

**SIMULATION OF PAVEMENT DEFORMATIONS FOR  
DIFFERENT APPROACH SLABS CONCEPT CONSTRUCTED  
ON BATU PAHAT SOFT CLAY (BPSC)**

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This dissertation is submitted as a fulfilment of the requirements for the award of  
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*Special dedication to my beloved father and mother,  
Mr. Mohd Daud Kayat and Mrs. Hamsah Sandir, all family  
members and friends. Thanks for all your valuable  
contributions, patience and love.*

*May Allah S.W.T, The Almighty bless our every living days,  
Insyallah...*



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## ABSTRACT

Depression or bump that occurs between end of bridge approach slab and road pavement interface always arises a great concern among motorists. The occurrence of the bump that motorist feel as they leaves or approaches the bridge is caused by the differential settlement problem. This problem becomes more apparent particularly over soft soil condition such in Batu Pahat district. Currently, there is no guideline and specification provided by the Public Work Department in designing a proper bridge approach model, which has exceptional transition toward road pavement. The current conventional model used in many projects was reported to be less effective since the problem is still noticeable and it requires regular maintenance work when the problem reappears recurrently. Practically, it is clear that the problem is still unresolved and this is due to the complexity of the design problem itself that merge the structural and geotechnical perspectives in design. The studies on simulation modelling for approach slab and road pavement design also have been rare. It is essential since such design analysis, which is based on numerical analysis, could have advantages in providing preliminary expected outcomes for the modelling purpose. In conjunction to this matter, the modelling of several approach slab and road pavement concepts have been successfully conducted to verify the result expectancies using this approach in order to provide better understanding on the recurrent problem.

Keywords: bump, bridge approach slab, differential settlement, soft soil, simulation modelling

## ABSTRAK

Ketidakteraturan permukaan atau 'bonggol' yang berlaku di antara muka hujung papak julur bagi jambatan dan jalan raya kerap kali mengundang kebimbangan pengguna jalan raya. Kejadian tersebut yang dirasakan oleh pengguna jalan raya apabila menuju atau melewati jambatan adalah diakibatkan oleh masalah perbezaan pemendapan yang berlaku. Masalah tersebut menjadi lebih jelas apabila melibatkan pembinaan di kawasan tanah lembut seperti di daerah Batu Pahat. Pada ketika ini tiada garis panduan mahupun spesifikasi yang disediakan oleh Jabatan Kerja Raya dalam mereka bentuk papak julur yang mampu menangani permasalahan tersebut. Model konvensional yang digunakan pada ketika ini dilaporkan kurang efektif kerana permasalahan ini masih berulang serta memerlukan kerja penyelenggaraan yang kerap. Secara praktikalnya adalah jelas bahawa permasalahan ini masih belum dapat diselesaikan dan ini adalah disebabkan oleh kesukaran yang dialami ketika mereka bentuk model di mana ia melibatkan gabungan pemahaman daripada sudut kejuruteraan struktur dan geoteknik. Manakala kajian kaedah simulasi dalam hal ini adalah jarang dilakukan dan tidak meluas. Analisis seperti ini yang melibatkan analisis elemen terhingga adalah berguna dan mempunyai kelebihan dalam menyediakan platform rekabentuk awal. Berikutan ini, rekabentuk beberapa konsep papak julur bagi jambatan dan seksyen jalan raya telah dijalankan dengan jayanya dalam penyelidikan simulasi ini bagi menjelaskan jangkaan keputusan terhadap kajian, seterusnya memperolehi pemahaman yang lebih terhadap permasalahan yang berulang ini.

Kata kunci: bonggol, papak julur bagi jambatan, perbezaan mendapan, tanah lembut, simulasi

## CONTENTS

CHAPTER	TITLE	PAGES
	DECLARATION	i
	SUPERVISOR'S CONFIRMATION	ii
	CONFESSION	iii
	DEDICATION	iv
	ACKNOWLEDGEMENT	v
	ABSTRACT	vi
	ABSTRAK	vii
	CONTENTS	viii
	LIST OF FIGURES	xv
	LIST OF TABLES	xvii
	LIST OF SYMBOLS	xix
<b>I</b>	<b>INTRODUCTION</b>	
	1.1 Problem Statement	1
	1.2 Objective of Study	2
	1.3 History and Study Area	3
	1.4 Scope and Limitation of Research	5
	1.5 Hypothesis	5
	1.6 Research Methodology	7
	1.7 Flow Chart of Research Project	9



