GOVERNMENT OF PAKISTAN
MINISTRY OF COMMUNICATIONS
NATIONAL TRANSPORT RESEARCH CENTRE

***

ROADS SURFACE TEXTURE

IN

ISLAMABAD

NTRC NO. 203

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EXECUTIVE SUMMARY

For safe driving, among various other factors, it is necessary to have a non-slippery road surface specially during wet-road conditions. Studies have shown that frequency of wet-road accidents is about four times of dry-road accidents, although not all wet-road accidents result from road slipperiness. The slipperiness is dependent on both the pavement surface texture and tire condition of the vehicle. Since these are two very different aspects, the present study focuses on the pavement surface texture only.

There are two parts of the surface texture of a road that contribute to the overall skidding resistance of a road surface namely the microtexture and the macrotexture. The micro-texture is the surface roughness of the aggregate exposed at the road surface and is primarily dependent on the polishing characteristics of the aggregate. As regards the macrotexture, it is provided by the orientation, size and shape of the aggregate particles at the road surface. The function of the macrotexture is to provide drainage channels which allow the dispersion of the surface water ahead of, and around the rolling tyre.

On the request of CDA, NTRC has carried out the study of surface texture of six roads in Islamabad. The study has assessed the existing surface macrotexture of the roads in Islamabad and has proposed the minimum level of surface macrotexture for safer driving specially in conditions of light drizzle.

The methodology adopted for the study covers the macrotexture testing of roads in Islamabad as per American Society of Testing Materials (ASTM) standards. Standard test method for measuring surface macrotexture depth by

using a volumetric technique has been adopted for the selected road sections of Islamabad.The report includes literature review in order to ascertain the standards for skid resistance adopted by other countries such as U.S.A, U.K and Australia.

On all the six selected road sections, three test locations per section were marked for " Sand patch testing " and at each test location, the same operator performed four tests at random in order to get the representative value of mean macrotexture depth at the test location.

From the test results, it has been observed that the value of mean macrotexture depth of roads in Islamabad ranges from 0.19 - 0.43 mm, whereas the international standards propose a minimum value of 1.00 mm for the same parameter. Therefore from the safety point of view, all the road sections tested in Islamabad for this study are more slippery than normal and hence unsafe for driving specially during light drizzle.

The reason for the above situation is that the Asphaltic concrete design method (Marshal procedure), which is mostly used in Pakistan was evolved in early part of the 20th century and at that time, almost no consideration was given to the Skid resistance properties in the mix design. As a result the maximum macrotexture depth (roughness) does not exceed 0.6 mm. The increasing importance of skid resistance has led to the development of new procedures and materials such as Dense Bitumen Macadam, Pervious Macadam etc. which give much better macrotexture depth that is in the range of 0.6 mm to 3.5 mm.. Therefore for improving the Skid resistance of the pavement, new materials like Dense Bitumen Macadam, Pervious Macadam must be introduced.

1. INTRODUCTION

The performance of any road can be assessed on the basis of three distinct measurements, namely, Road roughness, Skid resistance and Surface distress. Skid resistance and Road roughness are aspects which directly affect the interaction between vehicles and the Pavement Surface, while Surface Distress include faults such as cracking, rutting and patching etc.

The key service properties of a road surface are its Skid resistance and roughness. Skid resistance is a summary measure of the pavement surface characteristics which contribute to skidding accidents. Macrotexture, Microtexture, tire treads pattern and water film thickness all influence the skid resistance. The value of skid resistance varies with the type of test and test speed [1]. The road surface viewed by the naked eye is termed as Macrotexture of the road surface. It is the Macrotexture that could be felt by the human hand and it is measured by the sand patch method. The Macrotexture largely determines the noise generation of the road surface, its drainage capability and partly determines the skid resistance. Macrotexture is necessary at high vehicle speeds to facilitate rapid drainage of water from the road surface and to utilize the tyre tread rubber to absorb some of the kinetic energy of the vehicle. Macrotexture generates resistance to sliding via the hysteresis effect in the tread rubber and facilitates the expulsion of water from the tire pavement interface [2].

