Pavement Performance Model

Dr. Florentina Pungky Pramesti, ST., MT.

Part IV Pavement Performance Model

Pavement Performance model

after Groenendijk 2008

Beberapa klasifikasi model kondisi jalan berdasarkan kriteria:

- **Single quality parameter VS Distinct distress type or quality aspect**
- **Empirical VS Mechanistic**
- **Deterministic VS Probabilistic**
- **Absolut VS Relative**

Performance model

Single quality parameter

VS

Distinct distress type or quality aspect

- A number of individual distress types
- Measureable

- Express in an arbitrary quality rating

Performance model

Empirical VS Mechanistic

Empirical

- Describe the development of the pavement condition as it was observed in the past
- Regression analysis
- The model perform very well under specific conditions which were taken into account in the observation process
- The model less applicable outside the limit of observed conditions
- Take a long time to develop this sort of model

Mechanistic

- Predict the development of the pavement conditions using descriptive hypotheses about the physical mechanisms that influence that condition
- Typically based on laboratory tests to describe the relevant mechanism
- The model can be used for a wide range of conditions and material
- For new material/conditions, only some new laboratory tests have to be executed ➔ establish the relevant parameters
- Often a shift factor need to be applied to bridge the laboratory results to in-service conditions

Performance model

Deterministic VS Probabilistic

Deterministic

- Predict a discrete value for the pavement condition
- No possible variations in influencing factors

Probabilistic

- Take these variations (temperature, traffic, etc) into account
- Information about the (probability) distribution of the influencing parameters are required
- Result: gives the probability that a certain pavement condition will occur

Performance model

Absolut VS **Relative**

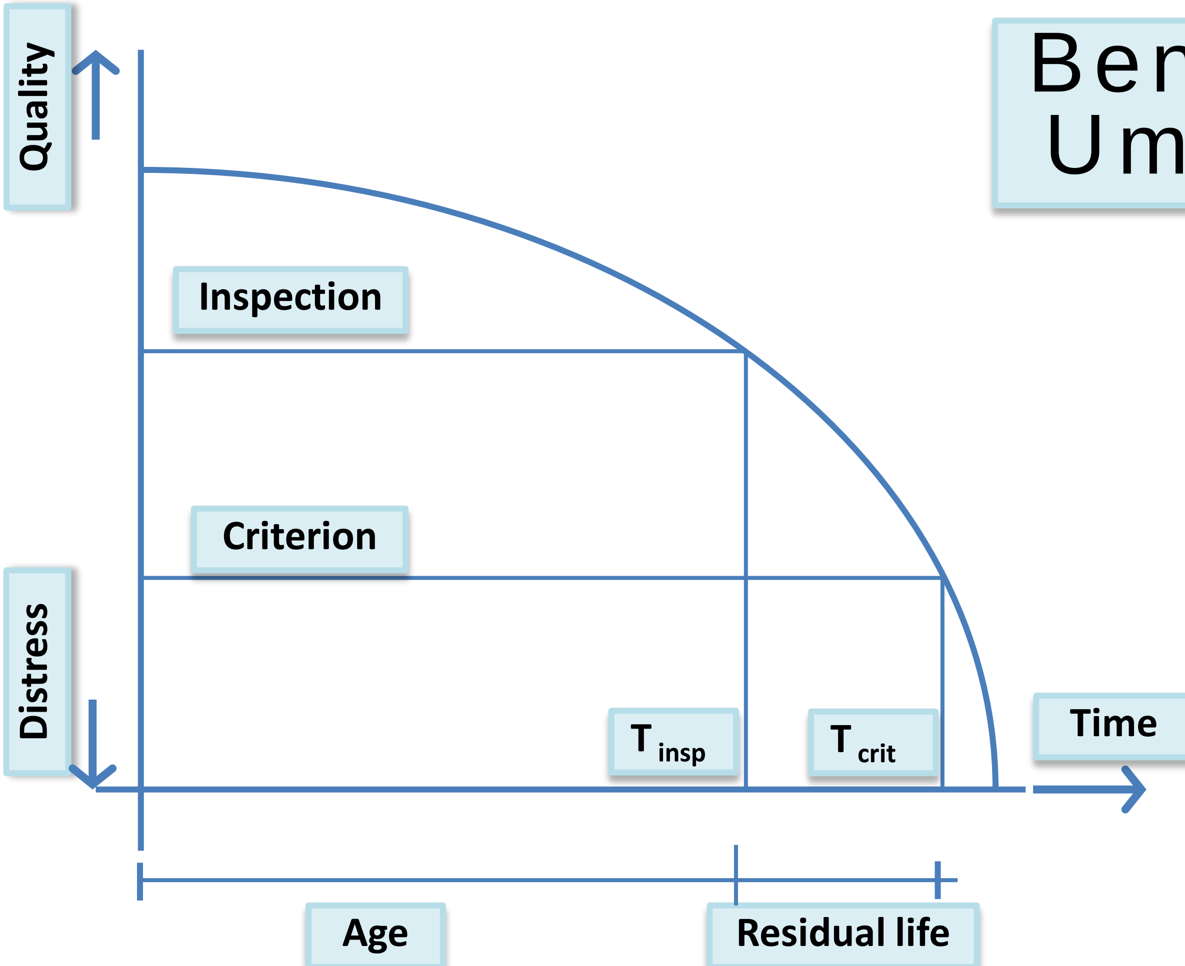
Absolut

- Predict a certain condition (e.g. severity and extent of a distress type) at a certain moment in time or after a certain number of load repetitions

Relative

- Also called dimensionless models
- Give no absolut predictions but only relative
- E.g. At half of the pavement life, 25% of the maximum distress is reached

Performance model



Bentuk Umum

Use of a dimensionless prediction model with a maintenance criterion (after Groenendijk)

Performance model

Residual life

is the difference between the original design life of the pavement (N_{DI}) and the life used prior to testing (N_{AI}).

