Kursus Rekabentuk Turapan Jalan
(Flexible Pavement)
7 - 9 Ogos 2019

Rekabentuk Pavemen (Jajaran Sedia Ada)

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Cawangan Jalan

KANDUNGAN

- Pengenalan
- Keadaan semasa jalan
- Kaedah Rekabentuk Empirical
- Kaedah Rekabentuk Mekanistik
- Contoh pengiraan
- Hands on

PENGENALAN

- pavemen sedia ada perlu direkabentuk
- tujuan penyenggaraan
- tujuan pavement management system
- data utama - keadaan jalan sedia ada

KEADAAN SEMASA JALAN

- jenis-jenis kerosakan
- ketebalan lapisan sedia ada
- kekuatan residual lapisan
- bilangan trafik
- rekod penyenggaraan

KEADAAN SEMASA JALAN - keretakan

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Condition	Structural coefficient
Sound, stable, uncracked. Little deformation in wheelpaths.	0.8
Crack type 1, < 5 mm rutting.	0.7
Crack type 2 – 3, 5 – 10 mm rutting.	0.5
Crack type 4 or greater, > 10 mm rutting.	0.4

Jadual 1: Estimated values of structural coefficient for various conditions of asphalt.

Severity of crack		
0	-	No crack
1	-	Single crack
2	-	Many cracks but not interconnected
3	-	Block cracks
4	-	Crocodile cracks
5	-	Crocodile cracks and spalling

Jadual 2: Penentuan tahap keretakan.

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Jadual 2: Penentuan tahap keretakan.

KEADAAN SEMASA JALAN - roadbase & subbase

Layer	CBR	Estimate of structural coefficient
Sub-base	> 30 %	0.30
	20 – 30 %	0.20
	< 20 %	0.10
Roadbase	> 100 %	0.32
	80 – 100 %	0.30
	< 80 %	0.25

Jadual 3: Estimated values of structural coefficient for various conditions of base course.

KEADAAN SEMASA JALAN - berdasarkan penilaian pavemen

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PAVEMENT LAYER	STRENGTH INDICATION	RATING	ESTIMATED STRUCTURAL COEFFICIENT
Subgrade	CBR <5% (50MN/m2) 5 – 10 % > 10 % (100 MN/m2)	Poor Satisfactory Sound	0.1 0.20 0.23
Sub-base	Modular ratio (E3/Esg) < 1 1 – 1.5 > 1.5	 Poor Satisfactory Sound	 0.23 0.30 0.32
Granular Base	Modular ratio (E2/Esg) < 1.5 1.5 – 2.0 > 2.0	 Poor Satisfactory Sound	 0.25 0.30 0.32
Bituminous Surfacing	Modulus value (MN/m2) < 1500 1500 – 2500 2500 – 3500 > 3500	 Very poor Poor Satisfactory Sound	 0.6 0.7 0.85 0.95

REKABENTUK KAEDAH EMPIRIKAL - ATJ 5/85

1. KIRA ESAL

Bagaimanakah cara untuk mengira unjuran trafik dan beban gandar?

i. Dapatkan purata trafik harian (average daily traffic ADT) dari Bahagian Perancang Jalan (BPJ).

ii. Dapatkan peratus kenderaan perdagangan (Pc) dari BPJ (kenderaan perdagangan adalah kenderaan tanpa muatan yang melebihi berat 1.5 tan).

iii. Dapatkan kadar pertumbuhan trafik tahunan (r) dari BPJ.

iv. Kira bilangan kenderaan perdagangan tahunan bagi satu hala (Vo):

Vo = ADT x 365 x Pc/100 x directional split (directional split = 0.5 sekiranya tidak diketahui)

v. Kira jumlah kenderaan perdagangan bagi satu hala (Vc);

$$Vc = \frac{Vo \times \left[(1+r)^n - 1\right]}{r}$$

n = hayat rekabentuk (tahun)

vi. Kira Equivalent Standard Axle Load (ESAL)

$$ESAL = Vc_1 \times e_1 + Vc_2 \times e_2 + \ldots + Vc_n \times e_n$$

Vc_n = jumlah kenderaan untuk setiap kategori gandar
e_n = equivalent factor untuk setiap kategori gandar
(lihat Table 3.1 Arahan Teknik (Jalan) 5/85, Pindaan 1/93)

vii. Jika tiada tinjauan terhadap beban gandar dilakukan, gunakan 2.52 sebagai equivalent factor.

