

time. Ongoing monitoring of the trial sections to failure is required to substantiate any relationship between performance and product properties.

REFERENCES

AUSTROADS, Pavement Research Group (1992), Proceedings of the Surfacing Workshop, *APRG Report No. 7 Part 1*.

_____ (1992), Guidelines for the Selection & Use of Polymer Modified Binders, Specification for Polymer Modified Binders & Methods of Sampling & Testing, *APRG Report No. 7, Part 4*.

HARDIMAN, K.F. (1992), Crack Seal Trials, North West Coastal Highway 184-205 SLK. *Main Roads Western Australia Materials Engineering Report 91/74M*.

_____ (1992), Polymer Modified Binder Strain Alleviating Membrane Trials, North West Coastal Highway 184-205 SLK. *Main Roads Western Australia Materials Engineering Report 92/17M*.

NATIONAL ASSOCIATION OF AUSTRALIAN STATE ROAD AUTHORITIES (1987), *A Guide to the Visual Assessment of Pavement Condition*.

RUST, F.C. SERVAS, V.P. and FREEME, C.R. (1987), Measuring Load-Associated Crack Movement in Roads to Aid Rehabilitation Design. *Proceeding of the Annual Transportation Convention, Pretoria S.A. Vol 3A Paper 3A/VI, 26pp. NITRR, RR 492*.

PAVEMENT RECYCLING USING FOAMED BITUMEN

S. Maccarrone, B.Sc., Dip.Proc.Eng., M.Eng.Sc., MRACI, AAPT
R&D Laboratory Manager, Emoleum (Australia) Ltd

G. Holleran, M.App.Sci., MRACI CC, AAPT
Group Technical Manager, Mobil Bituminous Products

D.J. Leonard, B.Eng., MIE, AAPT
Manager Emoleum (Australia) Ltd

S. Hey, Dip. Blg., MIHT(UK)
Stabilisation Manager, Emoleum (Australia) Ltd

SUMMARY

In Australia, as in many other parts of the world, the need for recycling of scarce resources has been recognised as an important activity. The ever increasing traffic volume means that pavement strengthening is required for many roads. With typical Australian pavement make up, in situ stabilisation of granular bases eliminates costly replacement of existing materials.

In this paper the design and application of the foamed bitumen process is described and examples of completed construction jobs are reported. Foam characterisation, mix design, curing and mechanical characterisation of foamed bitumen mixes is discussed, together with pavement design methodology.

Foamed bitumen stabilisation, FOAMSTAB™, offers a cost effective, rapid form of road rehabilitation in which all of the existing failed or fatigued pavement materials is re-used to obtain a new flexible pavement base. For the various jobs carried out to date the FOAMSTAB™ process has provided significant savings in costs and materials and improved life by improving the strength and durability of the existing pavement materials with minimal disruption to the travelling public.



Sam Maccarrone graduated from University of Melbourne, Monash University and Royal Melbourne Institute of Technology with degrees in science and engineering. Sam has been with Emoleum for the last five years and is manager of the national R & D laboratory at Spotswood, Victoria. Activities undertaken in this position include Research and Development into bituminous binders and ad-mixtures for road surfacing applications.

Prior to this he worked with VicRoads as Scientific Officer at the Kew laboratories working on research projects dealing with bitumen rheology, asphalt creep and fatigue and rock durability. Prior to this, Sam spent three years with Australian Gypsum working as an analytical chemist.

Sam is a NATA assessor and is a member of various committees and associations dealing with bituminous products for road surfacing applications.

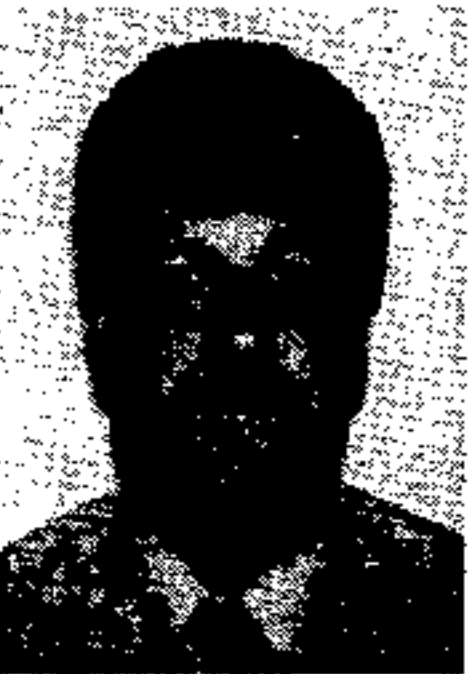


Glynn Holleran graduated from the University of Melbourne and went on to take a Masters degree. His main field of study was polymer rheology and physical properties. He worked for six years at ICI's central research laboratories. In 1983 he joined the Roberts Company as Chief Chemist dealing with R & D and quality of polymer emulsion adhesives. In 1985, he joined Emoleum where he directs the technical department that includes R & D technical service, quality assurance and TQM. In 1992 he became Group Technical Manager for Mobil Bitumen directing R & D and advising Mobil refineries as well as Emoleum. He also advises Mobil International on bitumen related projects. Glynn works on a number of technical committees. Co-author of the ARRB Directors' prize winning paper (1988) on bitumen emulsion and slurry sealing.



After graduating in Civil Engineering from Monash University in 1972, David Leonard joined the Country Roads Board of Victoria and worked in an operations division in Melbourne where he spent several years involved in the bituminous surfacing area.

In 1981 he joined Emoleum (Australia) Limited and initially worked in Head Office before appointments as Manager Tasmania followed by State Manager Victoria, and currently National Manager.



Steven Hey obtained a Diploma in Building from the Leeds College (UK) in 1975. He then moved to South Africa where he worked with civil engineering contractors involved with soil stabilisation.

In 1983 he returned to the UK and after a number of years joined a specialist soil stabilisation company MSC. Whilst with MSC he formed a company called Road Recycling Ltd with a colleague and pioneered road recycling with bitumen throughout the UK and Europe using the Mobil Foam process.

In 1993 he joined Emoleum in Australia as National Stabilisation Manager with responsibility for Foamed Bitumen Stabilisation and Coldmix processes.

INTRODUCTION

1. In Australia, as in many other parts of the world, the need for recycling of scarce resources has been recognised as an important activity for today and the future. In the pavements industry this has mostly meant recycling of hot mixed asphalt into base course and surface hot mixes. However, most roads are constructed of crushed rock bases on natural subbases. These crushed rocks are themselves becoming scarcer and have required stabilisation to make them suitable to bear the ever increasing loads. This has often meant stabilisation with cement either in initial construction or in recycling. Cement is subject to shrinkage cracking and pavement stiffness can be markedly reduced quite early in life. Thus asphalt overlays must be designed thicker to overcome this problem.

2. The alternative is to stabilise with bitumen based materials. This offers a flexible, water impermeable road base with other advantages including reduced cost and quicker construction times. This paper describes the design and application of the foamed bitumen process and examples of construction jobs are reported.

BACKGROUND

3. The first foamed bitumen processes were described by Csanyi (1957). In the late 1960's and early 1970's Mobil developed a low pressure, cold water system. Mobil has continued to develop the technology and today's system employs individual expansion chambers which allow tight control of distribution of foam. Also the extensive work carried out on bitumen composition and chemistry has allowed the development of a range of specialty additives to control foam expansion and life, thereby allowing the use of any bitumen, and close control of wetting in the mixing process.

4. Foamed bitumen stabilisation was first carried out in Australia by Mobil in the 1960's. The unique process was developed by Mobil as a means of conserving natural resources. It provides a pollution free application of bitumen to improve the physical properties of inferior pavement materials. The oil crisis of the 1970's and the rising bitumen prices made the process less attractive to Australian markets. However development of bitumen stabilisation has continued with advances in equipment and mix design. Emoleum (Australia) Ltd has recently reintroduced the Mobil-patented foamed bitumen stabilisation process to Australia, bringing in the state-of-the-art construction equipment and expertise from international affiliates.

