032	1444
23	2.320	2.349	2.354	1135	1161	1331
24	2.326	2.359	2.372	991	1084	1179
25	2.311	2.345	2.388	1252	1286	1455
26	2.328	2.362	2.354	1036	1054	1178
27	2.303	2.338	2.337	1224	1258	1643
28	2.345	2.358	2.378	1133	1165	1670
29	2.325	2.352	2.375	985	1047	1198
30	2.334	2.369	2.380	1170	1202	1493

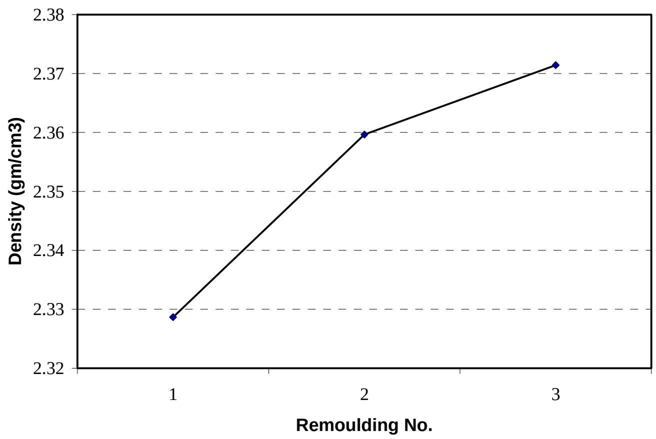

Fig. 1: Effect of remoulding process on mix density for mix 4C

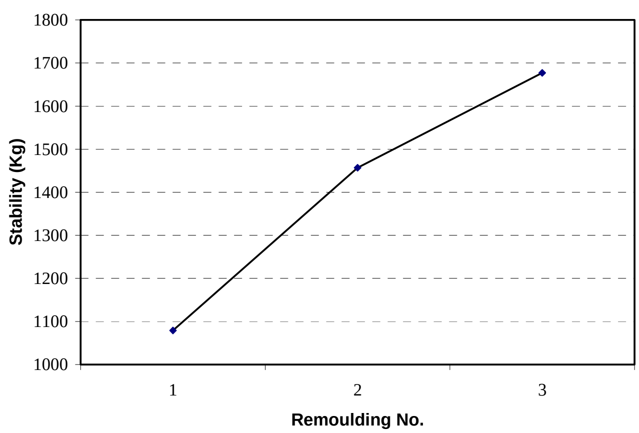

Fig. 2: Effect of remoulding process on mix stability for mix 4C

The density data shown in Table 4 and Figure 1 show that the average density of the mix 4C increases from 2.33 gm/cm3 obtained after the first remoulding process, to 2.36 gm/cm3 after the second remoulding process and then reached to 2.37 gm/cm3 after the third remoulding process. This indicates that the rate of density change tends to decrease by repeating the remoulding process. On the other hand, the stability data shown in Table 4 and Figure 2 show that the average stability of the mix 4C increases from 1079.2 kg obtained after the first remoulding process, to 1457.07 kg after the second remoulding process and then reached to 1677.27 kg after the third remoulding process. This also indicates that the rate of stability change tends to decrease by repeating the remoulding process.

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Table 5: Density and stability of the cores specimen after the remoulding processes for mix 3D

Specimen number	Density (gm/cm3)			Stability (kg)		
	Remoulding Process No.			Remoulding Process No.		
	No. 1	No. 2	No. 3	No. 1	No. 2	No. 3
1	2.275	2.307	2.347	896	1615	1824
2	2.296	2.322	2.356	889	1544	1921
3	2.280	2.317	2.355	898	1723	1990
4	2.270	2.310	2.351	882	1625	1798
5	2.284	2.324	2.346	860	1544	1801
6	2.288	2.319	2.339	856	1489	1725
7	2.297	2.330	2.370	887	1320	1663
8	2.281	2.321	2.359	892	1710	1923
9	2.288	2.326	2.360	862	1680	1889
10	2.282	2.325	2.359	851	1455	1705

