COMPARATIVE LABORATORY PERFORMANCE OF HOT ROLLED SHEET (HRS) AND ASPHALT TREATED BASE (ATB)

T H E S I S

BY :

ALOYSIUS TJAN

S2 818411

PROGRAM SISTEM DAN TEKNIK JALAN RAYA
FAKULTAS PASCA SARJANA
INSTITUT TEKNOLOGI BANDUNG

1 9 8 6

COMPARATIVE LABORATORY PERFORMANCE OF HOT ROLLED SHEET (HRS) AND ASPHALT TREATED BASE (ATB)

T H E S I S

A thesis submitted in partial satisfaction of the requirements for completion of the S-2 programme at the Institut Teknologi Bandung

BY :

ALOYSIUS TJAN

S2 818411

PROGRAM SISTEM DAN TEKNIK JALAN RAYA
FAKULTAS PASCA SARJANA
INSTITUT TEKNOLOGI BANDUNG

1 9 8 6

FAKULTAS PASCA SARJANA - INSTITUT TEKNOLOGI BANDUNG
PROGRAM SISTEM DAN TEKNIK JALAN RAYA

COMPARATIVE LABORATORY PERFORMANCE OF HOT ROLLED SHEET (HRS) AND ASPHALT TREATED BASE (ATB)

THESIS SUBMITTED IN PARTIAL SATISFACTION OF THE REQUIREMENTS FOR THE M.Sc. DEGREE IN SISTEM DAN TEKNIK JALAN RAYA

BY :

ALOYSIUS TJAN

S2 818411

AUGUST 1986

In collaboration with
Direktorat Jenderal Bina Marga - Departemen Pekerjaan Umum
and University College London - United Kingdom

COMPARATIVE LABORATORY PERFORMANCE OF HOT ROLLED SHEET (HRS) AND ASPHALT TREATED BASE (ATB)

BY :

ALOYSIUS TJAN

S2 818411

Approved by :

pp DR. A.N.S. BEATY
Supervisor

Ir. PAMUDJI WIDODO MSc.
Co Supervisor

Ir. DJUANDA SURAATMADJA
Head of the Program Sistem dan Teknik Jalan Raya
Fakultas Pasca Sarjana
Institut Teknologi Bandung

ACKNOWLEDGEMENTS

The author is deeply indebted to his supervisors, DR. A.N.S. Beaty and DR. J. Mc Elvaney, and co supervisor, Ir. Pamudji Widodo MSC., for their patient advice, guidance, suggestions and encouragement throughout the research and during the preparation of this thesis; gratefully acknowledgements are addressed to them.

Thanks are extended to Mr. Djuanda Suraatmadja, head of the Program Sistem dan Teknik Jalan Raya, Fakultas Pasca Sarjana ITB, for making available all facilities during the author's study at that programme.

Thanks are also extended to Mr. H.A.B. Hasibuan, head of Indonesian Road Research Institution (Puslitbang Jalan), for allowing the author to do some tests there.

Any results, conclusions and recommendations expressed in this thesis are those of the author and do not necessarily reflect the views of Puslitbang Jalan or ITB.

CONTENTS

		page
	ACKNOWLEDGEMENTS	i
	CONTENTS	ii
	LIST OF TABLES	iv
	LIST OF FIGURES	v
	SYNOPSIS	viii
	RINGKASAN	x
I	INTRODUCTION	1
II	OBJECTIVES OF INVESTIGATION	3
III	LITERATURE REVIEW	4
IV	LABORATORY AND FIELD WORK PROGRAMME AND PROCEDURES	20
	IV.1 Aggregates	20
	IV.2 Bitumen	20
	IV.3 Mix design	21
	IV.4 Marshall and indirect tensile tests at optimum binder content	21
	IV.5 Wheel tracking, skid resistance and sand patch tests on slabs prepared at optimum binder content	22
	IV.6 Skid resistance and sand patch measurements in the field	23
V	DATA PRESENTATION	28
	V.1 Aggregates	28
	V.2 Bitumen	28
	V.3 Mix design	28
	V.4 Marshall test	28
	V.5 Further Marshall tests at optimum bitumen content	28
	V.6 Indirect tensile test	28