1.1 METHODS OF MEASURING MACROTEXTURE DATA: Macrotexture is measured by either volumetric or profilometric techniques.

1.1.1 Volumetric: A measured quantity of a uniform granular material is spread and leveled off across the surface in a prescribed manner and the area covered is measured. The macrotexture depth is the mean thickness of the layer of material that fills the cavities. The dependence of skid resistance on speed is a function of texture depth and can be established by correlation [3]. The method is inexpensive but slow, and hence its use is usually limited to research studies or accident analysis investigations.

1.1.2 Profilometric: Optical methods using visible light are proving to be reliable and used either photographic interpretation or laser profilometry as the Tandell Meter and the British HRM (High Speed Road Monitor) and Swedish laser RST (Road Surface Test) [4].

2. THE PROBLEM

One of the basic reason of increasing skidding accidents in Islamabad is the smooth road surfaces offering lesser friction between the tyre and the pavement specially during and after slight drizzle. Observing the severity of the skidding accident in Islamabad, the Traffic Engineer, C.D.A. has requested the N.T.R.C to under take a study in order to survey the surface texture (Macrotexture) of the roads in Islamabad in detail and establish the minimum standards for skid resistance specified for various categories of roads in Islamabad.

3. OBJECTIVE AND SCOPE OF THE STUDY

The basic objective of the study is to survey the different road sections of Islamabad city for the Macrotexure testing and after analyzing the results and consulting literature , propose the minimum standards for the roads in Islamabad.

4. METHODOLOGY

The methodology adopted for the study comprised of the following steps:

i. Literature review.
ii. Selection of road sections and spots for the Macrotexture testing.
iii. Demarcation of prints for sand patch tests.
iv. Execution of the sand patch tests.
v. Compilation and analysis of testing data.
vi. Literature review for the standards adopted in other countries.
vii. Report writing.

5. LITERATURE REVIEW

Skid resistance is a pavement characteristic and it is a function of the surface properties i.e the Macrotexture and Microtexture of the surface. It is well known that skid resistance is a rather irregular function of time and it is difficult to predict at any time other than the time it is measured [5].

Systems for measuring skid resistance vary widely but can be classified by three major methods:

1. The locked wheel method, producing a skid number (SN) as a function of test speed.
2. The slip method, producing brake slip numbers (BSN) as a function of percent slip and test speed.
3. The side force method, producing side force coefficients (SFC) as a function of Yaw angle and the test speed or in other words the side force developed in a wheel placed at an angle to the direction of travel.

Two most popular side force measurement systems are the Side-force Coefficient Inventory Machine (SCRIM) and the Mu meter, both developed in the U.K. The SCRIM was developed for highway evaluation and has achieved popularity in Europe and British Common wealth. In the SCRIM the two smooth tired test wheels are free rolling parts of the test truck and run at an angle of 20^0 to the travel direction in each wheel path. The road in front of the wheel is kept wet by a water tank in the vehicle and the test wheel has its own dead weight and suspension. Electrical resistance load cells measure the side ways force produced. The operating speed is usually 80 km / hr or less.

The other indirect method of measuring skid resistance of any pavement surface is to measure surface Macrotexture. While pavement surface Macrotexture has an important effect on other Engineering properties such as tyre/ road noise, vibration, rolling resistance, spray etc. The Highway Engineer's main interest in this property lies in the effect that Macrotexture has on the drainage capacity of a surface under tyre pressures at varying modes of operation (rolling or sliding) and at various speeds. Hence it is the main factor governing the friction/speed relationship [6].

The literature suggests that a high side-force coefficient (SFC) from the SCRIM , together with a high Macrotexture depth as measured by Sand Patch method, would thus indicate a level of skid resistance adequate to ensure safety. Infect, in the United Kingdom, SCRIM data are used in conjunction with required minimum level of pavement Macrotexture: 1.5 mm for newly constructed bituminous concrete pavements, with maintenance required when the Macrotexture falls below 1 mm [7].

