Comparison Between Thickness Design Based on Arahan Teknik Jalan 5/85 and 5/85 (2013)

by

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18871

Dissertation submitted in partial fulfilment of

The requirement for the

Bachelor of Engineering (Hons)

(Civil)

SEPTEMBER 2017

Universiti Teknologi PETRONAS

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CERTIFICATION OF APPROVAL

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A project dissertation submitted to the

Civil and Environmental Engineering Programme

Universiti Teknologi PETRONAS

In partial fulfilment of the requirement for the

BACHELOR OF ENGINEERING (Hons)

(CIVIL)

Approved by,

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UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

September 2017

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

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(MUHAMMAD HAFIZ BIN MOHD SAIDI)

ABSTRACT

This Final Year Project is about the comparison of thickness design between ATJ 5/85 (1995) and ATJ 5/85 (2013). The comparison focused on the California Bearing Ratio design which changing the thickness of pavement for both manual. During this project, the sensitivity of CBR parameter has been analyzed according to the thickness of pavement for both manual. The thickness of pavement also compared based on different traffic volume which is low traffic volume, medium traffic volume and high traffic volume. Based on this study, the result shown where the thickness design based ATJ 5/85 (2013) must complied with CBR parameter more than 5%. Besides, the CBR parameter based on high traffic volume must be greater than 12%. As the CBR value is increase, the thickness of pavement is decrease as respectively. The CBR parameter must be considered in designing the thickness of pavement to overcome the pavement structure failure during the design period.

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ACKNOWLEDGEMENT

Alhamdulillah, all praise to Allah for the good health and well-being that were necessary to complete this research project. For this final year project, I am especially grateful to my project's supervisor, Assoc. Prof. Dr Madzlan Bin Napiah, from Civil and Environmental Engineering Department. I would like to appreciate him for sharing his knowledge and experiences in helping me to finish this project. After that, I am also thankful to Jabatan Kerja Raya (JKR) for providing me with necessary data and information according to my research. I also place on record, my sense of gratitude to one and all, who directly or indirectly, have lent their hand in this venture.

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Historically, pavements have been divided into two broad categories, rigid and flexible. These classical definitions, in some cases, are an over-simplification. However, the terms rigid and flexible provide a good description on how the pavements reacts to loads and the environment. In every country, the road pavements were designed in different methods according to the total volume of commercial traffic where the pavements designed can withstand traffic and environmental effects. The pavement design shall be based on the California Bearing Ratio (CBR) followed the traffic volume which is low traffic, medium traffic and heavy traffic. This study will be covered on the manual Arahan Teknik Jalan (ATJ) 5/85 and ATJ 5/85 (Pindaan 2013). This manual is to be used for the design of flexible pavements for roads under the jurisdiction of Jabatan Kerja Raya (JKR). It comprises of details for the thickness design, materials specification and the mix design requirements.

The pavements are usually composed of layers of different materials: layering of a pavement has a significant effect on its performance. Composition, density and thickness of paving materials which are bituminous materials, stabilized granular materials, unbound granular road base and sub-base shall be selected so that they perform as an integral structure and meet intended performance requirements.

1.2 Problem Statement

In Malaysia, there are many issues about the road pavement failure which caused by the high loading on the pavement. Besides, the failure also due to the weakness in the pavement layers which are surface, base and sub-grade. The pavement failure occurs when the thickness of layers designed were too thin which cannot withstand due to high volume of loading. However, the pavement failure in Malaysia can be caused by the California Bearing Ratio (CBR) strength where the designed was not satisfied according to the traffic volume on the road.

This study was made to compare the sensitivity of CBR strength due to thickness design based on ATJ 5/85 (1995) and ATJ 5/85 (2013). Meanwhile, the design of pavement thickness involved many data, graphs and particular selection of properties for different type of layer which make the design phase was complicated. Based on this study project, a new software of thickness design based on Arahan Teknik Jalan 5/85 (2013) manual has been developed to improve the design phase according to the calculation of traffic volume and CBR strength in order to select the suitable thickness design based on the pavement catalogue.

1.3 Objectives

The objectives based on this study project as the following:

- To compare the thickness design according to the ATJ 5/85 (1995) and ATJ 5/85 (2013) based on Full Depth: Asphaltic Concrete Base.
- To compare the sensitivity of parameter of California Bearing Ratio (CBR) designed depends on the thickness design.
- To develop a thickness design software of flexible pavement by using programming language.