2. DAPATKAN KETEBALAN EFEKTIF DARI NOMOGRAPH

- CBR Subgrade
- ESAL

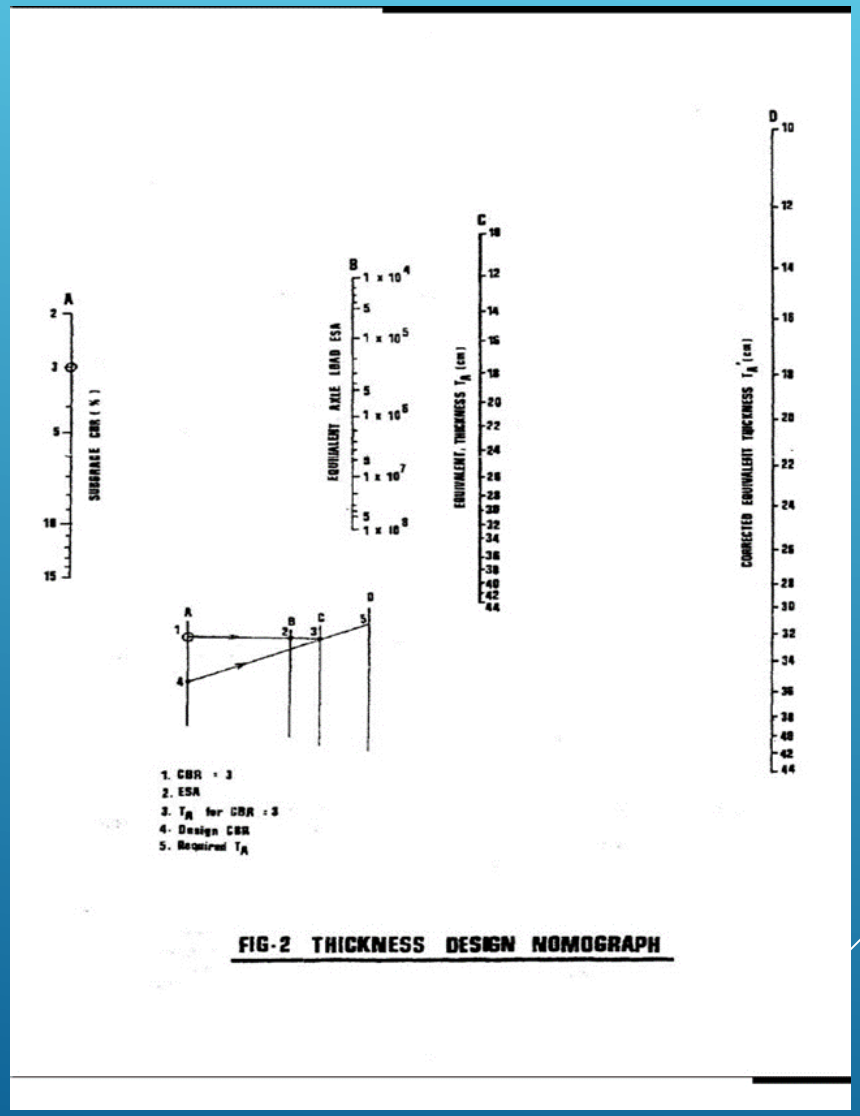
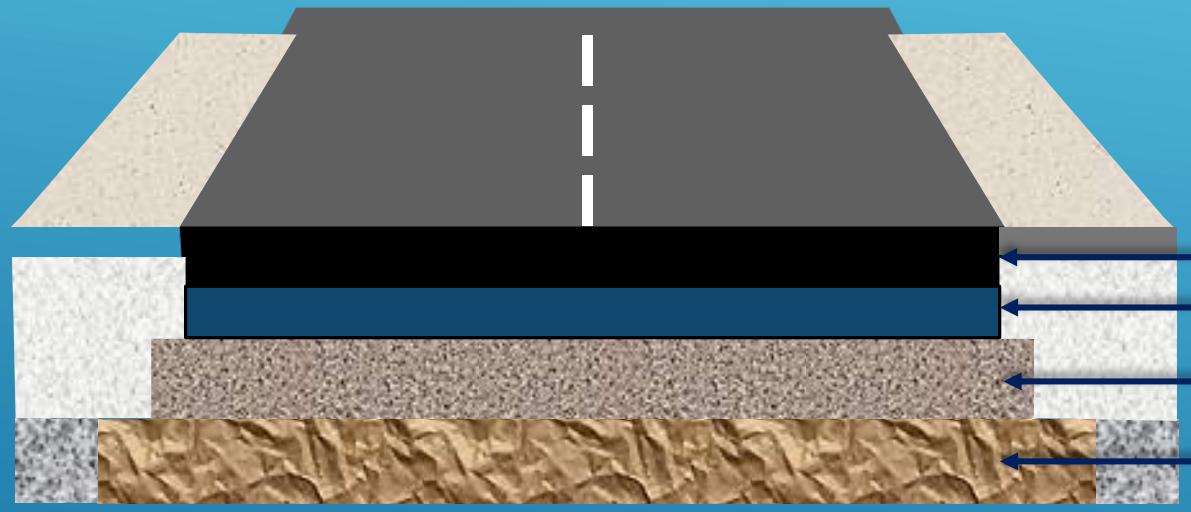


