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IMPROVEMENT OF ROAD SURFACES SKID RESISTANCE BY CHIP SEAL COATS IN THAILAND

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PREFACE

Many traffic accidents are the result of mechanical failure and human error. However, the pavement surface condition is also an important factor in many accidents. Accidents involving skidding, for instance, frequently occur on slippery surfaces which have low coefficient of friction. With safety as an essential objective, pavement surfaces can be designed, constructed and maintained to save lives, reduce personel injuries and property damage.

The Department of Highways hopes that this report will be a guide for road engineers and road users in our country and other tropical countries which have similar conditions. Nevertheless, more research should be encouraged to further the knowledge in this field.

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SYNOPSIS

The primary objectives of the paper are to study the improvement of road surfaces skidding resistance by chip seal coats in Thailand and try to estimate the service life. The instruments used in measuring the skidding resistance values are the Mu-Meter and the British Portable Tester of the Transport and Road Research Laboratory. The road surfaces were measured before and after the treatment. The increase in skidding resistance valure was found being highly significant. With safety as an essential objective, the service life of the $\frac{3}{8}$ in. limestone chip seal coat found was approximately after the 2 million vehicle passes. This depends

mainly on the construction control, the percentage of heavy vehicles and the resisting to polishing of the limestones. The standard of the chip seal coats used in Thailand is included. The surface texture depths and the skidding resistance values on basalt, granite andcrushed gravel with various ages were also measured. The correlation tests between the two measuring instruments were carried out. The guidelines for the minimum skidding resistance values and surface texture depth were recommended in this paper.

INTRODUCTION

Improving and maintaining a skid-resistant surface is a very important factor in the performance of any highways. All types of pavement surfaces will eventually show some reduction in coefficient of friction values during their service life. This reduction is caused mainly by wear, polishing of surface aggregate due to traffic and bleeding of asphalt. Like in other tropical countries, the road surfaces in Thailand are always covered with water film, and accidents involving skidding frequently occur and confront road engineers. Moreover, lack of granite or harder aggregates in the central part of the country is another problem. Limestone which is generally found in ample amount has been used for constructing the road surfaces.

The Materials and Research Division, Thai Department of Highways has been interested in road friction since 1971. Two publications (8,11), were published in 1972 and 1973. As shown in Fig. 1, the skidding resistance values of about 1,100 kilometers of road surfaces were measured from 1971 to 1974.

There are many methods of improving skidding resistance values of road surfaces such as pavement groovings, resurfacings, etc. In Thailand, resurfacings can be classified as overlaying by asphaltic concrete, penetration macadam, surface treatments and chip seal coat.

Chip seal coat has for many years been a cheap and effective process for improving resistance to skidding and for providing general protection to the road structure. The process is being used throughout the world, not only on low cost roads but also on some of the most expensive and highest quality highways.

A chip seal coat is a thin film of asphalt which is sprayed on the road surface and then covered with a single layer of stone chippings. It has primarily been accepted as a means of

a) waterproof seal and prevents the entry of surface water into the road structure,

b) improving frictional relationships between vehicle tires and road surface even in wet conditions,

c) protecting the surface of bituminous mats from oxidation or polymerization of the bituminous cement exposed at the surface(1), and,

d) producing better night visivility characteristics of the surface.

The surface roughness and wearing characteristics are described by the Macro and Micro-Texture (6). Both Macro and Micro-Texture are very important in developing and maintaining high level of coefficient of friction. The mean surface texture depth measured from the new chip seal coats constructed in Thailand was approximately 2.0 mm. compared with the new asphaltic concrete surface which was about 0.8 mm.

To cover wide range of coefficient of friction values, three classes of road with various ages, surface aggregates, surface texture depths and traffic valume were chosen. The main objectives of this paper are to study the improvement of road surfaces skidding resistance by chip seal coats in Thailand and try to estimate the service life.