1.4 Scope of Study

This study focuses on the design of road pavement in Malaysia based on the volume of traffic referred on manual Arahan Teknik Jalan 5/85. Road and surface failure has become a critical issue in Malaysia on the flexible pavement shown a bad quality and an error in the design stage. The study need to be made to improve the pavement design according to the specified parameters. The traffic characteristics, materials composition and thickness of pavement need to be considered during this study. Besides, the study also focuses on the selection of California Bearing Ratio (CBR) in designing the road pavement according to the type of traffic category below.

Traffic Category	**Design Traffic (ESAL x 10^6)**	**Probability (percentile) Applied to Properties of Sub-Grade Materials**
T 1	≤ 1.0	≥ 60%
T 2	1.1 to 2.0	≥ 70%
T 3	2.1 to 10.0	≥ 85%
T 4	10.1 to 30.0	≥ 85%
T 5	> 30.0	≥ 85%

Table 1 Traffic Categories

CHAPTER 2

LITERATURE RIVIEW

2.1 Flexible Pavement

Pavement structure comprises of few material layers that have a specific level of bonding at the interfaces.(Aziz, Rahman, Hainin, & Bakar, 2015) stated that there are three primary groups of pavements:

(1) Type I: asphalt pavement.

(2) Type II: concrete pavement.

(3) Type III: concrete block pavement (CBP)

The flexible pavement is an asphalt pavement. It generally consists of a relatively thin wearing surface of asphalt built over a base course and subbase course. Base and subbase courses are usually gravel or stone. These layers rest upon a compacted subgrade (compacted soil). In contrast, rigid pavement is made up of the Portland cement concrete and may or may not have a base course between the pavement and subgrade. The guide recommends the following structural of component layers of a flexible pavement design.

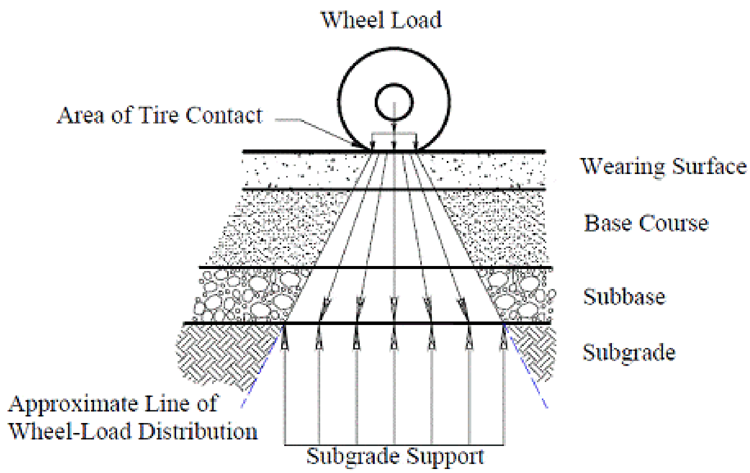


Figure 1 Components Layers of a Flexible Pavement

1. **Wearing surface**
    - This layer is the uppermost layer of the pavement, it will normally consist of a bituminous 'surface dressing' (spray and chip treatment) or a layer of premixed bituminous material.
2. **Base course**
    - This layer is the main load-spreading layer of the pavement; it will normally consist of crushed stone or gravel, or of gravelly soil, decomposed rock, sands and sand-clay stabilized with cement, lime, bitumen and fly ash.
3. **Sub-base**
    - This layer is the secondary load spreading layer underlying the base; it will normally consist of a material of lower grade than that used in the base as example gravel-sand or gravel-sand-clay.
4. **Subgrade**
    - This layer is the upper layer of the natural soil which may be undisturbed local material or may be soil excavated elsewhere and placed as fill; in either case, it is compacted during construction to give added stability.
    - This layer where very weak soils are encountered, the subgrade may be improved by mixing in an imported better soil or a small amount of a stabilizing agent.

2.2 Traffic Design

In designing the road pavements, the total number and the axle loading of the commercial vehicles that will use the road during its design life need to be considered. A commercial vehicle defines as any goods or public vehicle that has unladen weight of 1500 kg (1.5 tons) or more. Thus, private cars and vehicles less than 1500 kg unladen weight can be ignored because the loads imposed by them do not contribute to the structural damage caused to road pavements by traffic.

