

Faculty of Engineering Department of Civil Engineering



**Maintenance of transportation networks
by Dr. Mahmoud Enieb**

Accreditation

- The Accreditation Board for Engineering and Technology.
- With Accreditation, students, employers and the society we serve can be confident that a program meets the quality standards that produce graduates prepared to enter a global workforce.

Maintenance of transportation networks covers



To familiarize students with the different types of flexible and rigid pavements distresses (1).



To familiarize students with the different methods to characterize distresses causes (1).



Learn how to collect data in terms of zone, branch, section and sample units (2).

Maintenance of transportation networks covers

- Learn how to calculate Pavement Condition Index (PCI) for flexible and rigid pavements (1, 2, 5) .
- Be able to understand the basic concepts of pavement Maintenance and Rehabilitation Methods M&R (5).

Maintenance of transportation networks

Relationship to program outcomes

ABET

1-7

Civil Engineering Student Outcomes

1

√

An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.

2

√

An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety and welfare, as well as global, cultural, social, environmental, and economic factors.

5

√

An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks and meet objectives.

Civil Engineering Student Outcomes 1 to 7

- **1** An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics. ✓
- **2** An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety and welfare, as well as global, cultural, social, environmental, and economic factors. ✓
- **3** An ability to communicate effectively, with a range of audiences.
- **4** An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.

Civil Engineering Student Outcomes 1 to 7

- 5 An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks and meet objectives. ✓
- 6 An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.
- 7 An ability to acquire and apply new knowledge as need using appropriate learning strategies.

Maintenance of transportation networks

Prerequisite

- Highway and airports Engineering

Instructor:
Dr. Techn. Mahmoud Enieb
Associate Prof. of Highway
and Traffic Engineering

Instructor's Office 101

m.enieb@aun.edu.eg

Office hours

12:00 AM – 14:00 AM,
(Sun)

Classroom

Section 1 (Classroom 2)

(Thu, 11:00-13:00)

Course Description

- This course covers types of distresses in both flexible and rigid pavements and the causes for each type. Also it covers the principles of pavements maintenance and rehabilitation.
- Moreover, it covers the method for calculating pavement condition index (PCI) by using charts.

Textbooks

- 1. Shahin, M.Y., "Pavements Management for Airports, Roads, and Parking Lots". 2nd Ed. 2004.
- 2. Technical Manual "TM5-623", "Pavement Maintenance Management" by the Headquarters Department of the Army, Washington, DC, November 1982.

Course objectives

- To familiarize students with the different types of flexible and rigid pavements distresses. (1)
- To familiarize students with the different methods to characterize distresses causes. (1)
- Learn how to collect data in terms of zone, branch, section and sample units. (2)

Course objectives

- Learn how to calculate pavement condition index (PCI) for rigid and flexible pavements. (1, 2,5)
- Be able to understand the basic concepts of pavement Maintenance and Rehabilitation Methods M&R. (5)

Topics Covered

- Distresses in flexible pavement.
- Distresses in rigid pavement.
- PCI of flexible pavements.
- PCI of rigid pavement.
- Pavement maintenance and rehabilitation methods M&R

Class Schedule

- 1 class session each week; 75 minutes.
 - (Thu, (11:00-13:00))

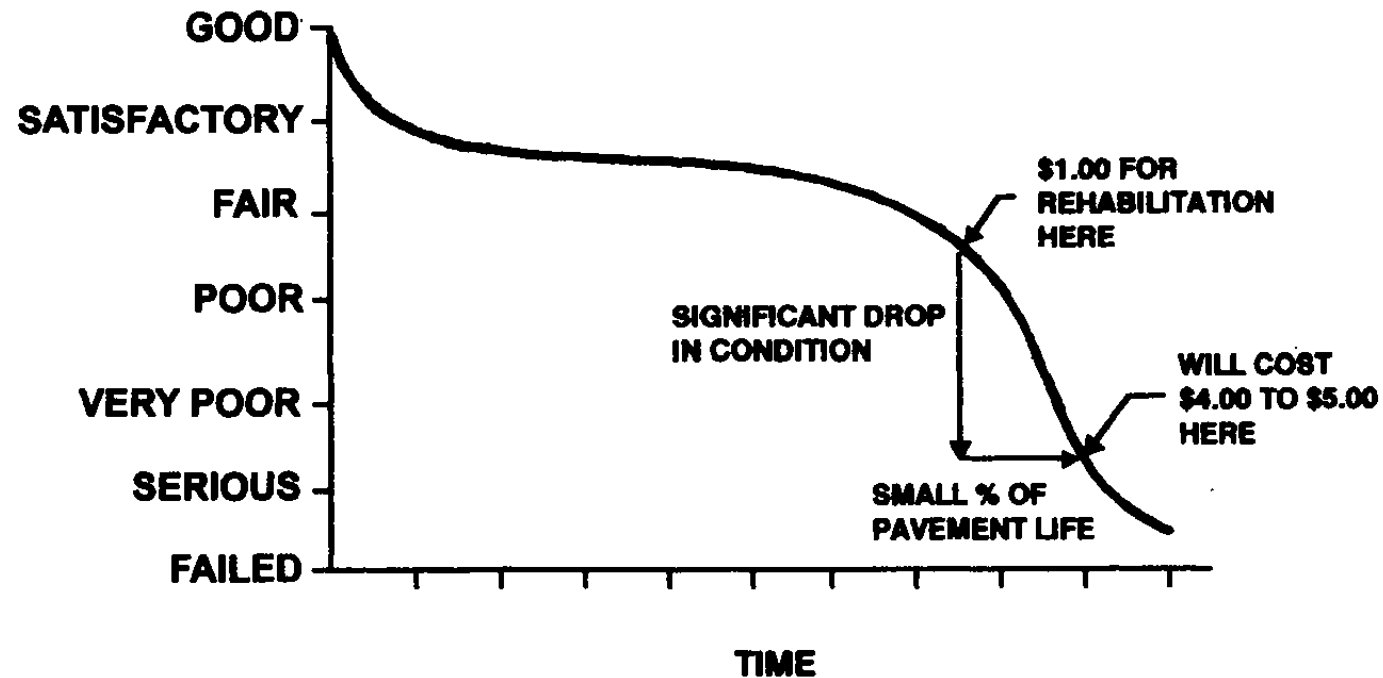
Grading Plan:

- Assignments & Project (5), Attends and participation (5).
- Mid Exam (15 Marks)
- Final Exam (50 Marks)

General notes

- All cellular phone must be turned off before class begins.
- Eating and/or drinking is not allowed in the classroom.
- Talking to a fellow student while the lecture is in progress will not be tolerated.
- You will be asked to leave the class if this behavior is disruptive.
- As required by the university, cases of academic dishonesty will be handled through the proper channels.

Introduction , pavement condition



- Conceptual illustration of a pavement condition life cycle

Distresses

Elements of pavement evaluation:

- Type of distress.
- Severity level: (L : low), (M : medium) and (H :high).
- Density / Extent.
- Unit of measure

Two types of pavement failure :

- **Structural failure** is associated with the ability of the pavement to carry the design load, whereas
- **functional failure** is associated with ride quality and safety. When structural failure increases in severity, it always results in functional failure as well.