FIG-2 THICKNESS DESIGN NOMOGRAPH

DAPATKAN KETEBALAN EFEKTIF SEDIA ADA



Wearing Course = ?mm

Binder Course = ?mm

Roadbase = ?mm

Granular Subbase = ?mm

CBR Subgrade = ? %

RUJUKAN KEADAAN PAVEMEN SEDIA ADA

- tahap keretakan - coefficient
- roadbase - coefficient
- sub base - coefficient

PERBANDINGAN

- Tebal Efektif Sedia Ada > Tebal Efektif Diperlukan – tidak perlu pembaikan
- Tebal Efektif Sedia Ada < Tebal Efektif Diperlukan – cadangan pembaikan

CONTOH PENGIRAAN

Membaikpulih struktur pavemen untuk jalan utama 2 lorong berdasarkan parameter di bawah:

Initial daily traffic volume, ADT	12,000
Directional split	55/45
Percentage of commercial vehicles, Pc	15%
Annual growth rate, r	7%
Hayat rekabentuk, n	8 tahun
Axle load survey	NA

1. PENGIRAAN ESAL

i. Penentuan TA rekabentuk pavemen

V_o = ADT x 365 x Pc/100 x directional split
= 12,000 x 365 x (15/100) x 0.55
= 362,000 kenderaan

$$V_c = Vo \left[\frac{(1+r)^n - 1}{r}\right]$$

$$= 362{,}000 \left[\frac{(1+0.07)^8 - 1}{0.07}\right]$$

$= 3.7 \times 10^6$ kenderaan

ESAL = V_c x 2.52*
= 3.7×10^6 x 2.52*
= 9.35×10^6

(*Tiada kajian axle load. Jadi, equivalent factor = 2.52)