USE OF BITUMEN IN STABILISATION

5. The two main methods of bitumen addition to base materials in Australia are:

- Emulsion mixed in place or in plant, and
- Foamed bitumen

Emulsion mixed in place or in plant is becoming popular in Europe and this system was extensively reported on in Eurobitume (1993). The draw backs of such a system relate to cure time. Emulsions introduce high levels of water and this must be dried out for the system to attain full strength. Also in some newer systems cement is mixed with emulsion to overcome such difficulties and such systems are currently adopted in Australia by various companies including Mobil (Emoleum). Associated with water content of emulsion systems is the disadvantage of

higher transportation costs, especially in remote areas.

6. Foamed bitumen is another way of delivering bitumen into a mix. Foamed bitumen cures rapidly and is easy to use. Field evidence of the faster curing of foamed bitumen compared to emulsion is reported by Bergeron (1992) via pavement deflection results. Another advantage of foamed stabilised pavements is that curing rate is not greatly influenced by weather conditions. In contrast emulsions cure very slowly under cold, wet weather conditions. This was also demonstrated by Bergeron (1992). Fast curing coupled with the use of advanced mix design and pavement design techniques from asphalt technology create a system that makes the use of bitumen stabilisation economical and effective.

FOAMED BITUMEN STABILISATION

PHYSICAL AND CHEMICAL ASPECTS OF BITUMEN FOAM

7. Foamed bitumen provides an alternative to reducing the viscosity of bitumen without the use of cutters or high levels of water (emulsions). The fineness of the foam created enables successful wetting of the aggregate surfaces. Foam composition by mass is typically 97% bitumen, 2% water and 1% additive. In the expanded state, water is mostly lost as steam and the remaining binder has the morphological structure of bitumen and air. The foam then consists of approximately 95% air by volume. As air escapes and the foam collapses it leaves a bitumen residue with properties similar to the original bitumen prior to foaming.

FOAM CHARACTERISATION

8. A laboratory pilot unit is used to assess foam expansion and half life. For each bitumen and application an optimum foam may be designed. The pilot unit consists of tanks of bitumen and water fitted with controls for flow, temperature, pressure and various switching devices. The same specially designed foaming chamber as used in the field is used in the laboratory unit.

9. Fig. 1 shows a typical relationship between bitumen additive on volume expansion and half life. Optimum expansion (about 15 times) and half life (60 s) is obtained with water content of about 2.6% and about 0.7% additive. Bitumen temperature must also be considered during foam optimisation as it also affects foam expansion and half life. Foaming is carried in the temperature range 170°C to 190°C.

DESIGN OF FOAMED BITUMEN MIXES

MIX DESIGN OUTLINE

10. Design of foamed bitumen mixes follows the same rational approach now introduced for asphalt. Design is carried out on crushed material representative of the on-site material. The basic design procedure is as follows:

- obtain a representative field sample of crushed base material;
- determine grading of crushed pavement material;
- determine optimum moisture content of foamed mix;
- prepare foamed bitumen samples;
- cure samples for three days at 60°C;
- measure resilient modulus (dry and wet) and creep using MATTA.

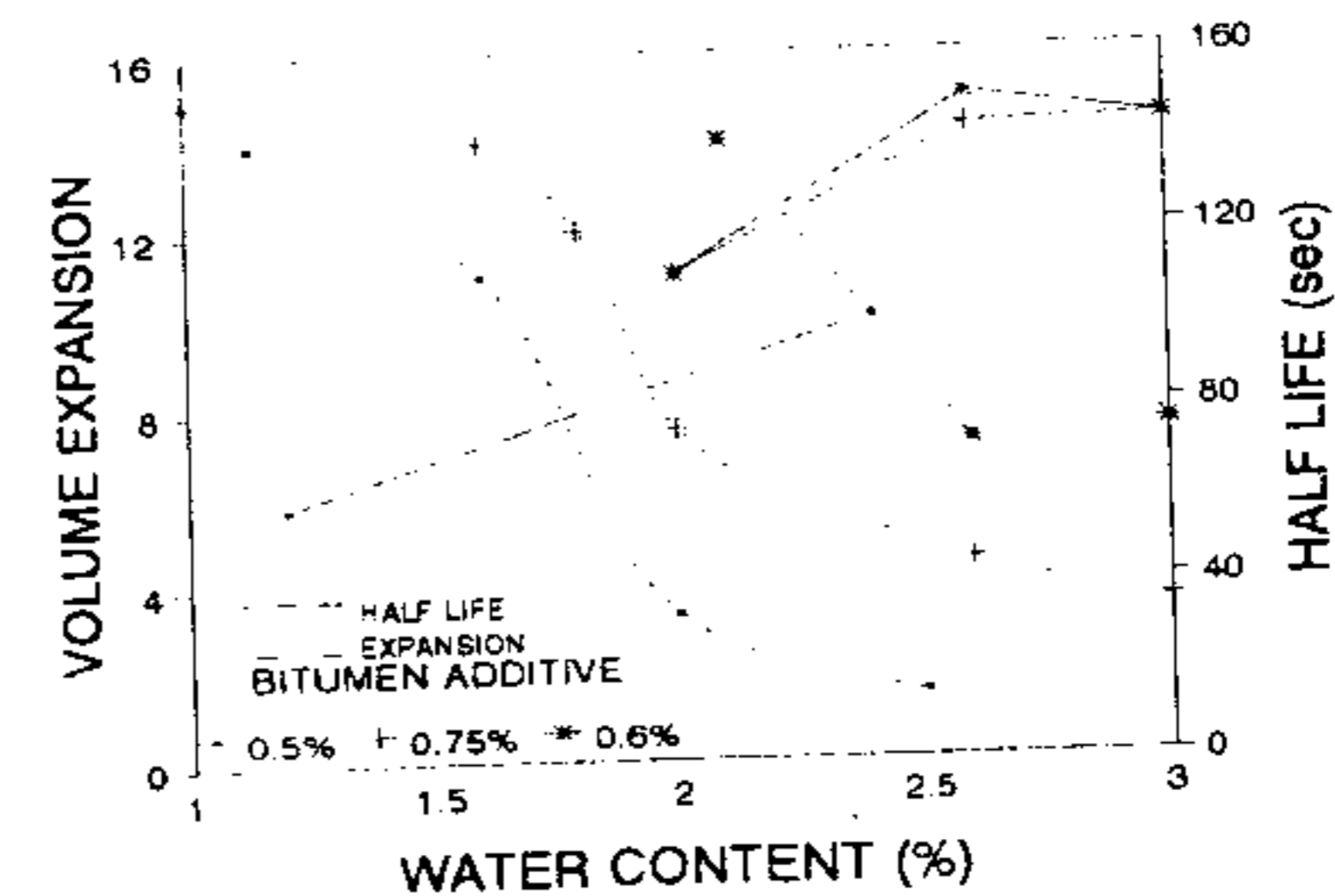


Fig. 1 Optimisation of water content and bitumen additive

SAMPLE PREPARATION

11. Sample preparation consists of bringing the mineral aggregate to optimum moisture content and then mixing intimately with freshly prepared foamed bitumen. The sample is shaped in either a 100 mm or 150 mm diameter mould. The 100 mm mould is used when the percentage retained on the 19 mm sieve is less than 10%. A minimum of three binder contents in the range 3% to 5% is used to prepare the samples. Laboratory compaction is carried out using a gyratory compactor. The compaction conditions shown in the Table I are used for mechanical characterisation as they are indicative of compaction level achieved in the field. The modified soil compaction procedure (Standards Australia, 1993a) can be used as a compaction reference.

TABLE I
COMPACTION CONDITIONS FOR MECHANICAL CHARACTERISATION

Mould diameter, mm	Gyratory compaction conditions
100	150 cycles, (2° and 240 kPa)
150	150 cycles, (3° and 540 kPa)

Curing

12. Samples are cured in a fan forced oven at 60°C for 3 days. Curing is by evaporation of water. Curing could be carried out at a lower temperature but this would prolong the curing period and make laboratory design impractical.

13. The validity of curing at 60°C to indicate mechanical properties of field cured material appears appropriate. From a UK study (Durkin, 1993) both the resilient modulus and creep properties of oven cured samples gave similar results to those obtained from cores taken about 12 months after construction. A summary of modulus results is shown in Table II.