In this context, "life" is expressed as a number of standard axle load applications

Estimasi umur sisa perkerasan

- Dengan pendekatan empiris
  - Asphat Institute
  - Transport and Road Research Laboratory
- Dari survai visual

Shell (SPDM) Performance model

Permanent deformation prediction

Rut Depth = $C_m \times h \times \sigma_{ave} / S_{mix}$

Where:

C_m : Empirical correction factor

h : Thickness

σ_{ave} : average stress

S_{mix} : Stiffness

Performance model

Contoh menghitung Residual life

Menentukan umur sisa perkerasan dari survei visual

Menurut Groenendijk, Rut Formation (formasi deformasi) dapat dideskripsikan dengan rumus non-dimensional berikut:

- $S_n / S_N = (n / N)^{0.41}$

Dimana:
S_n = rut depth pada n pembebanan
S_N = rut depth pada saat runtuh = 18 mm
n = jumlah beban yang telah diterima oleh perkerasan
N = jumlah beban pada saat rut depth nya mencapai 18 mm.

Nilai 0.41 berlaku untuk seksi perkerasan yang diuji (GAC LINTRACK sections) , belum tentu bisa diaplikasikan untuk kondisi lain

Lihat halaman 21 (performance Model AAA Molenaar) untuk kondisi jalan yang lain yang diuji oleh project SHRP-NL (lebih dari 50 ruas jalan), nilai a = 0.585

Contoh:
Untuk kondisi perkerasan Gravel asphalt concrete dengan kedalaman rut :

Sn = 10 mm

SN = 18 mm

Jumlah traffic yang telah lewat sejak konstruksi adalah 10.000 load cycle

$$10 / 18 = (10.000 / N)^{0.41}$$

N =

Sisa umur layan =

Shell (SPDM) Performance model

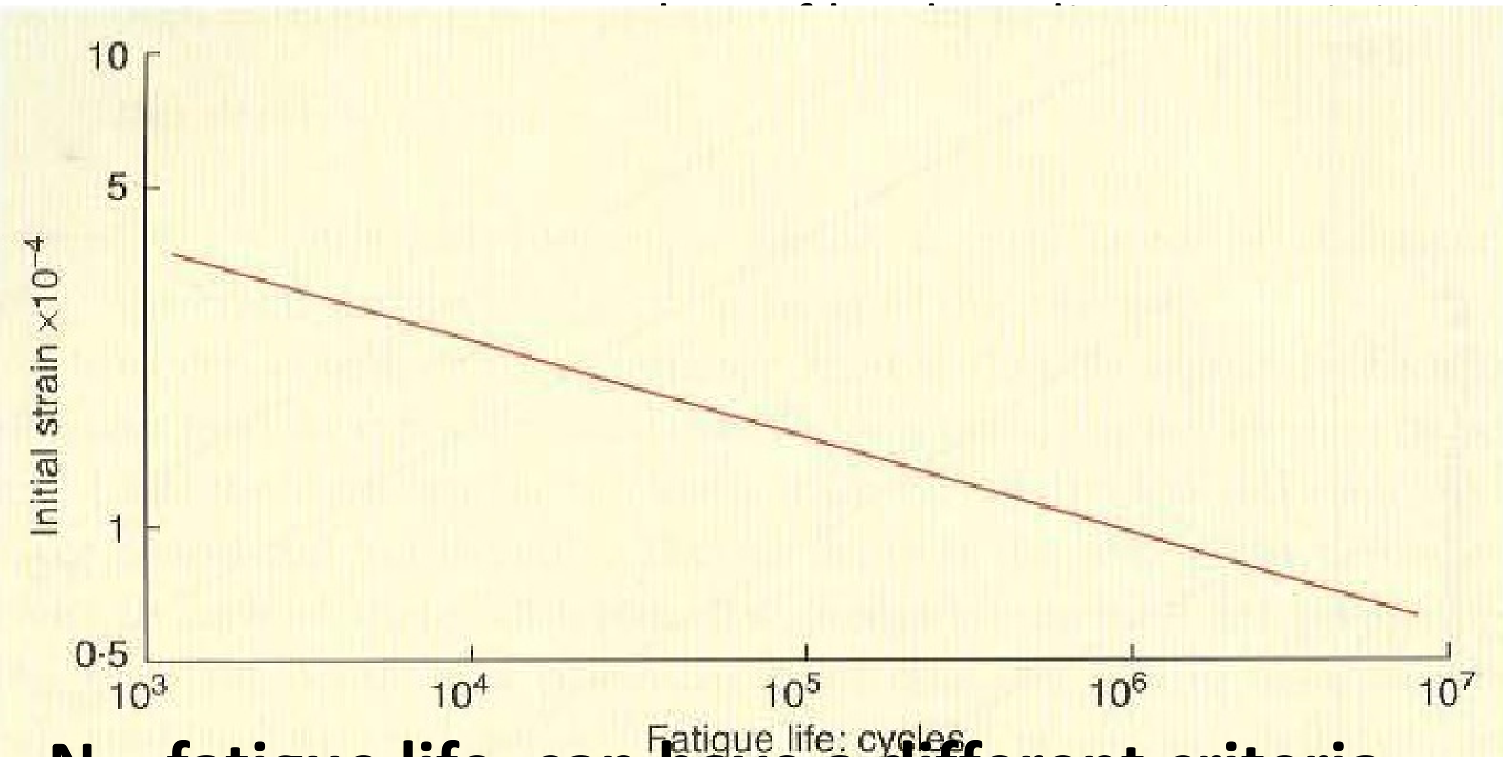
Fatigue life prediction

$N_f = c \times (1/\varepsilon_f)^m$ Where:

a

and

strain



N_f , fatigue life, can have a different criteria

Fig. 17.7 Fatigue lines from Fig. 17.6 – strain criterion[440]

Accelerated Pavement Test: Lintrack

4 identical lanes (section I to IV)

