EAVALUATION OF LABORATORYCOMPACTIVE EFFORT ON ASPHALTIC CONCRETE MIXES

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This is tough,
But,
The quitter never wins,
And,
The winner never quits.

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ABSTRACT

Good compaction is the most important factor to consider when constructing asphalt mixture either in the laboratory or in the field. The higher compactive effort presents the higher density to the pavement. The 75 blows as compactive effort in designing laboratory Marshall mixes sample is usually selected. Too high compaction could affect the pavement durability. The aim of this study is to investigate the performance of 50 blows comparing to 75 blows of compactive effort in Marshall Mix Design. The experiment included two types of mixes, ACW14 and ACW20 where 50 and 75 blows were used for each mix. ACW20 samples were tested according to AASHTO T283-89 "Resistance of Compacted Bituminous Mixture to Moisture Induced Damage" and ACW14 samples were tested using Universal Testing Machine according to ASTM D4123 "Standard Test Method for Indirect Tension Test for Resilient Modulus of Bituminous Mixtures." 50 blows compactive effort for ACW20 showed the higher tensile strength ratio when tested for moisture induced damage. For ACW14, the 50 blows compactive effort indicated lower Resilient Modulus than the 75 blows but still above the estimated performance. In general, mixes with 50 blows compactive effort indicated the same performance with the 75 blows samples.

ABSTRAK

Kaedah pemadatan yang betul merupakan faktor utama di dalam kerja-kerja penurapan jalan di makmal atau di tapak. Mampatan yang tinggi menghasilkan turapan jalan yang lebih padat. Rekabentuk Campuran Marshall menggariskan 75 hentakan sebagai nilai pemadatan yang digunakan di dalam kerja makmal. Masalah timbul apabila pemadatan yang terlalu tinggi ini menyebabkan pengurangan terhadap ketahanan turapan jalan tersebut. Tujuan kajian ini lebih menjurus kepada mengenal pasti kebolehan 50 hentakan berbanding dengan 75 hentakan yang biasa digunakan di dalam Rekabentuk Campuran Marshall. Kajian ini melibatkan ujikaji terhadap dua jenis camapuran asphalt iaitu ACW 20 dan ACW 14. Kedua-dua campuran dibahagikan kepada 2 jenis hentakan iaitu 50 dan 75 hentakan. Campuran ACW 20 diuji dengan menggunakan prosedur AASHTO T283-89 manakala campuran ACW 14 diuji berdasarkan prosedur ASTM D4123. Hasil ujikaji bagi ACW 20 menunjukkan bahawa 50 hentakan memberikan nilai kekuatan tegangan yang lebih tinggi berbanding dengan 75 hentakan. Ujikaji bagi ACW 14 pula menunjukkan bahawa 75 hentakan memberikan nilai modulus kekenyalan yang lebih tinggi berbanding 50 hentakan. Akan tetapi, modulus kekenyalan bagi campuran yang menggunakan 50 hentakan masih memenuhi piawaian. Secara keseluruhannya, campuran yang menggunakan 50 hentakan mempunyai kebolehtahanan yang sama dengan campuran yang menggunakan 75 hentakan sebagai daya pemadatan.

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CHAPTER 1

INTRODUCTION

Compaction is one of the most essential factors in designing and constructing the pavement. Besides, it is already known that the aim of compaction during the construction is to increase the pavement strength especially to the subgrade. This is because the whole strength of pavement is depending on the strength of the base soils. The importances of the compaction of soils are listed below.

1. To increase the shear strength and therefore being capacity,
2. To increase stiffness and therefore reduce the future settlement,
3. To decrease voids ratio and the permeability.

The Figure 1.1 below shows the effect of compaction to the soil density. If there is increasing number on compactive efforts, the optimum water content will decrease. The situation occurs because of the lowering air volume in the soils content.

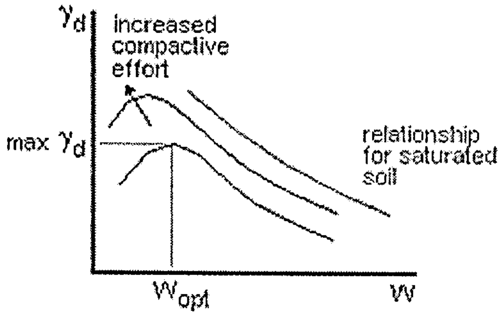

Figure 1.1 Dry density and water content relationship

The similar concept can be applied in the hot mix asphalt design. In the hot mix asphalt design the consideration is focusing on the optimum bitumen content in the laboratory compaction due to the optimum water content during construction work. The explanation on the concept is also similar in order to decrease the air void level to get the better result on pavement density.