page

V.7 Wheel tracking test 28

V.8 Skid resistance test 29

V.9 Sand patch test 29

VI OBSERVATIONS ON TEST DATA 52

VI.1 Aggregates 52

VI.2 Bitumen 52

VI.3 Marshall test 53

VI.4 Wheel tracking test 53

VI.5 Indirect tensile test result 54

VI.6 Skid resistance and sand patch tests result 54

VII CONCLUSIONS AND RECOMMENDATIONS 56

VII.1 CONCLUSIONS 56

VII.2 RECOMMENDATIONS 57

REFERENCES 58

APPENDICES 60

A. Complete Marshall test results for ATB mix 61

B. Complete Marshall test results for HRS mix 62

C. Complete Marshall test results of ATB mix at optimum binder content (5.5%) 63

D. Complete Marshall test results of HRS mix at optimum binder content (8.2%) 63

E. Complete indirect tensile test results of ATB mix at optimum binder content 63

F. Complete indirect tensile test results of HRS mix at optimum binder content 64

LIST OF TABLES

		page
Table III.1	The influence of aggregate type on mix characteristics	14
Table V.1	Relative density and absorption of aggregate used in mix (BS-812-1975)	30
Table V.2	Aggregate test results.	31
Table V.3	Bitumen test results.	31
Table V.4	Percentage of each fraction in total mix.	32
Table V.5	Marshall test results for ATB mix.	33
Table V.6	Marshall test results for HRS mix.	33
Table V.7	Marshall test results at optimum binder content.	34
Table V.8	Indirect tensile test results at 60°C at optimum binder content.	34
Table V.9	Wheel tracking test results.	35
Table V.10	Sand patch test results.	35
Table V.11	Portable skid-resistance test results.	35

LIST OF FIGURES

		page
Fig. III.1	The typical flexible pavement layers.	15
Fig. III.2	The relation between tensile strain and fatigue life for asphalt concrete (After Marais, 1974).	15
Fig. III.3	The relation between tensile strain and fatigue life for gap graded bituminuous mix (After Marais, 1974).	16
Fig. III.4	Grading specification for ATB (55% coarse)	16
Fig. III.5	Grading specification for HRS (30% coarse)	17
Fig. III.6	Relation between shear stress and layer modulus (After Brown & Pell, 1976).	17
Fig. III.7	Relation between Marshall quotient and stone content and different sand (After Knight, 1979).	18
Fig. III.8	The effects of various methods of compaction on the mix stiffness (After Hills, 1973).	18
Fig. III.9	A typical rate of tracking for gap graded mix and asphalt concrete (After Marais, 1974).	19
Fig. IV.1	The flow diagram of laboratory and field work programme.	24
Fig. IV.2	The Marshall testing apparatus.	25
Fig. IV.3	The steel compactor for making wheel tracking test specimen.	25
Fig. IV.4	The skid resistance apparatus.	26
Fig. IV.5	The wheel tracking machine.	27
Fig. IV.6	The wheel tracking controller and recorder.	27
Fig. V.1	Gradation for both types of mix and their specification.	36
Fig. V.2	Relation between bulk specific gravity and bitumen content for HRS mix.	37
Fig. V.3	Relation between bulk specific gravity and bitumen content for ATB mix.	37