The road pavements design should be consisting all the criteria needed based on CBR according to the volume of traffic. The minimum design of CBR for **low traffic is 5%** and for the **heavy traffic it might be more than 12%.** However, in designing the road pavements, there are three major steps to be followed. These are:

i. **Estimating the amount of traffic, and its axle-load distributions, that the road will carrying during its design life.**
ii. **Assessing the strength of the subgrade soil over which the road is to be built.**
iii. **After consideration of (i) and (ii), selecting the correct combination of materials and layer thickness that will produce an economical pavement with minimum maintenance.**

2.3 Failure Mechanism

Jabatan Kerja Raya (2013) stated that during the design procedure, the traditional concepts of pavement is applied, based on the assumption that there are two types of strains that critical to the performance of road pavement which are:

a) Vertical compressive strain ε_z at the top of sub-grade
b) Horizontal strain ε_t at the bottom of the lowest bound pavement course

Figure 2 Components of failure mechanism in flexible pavement design

Vertical compressive strain, ε_z which is react on the top of sub-grade is adopted as a design criterion to control accumulation of **permanent deformation** of the subgrade. Sub-grade deformation (strain) is primarily a function of sub-grade stiffness and strength, traffic (design load and cumulative traffic volume over design period), and the thickness and stiffness of the pavement structure above the sub-grade (Jabatan Kerja Raya, 2013).

However, the **horizontal tensile strain, ε_t** which is react at the bottom of the bound layer used to control **fatigue damage** due to repeated traffic loads. The vertical compressive strain and horizontal tensile strain are expressed as a function of traffic volume. (JKR, 2013) stated that during the design process, type and course thickness of paving materials are chosen to ensure that the above strains remain within an acceptable limit.

2.4 Parameters of road design

There is various type of method used in road pavement design which is the parameter of CBR used need to be highlighted during the pavement design according to the environmental and economically issues. (Aziz et al., 2015) an analytical method has been used in road pavement design in Romania, which its requires the following criteria to be met:

- The allowable tensile strain at the base of the bituminous courses criterion.
- The allowable compressive strain at the subgrade level criterion.

The purpose of the first criterion is **cracking control**, in the case of bituminous courses, whilst the second one is meant to limit permanent subgrade deformation. In addition, the third criteria need to be met in the case of semi-rigid pavements is the allowable tensile stress at the base of the stabilized course, which refers to cracking as well. This criterion is to determine the pavement acceptance.

(Ciont, Iliescu, & Cadar, 2017) the analytical pavement design method is intended to solve the state of **stresses and strains under the equivalent single axle load (ESAL)** and thus provide a structure which meet the eligibility criteria. The roadbed, characterized by **Young's modulus** and **Poisson's coefficient**, represents the road structure support. The first step is established the bearing capacity according to the climatic, hydrological and geotechnical conditions. Its upper part may be arranged as a subgrade, by employing different stabilizing procedures, in order to improve the roadbed bearing capacity.

(Ciont et al., 2017) in Romania, the Young modulus of the subgrade-roadbed system should **exceed 80MPa**, to rationally employ the granular subbase materials. In another design step is the traffic needed to complete the road pavement structural design is established.

Symbolized **N_c (Eqn. 1)**, it is expressed in millions of standard 11.5 tons axles, representing the number of such axles operating on the most intensely used road lane, during a certain prospect time interval:

$$N_c = 365.10^{-6}.l_d.\frac{1}{2}.\sum_{k=1}^{6}[AADT_k\ .EALF_k\ .\sum_{i=1}^{n}(P_{k,i} + P_{k,i+1}).t_i]$$

(1)

- N_c = Traffic
- l_d = Lane distribution factor
- $AADT_k$ = Annual average daily traffic in the base year (year 1), for vehicles in group k
- $EALF_k$ = Equivalent axle load factor, for vehicles in group k
- $P_{k,i}$, $P_{k,i+1}$ = Growth factor for vehicles in group k, at the beginning and ending of the, i, partial prognosis period
- t_i = Length of prognosis period (years)
- n = number of partial prognosis periods

Based on the method, the AADT evaluation was achieved using a WIM system. (Ciont et al., 2017) the used WIM system is installed on single carriageway, with four lanes, in a location immediately adjoining the Cluj Napoca urban area, in Romania. (Ciont et al., 2017) carried out studies on daily peak hours, their occurrence and their corresponding factors (PHFs), using peak five and fifteen-minutes flow rate intervals, while emphasizing the advantages of the employed software. The designed application also has been used in a study on flexible road pavement design, as well as to develop a polynomial short-term traffic flow prediction model. Two pavements were designed based on the calculus parameters.