2. THE STANDARD OF CHIP SEAL COATS IN THAILAND (12).

2.1 Standard of the materials

2.1.1 Asphalts : Type of asphalts and their spraying temperatures are shown in Table I.

2.1.2 Aggregates : Aggregates shall be clean, tough, durable, free from dirt or other objectionable matter and shall have the following requirements :

- Percentage of Wear not more than 35 %
- Stripping by the Plate Test not more than 20 %
- Flakiness Index of coarse aggregate not more than 35 %
- When crushed gravel is used, the percentage of the broken face chippings shall not less than 75 % by weight.

2.1.3 Size of aggregate : The chipping used should be nominally single-sized and preferably should be approximately cubical in shape. The nominal sizes of aggregate are shown in Table II.

2.2 Approximate amount of asphalt and aggregate

The approximate amount of aggregate and asphalt for each nominal size can be seen in Table III.

2.3 Nominal size of aggregate recommended in Australia(5)

Table IV shows nominal size of aggregate and the maximum flakiness index recommended in Australia in comparison to those used in Thailand.

Other details of chip seal coats used in Thailand such as asphalt additive and pre-coating agent, aggregate stockpiling, equipment and construction methods are not discussed in this paper.

3. SCOPE OF THE TESTS

For this study, skidding resistance(SR)measurements were made on :

3.1 Four primary (Route No. 1,2,4 and 24), one secondary (Route No. 321) and two provincial roads (Route No. 3037, 4025) from various regions,

3.2 various surface aggregates : limestone, basalt, crushed gravel and granite,

3.3 some types of original surfaces : asphaltic concrete and penetration macadamwhich tend to be slippery when wet, 3.4 various sizes of surface aggregate : $\frac{3}{4}$", $\frac{1}{2}$" and $\frac{3}{8}$",

3.5 wet and dry conditions (the dry condition results were not critical and were not included, the water film thickness on wet test was 0.508 mm.)

3.6 various ages of chip seal coats ranging from 2 days to 3 years,

3.7 different surface texture depths ranging from 0.762 to 2.032 mm.

The Mu-meter (side-force test trailer, 3, 4, 7) and the British Portable Tester of the TRRL (BPT, 9, 10) are used in measuring the skidding resistance values. Test speed of the Mu-Meter was 60 Kph.

The surface texture depths were measured by the Sand Patch Method (3, 9)

The percentage of non-carbonate in limestone aggregates (2) from Lopburi, Ratchaburi, Nakhon Sawan and Saraburi, the Los Angeles Abrasion Test, the Flakiness In dex and the Specific Gravity were also tested.

The ADT and percentage of buses and trucks used in calculating the vehicle passes obtained from the Statistics Section, Planning Division, Dept. of Highways(13).

4. SUMMARY OF RESULTS

The summaries of the mean SR values at 20°C from the BPT and the Mu-Meter, types and sizes of surface aggregates, Surface texture depths (STD), aggregate properties, number of vehicle passes and the percentage of buses and trucks, number of accidents, life of chip seal coats before the test and types of original surfaces are shown in Table V.

The laboratory test results of percentage of non-carbonate in limestone aggregates taken from 5 sources are summarized in Table VI.

5. DISCUSSION AND CONCLUSIONS

5.1 The mean SR value at 20°C of the 2 day $\frac{3}{8}$" limestone chip seal coat was 67.2 BPN (40 Mu-Meter Number, MN) with mean STD of 2.032 mm. This can improve SR value from 43 BPN (23 MN) on the asphaltic concrete surface having STD of 0.340 mm.

5.2 The mean SR value at 20°C of the 2 day $\frac{3}{8}$" granite was as high as 72.0 BPN and of the 2 month $\frac{3}{8}$" basalt was 69.3. These values were higher than that of the 2 day $\frac{3}{8}$" limestone chip seal coat. For 2 year $\frac{3}{8}$" crushed gravel, the BPN was 53.4 which is still above the minimum requirement (10). However, the tests should be carried on when the vehicle passes increase.