6. RESULTS OF MACROTEXTURE TESTING

Standard test method for measuring surface Macrotexture depth by using a volumetric technique as per ASTM: E 965-87 has been adopted for selected road sections of Islamabad.

In order to select the representative road sections and then to choose the test locations on these roads a preliminary survey has been conducted by the Engineers of NTRC and on the basis of the this survey following road sections have been selected for detailed testing:

1. Shahra-i-Islamabad.
2. Shahra-i-Kashmir.
3. Khayaban-i-Iqbal.
4. Khayaban-i-Quaid-e-Azam.
5. Faisal Avenue.
6. Constitution Avenue.

On all the above mentioned road sections, three test locations at each were marked for sand patch testing. At each location the same operator had performed four tests in order to get the representative value of Macrotexture depth at that location. The Macrotexture of the road is measured by the sand patch method in which a given (12 ml) volume of fine sand is used to fill a measured area of surface to the top of the aggregate pieces. The area so covered is an inverse measure of the mean depth of the texture. The Macrotexture depth (mm) is the mean thickness of the layer of material that fills the cavities. The dependence of skid resistance on a particular speed is a function of mean texture depth and can be established by correlation. The method is inexpensive but slow, and hence commonly used in research studies or accident analysis investigations.

The exact locations of the tests and their results have been presented in Table-6.1 to Table-6.6

Table- 6.1

KHAYABAN-I- IQBAL SURVEYED ON 10-4-97

Volume 0f Sand used= 12500 Cubic.mm

LOCATION NO.1 AT F-10 BOUND LANE 00+050 KM FROM F-7th AVENUE

	Sand patch Diameter (mm)			
	Test No.1	Test No.2	Test No.3	Test No.4
	205	200	205	210
	208	210	208	208
	206	208	206	210
	205	208	208	208
Average Diameter Of Sand Patch in mm	206	207	207	209
Av. Macrotexture Depth in mm For the Test	0.375	0.373	0.372	0.364
Av. Macrotexture Depth For Location No.1	0.371			

LOCATION NO.2 AT F-7 BOUND LANE 02+000 KM FROM F-7th AVENUE

	Sand patch Diameter (mm)			
	Test No.1	Test No.2	Test No.3	Test No.4
	210	210	208	215
	209	210	208	214
	212	212	210	214
	210	212	210	215
Average Diameter Of Sand Patch in mm	210	211	209	215
Av. Macrotexture Depth in mm For the Test	0.360	0.357	0.364	0.346
Av. Macrotexture Depth For Location No.2	0.357			

LOCATION NO.3 AT F-10 BOUND LANE 04+300 KM FROM F-7th AVENUE

	Sand patch Diameter (mm)			
	Test No.1	Test No.2	Test No.3	Test No.4
	200	205	212	208
	199	204	210	206
	200	202	212	206
	204	204	214	207
Average Diameter Of Sand Patch in mm	201	204	212	207
Av. Macrotexture Depth in mm For the Test	0.395	0.383	0.354	0.372
Av. Macrotexture Depth For Location No.3	0.376			

Mean Macrotexture Depth For the Khyaban-i-Iqbal = 0.360 mm.

Table-6. 2

SHAHRA-I-KASHMIR SURVEYED ON 11-4-97

Volume 0f Sand used= 12500 Cubic.mm

LOCATION NO.1 AT GOLRA BOUND LANE 08+000 KM FROM ZERO POINT.

	Sand patch Diameter (mm)			
	Test No.1	Test No.2	Test No.3	Test No.4
	270	269	270	271
	265	268	269	270
	268	268	268	272
	270	270	268	272
Average Diameter Of Sand Patch in mm	268	269	269	271
Av. Macrotexture Depth in mm For the Test	0.221	0.220	0.220	0.216
Av. Macrotexture Depth For Location No.1	0.219			

LOCATION NO.2 AT Z. POINT BOUND LANE 04+050 KM FROM ZERO POINT.