Both pavements consisted of the following courses:

- waring course: stone mastic asphalt (SMA)
- binder course: hot rolled asphalt (HRA)
- base course: HRA
- upper subbase: cement-stabilized aggregates
- lower subbase: gravel
- soil subgrade

Courses	Materials	Yound moduli [MPa]	Poisson's coefficients
Wearing course	SMA	3,300	0.35
Binder course	HRA	3,500	0.35
Base course	HRA	5,000	0.35
Upper subbase	Cement-stabilised aggregates	1,000	0.25
Lower subbase	Gravel	192	0.27
Soil subgrade	Clay	80	0.42

Table 2 Material properties according to Young Moduli and Poisson's coefficients

Based on the study, it shown the different between parameters used during road design in Malaysia compare to in Romania. The parameters used in Malaysia for road design is by using California Bearing Ration which is the ESAL used 80kN. In Romania, the parameters used based on the Young Moduli (MPa) and Poisson's coefficients for road pavement design.

CHAPTER 3

METHODOLOGY

3.1 Research Methodology

Methodology in simple word can be intended to bring an idea on what the researcher is carrying out. Methodology makes the right platform to the developer to napping out the development work in relevance to make a solid plan in a right point of time and to advance the research work.

A few steps of methodology have been done upon completion the selection the type of pavements design based on amount of traffic. The very first step taken is feasibility study. Feasibility study is used to determine whether if it is worth proceeding to the analysis phase which the outcome will determine either to proceed to the next phase or to take a step back and start to consider other possible options. In this phase of the project, the study of thickness design, materials specification and the mix design requirements are applied before reach to the next phase. Below is the flow of project methodology that been used in this project.

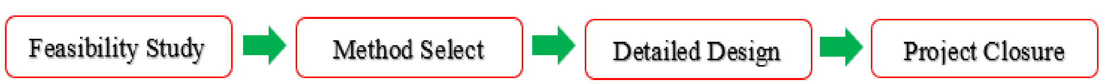


Figure 3 Flow of Project Methodology

The next phase is concept selection. At this phase, determination of pavements design concept is adapted after received the data from feasibility study. The method has been selected based on the following:

- Precedent - Standard thickness design for **road classification**.
- Empirical - **Soil classification or strength** using experience, experimentation, or both.
- Theoretical/**semi** - Mechanistic, based on mechanical model, **relate pavement parameters (stress, strains, deflections)** to physical causes (loads, material properties) using mathematical model.

After that, the project study will move to the next phase which is detail design. During this phase, the detailed drawings and conceptual drawings are applied after selected the suitable design of road pavement. Last phase is project closure which mean the project has completed and ready for submission proposal.

3.2 Gantt Chart

A Gantt chart is a visual representation of a project schedule. It helps the students to plan, manage and keep monitoring tasks in a project. Based on the chart, it shown the task is conducted during project execution within the time period according to respective week. Below are the Gantt Chart and suggested Key Milestones during the project study.

Details	Week													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Selection type of project														
Develop the planning schedule														
Study about the thickness design														
Identify the problem based on project														
Establish data collection plan														
Data findings and gathering														
Preparing extended proposal														
Submission of extended proposal														
Perform in - thickness design														
Perform in - parameters of CBR														
Perform in - traffic design														
Proposal defense														
Project work continue														
Preparation of interim report														
Submission of interim report														

Table 3 Gantt Chart for Final Year Project 1

Process   Key Milestones

Details	Week													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Analyzing the results for the pavement design														
Submission of progress report														
Project work continue														
Pre - SEDEX														
Submission of draft final report														
Submission dissertation report (soft bound)														
Viva														
Submission of dissertation report (hard bound)														

Table 4 Gantt Chart for Final Year Project 2

Process Key Milestones

3.3 Programming Language

Tools are the other basic subject to effectively executing an undertaking other than having a decent arranging in time administration for ventures. These tools can be particularly outlined instruments or general efficiency tools that can be received for any task administration. During this project, Dev-C++ has been used and a program has been developed for designing the pavement according to the sub-grade strength.

Figure 4 Dev C++

This program helps in minimizing the error during the calculation compare to manual calculation. This program used for traffic design and sub-grade strength for the pavement according to the CBR parameters used. C++ language has been developed by using this tool during designing of road pavement based on traffic category. The program was named Thickness Design. At the first phase, it will be the traffic design which is classification of traffic category. After that, the program will design the sub-grade strength of pavement based on the parameters of CBR. The parameters are important in determining the sub-grade category based on the traffic volume. Below is the program that has been developed during this project study.