TABLE II
COMPARISON OF LABORATORY VS FIELD SAMPLES
(RESILIENT MODULUS, MPa AT 20°C AND 120 ms rise time)

JOB	Laboratory prepared samples cured at 60°C for 3 days,	Laboratory prepared samples cured at 60°C for 3 days, and soaked in water for 24 h at 60°C	Field core recovered about 12 months after construction
A	4060		5100
B	4700	3500	3630
C	4600	3900	5000
D	4000		3930

MECHANICAL CHARACTERISATION

14. Mechanical characterisation of the mixes is carried out using a Materials Testing Apparatus (MATTA). Standards Australia (1993b and 1993c) draft procedures are used for resilient modulus and dynamic creep, respectively. Resilient modulus is determined at 25°C and rise time of 50 ms on both dry and "wet" conditioned samples. Wet conditioning consists of a 24 hour soak in a water bath at 60°C. Creep properties are determined at 50°C on dry samples at optimum binder content only.

GRADING REQUIREMENT

15. From field experience and laboratory results the ideal grading is shown in Fig. 2 as Zone A. Material meeting Zone B is suitable for low trafficked roads without any grading adjustment. For highly trafficked roads coarsening of the grading would be required. Material meeting Zone C would need fines incorporated to bring it to Zone A. To improve early wet strength of foamed bitumen mixes small additions (2%) of lime or cement works flue dust (CWFD) is used. If high levels of plastic fines are present (PI > 10), lime treatment is required before stabilising with foamed bitumen.

Fines Content for Improved Performance

16. The effect of increasing the proportion of non-plastic fines on mechanical properties was determined on size 20 mm crushed rock (Class 2) material. Materials A and B with grading as shown in Fig. 3 were evaluated. The fines content (material passing 75 µm) of material B was increased to 15% by using a higher proportion of sieved fines from the base crushed rock. Table III shows that both density and modulus values increased. Thus for improved mechanical properties a minimum of 8% fines would be recommended for this material.

MOISTURE CONTENT REQUIREMENT

17. Moisture content of the aggregate prior to foaming is critical to the foamed bitumen mixture. The effect of water is to aid foam dispersion through the pulverised material and assist with compaction. In the field moisture content is adjusted to bring it close to a laboratory determined optimum moisture content.