## II ROAD PAVEMENT-APPROACH SLAB CONSTRUCTION AND FAILURES

2.1	Introduction	10
2.1.1	Soft Clay in Batu Pahat	11
2.1.2	Road Pavement	12
2.1.3	Bridge Approach	13
2.2	Flexible Pavement: Design and Construction	14
2.2.1	Design Method	14
2.2.2	Design Factors	14
2.2.2.1	Traffic Loading	15
2.2.2.2	Material Characteristics	16
2.2.2.3	Failure Criteria	17
2.2.3	Road Pavement Design in Malaysia	17
2.2.4	Construction under Soft Clay Condition	20
2.3	Bridge Approach Slab: Design and Construction	21
2.3.1	Bridge Abutment and Approach Slab	21
2.3.2	Design Method	22
2.3.3	Construction of Approach Slab	23
2.4	Flexible Pavement and Approach Slab Performance	24
2.4.1	Flexible Pavement Failures	24
2.4.2	Causes of Road Pavement Failures	27
2.4.3	Problem on Approach Slab Structure	28

## III

## CASE STUDIES OF ROAD-BRIDGE INTERFACE PERFORMANCE

3.1	Introduction	30
3.2	Structural Performance of Bridge Approach Slabs under Given Embankment Settlement	31
3.2.1	Introduction	31
3.2.2	Objectives of Study	32
3.2.3	Research Methodology	33
3.2.3.1	Finite Element Modeling	33
3.2.3.2	Determination of Boundary Conditions	35
3.2.3.3	Effects of Embankment Settlements on Slab Performance	35
3.2.3.4	Test Result	36
3.2.4	Conclusion	37
3.3	Effect of Orientation of Approach Slabs on Pavement Deformation	38
3.3.1	Introduction	38
3.3.2	Objectives of Study	39
3.3.3	Research Methodology	40
3.3.3.1	Approach Slab	40
3.3.3.2	Measurement of Deformation	41
3.3.3.3	Test Result	41
3.3.4	Conclusion	43
3.4	Performance of Geocomposite Membrane in Pavement Systems	44
3.4.1	Introduction	44
3.4.2	Objectives of Study	45
3.4.3	Research Methodology	46
3.4.5	Conclusion	47
3.5	Discussions	48



## IV FAILURE SIMULATION USING PLAXIS

4.1	Introduction	50
4.2	PLAXIS Finite Element Modelling in Geotechnics	51
4.2.1	Mohr–Coulomb Model	52
4.2.2	Soft-Soil Model	53
4.2.3	Soft-Soil-Creep Model	54
4.3	PLAXIS Programmes	55
4.3.1	Determination of Boundary Condition	56
4.3.2	Input Parameter	56
4.3.2.1	Geometrical Input	56
4.3.2.2	Loads Types	58
4.3.2.3	Material Input	58
4.3.2.4	Mesh Generation	60
4.3.2.5	Initial Condition	60
4.3.3	Calculation Program	61
4.3.3.1	Calculation Types	61
4.3.3.2	Loading Input	61
4.3.3.3	Calculation Phases	62
4.3.3.4	Selection of Points	63
4.3.4	Output Data	64
4.3.4.1	Graphical Output	64
4.3.4.2	Cross-Section Output	65
4.3.4.3	Table Output	66
4.3.5	Curve Generation	67
4.4	Failure Simulation Analysis	69
4.5	Limitation of PLAXIS Software	70

## V

**RESEARCH METHODOLOGY AND TESTING**

5.0	Introduction	71
5.1	Gathering Data and Information	72
5.1.1	Literature Review	72
5.1.2	Interview	72
5.2	Field Investigation and Laboratory Testing	73
5.2.1	Geological Information of Study Area	73
5.2.2	Structural Condition	74
5.2.3	Subground Condition	75
5.2.4	Soil Testing	75
5.3	Traffic Loading	76
5.3.1	Type of Loading	77
5.3.2	Loading Configuration	78
5.4	Performing Simulation Program	78
5.4.4	Geometrical Parameters	79
5.4.4.1	Subgrade Thickness and Geotextile Layer	79
5.4.4.2	Control Model (Horizontal Slab)	80
5.4.4.3	Slab Inclined at 5 to Horizontal	81
5.4.4.4	Phreatic Level	81
5.4.5	Material Parameters	82
5.4.6	Pavement Properties	83
5.4.7	Soil Properties	83
5.4.8	Concrete Slab Properties	84
5.4.9	Geosynthetic Properties	84
5.4.10	Determination of Boundary Conditions	84