Distresses Causes

1. Design
2. Construction
3. Poor materials.
4. Load
5. Climate

Distresses in Flexible Pavements

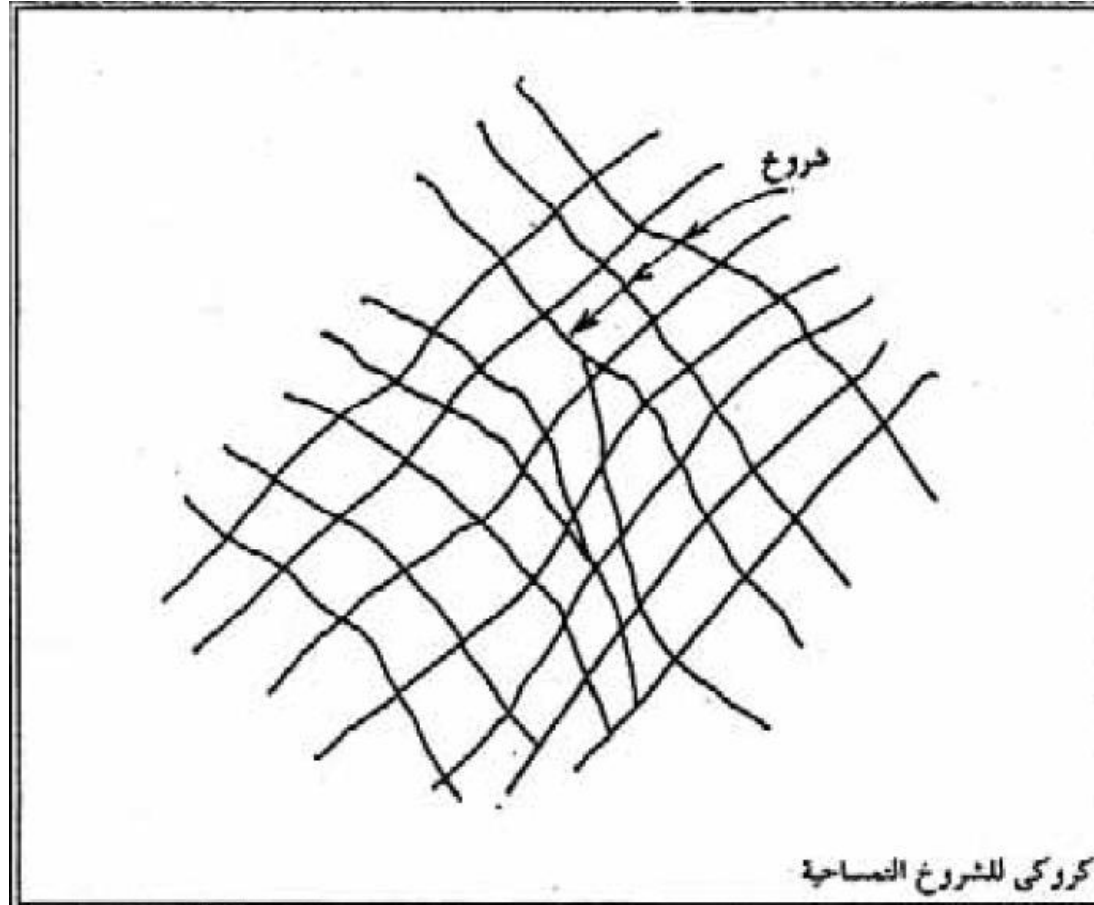
1 - Cracking

- Alligator Cracking.
- Block Cracking
- Edge Cracking.
- Longitudinal and Transverse Cracking.
- Slippage Cracking

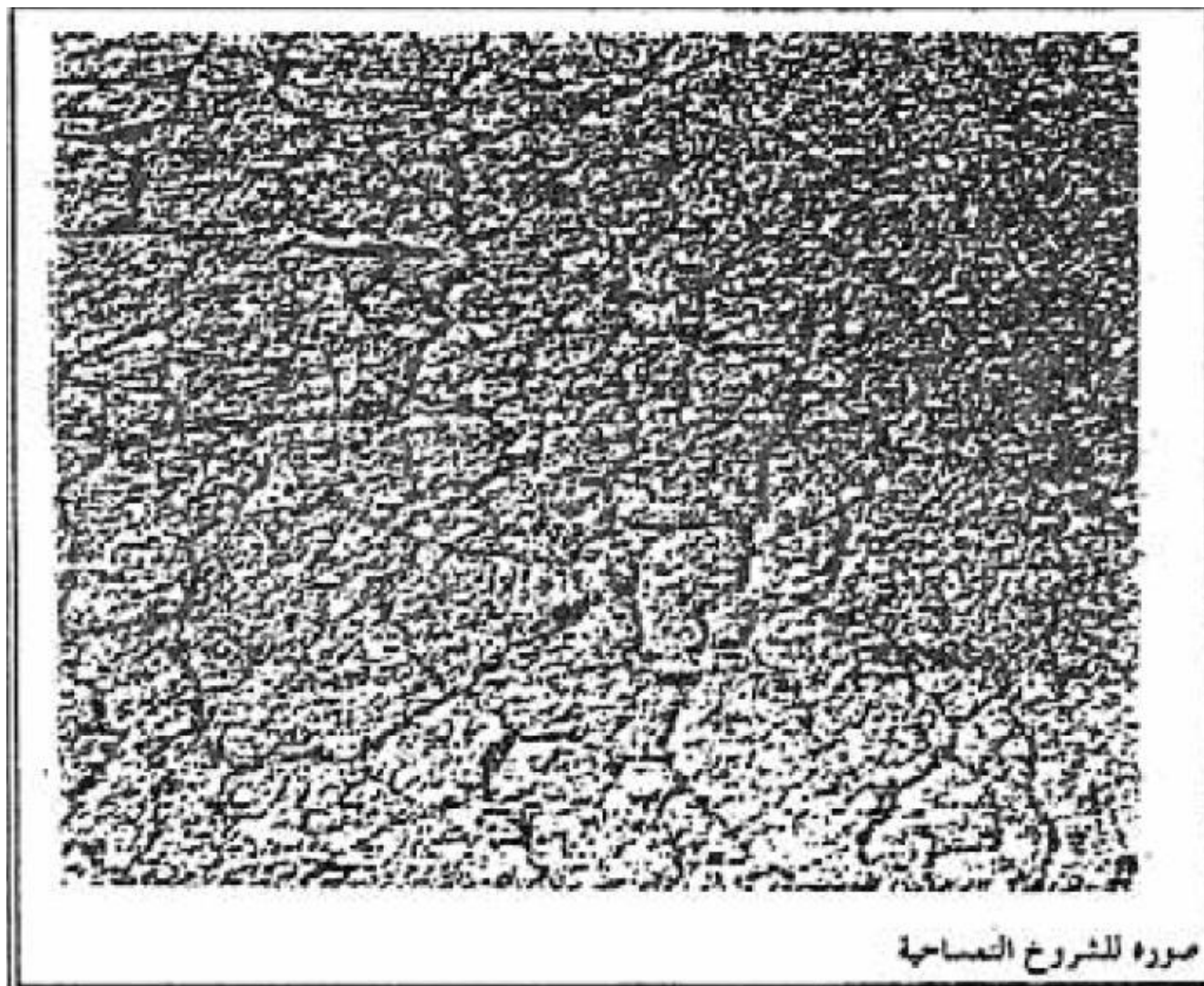
A. Alligator Cracking

- It is a series of interconnecting cracks caused by fatigue failure of the asphalt concrete surface under repeated traffic loading.
- The cracks propagate to the surface initially as a series of parallel longitudinal cracks. After repeated traffic loading, the cracks connect, develop a pattern resembling the skin of an alligator.

Sketch Alligator Cracking



Picture Alligator Cracking



Severity alligator cracking

درجة الشدة :

- قليلة الشدة " L " حيث تكون الشروخ شعيرية وموازية لبعضها البعض ولا تتقاطع وعرض الشرخ لا يزيد عن اسم .
- متوسطة الشدة " M " حيث تكون الشروخ بسيطة متقاطعة مكونة قطع صغيرة وعرض الشرخ يتراوح من اسم وحتى ٥ر ٢سم .
- عالية الشدة " H " حيث تكون الشروخ كبيرة ومتقاطعة لبعضها البعض مكونة تقسيمات ظاهرة وعرض الشرخ أكبر من ٥ر ٢سم .

low-severity alligator cracking:

- longitudinal cracks running parallel to each other with no, or only an interconnecting cracks.



- **Medium-severity alligator cracking :**
pattern or network of cracks.