5.3 At 0.42 million vehicle passes (MVP) and under the same conditions, the SR value measured on $\frac{3}{4}$" limestone was higher than on $\frac{3}{8}$" by 1.8 BPN. The BPN differed only 0.1 at 1.10 MVP, this can be explained by considering the STD which was different by 0.116 mm. at the 0.42 MVP and only 0.011 mm. at the 1.10 MVP. So in this study, the difference in SR values of $\frac{3}{4}$" and $\frac{3}{8}$" limestone is not significant. The BPN measured at 0.29 MVP on $\frac{1}{2}$" limestone with the age of 6 months, STD 1.300 was 57.0.

5.4 The relationship between the "Mean SR Value at 20°C" and the "Vehicle Passes" are shown in Fig. 2. The Mean SR Value decreases as the Vehicle Passes increases. It can be seen that there is a rapid fall in the SR value in the first million vehicle passes followed by a gradual falling. From the curve, with safety as an essential objective, the service life of ⅜" limestone chip seal coat can be estimated. The number of vehicle passes is approximately 2 millions when the BPN decreases to 45 (mininum requirement suggested by the TRRL). This depends mainly on the construction control, the percentage of heavy vehicles and the resisting to polishing of the limestones. The service life of ⅜" limestone chip seal coat may be approximately 3 years for ADT of about 2,000 and may last only 1 year on heavy traffic highway having ADT of about 5,500.

5.5 The relationship between the "Texture Depth on Chip Seal Surface Using ⅜" Limestone" and the "Mean SR Value" is shown in Fig. 3. It can be seen that the Mean SR valur increases as the STD increases. The minimum SR requirement suggested by the TRRL: 45 BPN, needs minimum texture depth on ship seal surface of about 0.8 mm. This may be a guide in maintaining and providing adequate SR on this type of road surfaces.

The investigations have shown that the results in decreasing in STD are the bleeding of asphalt and the polishing of aggregate due to traffic.

5.6 The percentage of non-carbonate in limestone aggregates taken from five sources in the central part of Thailand (Table VI) varied from 3 to 14 percent. These values are considerably low compared to the minimum requirement of 20 percent(2).

5.7 The correlation tests between the two measuring instruments were carried out. The tests were made at 14 different locations. The locations were selected so that a range of SR values would be covered. The Mu-Meter values ranged from 17 to 77 and the BPN from 38.4 to 103. After measurements with the BPT, the Mu-Meter was run over the same section and wheel track. The test speed of the Mu-Meter was 60 kph. The water film thickness for both tests was 0.508 mm. (measured from Nasa Water Film Depth Gage, ML-365). The results of the test are summarized and the regression line shown in Fig. 4.

The relation-ship obtained in this study gives the regression line as y = 1.09 x + 17.45 with a coefficient, r = 0.987.

5.8 Data on the number of accidents on Route No. 2 is available. There is a significant decrease in number of accident from 10 within 3 month period to 7 within 7 month period after the treatment. The number of accidents involving skidding especially on wet conditions is being studied.

5.9 The tests on surface aggregate properties are shown in Table V and VI. The Polished-Stone Value test should be introduced to check the rate of resisting to polishing of various aggregates.

6. RECOMMENDATIONS

The recommendations and future studies of this paper are :

6.1 Guidelines for Minimum Skidding Resistance Values on Chip Seal Coat Surfaces, Wet Condition are illustrated in Table VII.

However, these values may be revised by considering number of accidents involving skidding at each site and ADT.

6.2 Considerations in seal-coat construction:

6.2.1 Chip seals should be investigated and rated every 6 months after opening to traffic.

6.2.2 Old roads or weak roads with a history of high maintenance requirements should never be sealed. On this type of road patching will soon cover the seal coat.