		page
Fig. V.4	Relation between air voids and bitumen content for HRS mix.	38
Fig. V.5	Relation between air voids and bitumen content for ATB mix.	38
Fig. V.6	Relation between voids in mineral aggregates and bitumen content for HRS mix.	39
Fig. V.7	Relation between voids in mineral aggregates and bitumen content for ATB mix.	39
Fig. V.8	Relation between flow and bitumen content for HRS mix.	40
Fig. V.9	Relation between flow and bitumen content for ATB mix.	40
Fig. V.10	Relation between Marshall stability and bitumen content for HRS mix.	41
Fig. V.11	Relation between Marshall stability and bitumen content for ATB mix.	41
Fig. V.12	Relation between Marshall quotient and bitumen content for HRS mix.	42
Fig. V.13	Relation between Marshall quotient and bitumen content for ATB mix.	42
Fig. V.14	Relation between rut depth of HRS mix and time at different test temperatures.	43
Fig. V.15	Relation between rut depth of ATB mix and time at different test temperatures.	44
Fig. V.16	Relation between rut depth and time of HRS and ATB mixes, at 26°C.	45
Fig. V.17	Relation between rut depth and time of HRS and ATB mixes, at 40°C.	45
Fig. V.18	Relation between rut depth and time of HRS and ATB mixes, at 60°C.	46
Fig. V.19	Relation between percentage ratio of rut depth to rutting at 45 min and time for HRS mix at different test temperatures.	47
Fig. V.20	Relation between percentage ratio of rut depth to rutting at 45 min and time for ATB mix at different test temperatures.	47

page

Fig. V.21 Relation between percentage ratio of rut depth to rutting at 45 min and time for HRS and ATB mixes, at 26°C. 48

Fig. V.22 Relation between percentage ratio of rut depth to rutting at 45 min and time for HRS and ATB mixes, at 40°C. 48

Fig. V.23 Relation between percentage ratio of rut depth to rutting at 45 min and time for HRS and ATB mixes, at 60°C. 49

Fig. V.24 Plate showing ATB specimens after testing in wheel tracking machine at various temperatures. 50

Fig. V.25 Plate showing HRS specimens after testing in wheel tracking machine at various temperatures. 50

Fig. V.26 Plate showing typical surface of ATB in Jalan Raya Cianjur-Ciawi. 51

Fig. V.27 Plate showing typical surface of HRS in Jalan Raya Cianjur-Ciawi. 51

SYNOPSIS

In the current round of highway pavement betterment project in Indonesia, especially in West Jawa, Asphalt Treated Base (ATB) with 55% of coarse aggregate is used as a regulating course and is overlaid with a Hot Rolled Sheet mix containing 30% of coarse aggregate. ATB, a gap graded mixture is very close in composition to the BS 594-1985 specification for 50% coarse aggregate and the HRS is very close to BS 594-1985 specification for type F wearing course no. 9 (30/14).

Information from the betterment projects indicates that the bitumen content of the HRS used is about 15% higher than that of the ATB mix. The purpose of the investigation described in this thesis was to compare these mixes on the basis of laboratory performance tests. Tests used were Marshall test, indirect tension test, wheel tracking test and skid resistance test.

For the particular conditions under which this investigation was carried out, it may be concluded that on the basis of strength parameters the performance of ATB is comparable with that of HRS. In terms of resistance to rutting at elevated temperature (60°C), ATB has a clear superiority over HRS. ATB has an optimum binder content of 5.5% while that of HRS is 8.2%. The lower optimum binder content of the ATB combined with a high voids content (>8%) may present durability problems if this material is used as a wearing course. Laboratory measurements of skid resistance indicate equal performance in terms of BPN and within the specified value for critical sites while the texture depth of the ATB is approximately twice that of the HRS. Field

measurements of skid resistance show both mixes to have values of BPN less than the minimum specified value. 'Stiffness' of both mixes, as measured in the laboratory, is in excess of the maximum value recommended for wearing course mixes in Indonesian conditions. A study should be made of current methods of aggregate production in order to establish if gradations obtained comply with specification.

RINGKASAN

Dewasa ini pada proyek peningkatan jalan di Indonesia, terutama di Jawa Barat, digunakan Asphalt Treated Base (ATB) dengan 55% aggregat kasar sebagai lapisan perata dan diatasnya diberi lagi lapisan penutup Hot Rolled Sheet dengan 30% aggregat kasar. ATB adalah campuran gap graded yang sangat mirip dengan spesifikasi BS 594-1985 untuk 50% aggregat kasar dan HRS juga sangat mirip dengan spesifikasi BS 594-1985 untuk tipe F lapisan aus no. 9(30/14).