- **high-severity alligator cracking:**

Network or pattern cracking has progressed so that the pieces are well defined (pavement surface looks like separate particles).



How to Measure:

Alligator cracking is measured in **square feet** or **meter** of surface area.

- The major difficulty in measuring this type of distress is that two or three levels of severity often exist within one distressed area. If these portions can be easily distinguished from each other, they should be measured and recorded separately. **However, if the different levels of severity cannot be divided easily, the entire area should be rated at the highest severity present.**

Example

During asphalt pavement inspection of link (100*10 or 5) M, from desert road in Egypt during, 20 m² high, 30 m² low, alligator cracking distress type. Determine total deduct value for this distress.

61 78

78 61

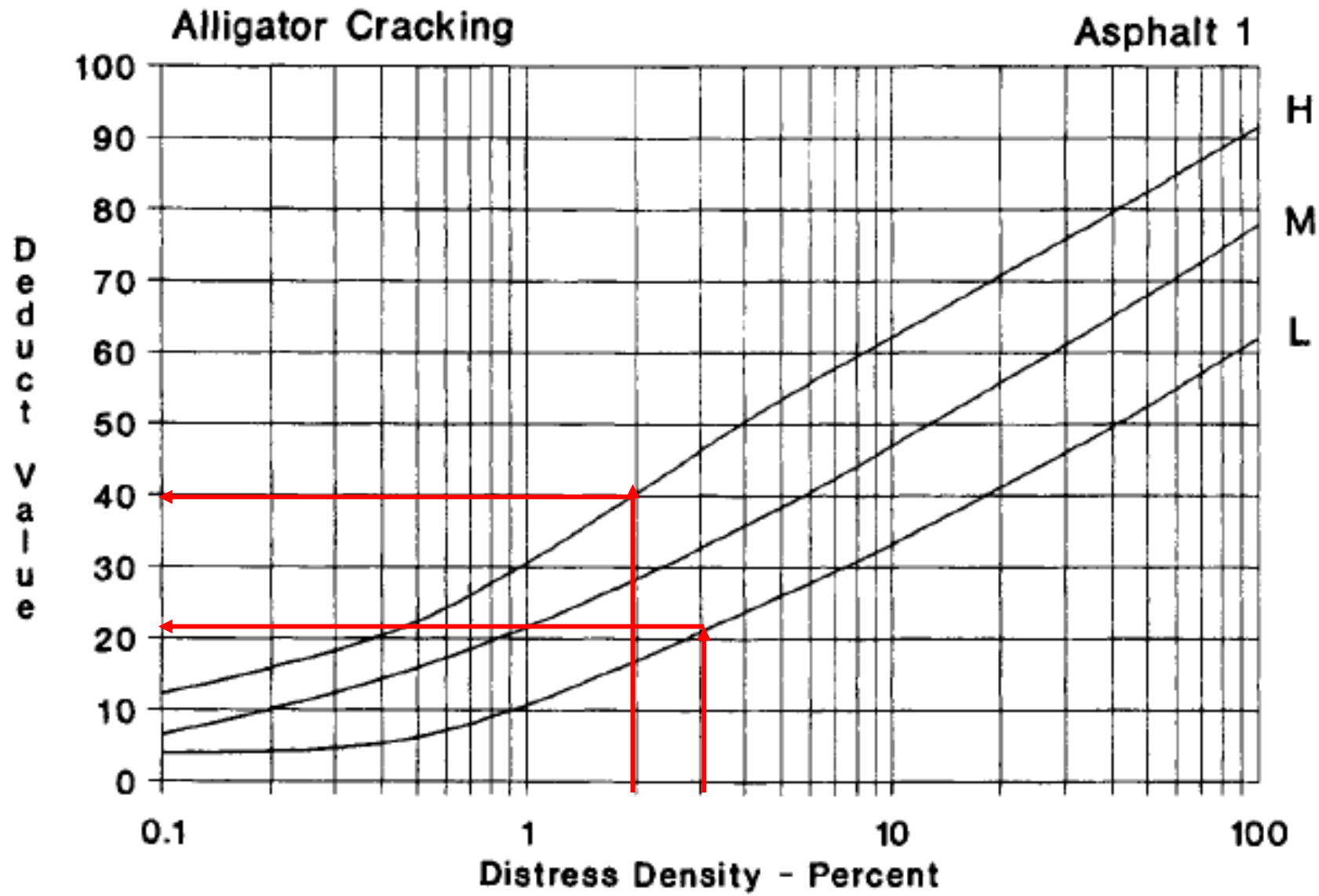
30 30

$$20/(100*10)*100 = 2\% \text{ H}$$

$$30/(100*10)*100 = 3\% \text{ L}$$

$$20/(100*5)*100 = 4\% \text{ H}$$

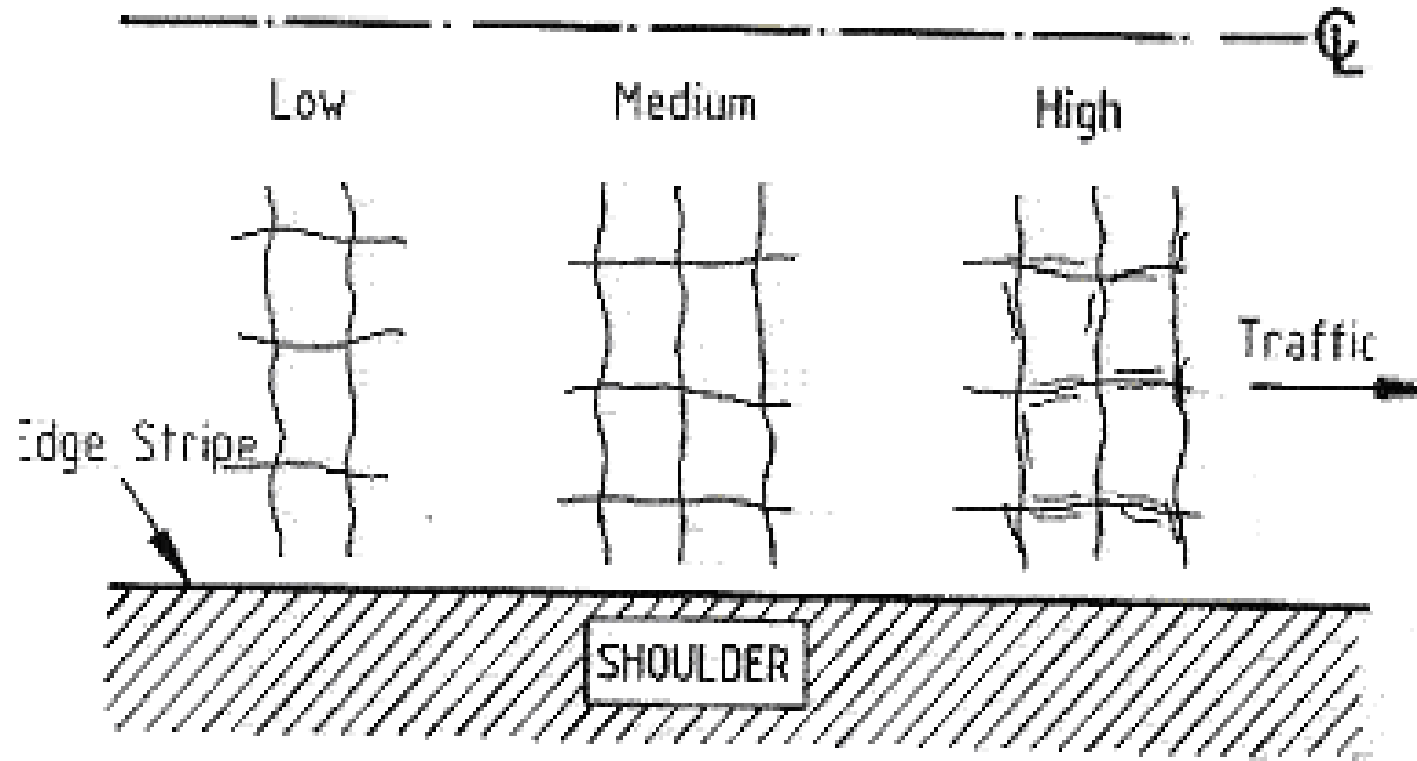
$$30/(100*5)*100 = 6\% \text{ L}$$



B -Block Cracking.