## VI DATA OBSERVATION AND ANALYSIS

6.1	Introduction	86
6.2	Consolidation Analysis on Transition Section	87
6.2.1	Horizontal Slab	87
6.2.2	5° Inclined Slab	90
6.3	Effect of Subgrade Thickness and Reinforcement on Deformation Profiles	92
6.3.1	Horizontal Slab without Geosynthetic Reinforcement	93
6.3.2	Horizontal Slab with Geosynthetic Reinforcement	94
6.3.3	Inclined Slab at 5° to Horizontal without Geosynthetic Reinforcement	96
6.3.4	Inclined Slab at 5° to Horizontal with Geosynthetic Reinforcement	97
6.4	Comparative Study on Deformation Profile of Different Approach Slabs Design	98
6.5	Deformation Analysis on Interface Region	101
6.6	Limitation of Research	103

## VII CONCLUSION AND RECOMMENDATION

7.1	Introduction	106
7.2	Conclusion	107
7.2.1	The Application of PLAXIS Software in Modelling Approach Slab Concept	107
7.2.2	Interface of Approach Slab and Flexible Road Pavement	108
7.2.3	Performance of 5° Inclined and Horizontal Approach Slab Concept	109
7.3	Recommendations	110

REFERENCES

113

APPENDICES

114

A Figures

116

B Tables

121

C PLAXIS Output Data

126



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## LIST OF FIGURES

FIGURES NO.	TITLE	PAGES
1.1	Plan View of Study Area	4
1.2	Flow Chart of Research Project	9
2.1	State Roads in Batu Pahat District (Batu Pahat PWD, 2004)	19
2.2	Typical Cross Section of Rural Road Pavement in Batu Pahat District (Public Work Department, 2001)	20
2.3	Typical Pavement Section Constructed on Parit Karjo State Road (State Public Work Department, 2006)	21
2.4	Typical Rut on Flexible Road Pavement	26
2.5	Typical Fatigue Cracking on Road Pavement Surface (Jestin, 2006)	26
3.1	Illustration of Slab Interaction with Soil (Cai, et. al, 2005)	32
3.2	Sketch of Materials Arrangement (Cai, et, al, 2005)	34
3.3	Deflection of Slab against Differential Settlement (Cai, et. al, 2005)	36
3.4	Rotation of Slab against Differential Settlement (Cai, et. al, 2005)	36
3.5	Test Section of the Control Horizontal Slab (Cai, et. al, 2005)	40
3.6	Test Section of the Slab at 5° to Horizontal (Wong, et. al 1994)	40
3.7	Test Section of the Slab at 10° to Horizontal (Wong, et. al, 1994)	41
3.8	Deformation Profile of the Control Horizontal Slab (Wong, et. al, 1994)	42
3.9	Deformation Profile of the Slab at 5° to Horizontal. (Wong, et. al, 1994)	42

3.10	Deformation Profile of the Slab at 10° to Horizontal (Wong, et. al, 1994)	43
3.11	Pavement Design (Section J and K) (Brandl, H. and Adam, D. (2000)	47
4.1	Geometry Model in Plaxis Input Program (PLAXIS Tutorial Manual, 2002)	57
4.2	Material Set and Configuration for Soil Properties (PLAXIS Tutorial Manual, 2002)	59
4.3	Typical Calculation Window in PLAXIS Calculations Program (PLAXIS Tutorial Manual, 2002)	63
4.4	Deformed Mesh Visualised Graphically in PLAXIS Output Program (PLAXIS Tutorial Manual, 2002).	65
4.5	Curve Generation Window in PLAXIS Curves Program (PLAXIS Tutorial Manual, 2002)	67
4.6	Load-Displacement Curve Generated by PLAXIS Curves Program (PLAXIS Tutorial Manual, 2002)	68
5.1	Typical Configuration of a Heavy Vehicle with Standard 18 kips (80 kN) Single Axle Dual Tyres	77
5.2	Cross Sectional View of Subsoil Layer and Approach Slab	80
5.3	Configuration Type of Inclined Slab to the Horizontal Surface	81
6.1	Horizontal Slab Deformation Profiles on Unreinforced Subgrade by Means of Consolidation	88
6.2	Horizontal Slab Deformation Profiles on Geotextile- Reinforced Subgrade by Means of Consolidation	89
6.3	Horizontal Slab Deformation Profiles on GCL-Reinforced Subgrade by Means of Consolidation.	89
6.4	5° Inclined Slab Deformation Profiles on Unreinforced Subgrade by Means of Consolidation	90
6.5	5° Inclined Slab Deformation Profiles on Geotextile- Reinforced Subgrade by Means of Consolidation	91
6.6	5° Inclined Slab Deformation Profiles on GCL-Reinforced Subgrade by Means of Consolidation	92