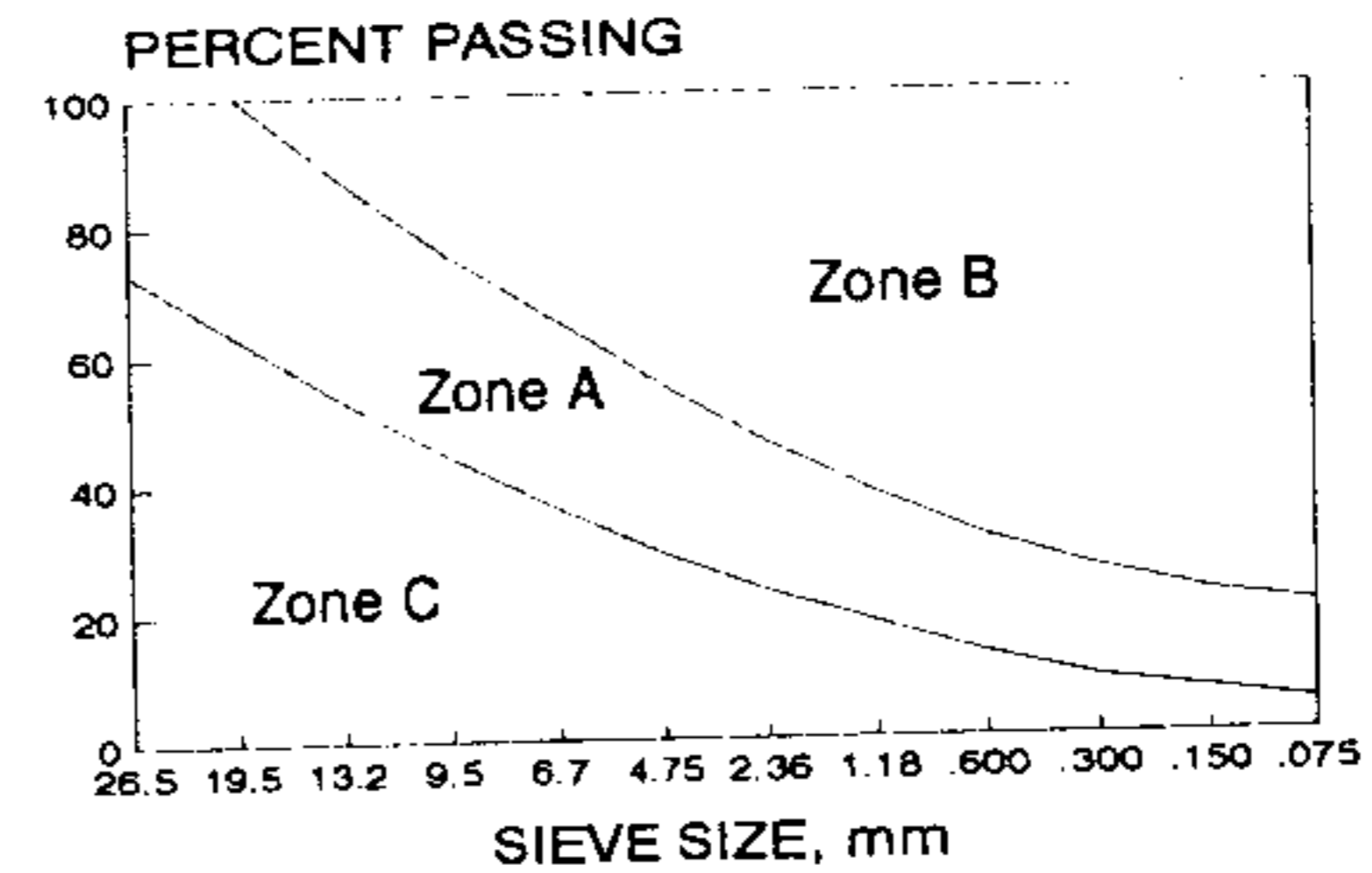


Fig. 2 Material Grading Zones

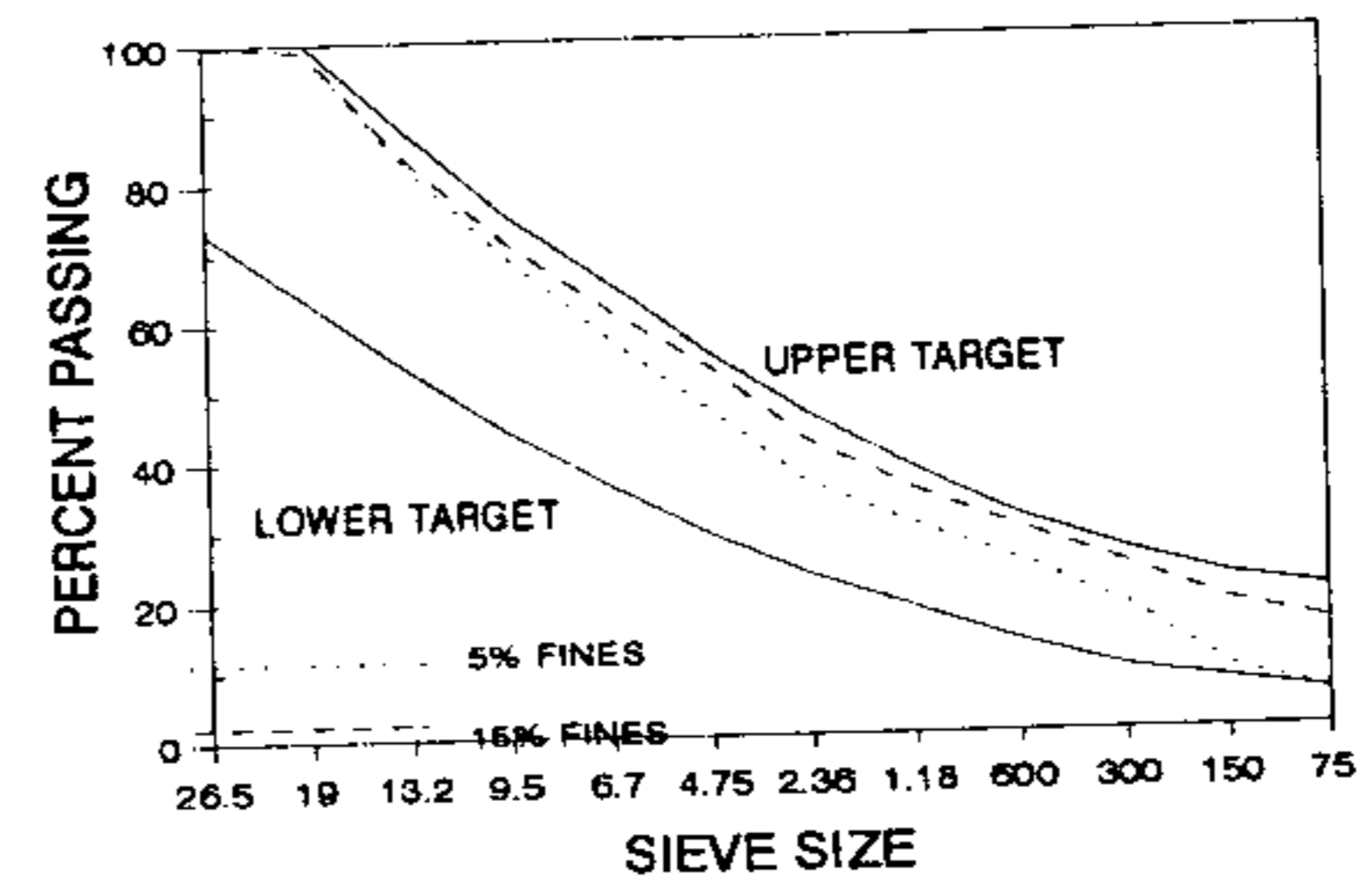


Fig. 3 Grading of Materials A and B

TABLE III
EFFECT OF FINES CONTENT ON PROPERTIES

	Fines Content (%)	Optimum Moisture Content (%)	Dry Density (t/m³)	Resilient Modulus (MPa)	
				Dry	Wet
Material A	5	6	2.10	3480	2400
Material B	15	8	2.16	3920	2940

Determination of optimum moisture content

18. Optimum moisture content (OMC) for foamed bitumen mixes is determined by preparing a series of foamed mixes at different moisture contents. Samples are compacted, cured and tested for density and resilient modulus. OMC is taken to coincide with maximum dry density. A typical example is shown in Fig. 4. At OMC both wet and dry modulus are close to maximum.

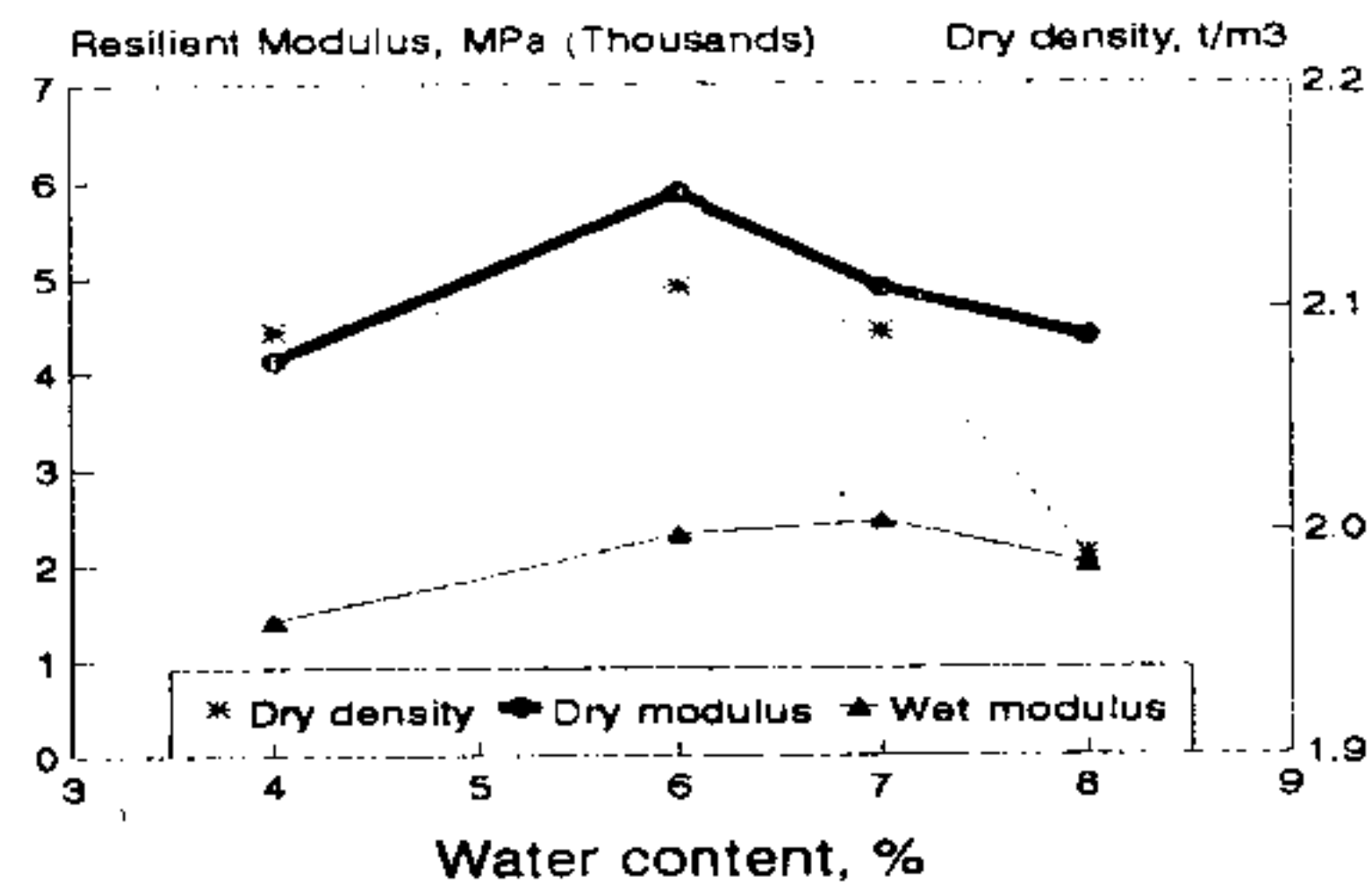


Fig. 4 Moisture content effect on properties

19. OMC is dependent on compaction level used in preparing samples- the higher the level the lower the OMC. The compaction level described in Table I is used as this simulates field compaction. Addition of fillers such as lime and CWFD increases the optimum moisture content by about 0.5%. OMC of foamed bitumen mixes is usually 1% to 2% less than that of neat granular materials.

TEMPERATURE AND RISE TIME EFFECT ON RESILIENT MODULUS

20. The effect of temperature and rise time on resilient modulus of foamed bitumen mixes is similar to asphalt. This is shown in Fig. 5. There is a halving in stiffness with a 10°C rise in temperature in the temperature range 20°C to 30°C. There is also about 50% reduction in stiffness when increasing the rise time from 30 ms to 120 ms. Similar results have been reported for both the effect of temperature and time on asphalt (Maccarrone and Holleran, 1993)

CREEP PROPERTIES

21. Creep resistance of foamed bitumen mixes appear to be good. An AUSTRoads Creep Class 7 is obtained for material meeting grading zone A and with 2% lime or CWFD as filler. The UK experience (Atkins, 1992) has been similar with laboratory creep results superior to asphalt.

BITUMEN GRADE

22. Most jobs done to date have used Class 170 bitumen. Laboratory results indicate no difference in modulus of mixes prepared with bitumen Class 170 or Class 320.