	Sand patch Diameter (mm)			
	Test No.1	Test No.2	Test No.3	Test No.4
	300	298	300	302
	298	297	301	301
	300	298	300	301
	301	298	302	300
Average Diameter Of Sand Patch in mm	300	298	301	301
Av. Macrotexture Depth in mm For the Test	0.177	0.179	0.176	0.176
Av. Macrotexture Depth For Location No.2	0.177			

LOCATION NO.3 AT GOLRA BOUND LANE 00+050 KM FROM ZERO POINT.

	Sand patch Diameter (mm)			
	Test No.1	Test No.2	Test No.3	Test No.4
	302	298	302	302
	301	299	304	300
	300	300	304	301
	302	300	302	301
Average Diameter Of Sand Patch in mm	301	299	303	301
Av. Macrotexture Depth in mm For the Test	0.175	0.178	0.173	0.176
Av. Macrotexture Depth For Location No.3	0.175			

Mean Macrotexture Depth For the Shahra-i-Kashmir = 0.190 mm.

Table-6. 3

SHAHRA-I-ISLAMABAD SURVEYED ON 15-4-97

LOCATION NO.1 AT AIRPORT BOUND CARRIAGEWAY 08+000 KM FROM ZERO POINT.

	Sand patch Diameter (mm)			
	Test No.1	Test No.2	Test No.3	Test No.4
	230	232	236	238
	235	235	236	238
	238	236	235	236
	232	236	234	236
Average Diameter Of Sand Patch in mm	234	235	235	237
Av. Macrotexture Depth in mm For the Test	0.291	0.289	0.287	0.283
Av. Macrotexture Depth For Location No.1	**0.288**			

LOCATION NO.2 AT ZERO POINT BOUND CARRIAGEWAY 08+000 KM FROM ZERO POINT

	Sand patch Diameter (mm)			
	Test No.1	Test No.2	Test No.3	Test No.4
	240	238	240	242
	242	239	242	242
	242	239	242	245
	241	240	241	245
Average Diameter Of Sand Patch in mm	241	239	241	244
Av. Macrotexture Depth in mm For the Test	0.273	0.279	0.273	0.268
Av. Macrotexture Depth For Location No.1	**0.273**			

LOCATION NO.3 AT AIRPORT BOUND CARRIAGEWAY 04+000 KM FROM ZEROPOINT.

	Sand patch Diameter (mm)			
	Test No.1	Test No.2	Test No.3	Test No.4
	245	248	248	246
	245	248	248	246
	246	246	247	246
	246	246	249	248
Average Diameter Of Sand Patch in mm	246	247	248	247
Av. Macrotexture Depth in mm For the Test	0.264	0.261	0.259	0.262
Av. Macrotexture Depth For Location No.1	**0.261**			

Mean Macrotexture Depth For the Shahra-i-Islamabad = 0.274 mm.

Table-6. 4

KHAYABAN-I- QUAID-E-AZAM SURVEYED ON 16-4-97

Volume 0f Sand used= 12500 Cubic.mm

LOCATION NO.1 AT 10th AVENUE BOUND CARRIAGEWAY 00+050 KM FROM CONS.AVENUE

Sand patch Diameter (mm)

Test No.1	Test No.2	Test No.3	Test No.4
200	200	205	202
201	204	204	202
202	202	204	200
200	202	205	202
201	200	205	202
0.395	0.398	0.380	0.392
0.391			

Average Diameter Of Sand Patch in mm
Av. Macrotexture Depth in mm For the Test
Av. Macrotexture Depth For Location No.1

LOC. NO.2 AT CONSTI. AVE BOUND CARRIAGEWAY 04+500 KM FROM CONSTI.AVENUE

Sand patch Diameter (mm)

Test No.1	Test No.2	Test No.3	Test No.4
200	204	208	210
202	206	208	208
202	206	210	208
200	204	210	210
201	205	209	209
0.394	0.379	0.364	0.364
0.375			

Average Diameter Of Sand Patch in mm
Av. Macrotexture Depth in mm For the Test
Av. Macrotexture Depth For Location No.2

LOC.NO.3 AT 10th AVENUE BOUND CARRIAGEWAY 08+000 KM FROM CONSTI.AVENUE

Sand patch Diameter (mm)

Test No.1	Test No.2	Test No.3	Test No.4
200	205	212	208
199	204	210	206
200	202	212	206
204	204	214	207
201	204	212	207
0.395	0.383	0.354	0.372
0.376			

Average Diameter Of Sand Patch in mm
Av. Macrotexture Depth in mm For the Test
Av. Macrotexture Depth For Location No.3

Mean Macrotexture Depth For the Khyaban-i-Iqbal = 0.380 mm.