6.7	Development of Subgrade Deformation on Horizontal Slab Model with Different Thickness of Unreinforced Subgrade Layer	94
6.8	Development of Subgrade Deformation on Horizontal Slab Model with Different Thickness and Reinforced Subgrade Layer	95
6.9	Development of Subgrade Deformation on 5° Inclined Slab Model with Different Thickness of Unreinforced Subgrade Layer	96
6.10	Development of Subgrade Deformation on 5° Inclined Slab Model with Different Thickness and Reinforced Subgrade Layer	98
6.11	Development of Subgrade Deformations on Different Approach Slab Models	100
6.12	Deformation profiles of Horizontal and 5° Inclined Slab within Interface Region	102
6.13	Deformation profiles of Horizontal and 5° Inclined Slab within Interface Region for Various Subgrade Thickness and Reinforcement	103



**LIST OF TABLES**

<b>TABLES NO.</b>	<b>TITLES</b>	<b>PAGES</b>
2.1	Roads Categories in Malaysia (Meor, et. al, 2001)	18
2.2	Pavement Failures According to Several Researchers (Jestin, 2006)	25
3.1	Material Parameters (Cai, et. al, 2005)	34



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## LIST OF SYMBOLS

AASHTO	American Association of State Highway and Transportation Officials
CBR	California Bearing Ratio
CD	Consolidated Drained Test
CU	Consolidated Undrained Test
DVL	Digital Video Logger
FWD	Falling Weight Deflectometer
EPS	Expanded Polystyrene
ESAL	Equivalent Standard Load
GCL	Geosynthetic Clay Liner
GPR	Ground Penetrating Radar
HPU	Highway Planning Unit
LaDOTD	Louisiana Department of Transportation Development
NDT	Non-Destructive Test
NYDOT	New York Department of Transportation
PSI	Present Serviceability Index
PWD	Public Work Department
$\sigma$	normal stress
$\sigma'$	effective normal stress
$\sigma_3$	confining pressure
$E$	modulus of elasticity
$\phi$	friction angle
$\Delta\sigma$	deviator stress
$u$	pore pressure
$C$	cohesion
$C_c$	coefficient of consolidation
$C_\alpha$	coefficient of secondary compression

$f$	yield function
$\bar{f}$	function of the stress state
$\kappa^*$	modified swelling/ recompression index
$\lambda^*$	modified compression index
$P_p$	pre-consolidation stress
$t_0$	time at which creep is assumed to commence
$t_1$	time
$e_0$	initial void ratio
$e_1$	void ratio
$s$	shear stress
$\mu^*$	modified creep index
$\nu$	Poission Ratio
$\psi$	dilatancy angle



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## CHAPTER I

### INTRODUCTION

#### 1.1 Problem Statement

The concrete bridge found in Parit Karjo, Batu Pahat is constructed on deep foundation pile which is structurally stable and sound. Construction of pavement and bridge under soft soil circumstance is always linked to the differential settlement problems between bridge abutments and roadway ends. Though, bridge approach slab is provided to span across any difference in level due to settlement between the bridge approach and the roadway ends. The long span concrete slab certainly will provide smoother transition at the end of the roadways to the approach bridge. Thus, providing better comfortability and rideability to commuters and road-users.

The occurrence of settlement for road pavements-bridge interface sections will be noticeably when there is a sudden change of joint level between the ends of paved roadway and constructed bridge approach slab. Undoubtedly, this will affect the rideability quality or factor of the roadway in the long run. This complaint involves a 'bump' that motorists feel as they are leaving or approaching the bridge. The only alternative available now is rehabilitation or remedial work that is to

increase the serviceability of the pavement before the same deformation problem reappears gradually. According to Azman and Masirin (2000), about 20% to 30% of total rural road in Batu Pahat district experienced varieties types of failure. Noticeably some damage problem such as deformation of pavement creates uncomfortable manner and also rise of worries of safety among the road users. Thus, it will raise the cost of maintenance as additional maintenance work must be carried out after some period of serviceability.