PERMEABILITY

23. Foamed bitumen mixes are less permeable to water than neat granular materials. Bowering (1970) has reported a reduction of 10 to 100 times in permeability when granular materials are foamed with 4% bitumen. In Bowering's work permeability was measured as the amount of water passing into or through the specimen under 63 mm of falling head in 24 hours. The consequence of reduced permeability is less potential damage by water ingress and this may lead to longer life.

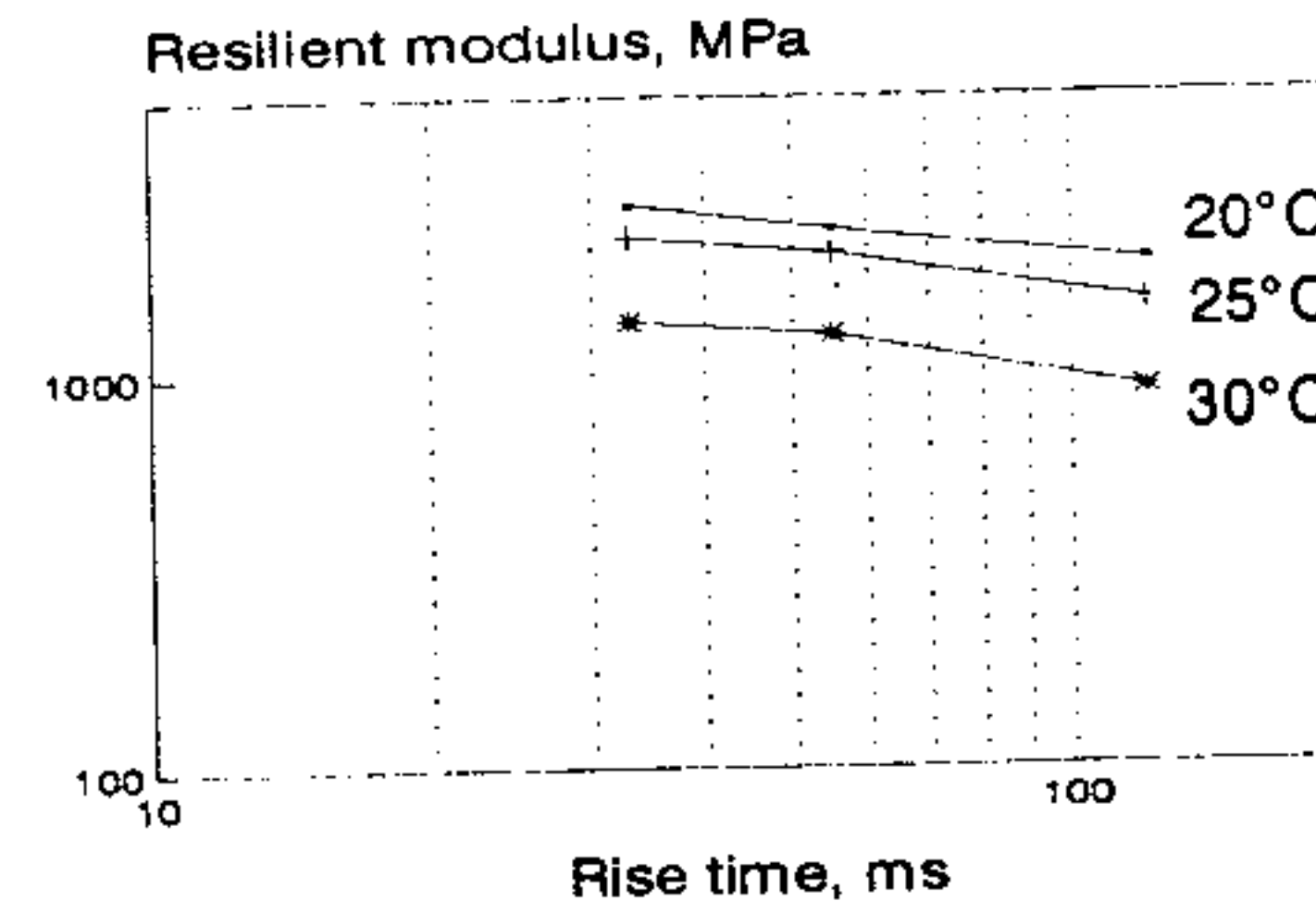


Fig. 5 Temperature and rise time effect on resilient modulus

PAVEMENT DESIGN

24. The principles of pavement design used in AUSTRoads (1992) Pavement Design manual are used for foamed bitumen mixes. Modulus determined at 50 ms loading on wet conditioned samples are used as input for CIRCLY (WARDLE, 1977) strain calculations. A conservative value of about 1500 MPa at 25°C can be used for designs. Foamed bitumen mixes use the same fatigue relationship as used for asphalt. This is based on work done in the UK by TRRL (Atkins, 1992). A comprehensive fatigue testing program is being conducted at ARRB to further establish the fatigue relationship of foamed bitumen mixes.

CONSTRUCTION

STABILISATION EQUIPMENT

25. The equipment used for stabilising and ancillary activities is as follows:

- Caterpillar RR250 Road Reclaimer specially fitted with foam spray bar and associated additive system.
- Bitumen tanker specially fitted for feeding hot bitumen to the Caterpillar. (Bitumen is accurately metered through a computerised flow meter)
- Water cart for distribution of water to aggregate
- Caterpillar 12 motor grader

- Single drum vibratory steel roller, 11 ton static weight, Dynapac CA 25
- Pneumatic tyred roller, 19 ton (fully ballasted)

OUTLINE OF CONSTRUCTION PROCEDURE

26. An outline of construction procedure is as follows:

- pulverisation of existing pavement;
- if necessary, application of materials for grading adjustment;
- application of water to predetermined OMC level;
- stabilisation with foamed bitumen
- shaping, trimming and compaction of the pavement
- application of a primerseal
- if necessary, application of asphalt wearing course or final chipseal or slurry seal

BINDER ADDITION AND SPREADING

27. Precisely metered bitumen foam is injected through specially designed spray nozzles placed inside the upper part of the mixing chamber. The upward rotating action of the mixing rotor ensures homogenous mixing of the bitumen foam with pre-wetted aggregate. This method of binder addition and dispersion is more precise than for the cement stabilisation process. Regular visual inspections and on-site calculations are made to check for binder content and uniformity of dispersion.

PULVERISATION

28. The Caterpillar RR250 Road Reclaimer is specially configured to pulverise and mix all layers of a pavement to a depth of 330 mm (including asphalt up to 150 mm). Where the pavement consists of asphalt layers greater than 150 mm or concrete, an alternative means of pulverising must be adopted as the Caterpillar RR250 is not a milling machine.

SHAPING, TRIMMING AND COMPACTION

29. Shaping, trimming and compaction is carried out with conventional equipment. This process is carried out over a period of three to four hours. This length of time is about 2 hours more than is available with cement stabilisation. The available extra time enables riding qualities not to be compromised. Compaction down to levels of 300 mm in a single layer can be satisfactorily achieved (see para 40). For this purpose a tandem vibratory steel roller (15 ton static weight) can be used. From experience the use of such roller does not require prior rolling by multi-tyred pneumatic roller to achieve compaction.

QUALITY CONTROL TESTING

30. Quality control testing is carried out on the following:

- grading
- binder content and dispersion
- compaction (nuclear densiometer), and
- resilient modulus

PRODUCTION RATES

31. Production rates range from 1400 m³/day to 2500 m³/day depending on the depth of stabilisation and type of traffic control.

JOBS

32. Several jobs have been completed in Australia since the re-introduction of the process in March 1993. Appendix 1 lists some of the jobs to date. Somerton Road rehabilitation is presented in more detail below as it was the first job completed and detailed deflection data is available.

REHABILITATION OF SOMERTON ROAD - SHIRE OF BULLA, VICTORIA

INITIAL CONDITIONS

33. The 2 km section of Somerton Road from Pascoe Vale Road to Hume Highway, 20 km north of Melbourne, carries about 20,000 vehicles per day with 15% heavy vehicles. The condition of this section of road was visibly distressed before rehabilitation works were commenced. There were extensive areas of cracking, rutting, patching and general shape loss.