16 m long, 4 m wide, 0.15 m Gravel Asphalt Concrete

2nd and 3rd lanes thickness was reduced to 0.08 m on 1995

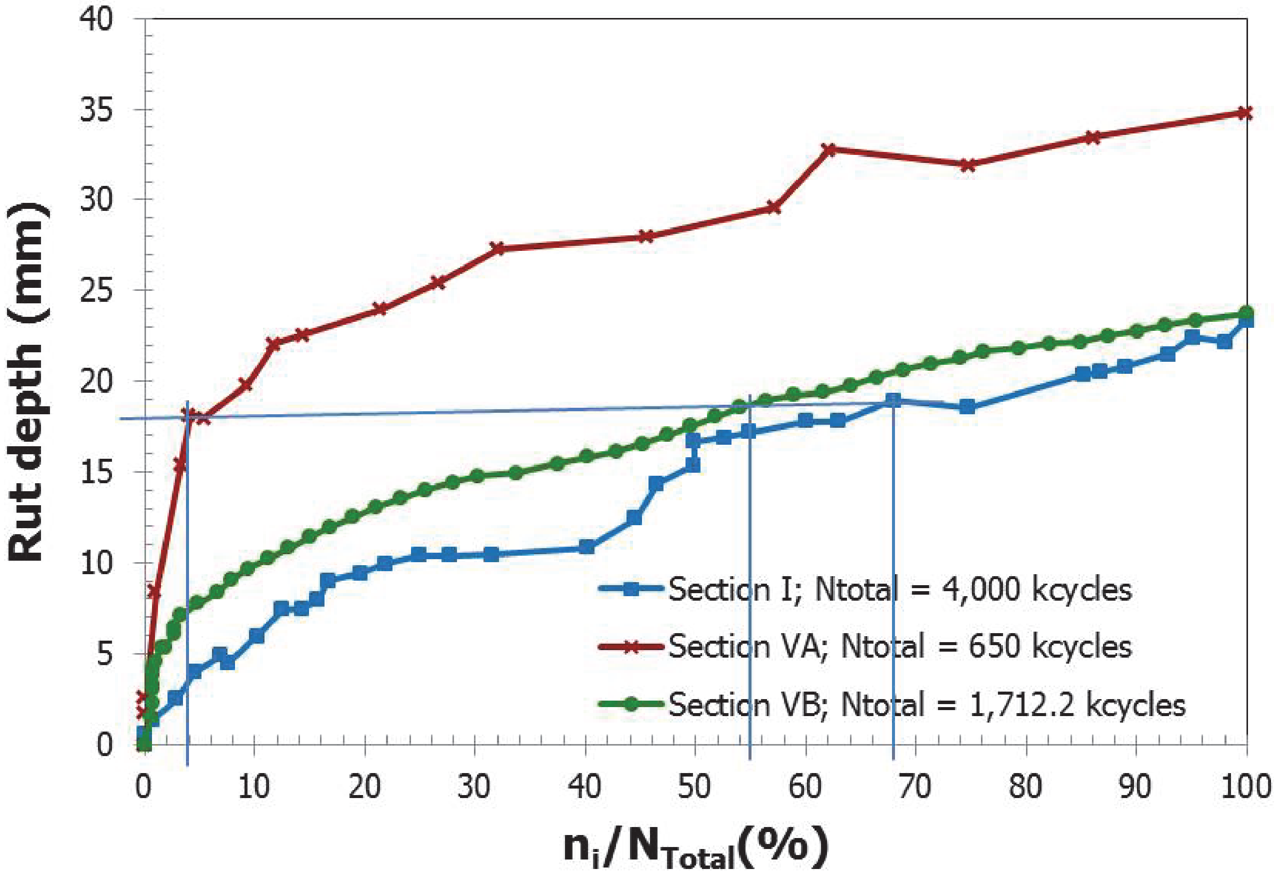
75 and 50 kN wheel load, 20 km/h
Transversal frequency 3Hz, Longitudinal frequency 8Hz