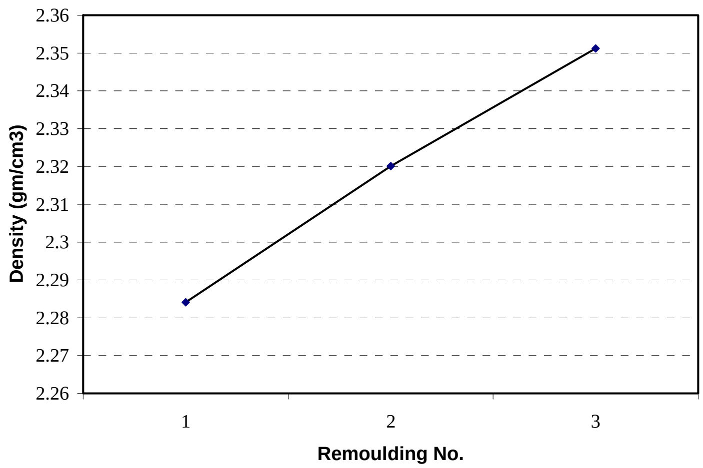

Fig. 3: Effect of remoulding process on mix density for mix 3D

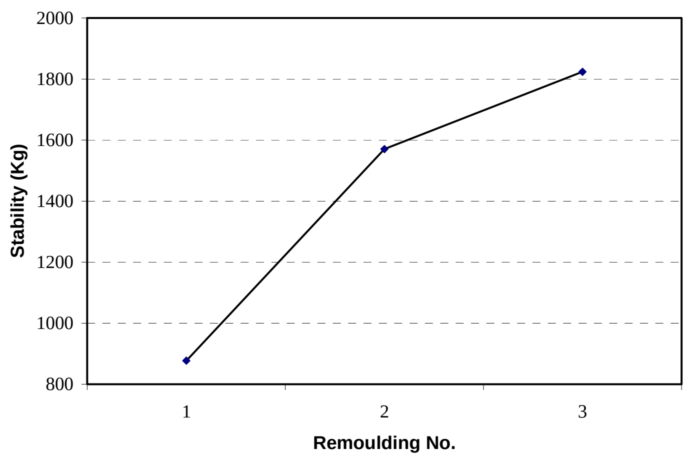

Fig. 4: Effect of remoulding process on mix stability for mix 3D

The density data shown in Table 5 and Figure 3 show that the average density of the mix 3D follows the same trend of the mix 3C. The average density increases from 2.29 gm/cm3 obtained after the first remoulding process, to 2.32 gm/cm3 after the second remoulding process and then reached to 2.35 gm/cm3 after the third remoulding process. This indicates again that the rate of density change tends to decrease by repeating the remoulding process. Also, the stability data shown in Table 5 and Figure 4 show that the average stability of the mix 3D increases from 877.3 kg obtained after the first remoulding process, to 1570.5 kg after the second remoulding process and then reached to 1823.9 kg after the third remoulding process. This also indicates that the rate of stability change tends to decrease by repeating the remoulding process.

It should be mentioned that although the two types of the mixes used in this study follows the same trends of the relationship of the number of the remoulding process versus the density/stability, however the rate of change in density and stability in the two cases is not the same. This can be referred to two main factors. The first factor is the difference between the components of the two mixes (binder content and gradation). The second one, which is believed to be the most important one, is the difference between the pre-conditions of the two mixes before starting the experimental program (remoulding processes). Where, as indicated before, the first mix (4C) was exposed only to the effect from the mix plant during the mixing process, while the second mix (3D) was exposed to the effect of both the mix plant (during the mixing process) and the compaction (during construction process).

Summary And Conclusions:

This paper presents the results of the experimental program carried out in order to investigate the effect of the remoulding process (reheating and recompaction) on the density and stability of the asphalt concrete mix. Two standard Egyptian hot-laid mixes for heavy traffic roads, namely 4C and 3D, were used. The first mix type 4C was used to study the effect of the remoulding process on the density and stability of the mix after its production from the asphalt plant, while the second mix 3D was used to study the effect of the remoulding process on the mix after its production from the mix plant and its compaction at the field. The results of the experimental program indicate that the density and stability results for the two mixes follow the same trend. Where, by repeating the remoulding process, the density/stability increases. However, the rate of change tends to decrease but it is not the same for the two mixes. This is referred to the difference between the composition of the two mixes and due to the difference between the agings that occur to the two mixes before starting the remoulding processes. It is recommended for future studies to create a set of master curves, for different types of mixes, that can be used by decision makers to evaluates the quality of the construction mixes by a simple method in case of absence of the design mix.

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