Above all the matters, it is important for engineers to provide better design and concept of approach slab thus will benefit many similar construction projects in the future. Cai et al. (2005) summarized approach slab design directly affects the safety and economy of the transportation infrastructure. Modification in design of approach slab is important in order to identify better solution for this problem. Though, other researchers such as Wong and Small (1994) in their laboratory scale test indicated that greater sloping angle of approach slab then  $10^\circ$  did not show any significant effect on pavement deformation. Alternatively, performance of designed approach slabs can be examined through simulation modelling using computer software. In this study some of the conceptual design of approach slabs will be proposed to be evaluated. All required data to be used as inputs in modelling process can be obtained from various laboratory tests.

## **1.2 Objective of Study**

This study is mainly to examine the effect of various formations and concept of approach slab on pavement deformation. The study focuses on Parit Raja rural road that is currently having severe deformation problem on its bridge connection between roadway end and bridge approach slab. Thus, the objectives of this study are as follows:

- To simulate the effect of various formation and concept of approach slab on pavement deformation using PLAXIS software.
- To examine the differential settlement behaviour of road pavement constructed in soft soil condition when interfaced with rigid bodies such as concrete bridge.
- To critically examine the performance of road pavement when interfaced with approach slab under given soft clay condition.

### 1.3 History and Study Area

Parit Karjo is located at wetland area of soft soil in Batu Pahat district. With the condition of high water table and weak soft soil properties, it is always being linked with engineering structures failures due to soil settlement problem. Currently, major problem of road pavement in this area is the occurrence road surface settlement with appearance of various kinds of distresses along the roadway section. In addition to that emerging problems, we had also noticed that differential settlement occurs between constructed bridge approach slab and road pavement that is apparently more problematic. It is well-known problem but unfortunately not yet to be resolved appropriately as claimed by the statement of Public Work Department authority.

Cai, et. al, (2005), summarized the embankment settlement is contributed by many factor accumulated all together such as subsoil conditions, materials, construction techniques, drainage provisions, and quality control methods during construction. The study on causes of the problem had been conducted commonly for

many years. Some of researcher such as Wong and Small (1994) had studied on the effect of orientation of approach slab model. Not merely restricted to the bridge construction alone, very similar structure such as culvert also shares the same interference problem. In this regard, Gue, S. S. et. al (2002) recommended the use of oversize culvert without end bearing piles to provide smooth riding comfort.

According to the initial field observation, deformations of road surface were severe. Rideability of pavement was so poor and rehabilitation action must be done as soon as possible to prevent more consequent damage and any safety threat to the road users. Plane view of study area is shown as follow:

