INTERNATIONAL SEMINAR
NATURAL RUBBER
IN ROADS

Experimental Study on the Natural Rubber Modified Asphalt

Present by

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Apr. 2017

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Outline

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2017
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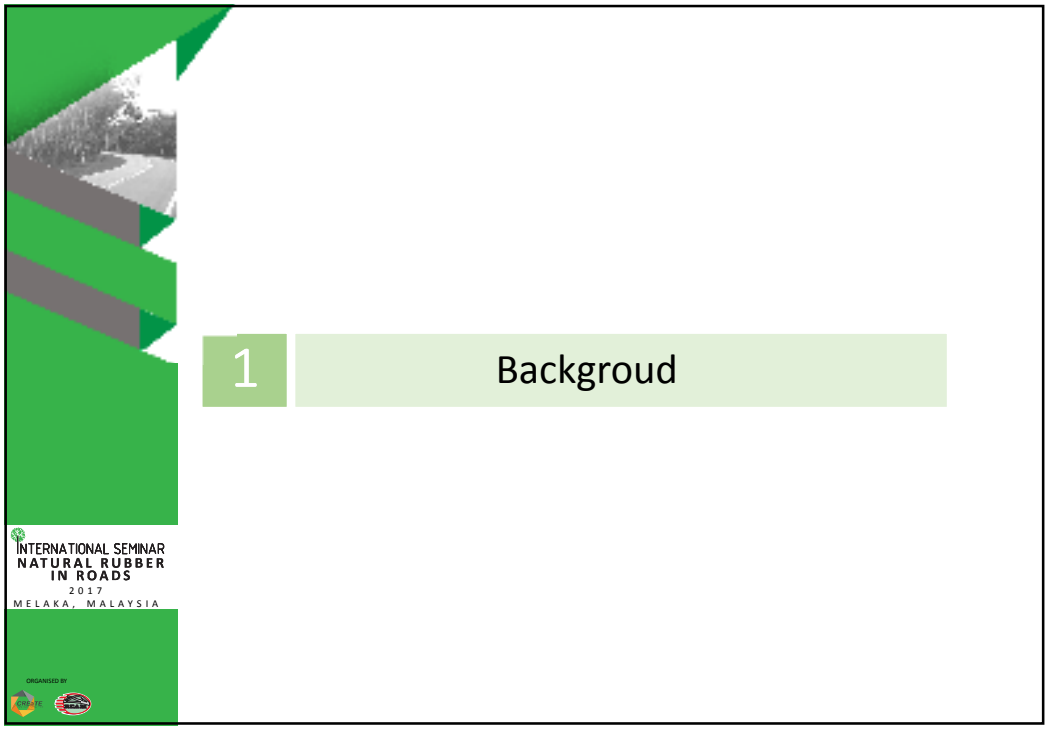

1. Background

- Challenge in Asphalt Pavement
  - Increasing traffic volume
  - Truck overload
  - Extreme climate
  - ……
- Increasing Use of PMB
  - SBS、SBR、PE、NR、EVA……
  - Reclaim Tire Crumb Rubber
  - Fiber
  - ……

1. Background

- SBS modified Bitumen
  - Reclaim tire
- Characters
  - Improve both high temperature and low temperature performance
  - Change Performance Grade obviously
- Process
  - proven technique
  - Stable quality
- Application
  - Widely used in the world
  - In China ,90% of PMB is SBS

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1. Background

- Crumb Rubber
  - Reclaim tire
  - Component: vulcanized rubber, carbon **black,** antiaging agent
- Asphalt Rubber
  - ASTM Definition
    - Wet Process
    - Rubber content >15%
  - Pavement
    - AR-AC
    - AR-OGFC
    - AR-SAMI
  - Application
    - USA, Europe ， China, South Africa, Brazil……