Abundant data

High cost

Lintrack Performance model

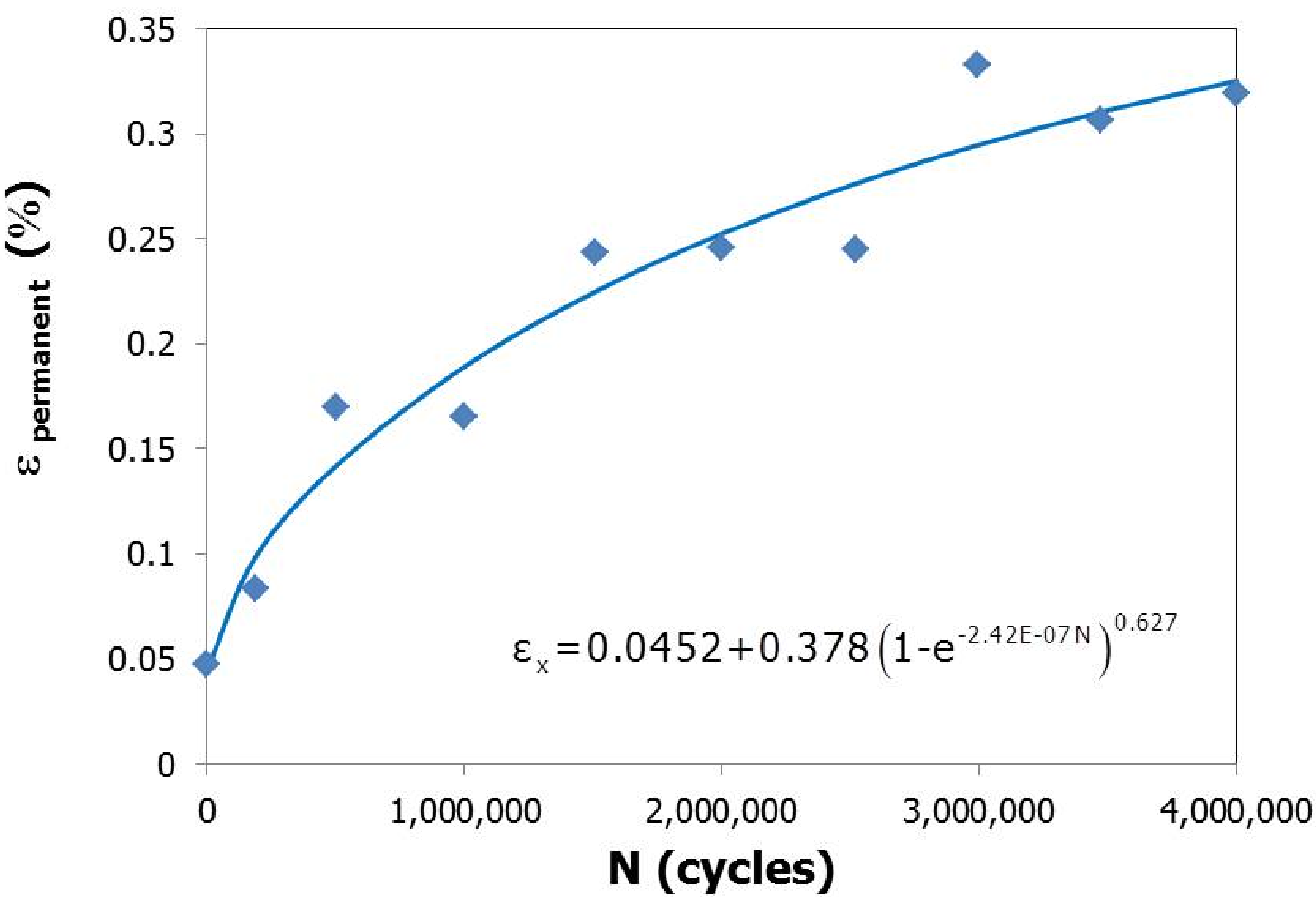
Permanent deformation observed



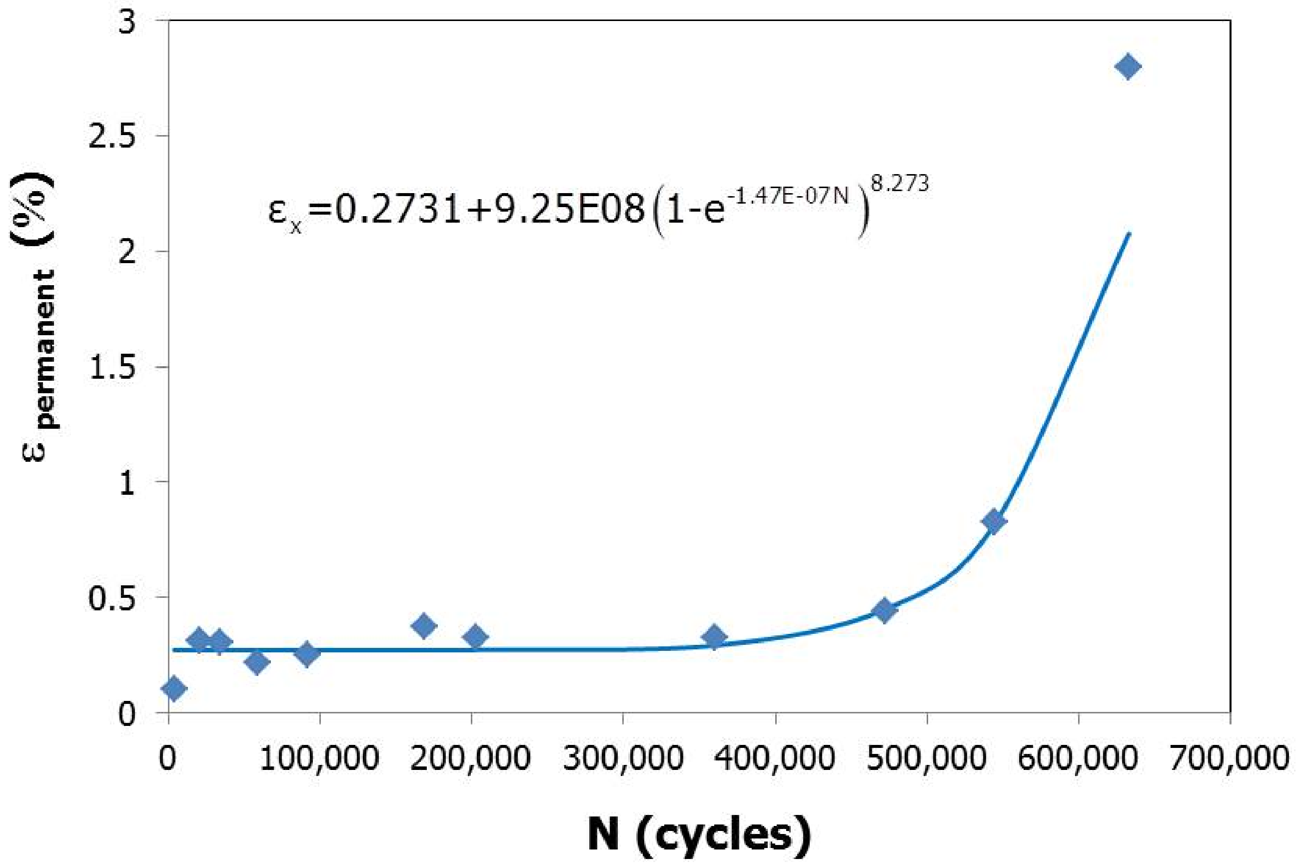
Rutting of Lintrack sections I, VA and VB