Table-6. 5

FAISAL AVENUE SURVEYED ON 17-4-97

Volume 0f Sand used= 12500 Cubic.mm

LOCATION NO.1 AT F. MASJID BOUND CARRIAGEWAY 00+050 KM FROM ZERO POINT.

	Sand patch Diameter (mm)			
	Test No.1	Test No.2	Test No.3	Test No.4
	188	192	192	188
	190	193	192	187
	192	193	190	188
	192	192	190	187
Average Diameter Of Sand Patch in mm	191	193	191	190
Av. Macrotexture Depth in mm For the Test	0.438	0.429	0.436	0.441
Av. Macrotexture Depth For Location No.1	**0.436**			

LOCATION NO.2 AT ZERO POINT BOUND CARRIAGEWAY 02+000 KM FROM ZERO POIN

	Sand patch Diameter (mm)			
	Test No.1	Test No.2	Test No.3	Test No.4
	190	188	190	200
	195	190	191	199
	196	190	188	199
	196	189	191	200
Average Diameter Of Sand Patch in mm	194	189	191	200
Av. Macrotexture Depth in mm For the Test	0.422	0.444	0.436	0.400
Av. Macrotexture Depth For Location No.2	**0.425**			

LOCATION NO.3 AT F.MASJID BOUND CARRIAGEWAY 04+000 KM FROM ZERO POINT.

	Sand patch Diameter (mm)			
	Test No.1	Test No.2	Test No.3	Test No.4
	195	193	190	190
	194	193	188	191
	194	192	188	191
	194	192	190	190
Average Diameter Of Sand Patch in mm	194	193	189	191
Av. Macrotexture Depth in mm For the Test	0.422	0.429	0.445	0.438
Av. Macrotexture Depth For Location No.3	**0.434**			

Mean Macrotexture Depth For the Faisal Avenue = 0.432 mm.

Table-6. 6

CONSTITUTION AVENUE SURVEYED ON 18-4-97

Volume 0f Sand used= 12500 Cubic.mm

LOCATION NO.1 AT SECRETARIATE BOUND CARRIAGEWAY 00+050 KM FROM T. CENTRE..

Sand patch Diameter (mm)

Test No.1	Test No.2	Test No.3	Test No.4
191	192	192	194
190	193	192	193
192	193	190	194
192	192	190	194
191	193	191	195
0.435	0.429	0.436	0.418
0.430			

Average Diameter Of Sand Patch in mm
Av. Macrotexture Depth in mm For the Test
Av. Macrotexture Depth For Location No.1

LOCATION NO.2 AT T.CENTER BOUND CARRIAGEWAY 01+000 KM FROM TRADE CENTER..

Sand patch Diameter (mm)

Test No.1	Test No.2	Test No.3	Test No.4
190	192	191	192
195	190	191	192
196	190	192	193
196	191	191	194
194	191	191	193
0.422	0.437	0.436	0.428
0.431			

Average Diameter Of Sand Patch in mm
Av. Macrotexture Depth in mm For the Test
Av. Macrotexture Depth For Location No.2

LOCATION NO.3 AT SECRETARIATE BOUND CARRIAGEWAY 02+000 KM FROM T.CENTER.

Sand patch Diameter (mm)

Test No.1	Test No.2	Test No.3	Test No.4
195	193	194	193
194	193	193	192
194	192	194	192
194	192	194	192
194	193	194	192
0.422	0.429	0.424	0.430
0.426			

Average Diameter Of Sand Patch in mm
Av. Macrotexture Depth in mm For the Test
Av. Macrotexture Depth For Location No.3

Mean Macrotexture Depth For the Constitution Avenue = 0.429 mm.