- Block cracks are interconnected cracks that divide the pavement into approximately rectangular pieces. The blocks may range in size from approximately (30 cm by 30 cm) to (3 by 3 m).
- Block cracking is caused mainly by shrinkage of the asphalt concrete and daily temperature cycling (which results in daily stress/strain cycling). **It is not load-associated**

Sketch block Cracking



Medium - Adjacent Low Severity Cracking
High - Adjacent Medium Severity Cracking



- Low-severity



- **High-severity block cracking**

Severity block Cracking

درجة الشدة :

- قليلة الشدة " L " في حالة الشروخ ذات عرض أقل من واحد سم .
- متوسطة الشدة " M " في حالة الشروخ ذات عرض من واحد سم الى ٢ سم .
- عالية الشدة " H " في حالة الشروخ ذات عرض أكبر من ٢ سم .

What are the difference between alligator and block cracking?

- **This type of distress differs from alligator cracking** in that alligator cracks form smaller, many-sided pieces with sharp angles.
- Also, unlike block, alligator cracks are caused by repeated traffic loadings, and are therefore found only in traffic areas (i.e., wheel paths).

How to Measure:

Block cracking is measured in **square feet or meter** of surface area.

Example

During asphalt pavement inspection of link (100*10 or 5) M, from road in Egypt, (5x8) 40 m² (4%, 8% density) medium, 50 m² high, block cracking distress type. Determine deduct value for this (high) distress.