Lintrack Performance model

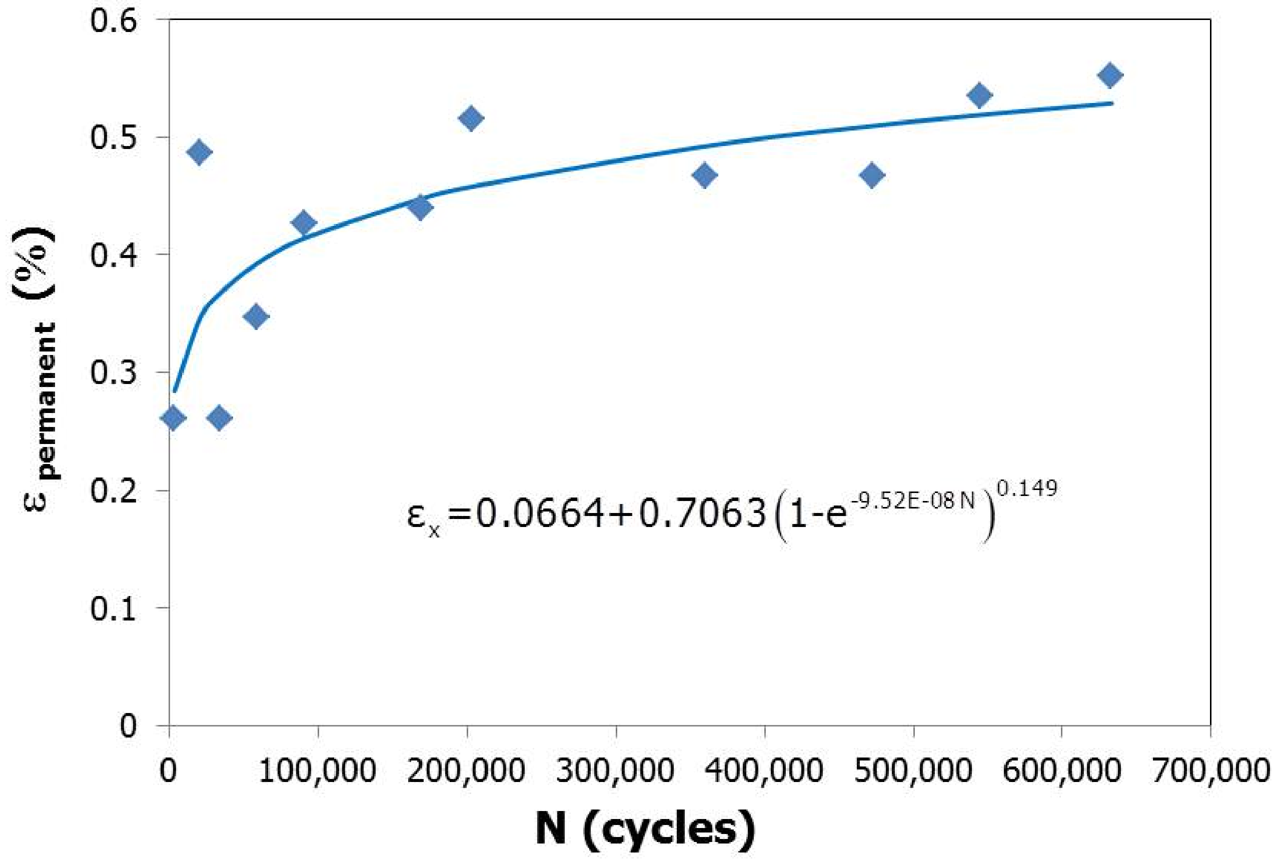
Permanent deformation prediction (empiric)



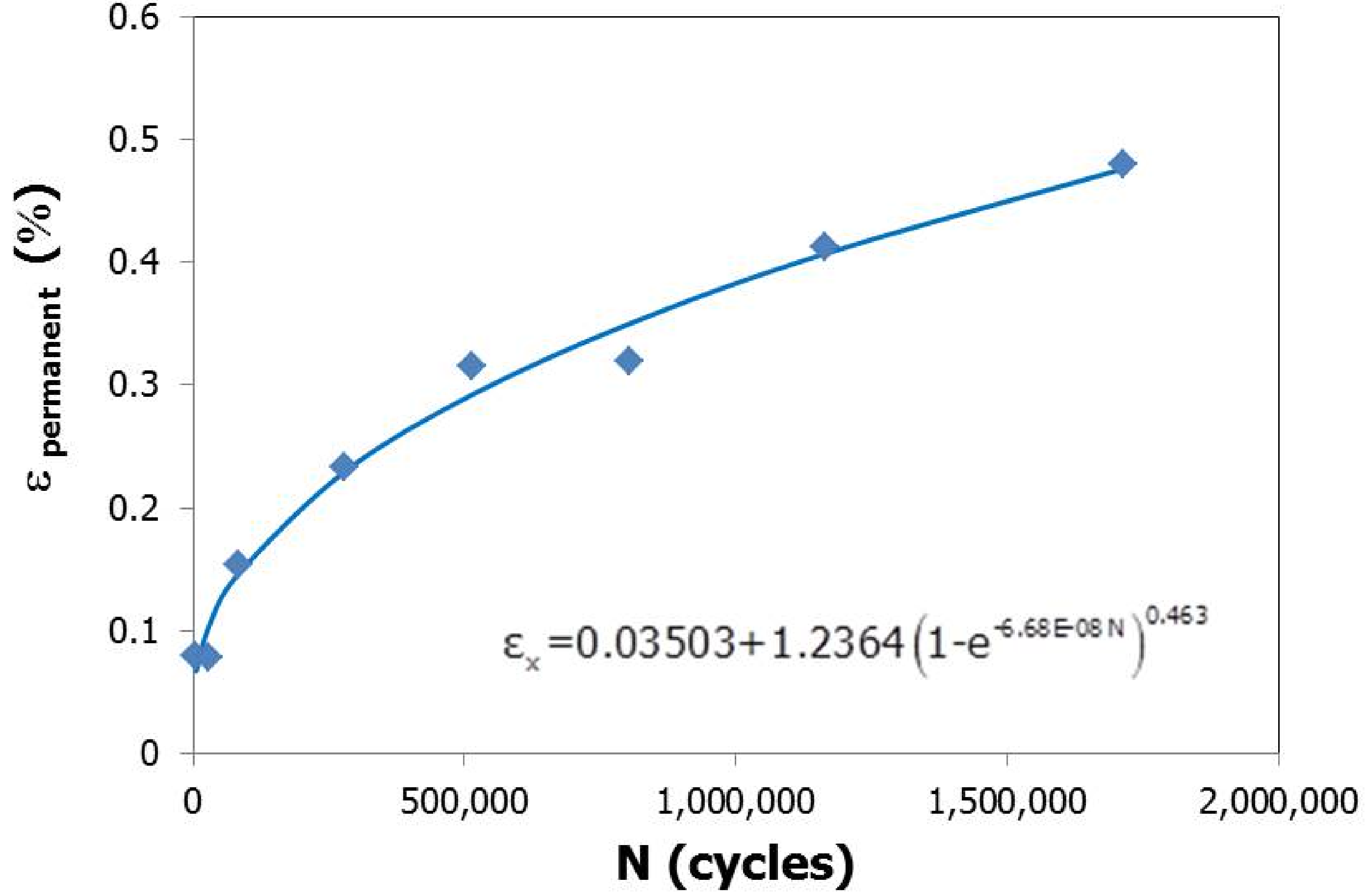
Development of the permanent strain in Section I