The previous studies by Bell at al (1984) had shown that too high compaction could reduce the pavement durability and cause the fatigue condition. However, to get the actual causes of this condition, it is necessary to consider many factors and one of them is asphalt content. The amount of asphalt is dependent upon the amount of compactive effort. In this project, this situation was observed according to laboratory studies on hot mix asphalt (HMA) design. The effect of the compactive efforts on HMA performance was analyzed and recommendations were made.

1.1 Problem statement

In Malaysia, *Standard Specification for Road Works,* JKR/SPJ/1988, is used as a guideline to pavement construction according to Marshall laboratory design procedure. Besides, considering increasing the pavement thickness due to the traffic loads , the step made to extend the pavement life is by using high blows compactive effort in mix design.

Currently, 75 blows is used as the compactive effort in order to get the higher density of pavement. The density and asphalt pavement film thickness are both important. The concept of increasing the compaction is actually to reduce the air voids but the problem occurs when the asphalt thickness is also being reduce.

Prowell (2000) stated that Virginia Department of Transportation had modified their specifications on pavement design in 1990 to increase the compactive effort to 75 blows as response to rutting and flushing problem. Anyhow in year 2000, the Virgina's Asphalt Cooperative found that the 75 blows mixtures with lower asphalt content would not be durable.

The effect of the compactive effort was also stated by Pell (1987) as the maximum asphalt content increase the durability because the thick asphalt film do not age and harden as rapid as thin ones do.

The lack of asphalt thickness causing the cracking distress to the pavement. It is because the durability of the pavement is decreasing due to repetation loads and the fatigue condition start to occurs. Cracking could be more worse with the penetration of water during the rain and this will lead to pavemant failure.

The situation ia also indicated by Chadbourn et al (2000) that the thin asphalt film that coating is one of primary causes that leading the premature aging of asphalt binder. The lack of the film thickness is also allowing the air oxidizing the asphalt and the pavement will begin to brittle.

1.2 Objectives

The main objectives of this study are:

1. To evaluate the performance of asphaltic concrete mixes with 50 blows and 75 blows compactive effort.

2. To determine, the feasibility of using 50blows compactive effort in the heavy traffic loading pavement as compared to the current 75 blows compactive effort.

1.3 Scope of study

This study focused on asphalt concrete mixes that more on hot mix asphalt design by using Marshall Mix Design Method. The scope of study involved the laboratory tests according to specified guidelines. The effect of using 50 blows and 75 blows as compactive efforts in the mix designs were chosen to be the main criteria to analyze. Performance of two types of mixes, ACW14 and ACW20 was observed according to the serial tests. The test procedures were explained in Chapter 3.

1.4 Purpose of study

This study was used to evaluate the compactive efforts between 50 blows and 75 blows in the laboratory design as to give the explanation according to the pavement densification that might occur because of over compaction. This study can be a reference to evaluate other studies according to the compactive effort performance in the pavement design.

1.5 Marshall Mix Design Method

The Marshall Method was developed by Bruce Marshall, bituminous engineer of Mississippi State Highway Department. U.S. Army Corps of Engineers had improved and used the method as common mix-design criteria after added some features to test procedure.

The main objective of the Marshall Method is to determine the optimum bitumen content and the properties of laboratory mix design to meet the construction requirement especially according to the optimum density and the air voids content.

The important features to study in the Marshall Method mix design are the density-voids analysis and the stability flow test of the compacted specimens. Chapter 2 discussed more about the previous study according to the mix designs.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Compaction is one of the important factor that has been considered for designing the asphalt pavement and constructing the road. Many studies had been conducted to measure the performances of the asphalt pavement compactive effort but it always led to some question that need to be addressed. This chapter will carry out the previous studies according to the influences of compactive effort to the pavement performance.

Besides, the causes and effects that influence the properties of pavement need to be recognized. The better quality of pavement could be increase by knowing the causes that decreasing the pavement performance and the understanding of the distress effects. Tables below show the causes of pavement distress and the effects on performance.