3.4 Calculation of Traffic Design

Traffic data is a key input parameter for structural design of pavements. This information is needed to determine the loads must be supported over the selected design life of the pavement. Two elements of traffic load which are particular importance are:

- Standard axle or wheel load.
- Traffic spectrum and traffic volume expressed as number of standard axle loads assumed during the design life of the pavement.

The **Equivalent Standard Axle Load (ESAL) in Malaysia is 80 kN**, which corresponds to the standard axle load used in the AASHTO pavement design procedure. Besides, traffic volume is calculated from a known or estimated volume of commercial vehicles (CV) and axle load spectrum. Axle loads of passenger cars are too low to cause significant pavement distress; therefore, traffic counts and axle load spectra used for pavement design are based on the volume and the type of commercial vehicles. Traffic data are considered based on the following:

a) Number of commercial vehicles during Year 1 of design period, which is the expected year of completion of construction.
b) Vehicles class and axle load distribution.
c) Directional and lane distribution factors.
d) Traffic growth factors.

Three types of raw traffic data are typically collected and analyzed into a data base; **vehicle counts**, **vehicle classification**, and **load data**. Based on current Malaysian practice of traffic characterization, two types of data are available for structural pavement design:

- **Traffic volume and percent commercial vehicles** from the JKR national traffic data base (administered by the Highway Planning Unit or HPU).
- **Axle load** studies, which provide information about the axle load spectrum for selected types of roads and highways in Malaysia.

Axle load studies provide information about the type of commercial vehicles and axle loads for a specific road section. Axle configurations and corresponding load equivalence factors (LEF) used as basis for this manual are shown in **Table 5**. For pavement design purposes, mixed traffic (axle loads and axle groups) is converted into the number of ESAL repetitions by using load factors.

The structural design of a pavement is then based on the total number of ESAL passes over the design period. Load factors can be determined from theoretically calculated or experimentally measured lorries ad axle loads. Information from axle load studies carried out in Malaysia and from legal loads in Malaysia (Maximum Permissible Gross Vehicle and Axle Loads, RTA 1987, Weight Restriction Order 2003) have been used as basis for calculating commercial vehicle load factors for traffic classes monitored by HPU in **Table 5.**

Vehicle		**Load Equivalence Factor (LEF)**
HPU Class Designation	**Class**	
Cars and Taxis	C	0
Small Lorries and Vans (2 Axles)	CV1	0.1
Large Lorries (2 to 4 Axles)	CV2	4.0
Articulated Lorries (3 or more Axles)	CV3	4.4
Busses (2 or 3 Axles)	CV4	1.8
Motorcycles	MC	0
Commercial Traffic (Mixed)	CV%	3.7

Table 5 Axle configuration and load equivalence (LEF)

The procedure for calculating the Traffic Category to be used as design input number of 80 kN ESALs over Design Period as follows:

1. From traffic counts for the project under consideration

    a. Initial **Average Daily Traffic in one direction (ADT)**; the average should be based on a minimum of 3 days, 24 hours per day. If traffic count covers a time period of 06:00 to 22:00 hours, multiply the traffic count reported by HPU with a factor 1.2.

    b. Percentage of **Commercial Vehicles (CV)** with an un-laden weight of more than 1.5 tons (P_{cv}) and break down into vehicle categories as shown in **Table 5**.

    c. Average **Annual Traffic Growth Factor (r)** for CV.

2. Determine the following information form the geometric design of the road for which the structural pavement design is carried out:

    a. **Number of lanes**
    b. **Terrain conditions (flat, rolling, mountainous)**

3. Select design period based on economic and social consideration. Design period of 10 years is recommended for low volume roads and other rural roads. A minimum design period of 20 years is recommended for roads having medium to high volume traffic.

4. Calculate the **Design Traffic (Number of ESALs) for the Design Lane and Base Year Y_1 (First year of design period)** using the following formula:

$$\mathbf{ESAL_{Y1} = ADT \times 365 \times P_{CV} \times 3.7 \times L \times T} \qquad \textit{(1)}$$

where;

$ESAL_{Y1}$ = Number of ESALs for the Base Year (Design Lane)

ADT = Average Daily Traffic

P_{CV} = Percentage of CV (Un-Laden Weight > 1.5 ton)

L = Lane Distribution Factor (refer to **Table 6**)

T = Terrain Factor (refer to **Table 7**)

Number of Lanes (in ONE Direction)	Lane Distribution Factor, L
One	1.0
Two	0.9
Three or more	0.7