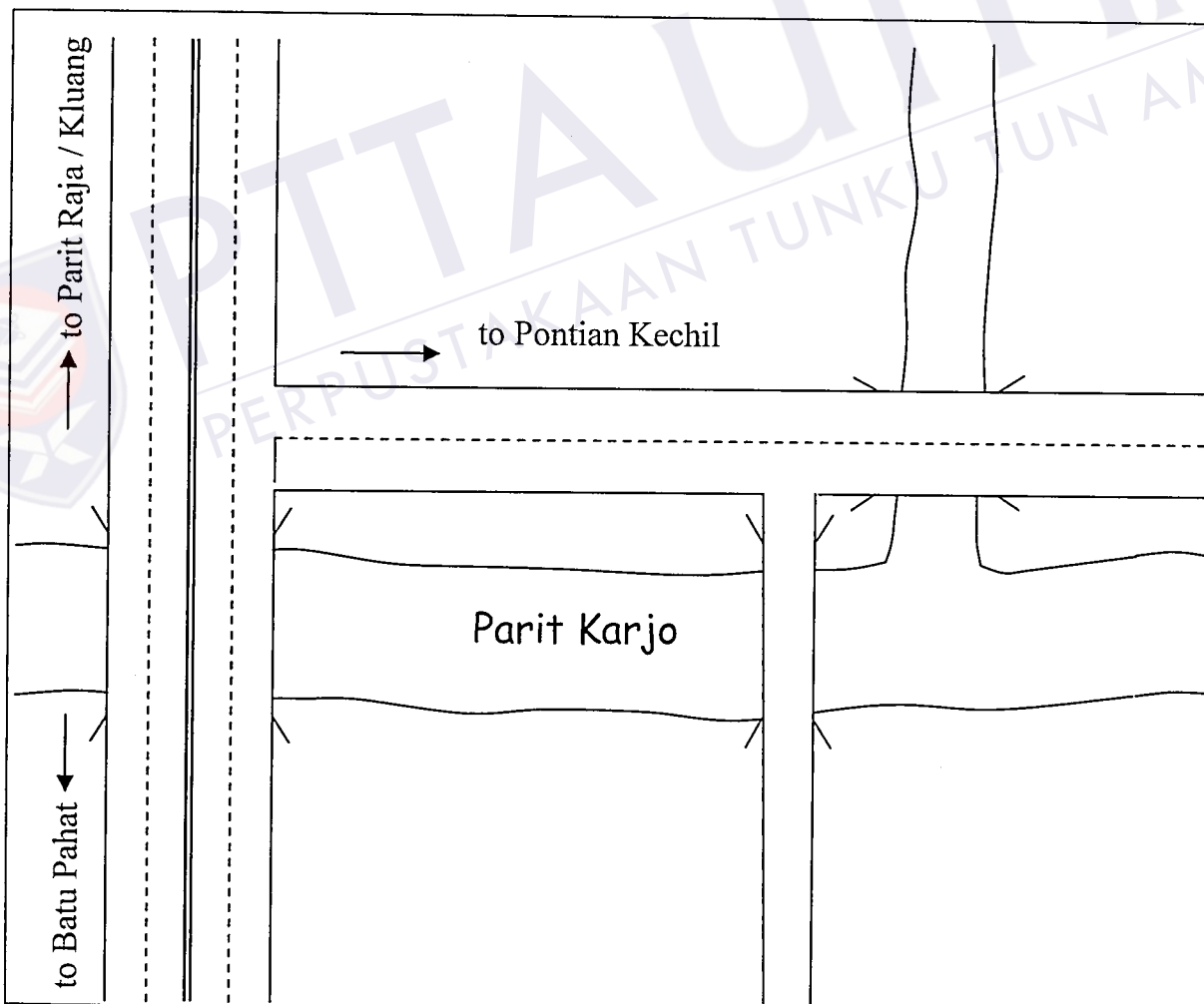


Figure 1.1: Plan View of Study Area

#### 1.4 Scope and Limitation of Research

Research scope will concern on simulation analysis of some concept and modification of approach slabs based on the given condition of soft soil using finite element method. PLAXIS Version 8 will be used in this regard with the ability to perform two dimensional analyses. Soil properties will be obtained from various literatures of previous researchers who doing research in this field. Modelling on the concrete bridge will be based on the actual drawing obtained from the consultant firm who was responsible in this project design. In modelling of soil material itself, established Mohr-Coulomb model will be used for this purpose of study.

Parit Karjo rural road and bridge found near to the T-junction of Kluang – Batu Pahat state road has been used as a research tool. Field observation and laboratory testing has been carried out to identify the required data and properties to be used in this simulation study. However, existing road-bridge in Parit Katjo only used as. Under the limitation of PLAXIS software, deformation analysis was based on static loads at selected point. PLAXIS V8 with capability of 2-dimensional modelling was used to perform the simulation analysis of deformation and stability of geotechnical structures.

#### 1.5 Hypothesis

Several hypotheses have be made based on the expected out comes of the research. Generally, modification in design especially beyond the end of provided approach slab would result in change of load transition behaviour. This was based on the explanation that any change in material stiffness between end of roadway and much stiffer material of approach slab would cause of smoother deformation profile. Thus, hypothesis of the research could be explained as follows:

- Conventional horizontal slab could provide better and smoother surface transition toward end of pavement if compared with the one, which was not provided with any transition of approach slab. Though, small depression of deformation beyond the end of constructed approach slab will noticeably exist. In long term effect especially under soft soil circumstance, surface deformation of pavement may become more severe if no rehabilitation work would be carried out.
  
- By providing some modifications on design models, performance at transition region between approach slab and road pavement might be improved and expectedly distinctive for every proposed approach slab model. Consequently, it would be able to demonstrate of how modification on the approach slab and road pavement geometry and material properties would affect on their performance against deformation.
  
- Interface region at connection between bridge approach slab and approaching roadbase were the critical area in which the depression of road pavement surface occurs significantly. The use of new approach slab concept with subgrade reinforcement could improve the transition behaviour at particular area.
  
- Modification of the approach slabs design could be extended with the use of additional reinforcement materials such as geotextile and geosynthetic clay liner that would possibly exhibit better performance particularly under soft soil condition. Such of material is widely use in numerous geotechnical and transportation engineering projects.



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