Table 2.1 Causes and effects of low pavement stability (Asphalt Institute Manual Series No 22)

Causes	Effects
Excess asphalt in mix	Washboarding, rutting and flushing or bleeding.
Excess medium size sand in mixture	Tenderness during rolling and for period after construction, difficulty in compacting.
Rounded aggregate, little or no crushed surfaces	Rutting and channeling.

Table 2.2 Causes and effects of lack of durability (Asphalt Institute Manual Series No 22)

Causes	Effects
Low asphalt content	Dryness or raveling
High void content through design or lack of compaction	Early hardening of asphalt followed by cracking or disintegration
Water susceptible (hydrophilic) aggregate in mixtures	Films of asphalt strip from aggregate leaving an abraded, raveled, or mushy pavement

Table 2.3 Causes and effects of permeability (Asphalt Institute Manual Series No 22)

Causes	Effects
Low asphalt content	Thin asphalt film will cause early aging and raveling
High voids content in design mix	Water and air can easily enter pavement causing oxidation and disintegration
Inadequate compaction	Will result in high voids in pavement leading to water infiltration and low strength.

Table 2.4 Causes and effects of workability problems (Asphalt Institute Manual Series No 22)

Causes	Effects
Large maximum-sized particle	Rough surface, difficult to place
Excessive coarse aggregate	May be hard to compact
Too low a mix temperature	Uncoated aggregate, not durable, rough surface, hard to compact
Too much medium-sized sand	Mix shoves under roller, remains tender
Low mineral filler content	Tender mix, highly permeable
High mineral filler content	Mix may be dry or gummy, hard to handle, not durable

Table 2.5 Causes and effects of poor fatigue resistance (Asphalt Institute Manual Series No 22)

Causes	Effects
Low asphalt content	Fatigue cracking
High density voids	Early aging of asphalt followed by fatigue cracking
Lack of compaction	Early aging of asphalt followed by fatigue cracking
Inadequate pavement thickness	Excessive bending followed by fatigue cracking

Table 2.6 Causes and effects of poor skid resistance (Asphalt Institute Manual Series No 22)

Causes	Effects
Excess asphalt	Bleeding, low skid resistance
Poorly textured or graded aggregate	Smooth pavement, potential for hydroplaning.
Polishing aggregate in mixture	Low skid resistance

The causes and effects that stated above are only the brief information according to the condition of pavement. However, there are still lots of studies to carry out to find the prevention and the rehabilitation of the pavement distress.

2.2 Effect of Compaction

Dickinson (1984), gave a description according to build a reliable asphalt pavement that can be use by the engineers to plan, design and construct the pavement in his book titled Bituminous Road in Australia. He stated that the laboratory design is the first process and modified according to traffic loading requirement. However, it also considered the factors that could influence the pavement performances such as temperatures, materials, traffic loading and the pavement design itself.

Figure 2.1 shows the flow chart that had been chose as a design method. It is shows that the 50 hammer blows was chose as a compactive effort for rural road while 75 hammer blows used to heavy vehicles road with high tire pressure such as airfield pavement.

Table 2.7 and 2.8 show the specification of Marshall Mix design that are used by National Association of Australian State Road Authorities (NAASRA) while Figure 2.2 shows the example result that usually get from Marshall Test. The result stated that if the degree of compaction is not attained, the asphalt layer will become hardened and causing the premature cracking. Figure 2.3 shows the compaction condition across a wearing course after three years of traffic. The dual- carriageway was carrying 13,000 vehicle/day with 7% of heavy vehicles and the Marshall design is 10mm nominal size for the mix .Average thickness for each carriageway is 25mm.