Table 6 Lane Distribution Factor

Type of Terrain	Terrain Factor, T
Flat	1.0
Rolling	1.1
Mountainous/Steep	1.3

Table 7 Terrain Factors

5. Calculate the Design Traffic (Number of ESALs) for the Design Period (Design Life in Years) using the following formula:

$$\textbf{Design Traffic } \mathbf{ESAL_{DES}} = \mathbf{ESAL_{Y1}} \times \frac{[(1+r)^n - 1]}{r} \qquad \textbf{\textit{(2)}}$$

where;

$ESAL_{DES}$ = Design Traffic for the Design Lane in One Direction (determines the Traffic Category used as Basis for selecting a Pavement Structure)

$ESAL_{Y1}$ = Number of ESALs for the Base Year ***(1)***

r = Average Annual Traffic Growth Factor for Design Period

n = Number of Years in Design Period

Design Period (Years)	**Annual Growth Rate (%)**					
	2	**3**	**4**	**5**	**6**	**7**
10	10.95	11.46	12.01	12.58	13.18	13.82
15	17.29	18.60	20.20	21.58	23.28	25.13
20	24.30	26.87	29.78	33.06	36.79	41.00
25	32.03	36.46	41.65	47.73	54.86	63.25
30	40.57	47.58	56.08	66.44	79.06	94.46

Table 8 Total Growth Factors (TGF)

CHAPTER 4

RESULTS AND DISCUSSION

The result is comparison between thickness design based on **ATJ 5/85 (1995)** and **ATJ 5/85 (2013)**. The comparison will be focused on **Full Depth: Asphalt Concrete Base** pavement type. However, the comparison has been completed to check the **sensitivity based on California Bearing Ration (CBR) parameters** and also **traffic volume** which affect the thickness of the pavement. The comparison based on the CBR parameters with constant traffic volume as below:

- CBR strength less than 5%
- CBR strength of 5%
- CBR strength more than 5%

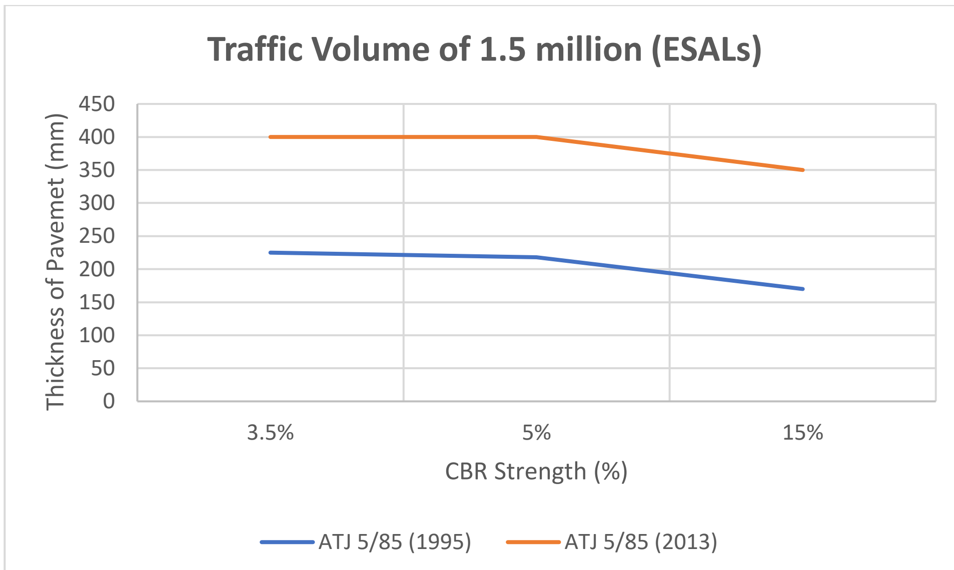
The thickness of the layer will be compared based on those CBR strength percentage. From the comparison data, the analysis has been done which to show the different in thickness design of Full Depth: Asphalt Concrete Base pavement based on parameter of CBR. Besides, the comparison and analysis of thickness design has been completed based on traffic volume with constant CBR parameters. The thickness of pavement will be compared based on traffic volume as follows:

- Low Traffic Volume
- Medium Traffic Volume
- High Traffic Volume

4.1 Comparison Based on CBR Strength

I. Low Traffic Volume

CBR Strength	Thickness of Pavement (mm)	
	ATJ 5/85 (1995)	ATJ 5/85 (2013)
3.5%	225	400
5%	218	400
15%	170	350