34. For most part the pavement consisted of a granular make up of about 400 mm depth with a bitumen seal. A small section of the road had a 50 mm asphalt overlay. Deflection results indicated that more than 30% of the tested pavement needed strengthening to resist rutting induced by heavy vehicle traffic. The poor condition of the pavement was further supported by curvature results. Design curvature was exceeded for most of the pavement.

REHABILITATION ALTERNATIVES

35. Initial rehabilitation alternatives (VicRoads, 1992) consisted of the following:

- a. thick asphalt overlay
- b. thick asphalt overlay and cement recycling
- c. cement recycling and thin asphalt overlay

36. According to VicRoads only the first two treatments would be suitable for a 20 year design life. The third option would only be suitable for a relatively short term. A thick asphalt overlay (minimum of 175 mm) is required to inhibit reflective cracking initiated in the cement treated layer.

37. A foamed bitumen stabilisation option was considered as this offered considerable cost savings compared to either total reconstruction or thick asphalt overlay. A comparison of predicted pavement lives for conventional deep strength asphalt and foamed bitumen stabilisation alternative is shown in Table IV. The foamed bitumen stabilisation alternative offered an increased predicted life at reduced cost. The cost of the foamed bitumen alternative was about 40% less than the deep strength asphalt alternative.

WORK PROGRAM FOR SOMERTON ROAD

38. Most of the work at Somerton Road was done under traffic. This involved stabilising alternating half road widths of about 400 m length. The stabilised sections were opened to traffic at the end of each days work without detriment to the surfacing. Application of the primerseal and the asphalt wearing course was able to be delayed two weeks from commencement of the stabilisation due to the relatively dry period. When rain is imminent a primerseal is required at the completion of each day's stabilising.

TABLE IV
COMPARISON OF TWO REHABILITATION ALTERNATIVES

Deep Strenght Asphalt	Foamed Bitumen Alternative
45 mm Wearing course asphalt	45 mm Wearing course asphalt
90 mm Intermediate asphalt layer	
100 mm Base asphalt layer	300 mm Foamed bitumen layer
150 mm Cement treated base	↓
Predicted Life: 3 x 10 ⁷ ESA's	Predicted Life: 5 x 10 ⁷ ESA's

Sections of Road with Vary Fine Gradings

39. Some sections of the Somerton Road pavement consisted of an asphalt wearing course over a granitic sand base. In these areas the granitic sand was removed and replaced with size 20 mm fine crushed rock before stabilising. Whilst it was possible to stabilise the granitic sand, the resultant pavement strength would have been insufficient for the Somerton Road traffic loadings.

FIELD PERFORMANCE

Compaction and Resilient Modulus

40. Field compaction measurements were carried out using a Troxler series 33 nuclear density gauge down to 275 mm depth. Density results were corrected for moisture content of insitu material. Results in Fig.6 indicate that compaction was achieved to full depth of stabilisation. Resilient modulus results were obtained on foamed material taken from the field and compacted in the lab. Fig. 7 shows that wet modulus exceeded 1300 MPa in all cases.

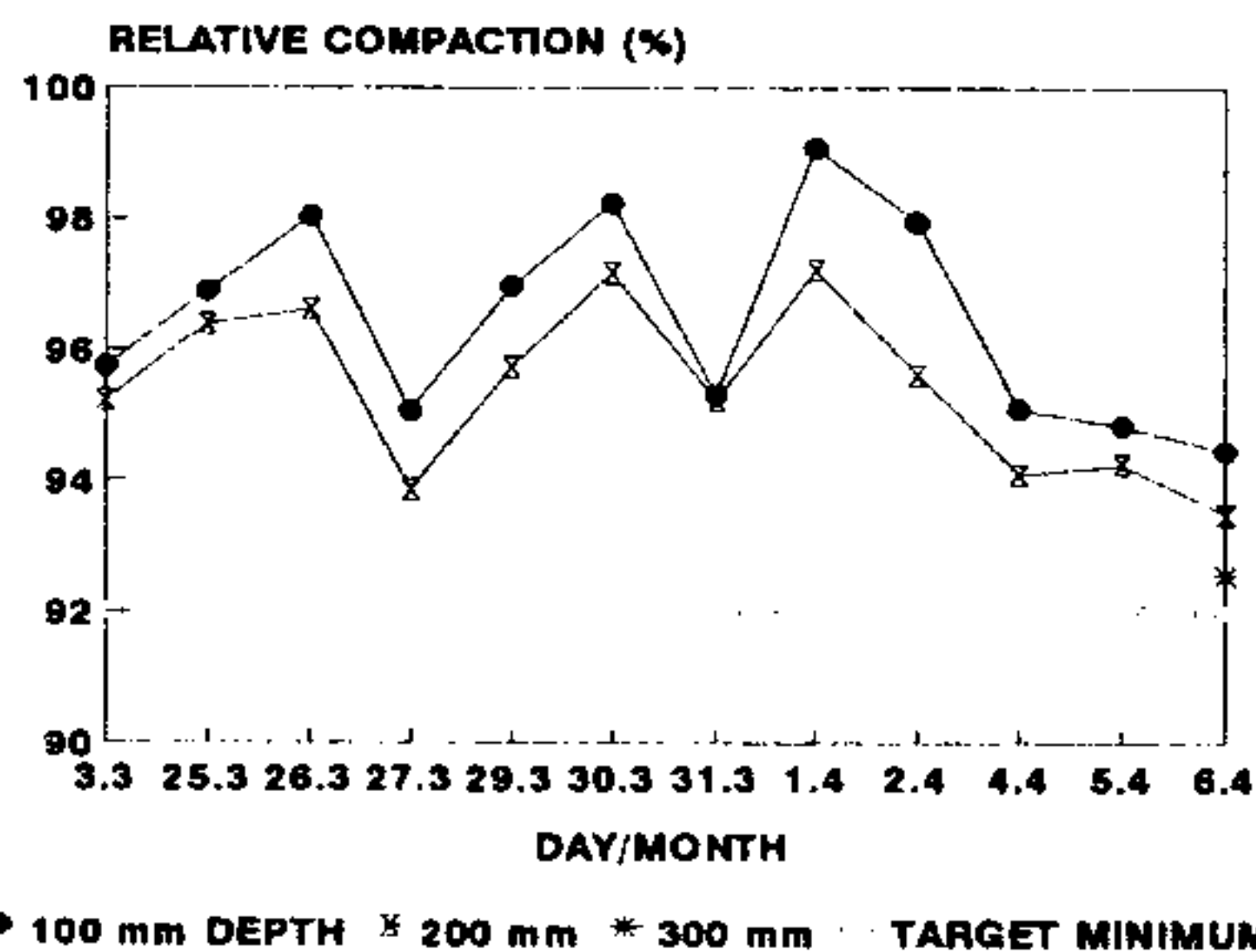


Fig. 6 Field compaction results at Somerton Rd.