Development of the permanent strain in Section VA-ridge



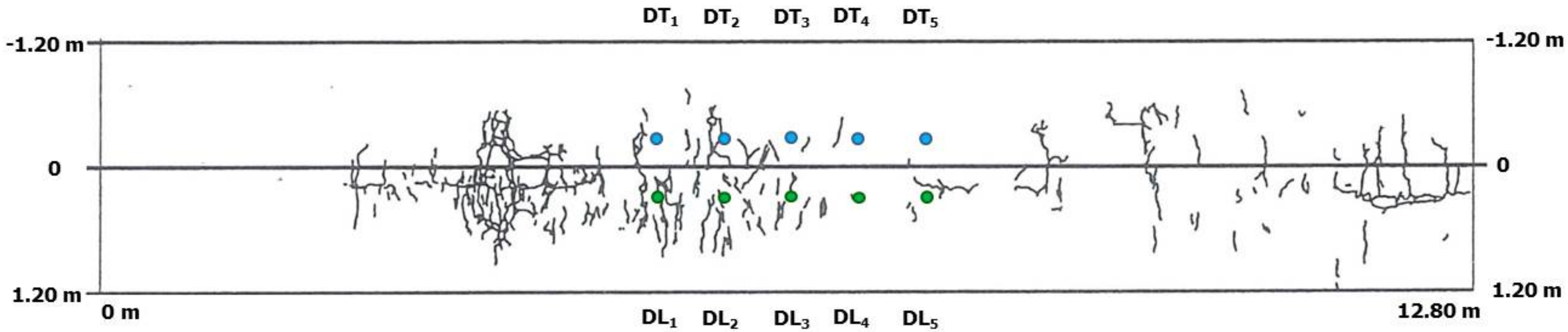
Development of the permanent strain in Section VA-valley



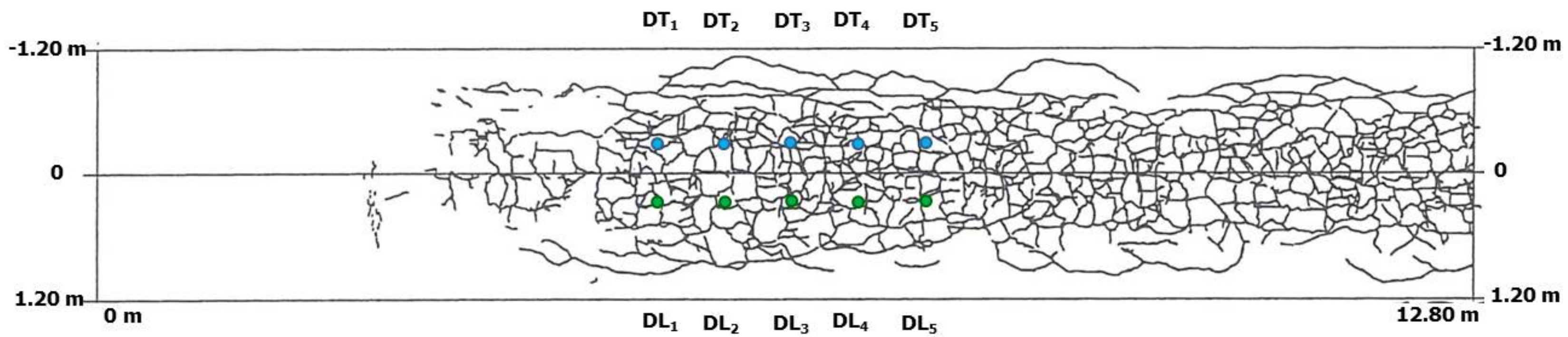
Development of the permanent strain in Section VB

Lintrack Performance model

Fatigue cracking observed



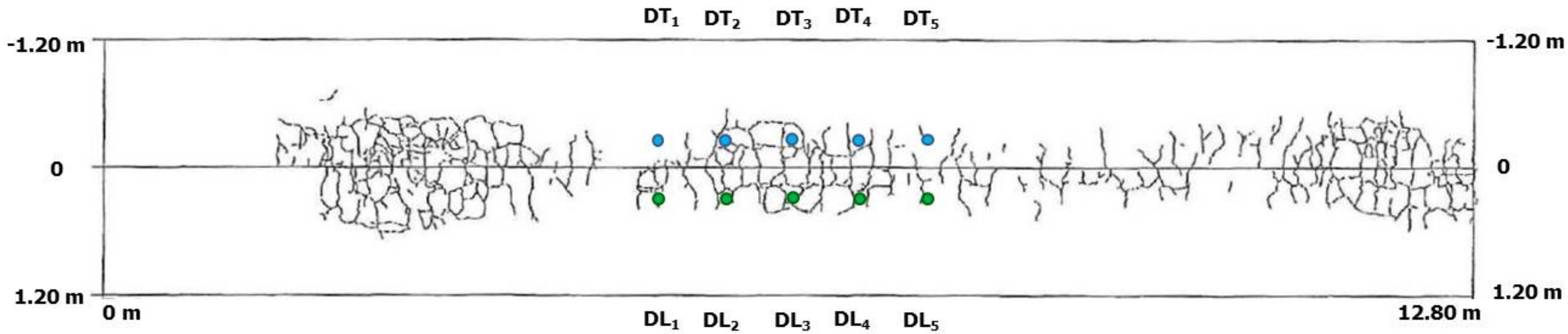
Crack pattern of Lintrack section I after 4 Million cycles, wheel load 75 kN, 150 mm thickness