Menurut informasi dari proyek peningkatan jalan, kadar aspal untuk HRS kira-kira 15% lebih tinggi dari ATB. Maksud dari penyelidikan dari thesis ini adalah untuk membandingkan performance dari kedua macam campuran ini berdasarkan hasil test laboratorium, seperti test Marshall, test indirect tension dan test skid resistance.

Berdasarkan keadaan di laboratorium maka dapat diambil kesimpulan bahwa parameter kekuatan dari ATB kira-kira sama dengan kekuatan HRS. Untuk ketahanan terhadap rutting pada temperatur 60°C, ATB menunjukkan kelebihannya dari pada HRS. ATB mempunyai kadar aspal optimum 5,5% sedangkan HRS 8,2%. Kadar aspal yang lebih rendah pada ATB dan dikombinasikan dengan air voids yang tinggi (>8%) akan dapat menimbulkan masalah durabiliti (tahan lama) bila dipakai sebagai lapisan aus. Pengukuran skid resistance di laboratorium memberikan hasil yang sama pada kedua campuran tersebut sedangkan texture depth ATB kira-kira 2 kali lebih besar. Hasil pengukuran di lapangan untuk kedua jenis campuran tersebut dibawah nilai minimum yang disyaratkan. 'Kekakuan' dari kedua campuran tersebut di laboratorium melampaui

nilai maximum yang disyaratkan sebagai lapisan aus untuk kondisi Indonesia. Penelitian harus dilakukan mengenai cara produksi aggregat yang berlaku sekarang sehingga hasilnya dapat sesuai dengan spesifikasi.

I INTRODUCTION

Highway pavements in Indonesia which were built before the Second World War are typically comprised of Telford type base, (a single layer of elongated stones 100 - 300 mm in diameter) overlain with a macadam which is built up in layers of progressively finer hand-split rock chips. The macadam layers are grouted with hand-sprinkled hot bitumen and the final surface is blinded with sand. The result is an all-weather pavement, but under growing traffic loadings the pavement deforms differentially as the non-uniform, hand placed materials are compacted and the Telford boulders are gradually forced deeper and deeper into the subgrade (Corne, 1983).

The condition of this kind of pavement, which is pervious, becomes worse if the drainage system is inappropriate. Water entering the pavement leads to bitumen stripping and rapid deterioration of the pavement surface as high pore pressure and suction are generated by passing wheel loads. These mechanisms of pavement failure lead primarily to surface irregularities, cracking and extensive pot-holing.

Since complete reconstruction of the old pavement on an extensive scale can rarely be justified economically at the present time, the obvious and urgent pavement maintenance priority is the application of overlay surfacings which are more impervious and more durable than the existing penetration macadam. Although surface dressings used extensivelly in neighbouring Australasia fulfill the sealing function satisfactorily, it is not considered to be a realistic proposition in Indonesia because surface dressing with thin chip

seals can not arrest the problem of continual pavement distortion nor contribute very significantly to regulating the existing distortions (Corne, 1983).

In 1979 The Directorate of Highways (Bina Marga) adopted a new policy under which all pavement betterment projects wherever possible were to carried out using overlays of asphalt treated base (ATB) and asphaltic concrete (AC) surfacing. This was subsequently changed to ATB plus Hot Rolled Sheet (HRS) instead of AC.

Once necessary crushing and mixing plant is in place, machine-laid dense mats of plant-mix asphalt can be laid rapidly and are able to provide the necessary stabilising and regulating function as well as giving a highly durable and smooth riding surface. The initial cost, moreover, is only of the same order as that required for the penetration macadam overlays while the long term construction cost of successive resurfacings is very much lower as a result of longer overlay life (Corne, 1983).

It is of interest to understand the basic characteristics of the current two-layer overlay, HRS over ATB. Both layers have a high bitumen content and in money terms both layers are costly. It would be interesting to see if a single layer of ATB offered any technical advantage over the current two-layer overlay.