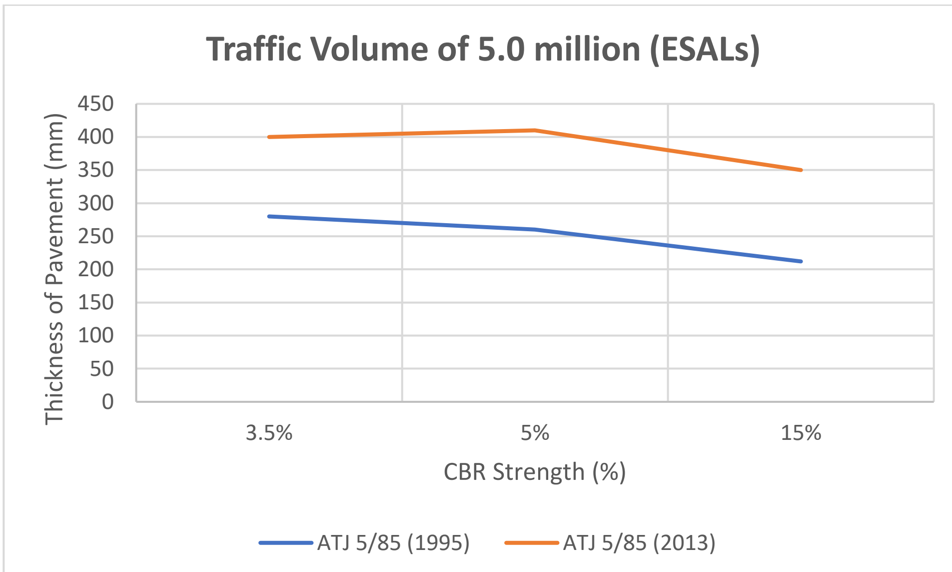


Graph 1 Thickness comparison based on low traffic volume

Based on the graph above, the traffic volume of 1.5 million (ESALs) has been used to compare the thickness of pavement according to the different of CBR strength. The minimum thickness of pavement based on ATJ 5/85 (2013) at CBR strength below than 5% is 400 mm based on the manual. The minimum CBR strength based on ATJ 5/85 (2013) must be **higher than 5%.** As shown in the graph, at CBR strength of 15%, the thickness of the pavement for ATJ 5/85 (1995) and ATJ 5/85 (2013) are **170 mm** and **350 mm** as respectively. The thickness of pavement based on ATJ 5/85 (2013) is **two times higher** compared to the ATJ 5/85 (1995). The increasing of CBR strength which provide to decrease of thickness of the pavement according to both manual.

II. Medium Traffic Volume

CBR Strength	**Thickness of Pavement (mm)**	
	ATJ 5/85 (1995)	**ATJ 5/85 (2013)**
3.5%	280	400
5%	260	410
15%	212	350