2. KETEBALAN EFEKTIF (DARI NOMOGRAPH)

Dari pengiraan,

CBR subgrade = 5%
ESAL = 9.35×10^6

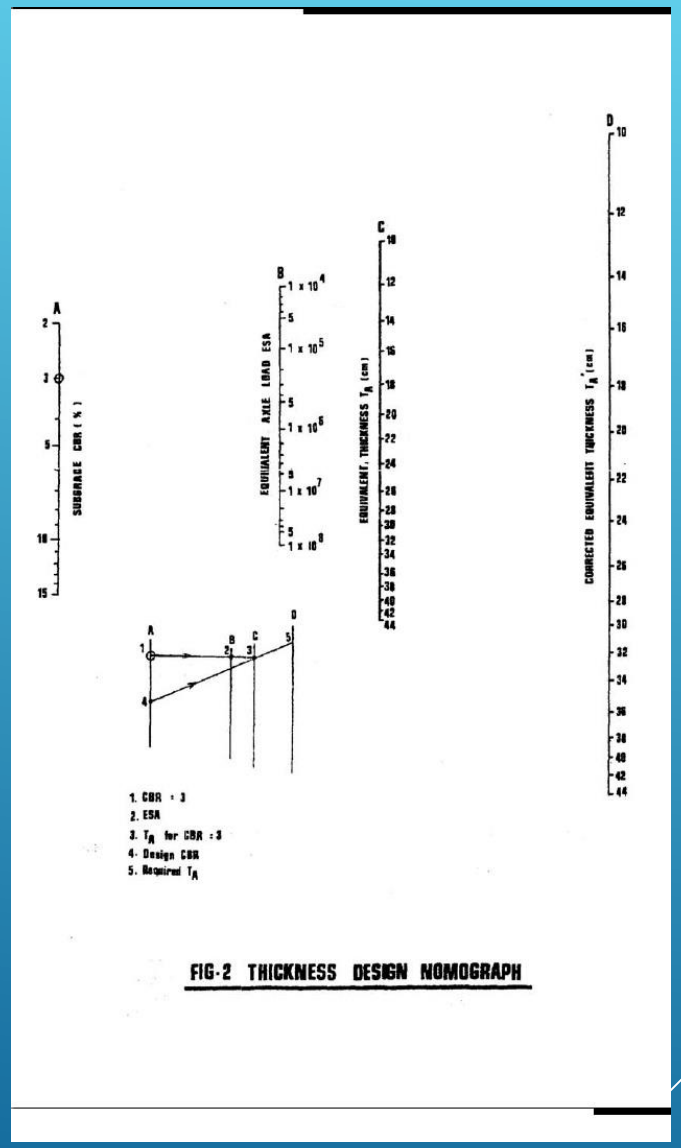


FIG-2 THICKNESS DESIGN NOMOGRAPH

2. KETEBALAN EFEKTIF (DARI NOMOGRAPH)

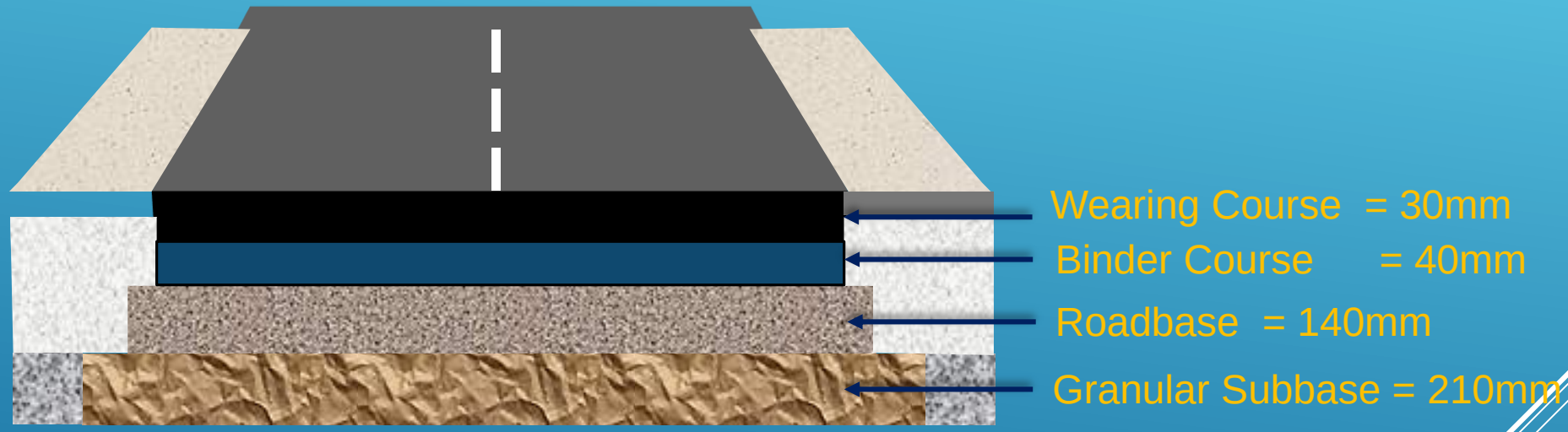
Dari pengiraan,

CBR subgrade = 5%
ESAL = 9.35×10^6

Dari Figure 3.1 Arahan Teknik (Jalan) 5/85 Pindaan 1/93, nilai T_A (rekabentuk) dapat ditentukan.