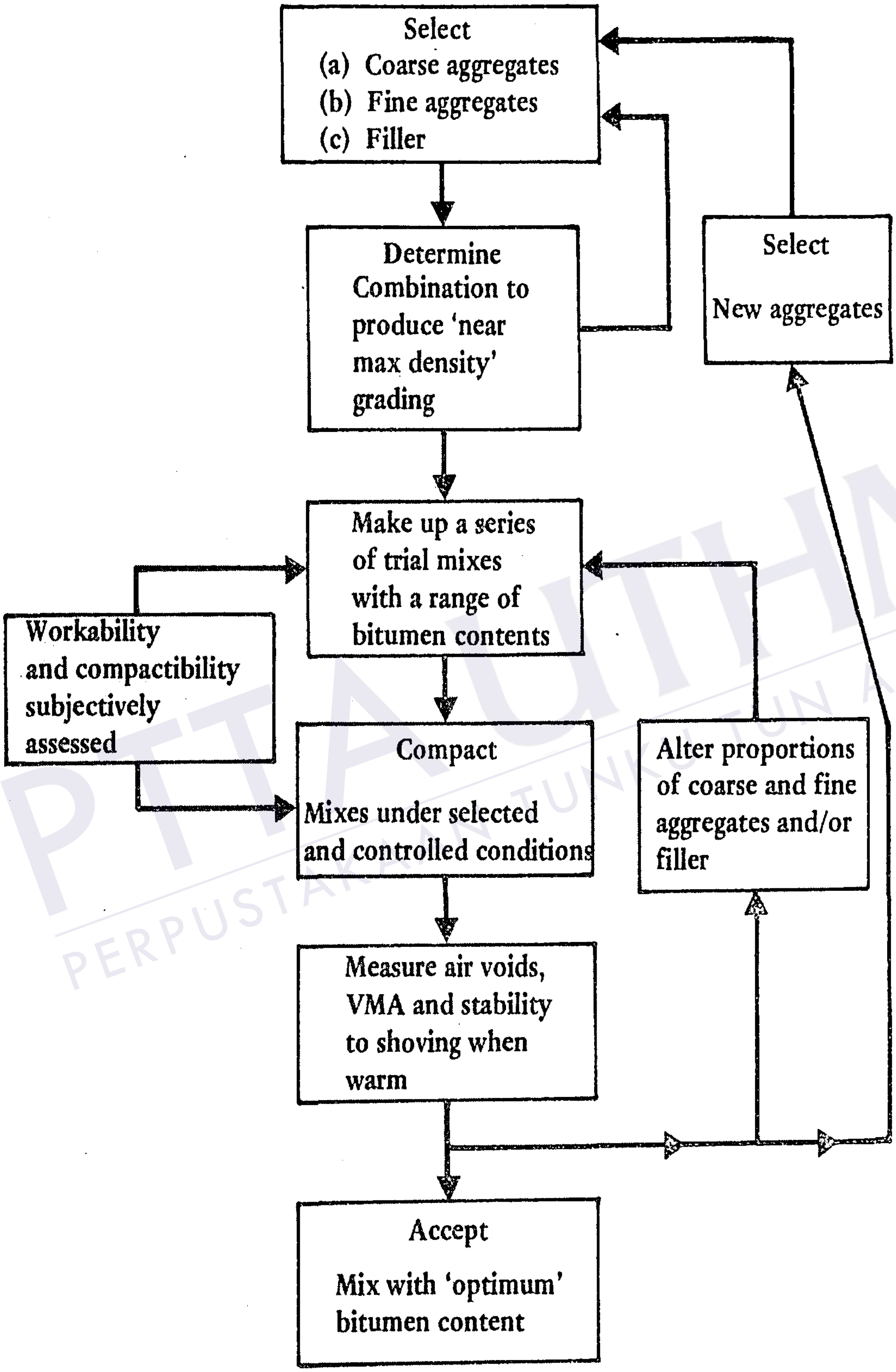

Figure 2.1 Design flow chart. (Dickinson,1984)

Table 2.7 Typical design criteria for dense-graded mixes designed by the Marshall Method for 75 blows compactive effort. (Dickinson,1984)

Test Property	Mix Size							
	7 mm		10 mm		14 mm		20 mm	
	min.	max.	min.	max.	min.	max.	min.	max.
Stability (kN)	7.0	—	8.0	—	8.0	—	8.0	—
Flow (mm)	2	4	2	4	2	4	2	4
% Air Voids —								
Wearing Course	3	5	3	5	3	5	3	5
Intermediate or Basecourse	3	6	3	6	3	6	3	6
% Voids in Mineral Aggregate	17	—	16	—	15	—	14	—

Table 2.8 Typical design criteria for dense-graded mixes designed by the Marshall Method for 50 blows compactive effort. (Dickinson,1984)

Test Property	Mix Size							
	7 mm		10 mm		14 mm		26 mm	
	min.	max.	min.	max.	min.	max.	min.	max.
Stability (kN)	5.5	—	6.5	—	6.5	—	6.5	—
Flow (mm)	2.0	3.5	2.0	3.5	2.0	3.5	2.0	3.5
% Air Voids —								
Wearing Course	3	6	3	6	3	6	3	6
Intermediate or Basecourse	3	6	3	6	3	6	3	6
% Voids in Mineral Aggregate*	17	—	16	—	15	—	14	—

* For heavily-trafficked roads minimum VMA should be increased by 1%.