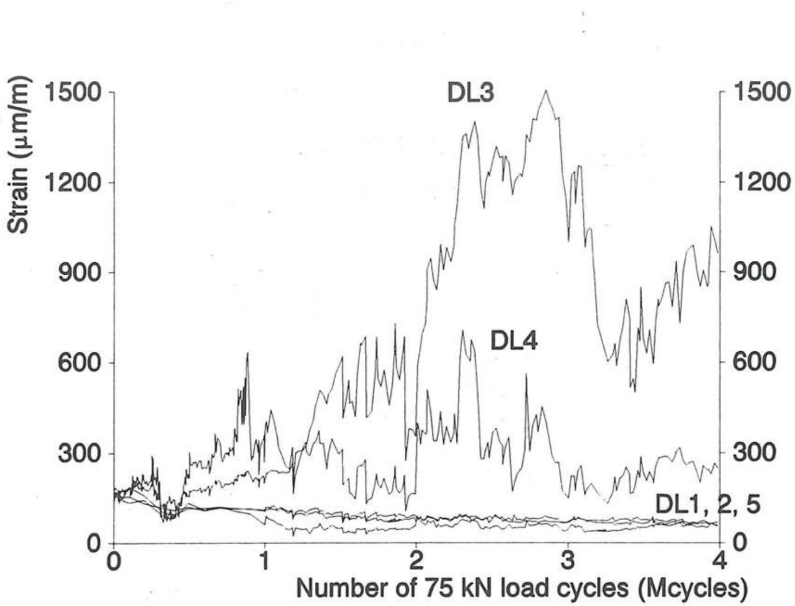
Crack pattern of Lintrack section VA after 650 kilocycles, wheel load 75 kN, 80 mm thickness

Lintrack Performance model

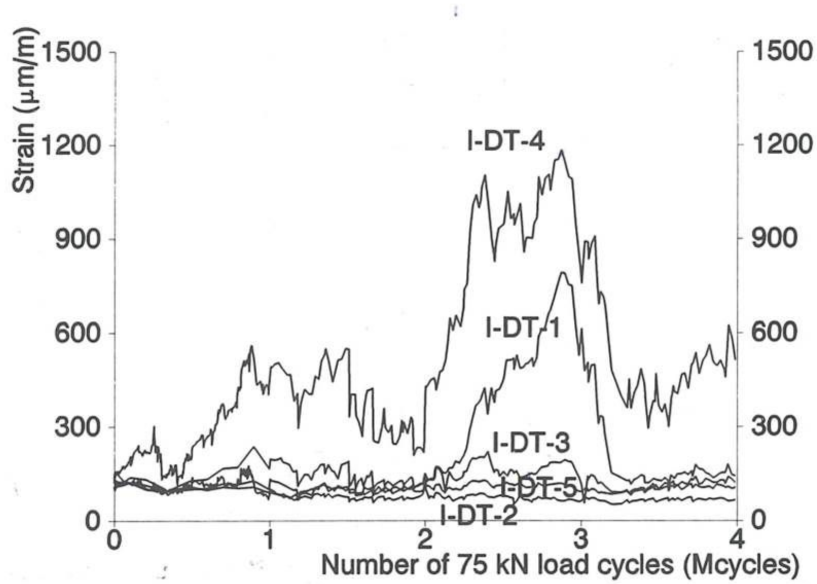
Fatigue cracking observed



Crack pattern of Lintrack section VB after 1722 kilocycles, wheel load 50 kN, 80 mm thickness



The development of the strain mesasured by longitudinal gauge



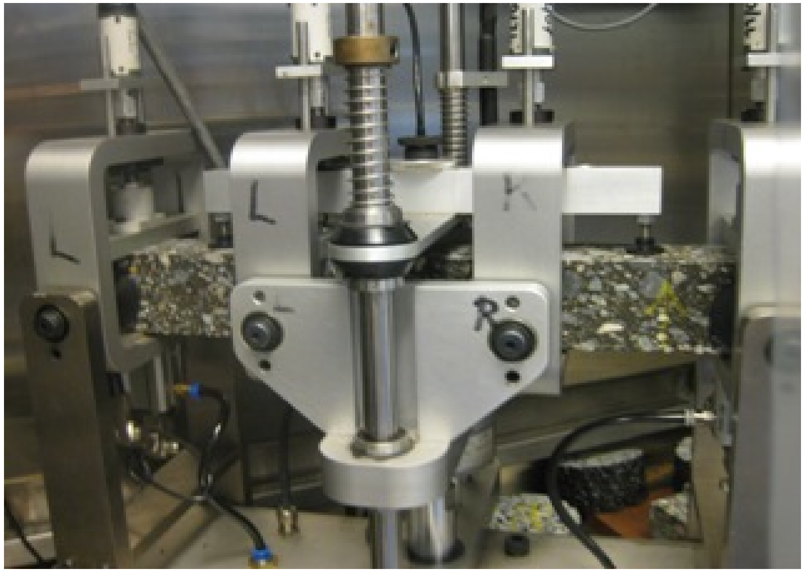
The development of the strain mesasured by transversal gauge