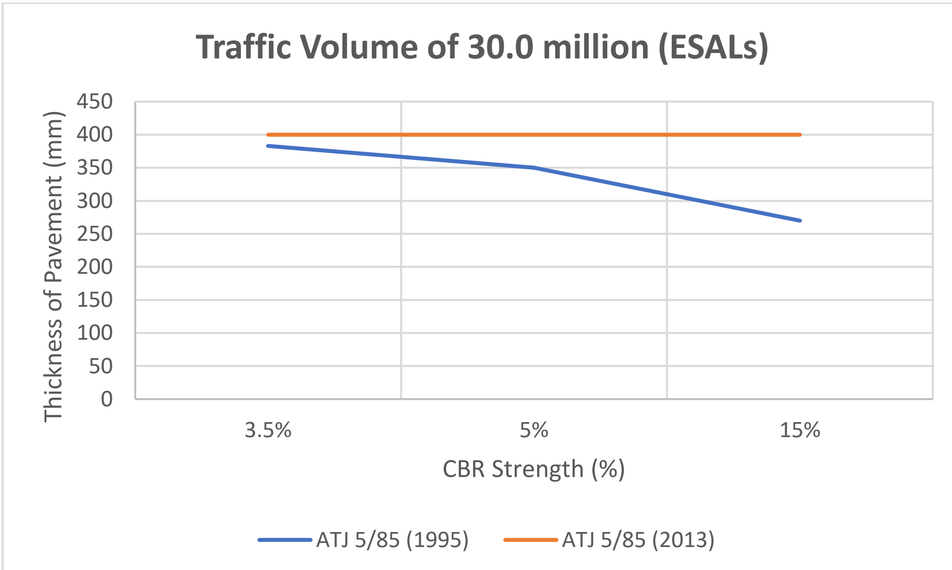


Graph 2 Thickness comparison based on medium traffic volume

Based on the graph, the thickness comparison has been done based on medium traffic volume. The increasing in thickness of pavement at CBR strength of 3.5% based on ATJ 5/85 (2013) shown that at CBR strength below than 5%, **the minimum thickness of pavement is 400 mm** based on the manual. As shown in the graph, the CBR strength affect the thickness of pavement for both manual. As the CBR strength increased, the thickness of pavement for ATJ 5/85 (1995) and ATJ 5/85 (2013) were decreased. If the CBR were used more than 15%, the line will be steeper as the thickness of pavement will decreased directly to the CBR strength.

III. High Traffic Volume

CBR Strength	Thickness of Pavement (mm)	
	ATJ 5/85 (1995)	ATJ 5/85 (2013)
3.5%	383	400
5%	350	400
15%	270	400



Graph 3 Thickness comparison based on high traffic volume

The thickness of pavement comparison is based on the high traffic volume with 30.0 million (ESALs). Based on the graph, the CBR strength recommended for **high traffic volume must be more than 12%** based on ATJ 5/85 (2013). As the result shown above, the blue line shown the thickness of pavement based on the ATJ 5/85 (1995) according to the CBR strength. The line become steeper as the CBR strength increased from 5% to 15%. It shown that, the parameter of CBR is very sensitive in changing the thickness of pavement based on both manual ATJ 5/85 (1995) and ATJ 5/85 (2013). The thickness based on ATJ 5/85 (2013) is **two times greater than** thickness design based on old manual because the design is due to over loading which need to increase the thickness of the pavement.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

In conclusion, the sub-grade strength must be selected based on the traffic category which consist of lower, medium and heavy traffic volume. The parameters of CBR is very important in road design pavement. The minimum of CBR value must be considered in road pavement design depend on traffic category design. If the CBR value does not meet the requirement, the sub-grade soil must be replaced or stabilized to ensure that the selected minimum CBR value is obtained under due consideration of applicable moisture conditions and probability of meeting the design input value. The CBR strength provided to decreasing of pavement thickness as the CBR value increased. The higher the CBR value, the lower the thickness of pavement layer of Full Depth: Asphaltic Concrete Base. This study project has achieved the objective as the following:

1) Able to compare the thickness design according to the ATJ 5/85 (1995) and ATJ 5/85 (2013) based on Full Depth: Asphaltic Concrete Base.
2) Able to compare the sensitivity of parameter of California Bearing Ratio (CBR) designed depends on the thickness design.
3) Successful in develop a thickness design software of flexible pavement by using C++ programming language.

5.2 Recommendation

A minimum CBR of 5% is recommended for pavements that have to support traffic volumes corresponding to low traffic volume, medium traffic volume and high traffic volume. If the sub-grade does not meet this minimum CBR requirement, at least 300 mm of unsuitable sub-grade soil shall be replaced or stabilized to ensure that the selected minimum CBR value is obtained under due consideration of applicable moisture conditions and probability of meeting the design input value.

For road pavements designed for medium and high traffic volume, a minimum sub-grade strength corresponding to CBR of 12% is recommended. Based on the result, the programming language has been developed based on ATJ 5/85 (2013) to ease the study project which the traffic volume was designed by using the developed programming language. The computer software is very important where the design stage can be made in a very short time period of design process and help to minimize the error factor compare to manual calculation.

```
*** Traffic Design ***
1) Average Daily Traffic (ADT): 250

2) Lane Highway: 2

3) Percentage Common Vehicles, PCV (%): 0.16

4) Lane Distribution Factor, L: 1

5) Total Growth Factor, TGF: 12.01

6) Load Equivalent Factor, LEF: 3.5

   Flat = 1.0
   Rolling = 1.1
   Mountain/Steep = 1.3

7) Terrain Factor, T:1.1

   DESIGN TRAFFIC    : 6.75e+005
   TRAFFIC CATEGORY : T1


*** Sub-grade Design (CBR) ***
1) CBR Mean (%): 8.5

2) CBR Standard Deviation,(%): 4.4

   DESIGN CBR (%)    : 7.39
   SUB-GRADE CATEGORY STRENGTH : SG1
```

Figure 5 Programming language based on ATJ 5/85 (2013)

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