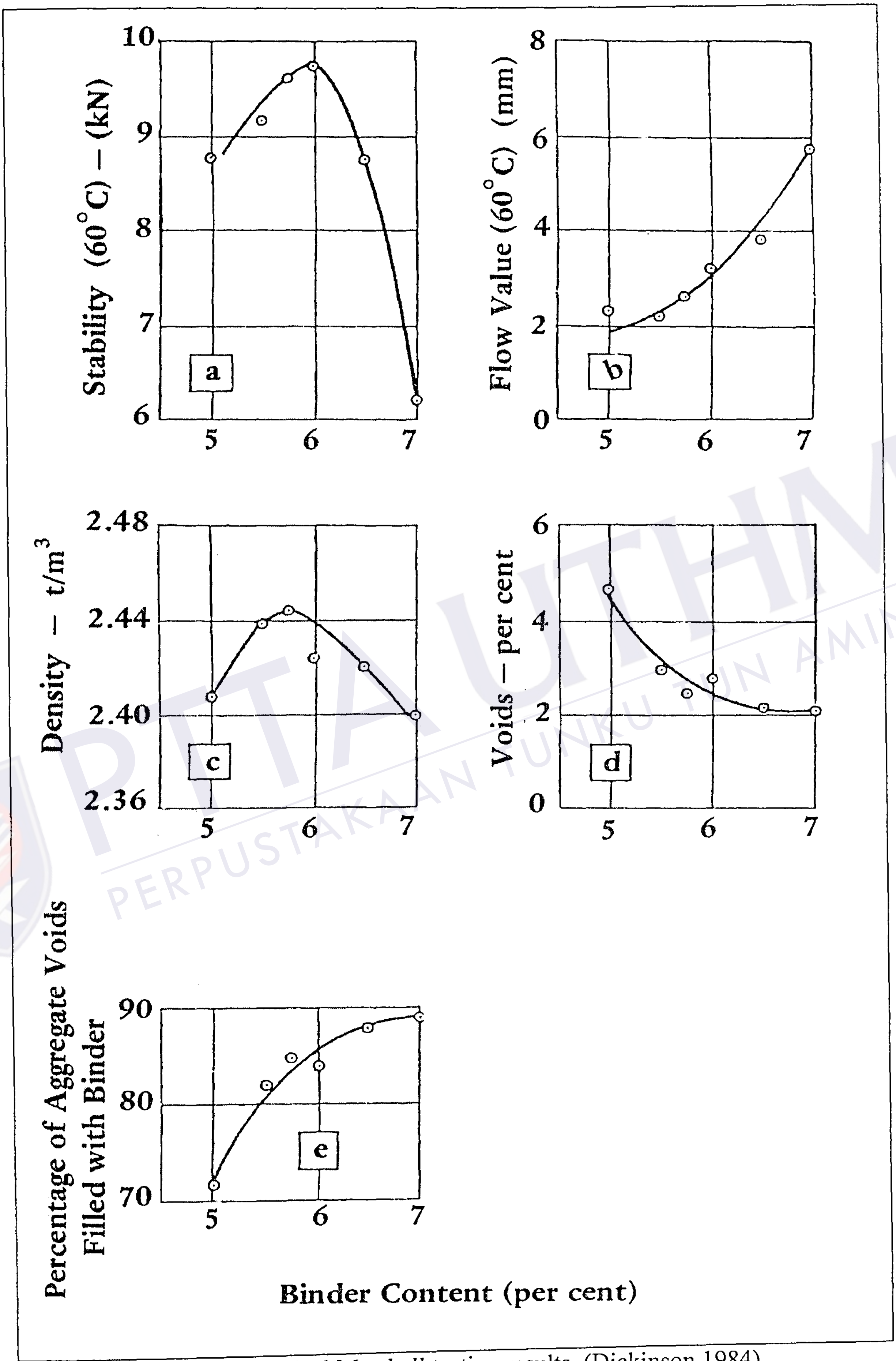

Figure 2.2 Typical Marshall testing results. (Dickinson,1984)

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