6.2.3 Before sealing any road, be sure that it can correct the deficiencies in the pavement.

6.2.4 Follow specification strickly.

6.2.5 Keep distributor functioning properly and maintain uniform application rates.

6.2.6 Before the design, old surface and geometric conditions should be recorded.

6.2.7 Use full-time inspectors with training and experience in chip sealing operations.

6.3 Life of chip seal coats should be considered when using limestone aggregates which have low resisting to polishing. Using harder aggregates or blending such limestones with harder aggregates are recommended expecially on high traffic road.

6.4 The improving skidding resistance of road surfaces by other methods should be studied for comparison. For overlaying 3 cm. limestone asphaltic concrete surface, the life is approximately twice(14) of the $\frac{3}{8}$" limestone chip seal but the construction cost is approximately 25.7 Baht per square metre. Consideration should also be given to the factor of the strengthening of road pavement.

6.5 The comparison and evaluation of chip seal coats using various types of asphalts should be studied. However, The South Dakota Chip Seal Coat Study(1)concluded that construction control, weather, equipment and the experience of construction personel are variables which apperently have more profound effects on a seal coat than the type of asphalt used.

6.6 To further the knowledge in this field, the equivalent value in passenger car units (P.C.U's) of heavy buses and trucks should be studied in terms of destroying skidding resistance values. The New York State Research in skidding resistance measurement of bituminous surfaces(1)used 1 truck equivalent to 11 cars. This equivalent value may not be the same in Thailand. This study may be of use to road engineers in estimating the service life of chip seal coats in terms of P.C.U's.