T_A (rekabentuk) = 265 mm

DAPATKAN KETEBALAN EFEKTIF SEDIA ADA



CBR Subgrade = 5 %

3. PAVEMEN SEDIA ADA

d_1 = ACW20 + ACB28 = 70
d_2 = Roadbase = 140
d_3 = Sub-base = 210
a_1* = 0.50 (rujuk Jadual 1)
a_2 = 0.32 (rujuk Jadual 3)
a_3 = 0.30 (rujuk Jadual 3)

Maka T_A sedia ada adalah seperti berikut:

T_A (sedia ada) = $a_1d_1 + a_2d_2 + a_3d_3$
T_A (sedia ada) = (70 x 0.50 + 140 x 0.32 + 210 x 0.30)
T_A (sedia ada) = 143 mm

- T_A (sedia ada) 143 mm < T_A (rekabentuk) 265 mm

4. CADANGAN PEMBAIKAN PAVEMEN

d_1 = ACW20 + ACB28 = 110 mm
d_2 = Roadbase = 340 mm
d_3 = Sub-base = 210 mm
a_1 = 1.00
a_2 = 0.32 (crushed aggregate)
a_3 = 0.30 (CBR > 30%)

$T_A = a_1d_1 + a_2d_2 + a_3d_3$
T_A (baikpulih) = (110 x 1.00 + 340 x 0.32 + 210 x 0.30)

- T_A (baikpulih) 282 mm > T_A (rekabentuk) 265 mm

i. Cadangan rekabentuk pavemen baru:

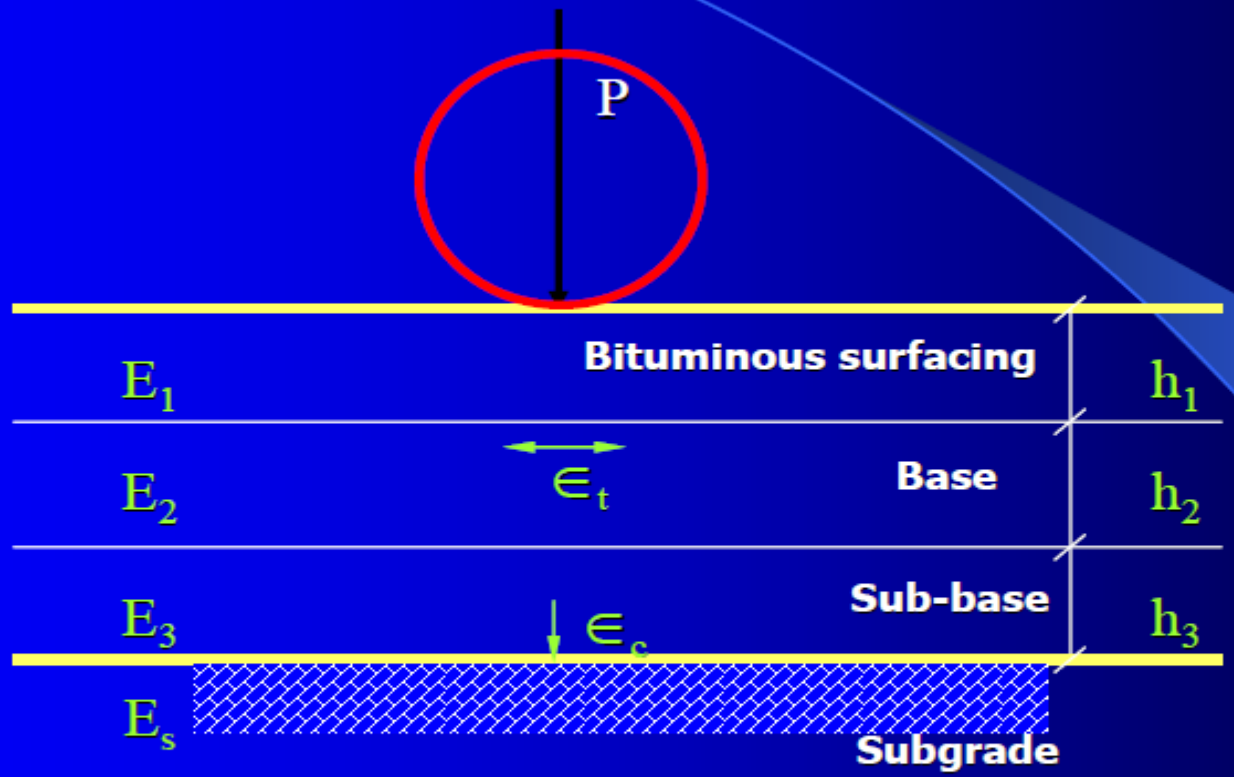
ACW 20	= 50 mm
ACB 28	= 60 mm
Roadbase	= 340 mm
Sub-base	= 210 mm