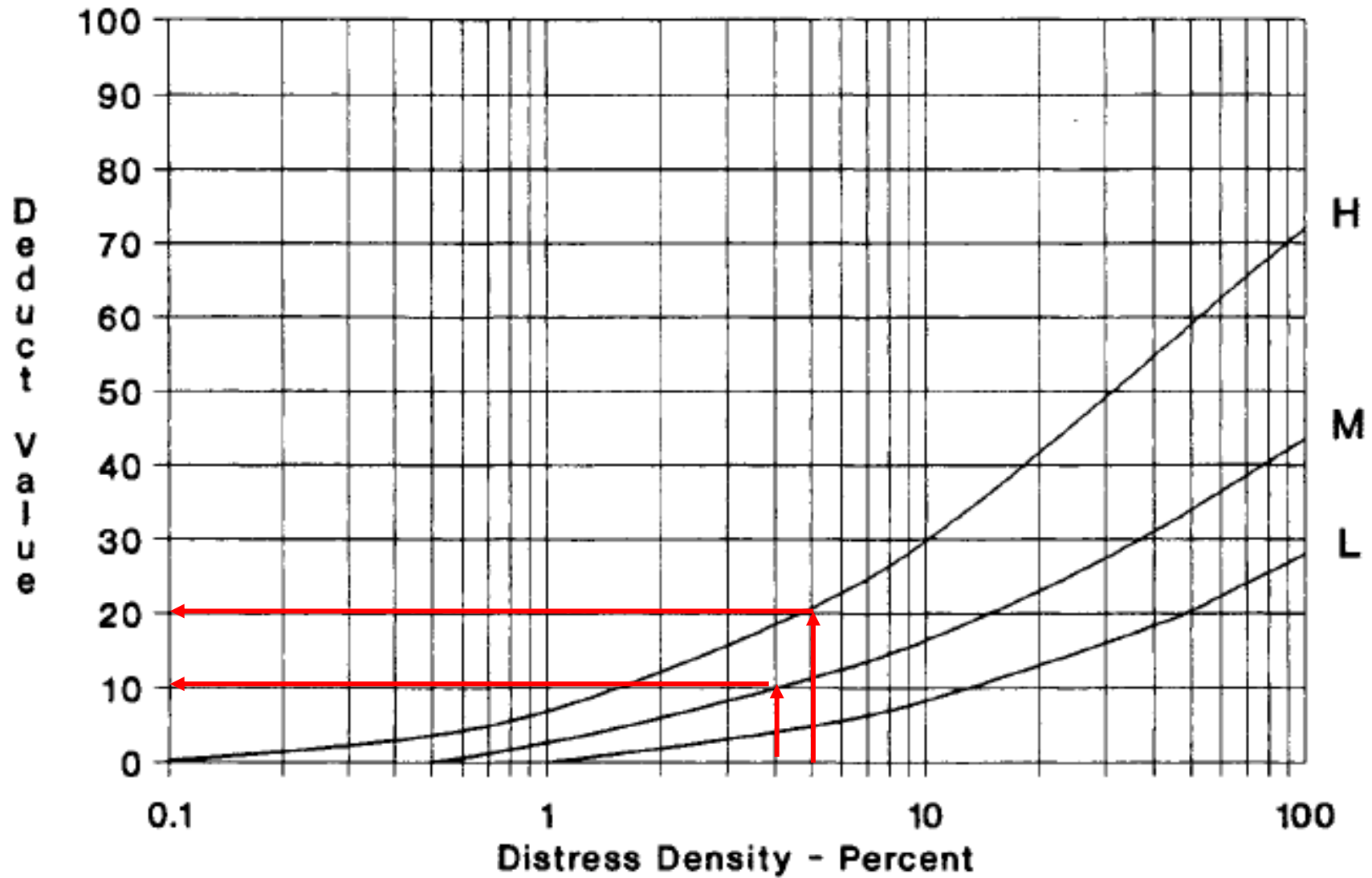
10 45

21 15

30 30

Block Cracking

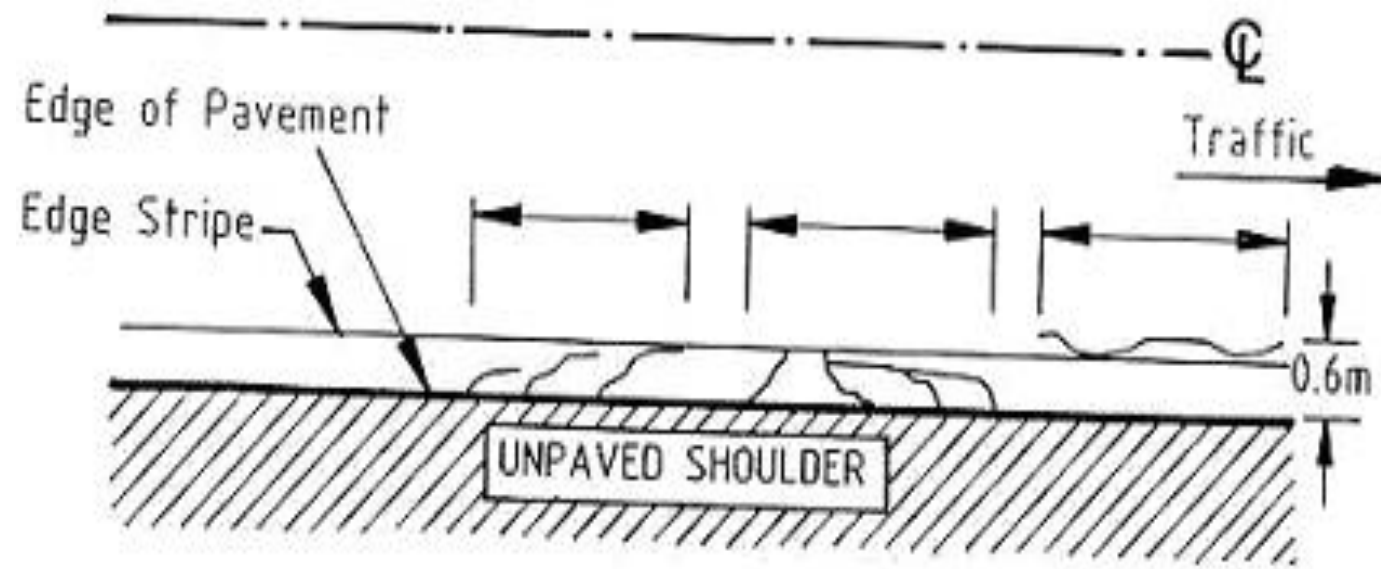
Asphalt 3



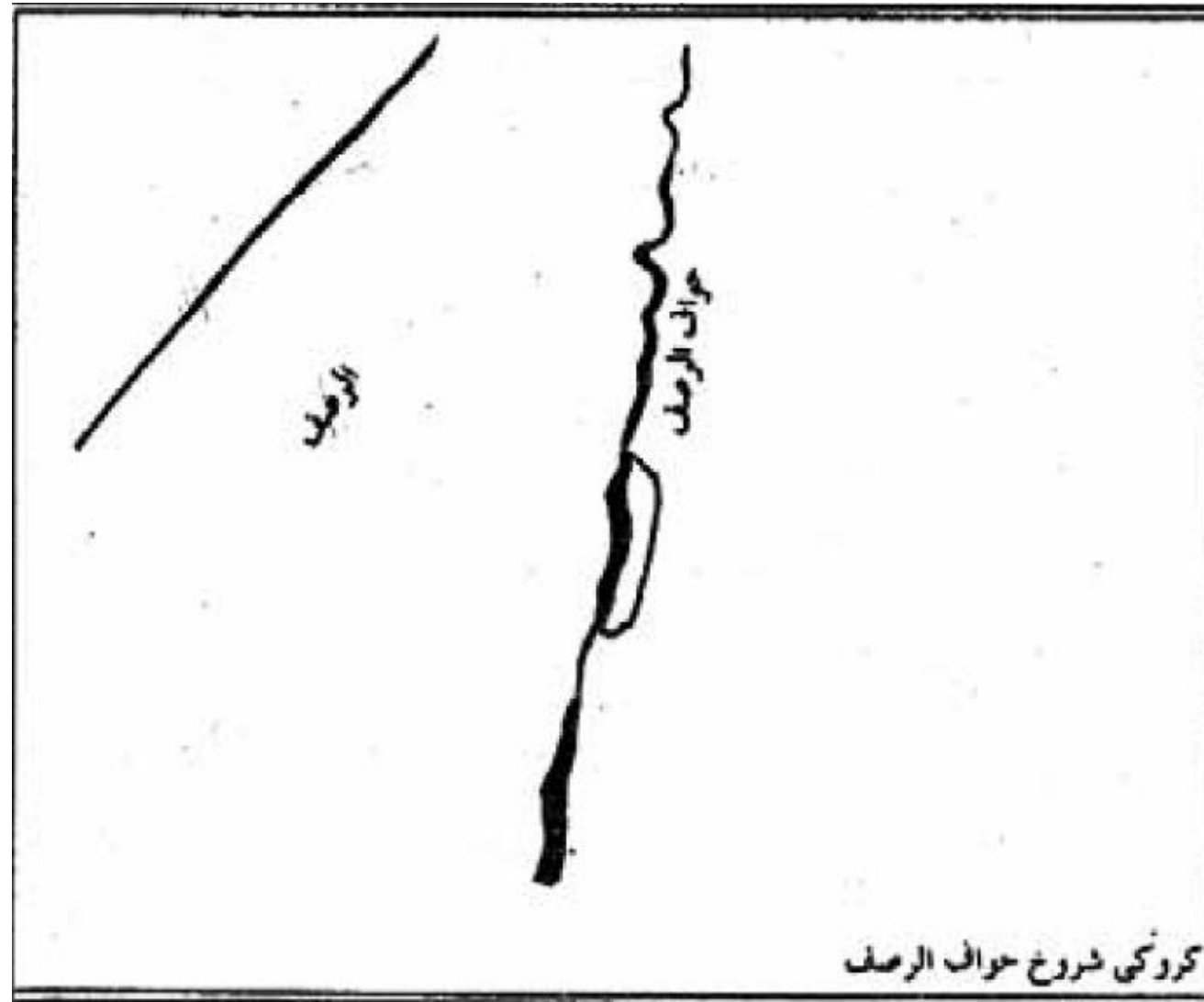
C. Edge Cracking

- Edge cracks are parallel to and usually within 1 to 2 ft (0.3 to 0.6 m) of the outer edge of the pavement.

في اماكن اتصال الاسفلت القديم بالحديث عند عمل توسعات بالطريق



Sketch Edge Cracking



Severity Edge Cracking

درجة الشدة :

- قليلة الشدة " L " شروخ طولية بسيطة بدون انفصال للمواد أو تكسير بعرض لا يزيد عن اسم .
- متوسطة الشدة " M " شروخ طولية متوسطة مع تكسير وانفصال للمواد في بعض المناطق وعرض الشرخ يتراوح ما بين اسم وحتى ٥ر اسم .
- عالية الشدة " H " شروخ طولية عالية الشدة مع تكسير وانفصال المواد على طول حرف الرصف وعرض الشرخ يزيد عن ٥ر اسم .

- This distress is accelerated by traffic loading and can be caused by **frost weakened base or subgrade near the edge of the pavement.**
- The area between the crack and pavement edge is classified as raveled **متصدعة** if it is broken up (sometimes to the extent that pieces are removed)

Low-severity edge cracking: no breakup or raveling.



How to Measure: Edge cracking is measure in linear feet or meter.