7. ACKNOWLEDGEMENTS

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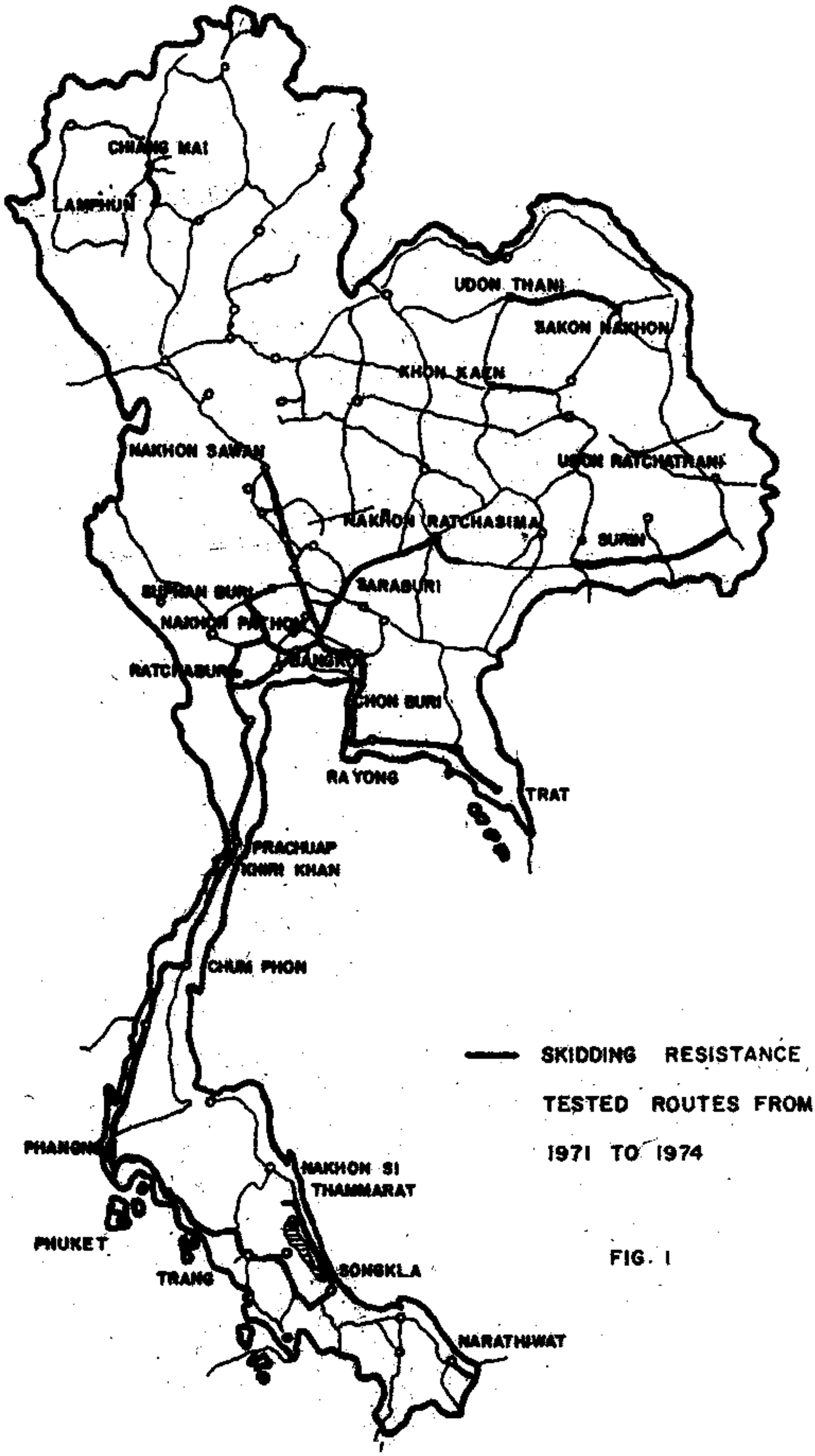