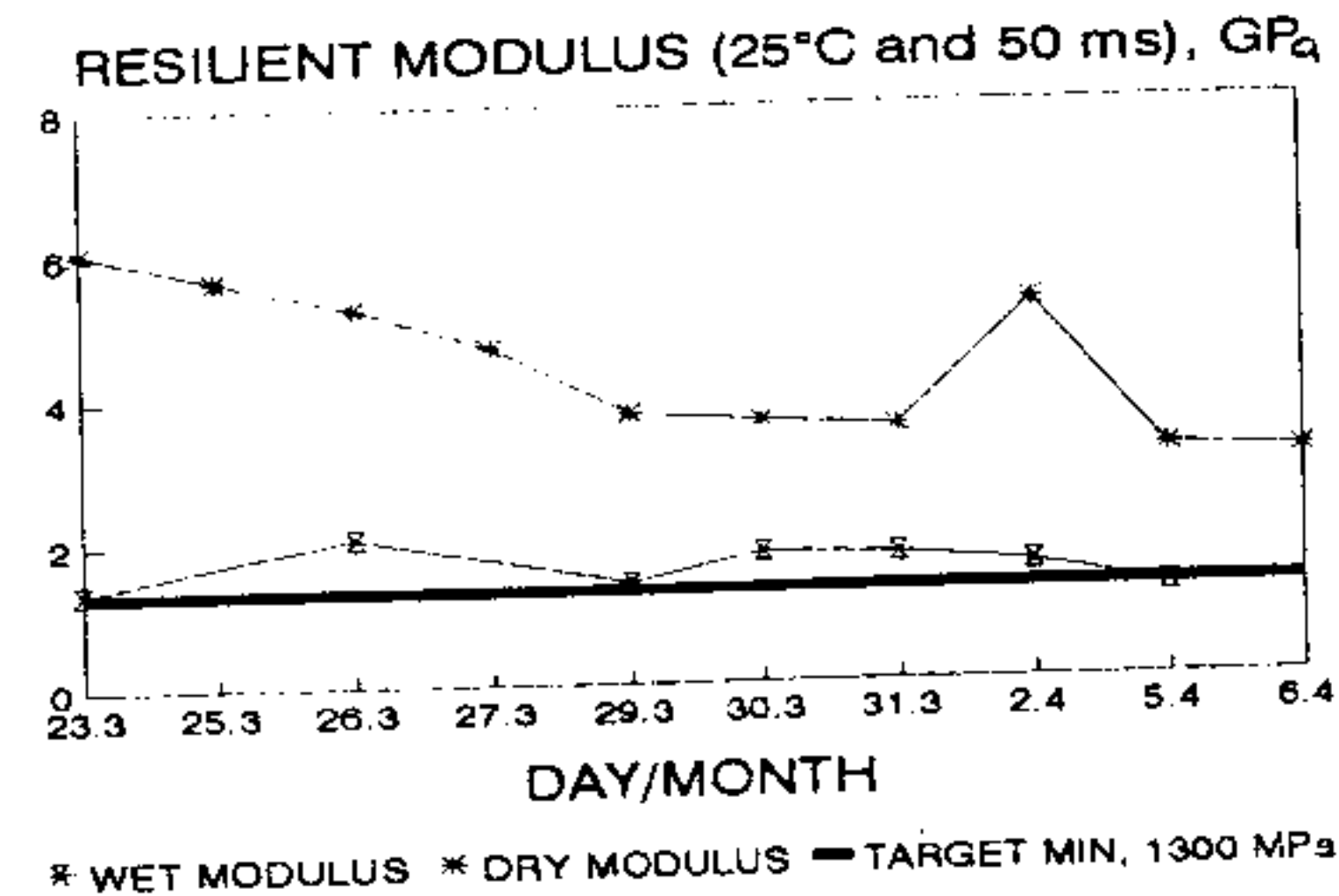


Fig. 7 Field modulus results at Somerton Rd.

Deflection Results

41. Results of deflection testing taken with Deflectograph by VicRoads are shown in Fig. 8. For the purpose of simplification results are for the outer wheel path of the west bound lane only. Deflection results two weeks after stabilisation were markedly reduced. Average deflection results for the entire 2 km section reduced from about 0.7 mm to 0.4 mm. Further reduction in deflection is anticipated over the next 12 months.

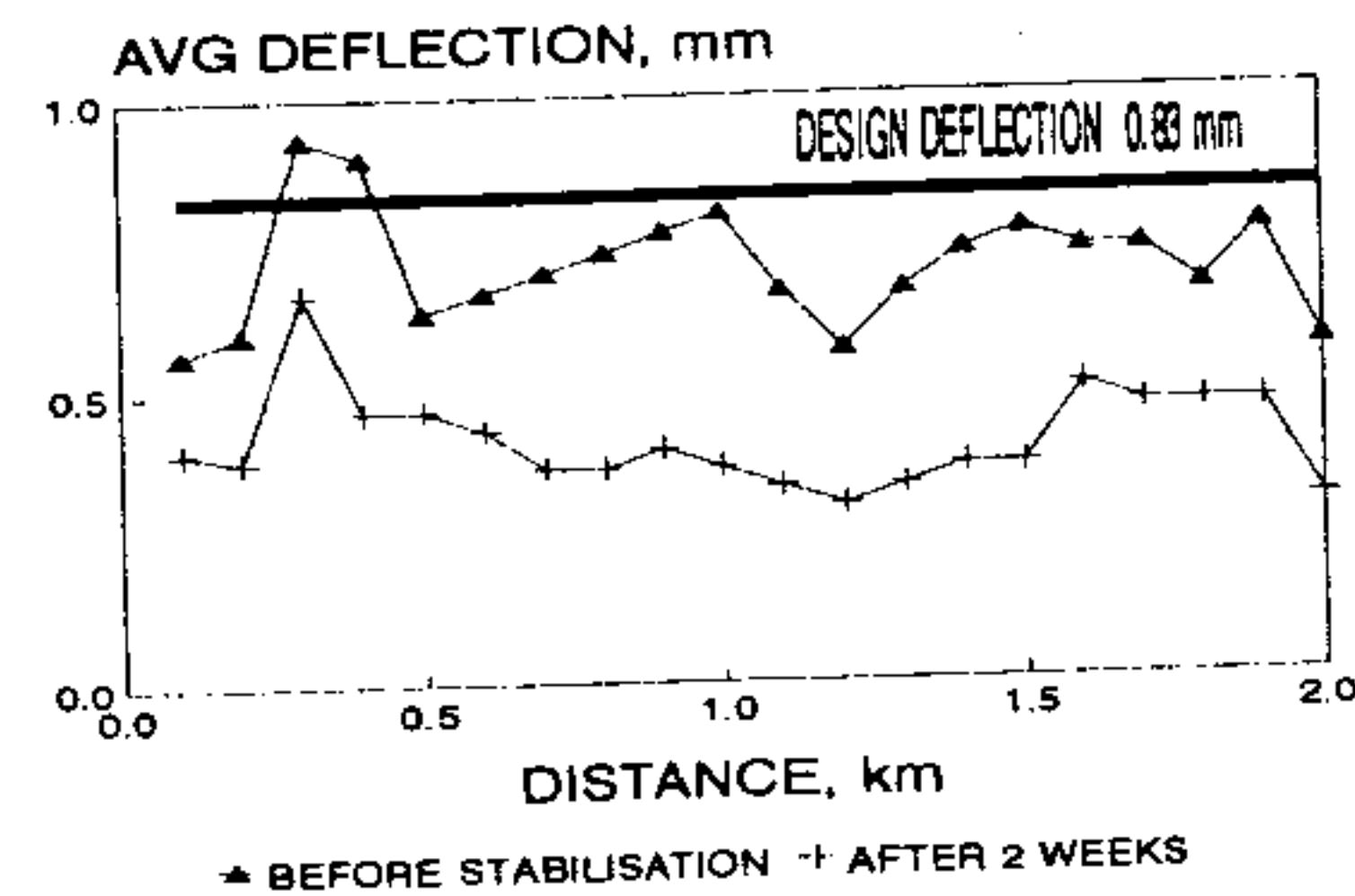


Fig. 8 Deflection results at Somerton Rd.

STUD ROAD, ROWVILLE

42. Stud Road is a highly trafficked arterial road in the eastern suburbs of Melbourne. A short term pavement rehabilitation was required for sections of the above road due to inadequate pavement depth. The sections to be rehabilitated had many edge defects and curvature results (VicRoads) indicated that the pavement lacked stiffness.

43. Rehabilitation work with foamed bitumen stabilisation commenced in May 93. Treated area totalled 22,000 m². Initial pavement consisted of spray seal(s) over unbound crushed rock and natural gravel. Crushed rock was present in variable thickness and in some cases deficient-virgin material had to be added to make up required thickness. The work was done in three sections. Stabilisation depth was 250 mm for the southern section and 300 mm for the northern section. The middle section had 150 mm of size 20 mm crushed rock added to the existing granular base to make up a total layer thickness of 300 mm layer before stabilisation. Lime(2%) was used for the middle section only. A 35 mm AC14 asphalt overlay was applied to all sections.