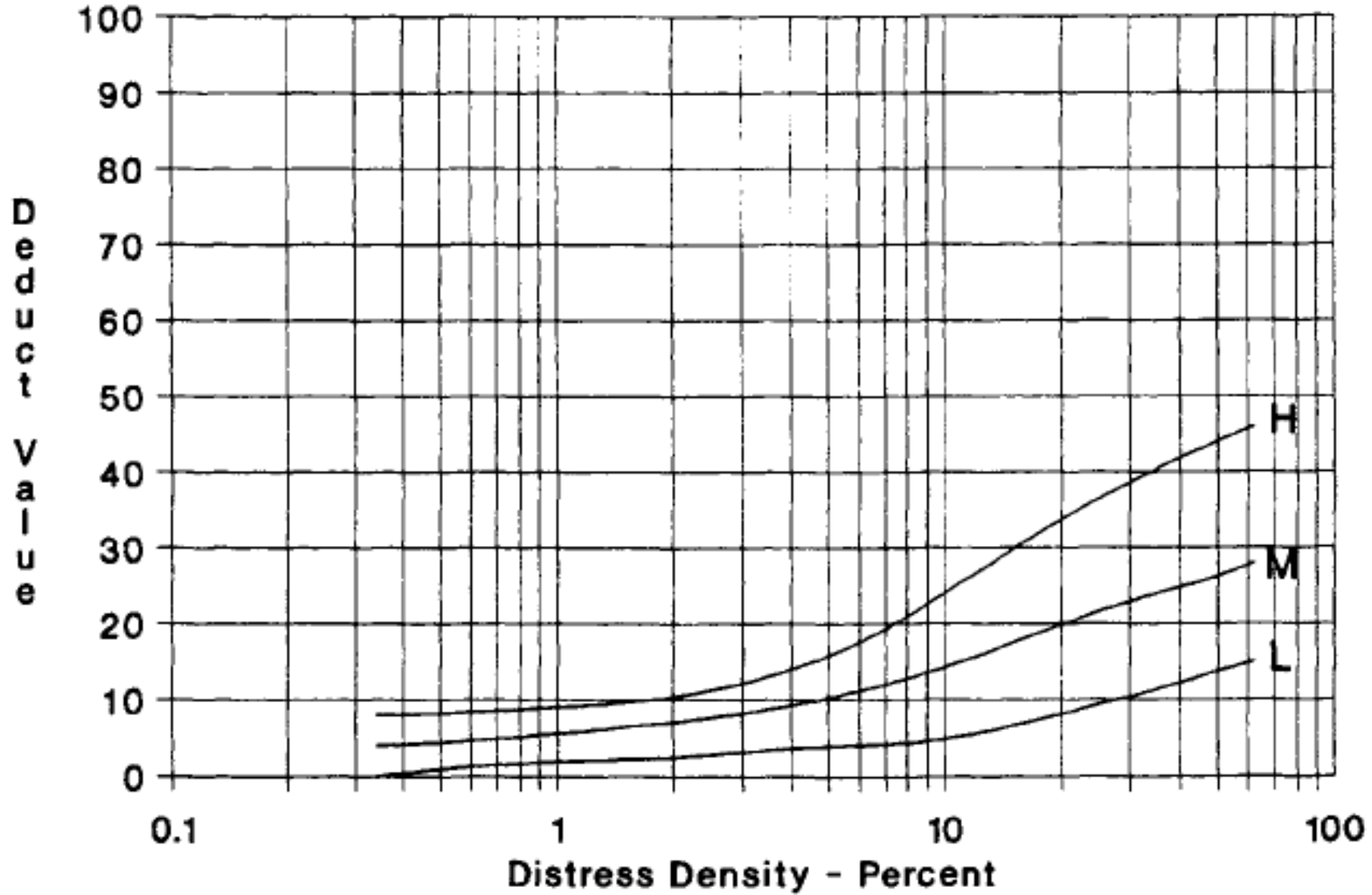
Example

During asphalt pavement inspection of link (100*7.5, 15) M, from road in Egypt during, 40 m low, 50 m high, Edge cracking distress type. Determine deduct value for this (high) distress.

4	13
18	22
22	18

Edge Cracking (Metric Units)

Asphalt 7



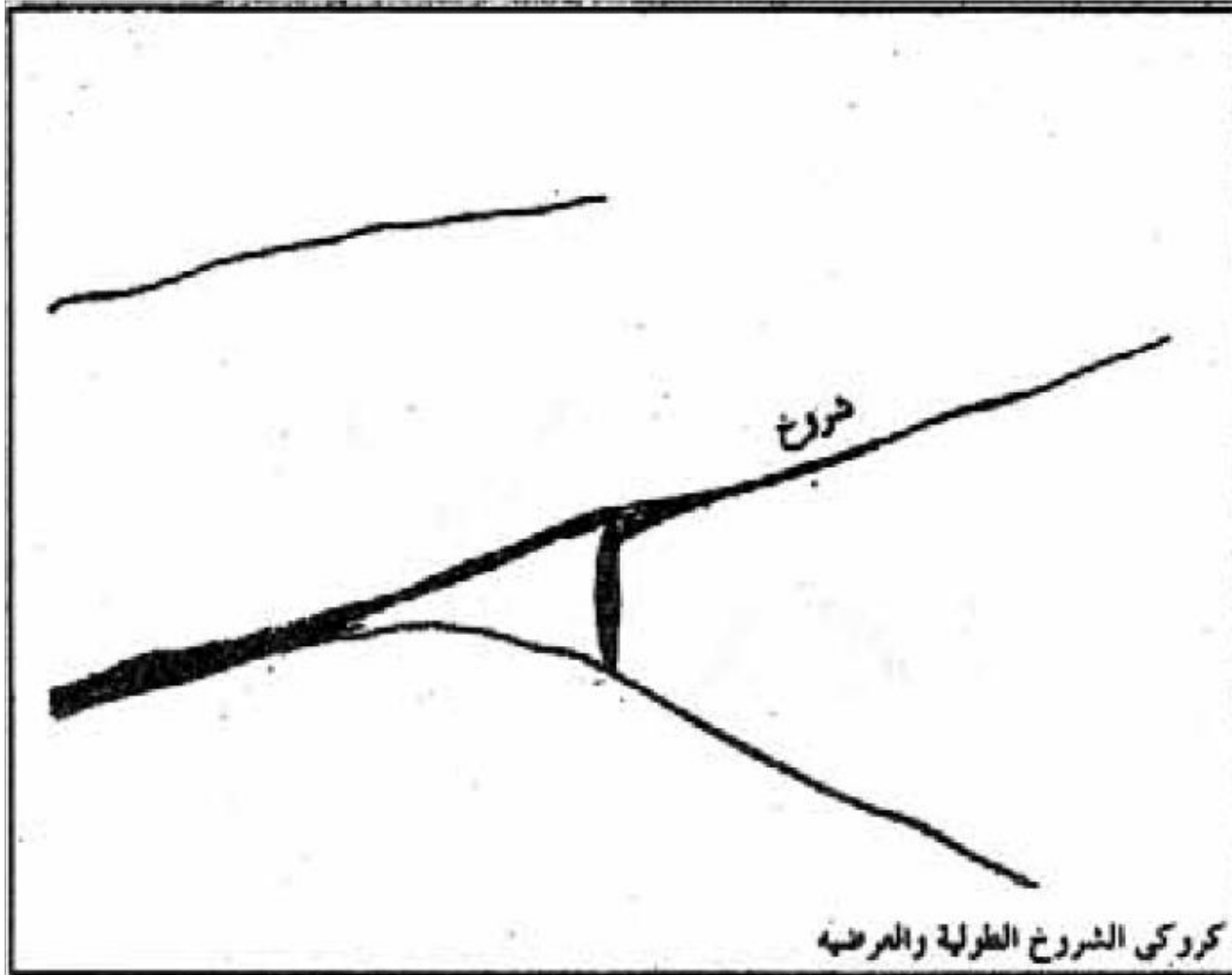
D -Longitudinal and Transverse Cracking

- Longitudinal cracks are parallel to the pavement's centerline while Transverse cracks extend across the pavement at approximately right angles to the pavement centerline .

They may be caused by:

- Shrinkage of the AC surface due to low temperatures or by daily temperature cycling.
- Hardening of the asphalts.
- Cracking reflection
- Loss of stability

Sketch Longitudinal and Transverse Cracking



Severity Longitudinal and Transverse Cracking

درجة الشدة :

- قليلة الشدة " L " عرض الشروخ أقل من واحد سنتيمتر .
- متوسطة الشدة " M " عرض الشروخ من ١ سم حتى ٢ سم
- عالية الشدة " H " عرض الشروخ أكبر من ٢ سم .

Field Longitudinal and transverse cracks



How to measure :Longitudinal and transverse cracks are measured in linear feet or meter.

Options for Repair

L—Do nothing; Seal cracks $> 1/8$ in. wide.

M—Seal cracks.

H—Seal cracks; Partial-depth patch.

Example

During asphalt pavement inspection of link (100*7.5, 10) M, from road in Egypt, 60 m high, 40 m medium, Longitudinal and transverse cracking distress type. Determine deduct value for this (medium) distress.