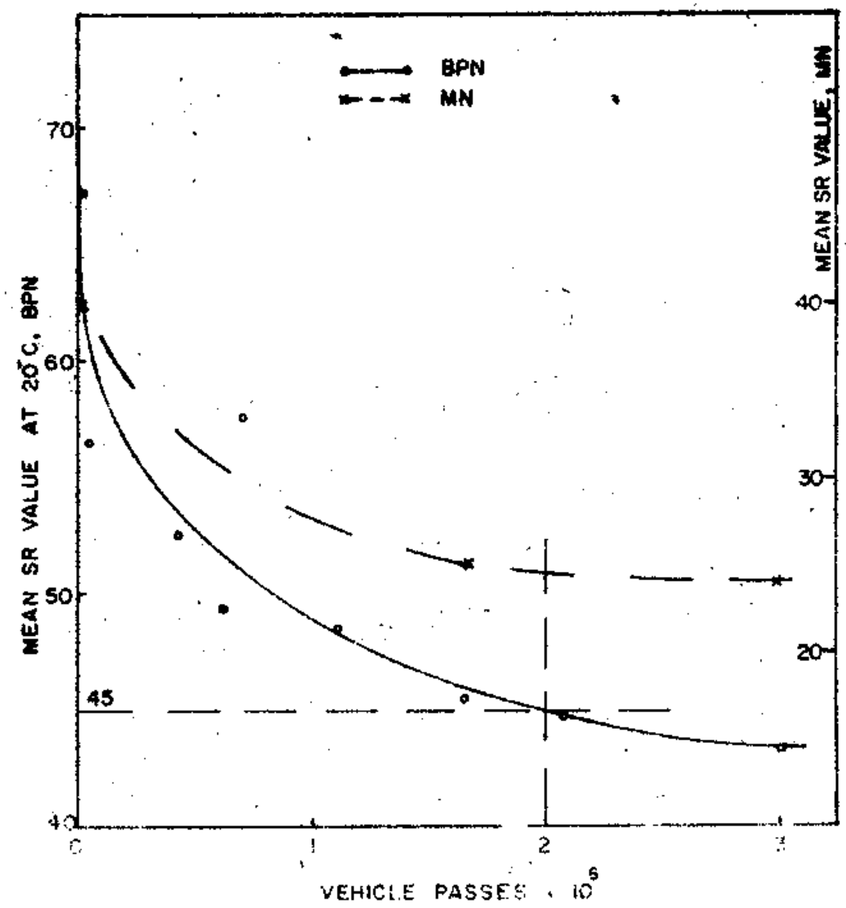
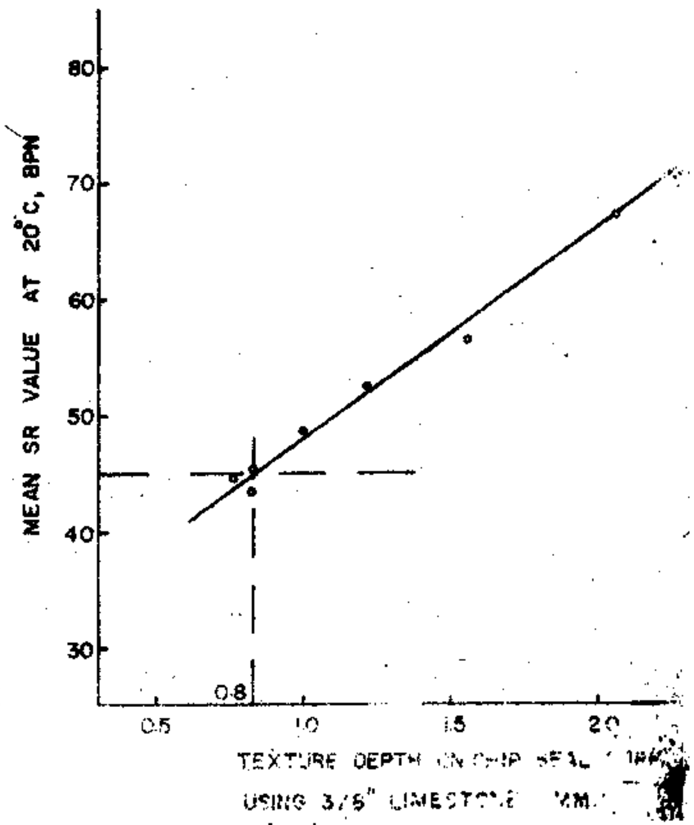