ii. Cadangan rawatan pengukuhan struktur pavemen adalah seperti berikut:

1. Menambah ketebalan lapisan roadbase sebanyak 200 mm.
2. Menurap binder course (ACB 28) 60 mm, diikuti wearing course (ACW 20) 50 mm.

REKABENTUK KAEDAH MEKANISTIK

Use Multi-layer Non-linear Elastic Theory



E_1 = Elastic modolus of bituminous surfacing.

E_2 = Elastic modolus of base course.

E_3 = Elastic modolus of sub-base.

E_s = subgrade modullus.

ϵ_t = tensile strain.

ϵ_c = compressive strain.

Overlay Design : Steps

(i) Use Falling Weight Deflectormeter (FWD) to test the existing road pavement.

(ii) With input of FWD deflection, imposed load and thickness of each pavement layers,

Calculate : - E_1, E_2, E_3, E_s and $\in_t$, $\in_s$.

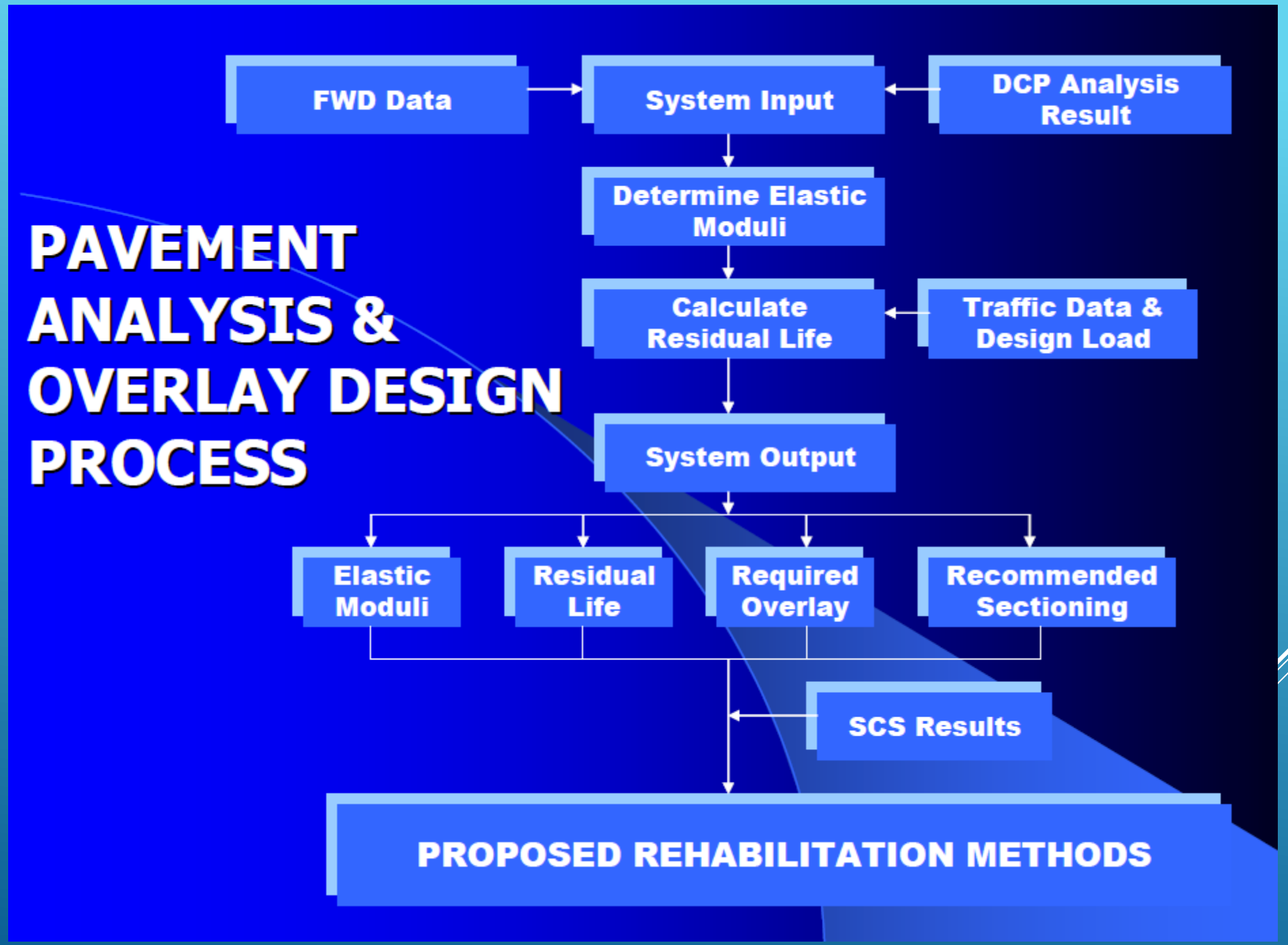
(iii) With input of past traffic loading compute residual life.