44. Deflection measurements were taken by VicRoads. Results after two months indicated that maximum curvature reduced from 0.5 mm to 0.3 mm indicating pavement strengthening. Deflections were more uniform however the magnitude of the deflections had not changed significantly. Performance after seven months was variable and this appears to be related to subgrade and drainage conditions.

TULLAMARINE FREEWAY, MELBOURNE

45. Tullamarine Freeway is a heavily trafficked road linking the centre of the Melbourne city with the airport. Due to increased traffic an emergency lane was converted into a traffic lane. The original pavement consisted of 30 mm open graded asphalt over a 100 mm of asphalt and 350 mm of granular base. Work involved profiling and removing the top two layers and then stabilising 300 mm of the granular base. Asphalt surfacing consisted of two 50 mm AC20 asphalt and 30 mm of polymer modified open graded asphalt as the wearing course. The work was done over a weekend with foaming on the first day and asphalt surfacing on the next day. The foam stabilised process was chosen by VicRoads on the basis of minimised disruption to traffic. Performance after one year is excellent.

SPRING ROAD, CITY OF MOORABBIN

46. Initial conditions of the pavement showed signs of general distress including cracking and pothole formation. Pavement consisted of about 20 mm thickness of spray seals and 175 mm of Macadam over a heavy clay subgrade. Foam stabilisation was chosen as the rehabilitation treatment. Cement stabilisation was not a viable alternative due to the low pavement thickness and the cost of reconstruction was prohibitive. The job consisted of pulverising to a depth of 180 mm and to stabilise the top 150 mm and finish the surfacing with 30 mm of AC10 asphalt overlay.

47. Field cores taken four months after construction showed modulus to be close to the design value (2300 MPa). Performance of the pavement after seven months is excellent.

BROWNS ROAD, SHIRE OF FLINDERS

48. Browns Road is a link road to the Mornington Freeway in the south eastern suburbs of Melbourne. The road showed general signs of deterioration including fatigue cracking and pothole formation. Rehabilitation alternatives considered by the Shire included reconstruction and cement stabilisation. Foam bitumen stabilisation was the preferred alternative on the basis of lower cost and potential for elimination of shrinkage cracking. The pavement consisted of sprayed seal(s) over a low quality natural gravel. Rehabilitation work included addition of 100 mm of size 20 mm crushed rock over the existing pavement and then pulverise to a depth of 200 mm. A double coat emulsion seal (size 10 mm and 7 mm) completed the surfacing. After nine months the pavement is performing very well as there are no signs of shrinkage cracking.

ADVANTAGES OF FOAMED BITUMEN STABILISATION (FOAMSTAB™)

49. FOAMSTAB™ offers a number of advantages when compared with traditional stabilisation techniques:

- Bitumen treated pavements may provide superior fatigue properties than cementitious pavements, thereby avoiding premature cracking. Bitumen treated pavements by the inherent nature of bitumen leads to relatively high fatigue lives when adequately constructed. In contrast cement treated pavements always lead to shrinkage cracking (MRD-Q 1988) which if not corrected leads to early loss of pavement life in the presence of water.
- FOAMSTAB™ cures rapidly allowing much quicker trafficking and less disruption to traffic than emulsion stabilised pavements. FOAMSTAB™ enables same day trafficking of a rehabilitated pavement and thus minimises disruption to traffic.
- FOAMSTAB™ allows more time for compaction, shaping and trimming than cementitious pavements, especially in hot weather conditions. This extra time enables riding qualities of the surfacing not to be compromised.
- Binder content and dispersion for the FOAMSTAB™ process is precisely controlled. Similarly quality control testing for binder content, binder dispersion and modulus are more readily achieved than for cemented materials.

CONCLUSIONS

50. Foamed bitumen stabilisation, FOAMSTAB™, offers a cost effective, rapid form of road rehabilitation in which all of the existing failed or fatigued pavement materials is re-used to obtain a new flexible pavement base.

51. For the various jobs carried out to date the FOAMSTAB™ process offers significant savings and improved life by improving the strength and durability of the existing pavement materials with minimal disruption to the travelling public.

ACKNOWLEDGMENTS

We wish to acknowledge the contributions of VicRoads North West Metropolitan Region (Messrs. T Phillips, R Warwick and L Macarthur) who supplied results of deflection testing and pavement assessment data for Somerton Road.

REFERENCES

- ATKINS W S (1992). Monitoring of a cold road recycling process on a heavily trafficked road. New practice report NP/60. (UK Department of the Environment)
- AUSTROADS (1992). Pavement Design- A Guide to the Structural Design of Road Pavements. AUSTROADS, Surrey Hills, NSW, Australia.
- BERGERON (1992). Research Perspective- In-situ recycling and rehabilitation. Internal seminar. Division of Roads and Materials, Ministry of Transport-Quebec Canada.

BOWERING (1970). Properties and behaviour of foamed bitumen mixtures for road building. Proc. 5th ARRB Conf.

CSANYI L.H. (1957). HRB Bull Vol. 10

DURKIN S.C. (1993). MOBIL UK, Internal report. Results of core testing program.

EUROBITUME (1993). Proceedings, Vol 1a

MACCARRONE S., and HOLLERAN G. (1993). Improving the performance of heavy duty asphaltic concrete pavements. Proc. SHRP Conf., Hague, Netherlands

MRD-Q (1988). Beerbum Deviation Crack Control Trial- Condition Assessment Report No. 1, Pavements Branch, RP 1256, Main Roads Department, Queensland

RTA NSW (1992). Proceedings of the workshop on in-situ recycling of pavements using cementitious binders, Roads and Traffic Authority, New South Wales

STANDARDS AUSTRALIA (1993a). Methods for testing soils for engineering Method 5.2.1 (AS 1289.5.2.1), Soil compaction and density tests- Determination of the dry density /moisture content relation of a soil using modified compactive effort.

STANDARDS AUSTRALIA (1993b). Methods of sampling and testing asphalt. Draft 93050, Method 12.0 (AS/NZS 2891.13.1): Determination of resilient modulus of asphalt.

STANDARDS AUSTRALIA (1993c). Methods of sampling and testing asphalt. Draft 93049, Method 12.1 (AS/NZS 2891.12.1): Determination of permanent and compressive strain characteristics of asphalt- dynamic creep test.

VICROADS (1992). Shire of Bulla - Pavement Rehabilitation Report No. 28PO72, by R. Jansz, Materials Technology Department, Kew Vic.

WARDLE L.J. (1977). Program CIRCLY User's manual. CSIRO Division of Applied Geomechanics.

APPENDIX I FOAMSTAB FIELD RESULTS

CONTRACT & CLIENT	DATE	TRAFFIC VOLUME vpd	HEAVY VEHICLE %	AREA TREATED m ²	DEPTH TREATED mm	DESIGN TRAFFIC LOADING ESA's	FILLER TYPE	AVERAGE DRY MODULUS MPa	AVERAGE WET MODULUS MPa	AVERAGE COMPACTION %
Somerton Road Vic Roads	26.04.93	20,000	18	15,000	300	5 x 10 ⁷	CWFD	4,629	1,385	95.2
Norwood Street Moorabbin	08.05.93	500	2	1,000	190	1 x 10 ⁶	CWFD	2,959	1,703	96.0
Stud Road Vic Roads	26.07.93	23,000	13	22,000	300	3 x 10 ⁷	Lime	6,138	3,167	96.3
Tullamarine Freeway Vic Roads	28.06.93	80,000	15	1,000	300	5 x 10 ⁷	Lime	5,052	2,183	95.0
Browns Road Shire of Flinders	18.07.93	800	0.5	6,000	200	1 x 10 ⁶	Lime	5,600	2,800	97.0
Keyworth Drive Blacktown, Sydney	29.09.93	800	0.5	2,400	200	1 x 10 ⁶	Lime	3,880	2,164	97.5
Smalls Road Ryde, Sydney	06.10.93	800	0.5	4,100	200	1 x 10 ⁶	Lime	3,050	1,900	95.7
Spring Road Moorabbin	26.10.93	400	0.5	1,700	150	1 x 10 ⁶	Lime	5,881	2,320	95.2