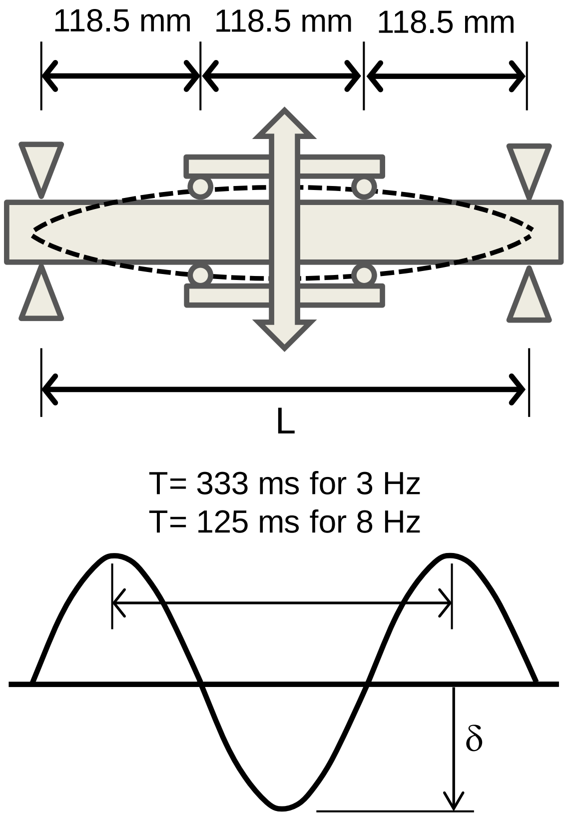
Section 1

Fatigue cracking: distress in a form of cracking due to tensile stress at the bottom of the asphalt layer because of repeated loadings. Thus the crack usually appear in the form of **bottom up cracking**.

Standard technique

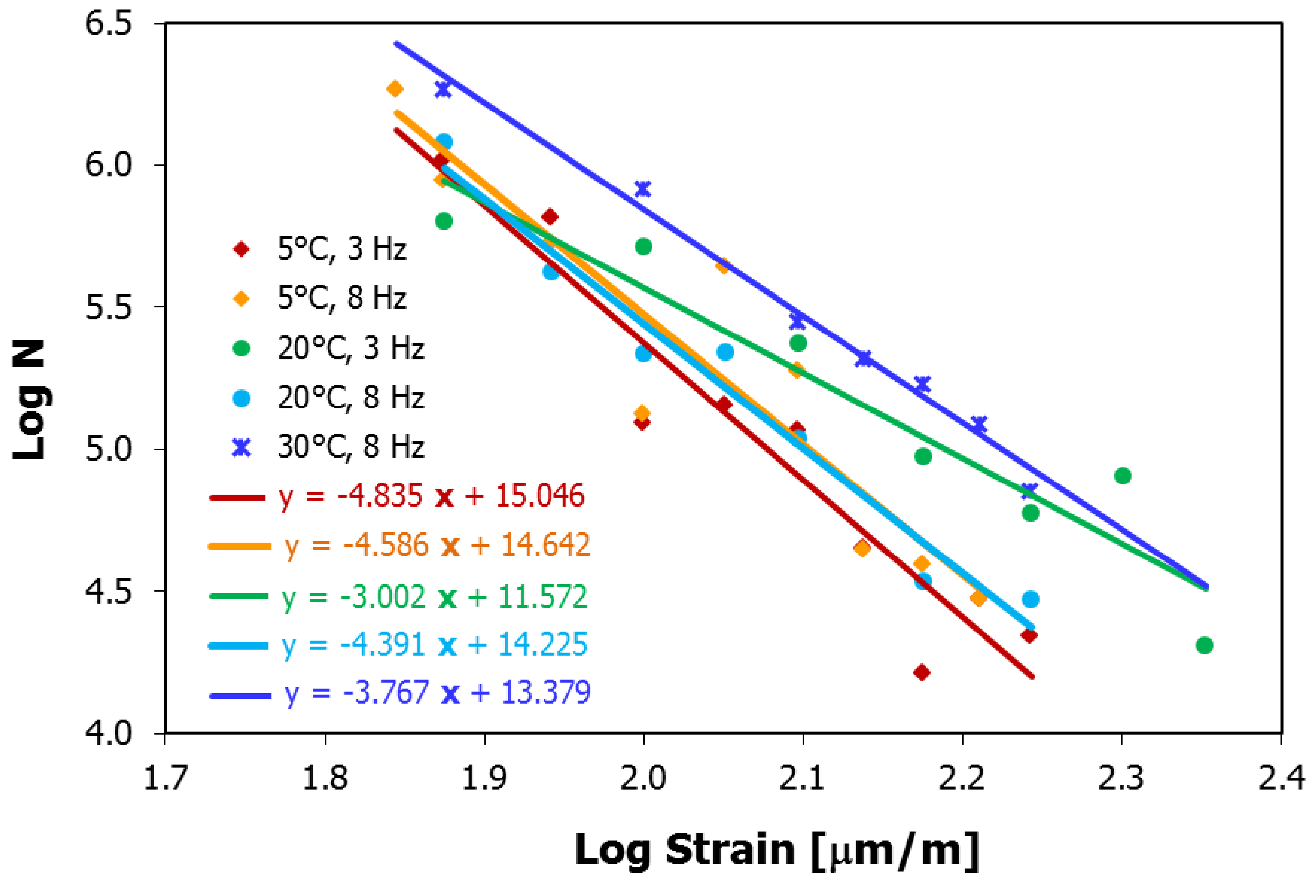
4PB test uses **cyclic bending load** to determine materials **fatigue life**





Lintrack Performance model

Fatigue life prediction



Gravel asphalt concrete fatigue lines

Model Prediksi lain

- HDM (Highway Design and maintenance Standard), diadopsi oleh IRMS (Integrated Road Management System), terbatas pada mode yang berkaitan dengan ketidakrataan.
- AASHTO (American Association of State Highway and Transportation Officials), kinerja perkerasan dinyatakan dalam PSI, kinerja perkerasan dari sudut pandang pengguna tentang mulus dan nyamannya berkendara pada waktu tertentu
- SPDM (Shell Pavement Design Method)

Catatan :

- Slide 3, klasifikasi model dapat di baca lebih lengkap dalam Disertasi Jacob Groenendijk, chapter 3.
- Cara menghitung sisa umur layan juga bisa dilakukan dengan cara empiris dan mekanistik. Lihat 4860 Molenaar VI (Structural Design of Pavement Part VI). Chapter 8 dan 9. Halaman 38 - 45