7. SKID RESISTANCE STANDARDS

The ability of a tire-pavement combination to provide adequate traction on wet roads is termed as Wet-pavement traction. When a standard tire and standard test conditions are utilized in a measurement of wet-pavement traction, the results are reported as the Skid resistance of the pavement. Skid resistance is therefore a pavement characteristic and it is a function of both microtexture and macrotexture.

Desirable skid resistance levels is a thorny issue. The problems relate to measurement difficulties, variations with season and recent rainfall and the fact that skid resistance levels are rarely the only causative factor in an accident. United Kingdom practice (Salt, 1977, et.al.) recommends SFC values ranging from 0.30 on generally straight sections of road in low risk areas to 0.75 on approaches to traffic control device, in high risk areas. Typical levels are shown in Table.7

Table.7 PROPOSED LEVELS OF SKID RESISTANCE APPLYING SCRIM

Road Section	Min. SFC	Test Speed (km/hr)
Braking and turning localities.	0.55	30
Speed limit 80 km/hr or less.	0.45	50
Speed limit more than 80 km/hr.	0.40	80

Similarly the U.K specifications for Macrotexture suggests that the required minimum level of pavement macrotexture as measured by sand patch method should be 1.5 mm for the newly constructed bituminous pavements, with maintenance is must when the macrotexture falls below 1 mm.

While in U.S.A, it is generally agreed that a skid number of 35 or more (as measured according to ASTM test method E274 [8] for skid resistance of paved surfaces using a full-scale tire gives adequate skid resistance under most conditions. Similarly the Australian standards suggests that the Mean texture depth between 600 & 900 μ m will provide adequate wet-pavement traction with out excessive tire abrasion.

Unfortunately in the developing countries like Pakistan no standards for either Macrotexure or Skid resistance are available for roads. Keeping in mind the importance of the Skid resistance, it is necessary to develop some minimum standards for roads in Pakistan.

8. MACROTEXTURE DEPTHS RANGES

Each form of bituminous surfacing has a typical range of Mean Macrotexture depths deriving mainly from the grading characteristics of the aggregate used. Typical figures are given in Table.-8.1 for reference.

Table-8.1 **TYPICAL MEAN MACROTEXTURE DEPTHS RANGES FOR DIFFERENT BITUMINOUS SURFACINGS**

Material	Normal Range of Texture Depths (mm)
Asphaltic Concrete	0.4 - 0.6
Dense Bitumen Macadam	0.6 - 1.2
Rolled Asphalt with precoated Chipping	0.5 - 2.5
Pervious Macadam	1.5 - 3.5
Surface Dressing	2.0 - 3.5

In the light of the above table, it can be observed that by changing the specifications of wearing course of the roads, the value of the Macrotexture depth can be improved.

9. CONCLUSIONS & RECOMMENDATIONS

From the test results, it has been observed that the value of mean macrotexture depth of roads in Islamabad ranges from 0.19 - 0.43 mm, whereas the international standards propose a minimum value of 1.00 mm for the same parameter. Therefore from the safety point of view, all the road sections tested in Islamabad for this study are more slippery than normal and hence unsafe for driving specially during light drizzle.

The reason for the above situation is that the Asphaltic concrete design method (Marshall procedure), which is mostly used in Pakistan was evolved in early part of the 20th century and at that time, almost no consideration was given to the Skid resistance properties in the mix design. As a result the maximum macrotexture depth (roughness) does not exceed 0.6 mm. The increasing importance of skid resistance has led to the development of new procedures and materials such as Dense Bitumen Macadam, Pervious Macadam etc. which give much better macrotexture depth that is in the range of 0.6 mm to 3.5 mm.. Therefore for improving the Skid resistance of the pavement, new materials like Dense Bitumen Macadam, Pervious Macadam must be introduced.

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