55 24

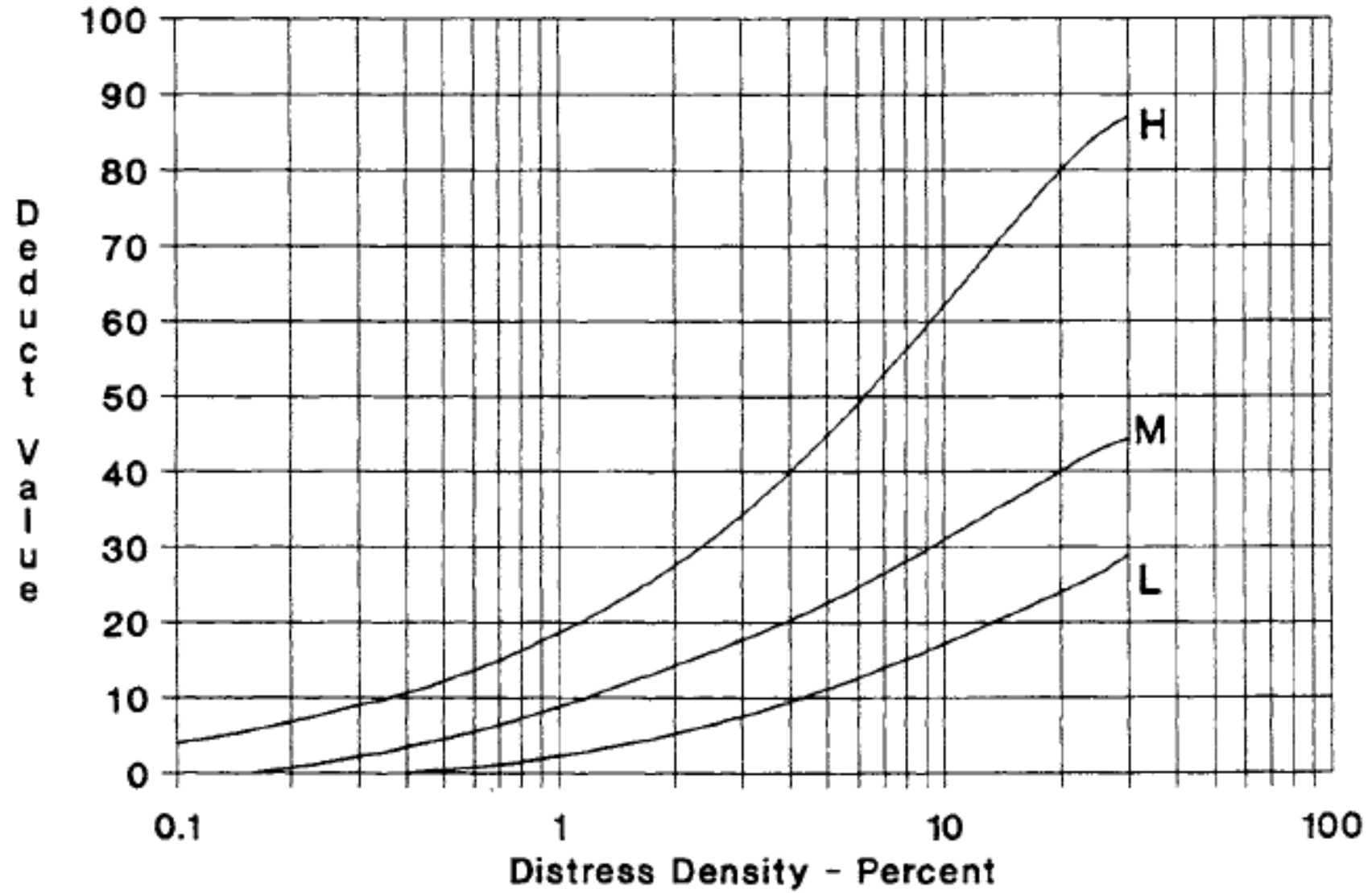
49 20

104 44

79 70

Longitudinal/Transverse Cracking

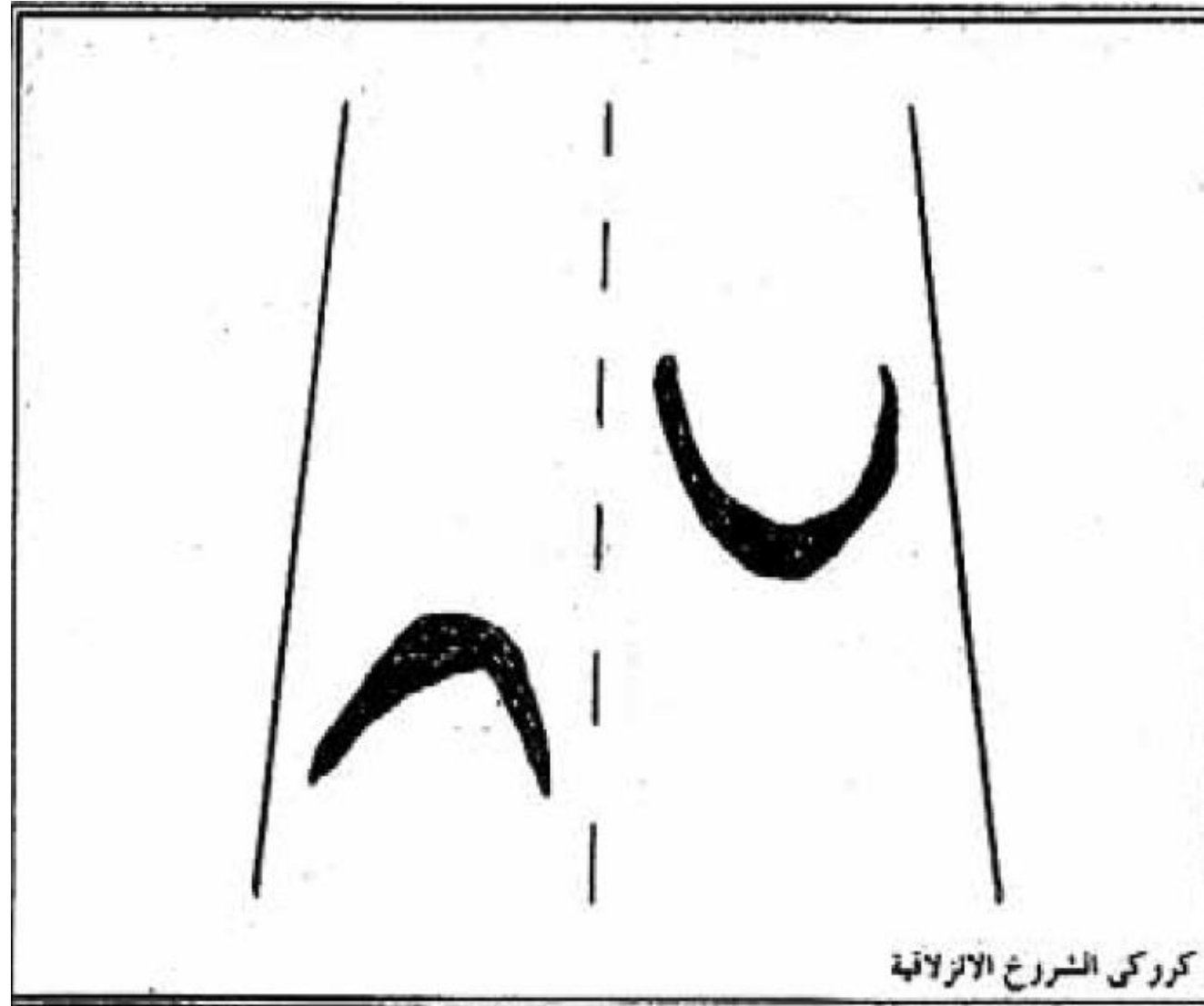
Asphalt 10



E. Slippage Cracking

- Slippage cracks are crescent or half-moon shaped cracks.
- They are produced when braking or turning wheels cause the pavement surface to slide or deform.
- This distress usually occurs when there is a low strength surface mix
- or poor bond between the surface and the next layer of the pavement structure.

Sketch Slippage Cracking



Field Slippage Cracking



Severity Level

- L—Average crack width is $< 3/8$ in. (10 mm).
- M—One of the following conditions exists:
 - 1. Average crack width between $3/8$ in. and $1-1/2$ in. (10 mm and 38 mm).
 - 2. The area around the crack is broken into tight-fitting pieces.
- H—One of the following conditions exists:
 - 1. The average crack width is greater than $1-1/2$ in. (38mm).
 - 2. The area around the crack is broken into easily removed pieces.

How to Measure Slippage Cracking

- The area associated with a given slippage crack is measured in **square feet or meter** and rated according to the highest level of severity in the area.
- **Options for Repair**
- L—Do nothing; Partial-depth patch.
- M—Partial-depth patch.
- H—Partial depth patch

Example

During asphalt pavement inspection of link (100*10 or 5) M, from road in Egypt, (8x10) 80 m² low, 100 m² high, Slippage Cracking distress type. Determine deduct value for this (high) distress.