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1. Background

- Natural Rubber
  - Over 30 years
  - Type
    - natural rubber latex
    - rubber sheet
      - block rubber (STR 20)
      - Ribbed Smoked Sheet (RSS)
      - ……
  - Rubber improve asphalt performance
    - increasing in viscosity,
    - enhance its durability
  - Application
    - Indian, Thailand, Malaysia, ……
  - Challenge
    - natural rubber price

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1. Background

- Objective
  - Natural Rubber
    - Skim Block Rubber (SBR)
    - Standard Malaysian Rubber (SMR20)
  - Investigate on Preparation Process in Lab
  - Opitimum Process Parameters
  - PMB Performance Comparing
    - NR, SBS, AR
  - Cost Analysis

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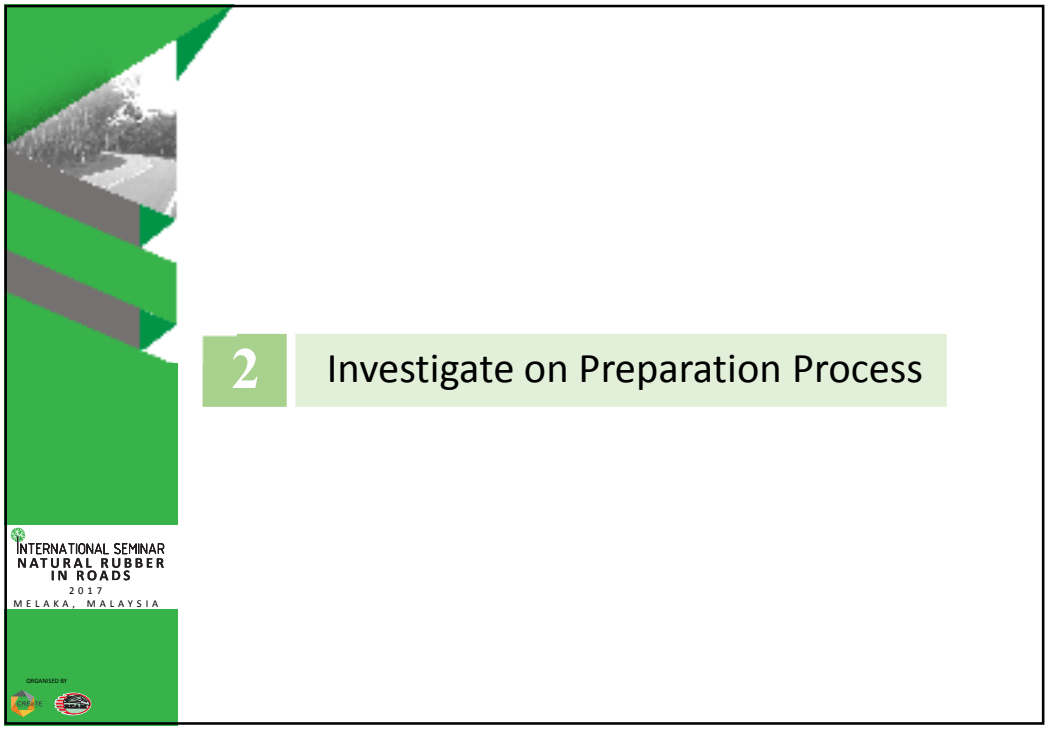
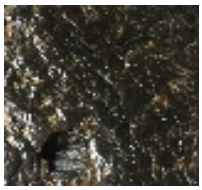


2. Investigate on Preparation Process

- Materials
  - Skim Block Rubber (SBR)
  - Standard Malaysian Rubber (SMR20)
  - Base Asphalt

Skim Block Rubber (SBR)



SMR20

	Penetration (25 ℃， 5s， 100g)(0.1mm)	Softening point (℃)	Ductility (15℃, cm)	Ductility (10℃， cm)	Viscosity (60℃, Pa·s)
Base Asphalt	64	47.5	＞100	＞100	184.2

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2. Investigate on Preparation Process