SKIDDING RESISTANCE
TESTED ROUTES FROM
1971 TO 1974
CHIANG MAI
LAMPHUN
UDON THANI
SAKON NAKHON
KHON KAEN
NAKHON SAWAN
NAKHON RATCHASIMA
SURIN
SARABURI
SUPHAN BURI
NAKHON PATHOM
BANGKOK
RATCHABURI
CHON BURI
RA YONG
TRAT
PRACHUAP
KHIRI KHAN
CHUM PHON
PHANGNGA
NAKHON SI
THAMMARAT
PHUKET
TRANG
SONGKLA
NARATHIWAT

FIG. 1

SR VALUE ON 3/8" LIMESTONE AND VEHICLE PASSES



MEAN SR VALUE AND TEXTURE DEPTH



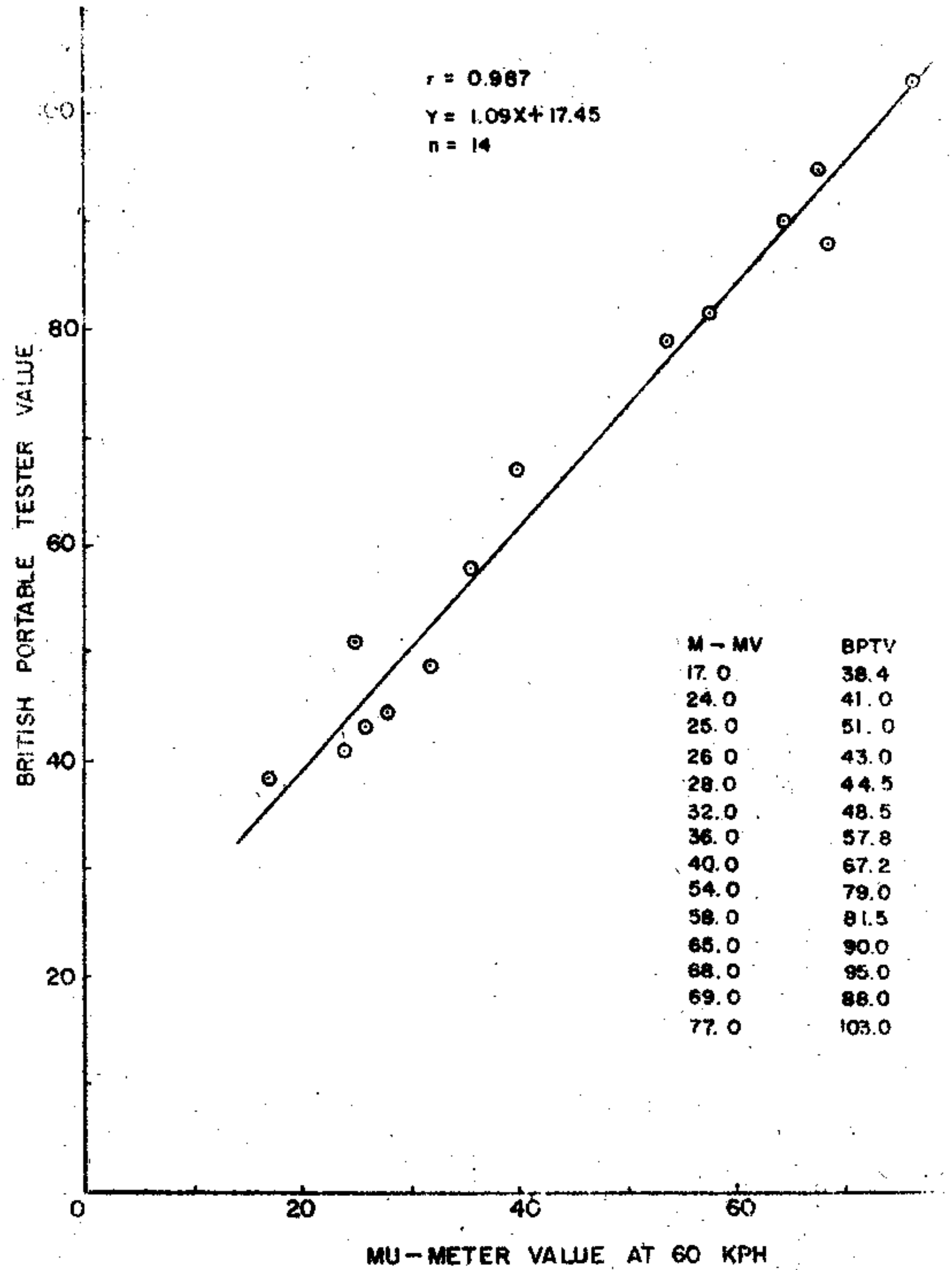


FIG. 4 CORRELATION RESULTS

[illegible]

[illegible]RAYING TEMPERAT[illegible]

Type of asphalt	Spraying temperature
	°C
RC – 3000	120 – 160
RC – 800	100 – 120
RC – 250	80 – 110
RC – 5	130 – 150
RC – 4	115 – 130
RC – 3	105 – 115
RC – 2	80 – 105
RS – 3K	60 – 80
RS – 2K	45 – 70
AC (120 – 150 pen.)	140 – 175
AC (80 – 100 pen.)	140 – 175

[illegible]

[illegible]ECOMMENDED IN [illegible]