24 91

67 78

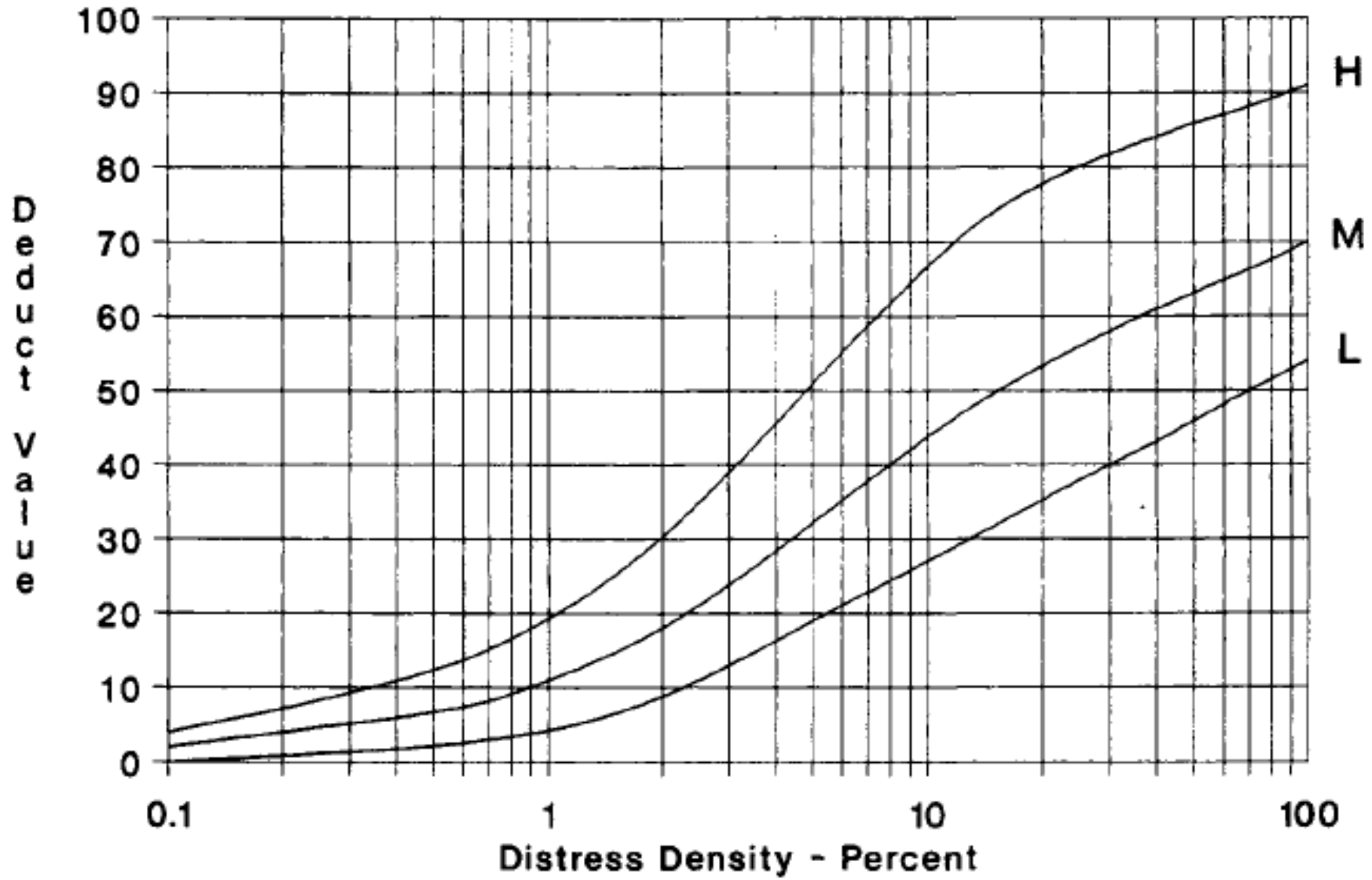
92 32

110 24

78 110

Slippage Cracking

Asphalt 17



2 – Surface Distortion

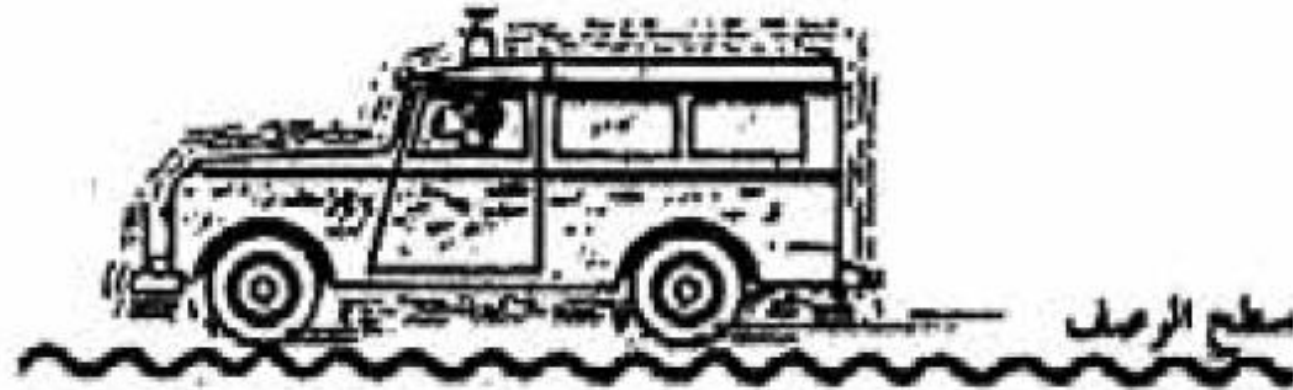
عيوب ناشئة عن تشوه استواء السطح

- Corrugations.
- Depression
- Shoving.
- Rutting.
- Swelling or upheaval.
- Sag and Bumps.
- Lane / shoulder Drop off

A. Corrugations

- Corrugation is a series of closely spaced ridges and valleys (**ripples**) occurring at fairly regular intervals, usually < 10 ft (3 m) along the pavement.
- The ridges are perpendicular to the traffic direction.
- This type of distress is usually caused by traffic action combined with an **unstable pavement surface or base**.
- If bumps occur in a series of < 10 ft (3 m), due to any cause, the distress is considered corrugation.

Corrugations Sketch



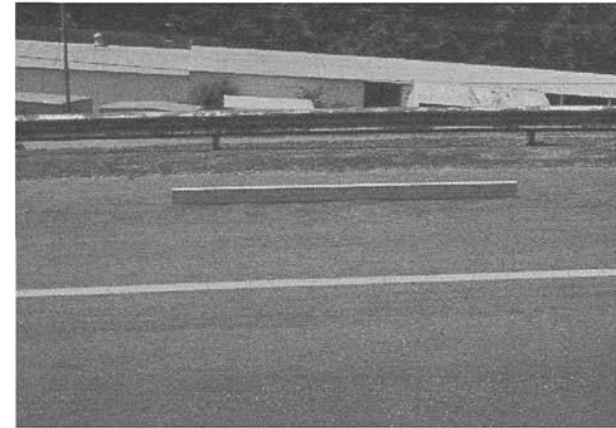
Corrugations Severity Levels

L—Corrugation produces low severity **ride quality**.



LOW

M—Corrugation produces medium-severity ride quality *جودة الطريق*.



MEDIUM

H—Corrugation produces high-severity ride quality



HIGH

Corrugations

How to Measure

Corrugation is measured in **square meters (feet)** of surface area.

Options for Repair

L—Do nothing.

M—Reconstruction

H—Reconstruction

Example

During asphalt pavement inspection of link (100*7) M, from road in Egypt, 49 m² low, 63 m² high, corrugation distress type. Determine deduct value for this (**high**) distress .

10 10

60 60

70 70

80 80