(iv) Use Design Loading, compute stresses and strains.

(v) By increasing overlay thickness, compute stresses and strains.

(vi) Repeat step (iv) and (v) till such overlay thickness that the induced stress/strain caused by design loading is less than the permissable stress/strain.

PAVEMENT ANALYSIS & OVERLAY DESIGN PROCESS



TYPICAL DESIGN OUTPUT

PAVEMENT ANALYSIS AND OVERLAY DESIGN

Route No : FR003, Jalan Pasir Puteh - Kota Bharu
Direction : Primary
Design Loading : 13 msa

Chainage	Lane	Resilient Modulus				Layer Thickness			CentralDef	CBR	Residual Life (msa)	CalcOverlay(mm)	Structural Coefficient		
		E1	E2	E3	Es	h1	h2	h3					a1	a2	a3
657.750	21	1122	79		71	175	462		835	7	2.61	25	0.59	0.22	
657.800	21	1977	103	80	77	128	198	149	864	8	1.00	40	0.82	0.22	0.20
657.850	21	1754	110	85	78	128	198	149	880	8	0.97	50	0.77	0.22	0.20
657.900	21	2272	101	83	80	128	198	149	816	8	1.26	90	0.87	0.22	0.20
657.950	21	1093	88	61	58	128	198	149	1213	6	0.28	100	0.58	0.22	0.20
658.000	21	2482	125	110	90	128	198	149	713	9	2.13	115	0.91	0.22	0.20
658.050	21	579	88		86	235	416		788	9	3.69	20	0.33	0.22	
658.100	21	584	84		82	235	416		802	8	3.22	80	0.33	0.22	
658.150	21	297	45		44	235	416		1536	4	0.32	70	0.06	0.22	
658.200	21	1040	183		98	235	416		506	10	17.15	60	0.56	0.28	
658.250	21	527	210		95	235	416		667	10	9.30	45	0.29	0.31	
658.300	21	588	83		81	235	416		806	8	3.14	30	0.34	0.22	
658.350	21	558	75		73	235	416		870	7	2.27	5	0.31	0.22	
658.400	21	672	85		83	235	416		749	8	3.97	5	0.39	0.22	
658.450	21	536	65	63	60	200	281	67	1138	6	0.51	-	0.30	0.22	0.20
658.500	21	521	49	48	46	200	281	67	1352	5	0.25	50	0.29	0.22	0.20
min		297	45	48	44	128	198	67	305	4	0	5	0.06	0.22	0.20
max		4464	351	110	190	235	462	149	1536	19	42	170	1.00	0.32	0.20
average		1701	127	76	97	172	369	126	709	10	8	73	0.67	0.24	0.20
stdev		1037	59	20	31	36	78	40	267	3	10	[illegible]	[illegible]	[illegible]	0.00
85%		583	82	60	73	152	281	67	882	7	1	135	0.33	0.22	0.20

Required strengthening overlay

TERIMA KASIH