Nominal size	% Passing by weight									Flakiness index max.
	1"	3/4"	5/8"	1/2"	3/8"	1/4"	NO. 4	NO. 8	NO. 16	
3/4"	100	95-100	-	0-20	0-5	-	-	-	0-0.5	35
5/8"		100	95-100	-	0-15	0-5	-	-	0-0.5	35
1/2"		100	-	95-100	0-30	0-5	-	-	0-0.5	35
3/8"				100	95-100	0-40	0-5	-	0-0.5	35
NO. 4						100	95-100	0-40	0-0.5	35

TABLE II NOMINAL SIZE AND

% PASSING BY WEIGHT

Nominal size	% Passing by weight						
	1"	3/4"	1/2"	3/8"	NO. 4	NO. 8	NO. 16
3/4"	100	90-100	0-30	0-8	-	0-2	0-0.5
1/2"		100	90-100	0-40	0-8	0-2	0-0.5

TABLE III APPROXIMATE AMOUNT OF

AGGREGATE AND ASPHALT

Nominal size	Approx. amount	
	Aggregate kg / m²	Asphalt l / m²
3/4"	18 – 30	1.2 – 2.5
1/2"	12 – 18	0.8 – 1.8

Route No. , km.	Type of old surf.	Age of CS – yrs.	Mean SR, BPN – wet at 20°C before trt.	after trt.	Type and Size of agg.	STD mm.	Agg. prop.	Veh. passes $\times 10^6$ (% B&T)	No. of acc.
1, 216 - 230	AC - LS	3	—	44.6	LS 3/8"	0.762	—	2.08 (77)	
2, 150 - 165	"	2 / 365	43.0 (MN 23)	67.2 (MN 40)	"	2.032	LAA 26.3 FL.IN. 32.0 SP.GR. 2.7	0.01 (53)	BEFORE 14 (10 MONTHS)
2, 165 - 170	"	1 1/2	" STD = 0.340 mm.	43.3 (MN 24)	"	0.822	—	3.01 (53)	BEFORE 10
2, 170 - 198	"	1	"	45.5 (MN 25)	"	0.829	—	1.66 (74)	(3 MONTHS) AFTER 7
4-28, 16 - 49	"	2	—	49.2	"	—	—	0.62 (80)	(7 MONTHS)
4-28, 58 - 69	"	2	—	53.4	G 3/8"	—	—	0.62 (80)	
24-02, 9 - 14	"	2/12	—	56.6	LS 3/8"	1.524	LAA 28.0	0.07 (79)	
24-01, 15 - 16	"	1/2	—	57.0	LS 1/2"	1.300	—	0.29 (75)	
"	"	3	—	38.7	"	—	—	2.19 (73)	
24, 6 - 19	"	2/12	—	69.3	BA 3/8"	1.778	LAA 22.0	0.07 (79)	
"	"	1/2	—	60.3	"	1.067	"	0.21 (79)	
321, 90 - 98	PM - LS	7/12	—	54.2	LS 3/4"	1.330	LAA 32.0	0.42 (63)	NA
"	"	1 1/2	—	48.7	"	1.012	"	1.10 (51)	
321, 112 - 116	"	7/12	—	52.4	LS 3/8"	1.214	"	0.42 (63)	
"	"	1 1/2	—	48.6	"	1.001	"	1.10 (51)	
3037, 6 - 9	"	2 1/2	—	57.6	"	—	"	0.69 (37)	
4025, 8 - 9	PM – GR	2 / 365	—	72.0	GR 3/8"	—	LAA 34.4	0.001 (47)	

TABLE VI

Source and size		Mean percentage of non-carbonate
Ratchaburi	1"	7.3
Ratchaburi	$\frac{1}{2}$"	14.0
Nakhon Sawan	$\frac{1}{2}$"	3.3
Lopburi	$\frac{3}{8}$"	7.5
Saraburi	$\frac{3}{8}$"	3.7

TABLE VII

Site	Min. SR
Difficult sites such as bends, roundabouts, gradients, approaches to traffic lights and high accident locations	50 BPN 30 MMN (60 kph)
Easy sites.....	45 BPN 25 MMN (60 kph)

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