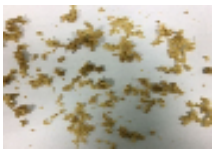
- Preparation Process

STEP 1 • Masticate of natural rubber

STEP 2 • Cut the natural rubber into small pieces

STEP 3 • Shearing with original asphalt with speed of 4000rpm for 1hr

STEP 4 • Curing at 150℃-180℃ for 2hr



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2. Investigate on Preparation Process

- Effect of Preparation Temperature
  - Dispersible uniformity
  - Aging property

4% of NR by weight of base asphalt

The proper preparation temperature: 150℃-180℃

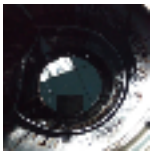
The COMPATIBILITY between NR and asphalt has to be improved!

SBR- Asphalt

SMR20 - Asphalt

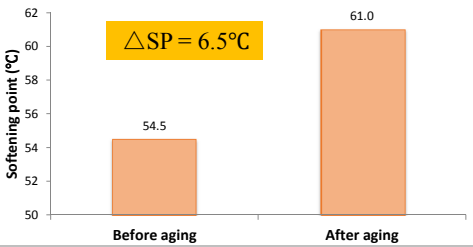
Prep. Temp.: 160-170℃

SBR- Asphalt



SMR20 - Asphalt

Prep. Temp.: 160-210℃



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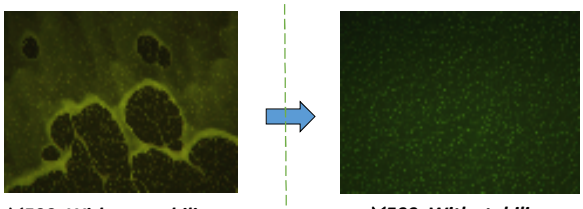
2. Investigate on Preparation Process

- Effect of Stabilizing Agent
  - SMR20 modified asphalt

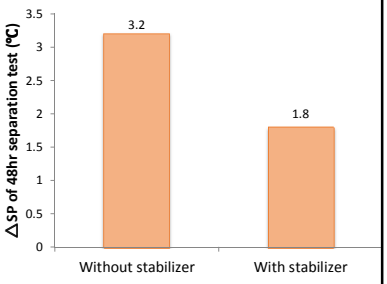
4% of SMR and 3% of Stabilizer by weight of base asphalt



×500, Without stabilizer
Prep.Temp.: 160-210℃

×500, With stabilizer
Prep.Temp.: 160-180℃

Fluorescence microscope photo



Do improve the compatibility between SMR20 and base asphalt

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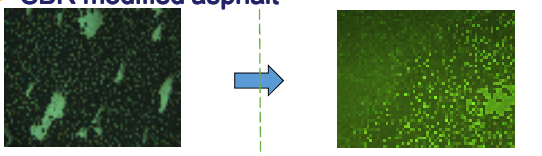
2. Investigate on Preparation Process

- Effect of Stabilizing Agent
  - SBR modified asphalt

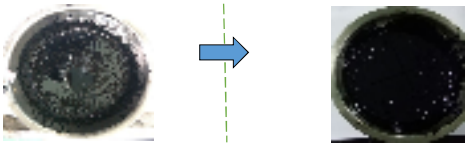
3% of Stabilizer by weight of base asphalt



×200, Without stabilizer
Prep.Temp.: 160-210℃

×200, With stabilizer
Prep.Temp.: 160-180℃

4% of SBR, Fluorescence microscope photo



4% of SBR, Without stabilizer
Prep. Temp.: 160-170℃

2% of SBR, With stabilizer,
Prep. Temp.: 160-170℃

Have no obvious effect for SBR modified asphalt

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2. Investigate on Preparation Process

- The suggested preparation temperature is 150℃~180℃ to avoid materials aging.
- Based on this experiment, The compatibility between natural rubber and base asphalt is not good.
- Stabilizing agent can be used to improve the compatibility of SMR20 and base asphalt, However, it is useless for Skim block rubber and asphalt system.

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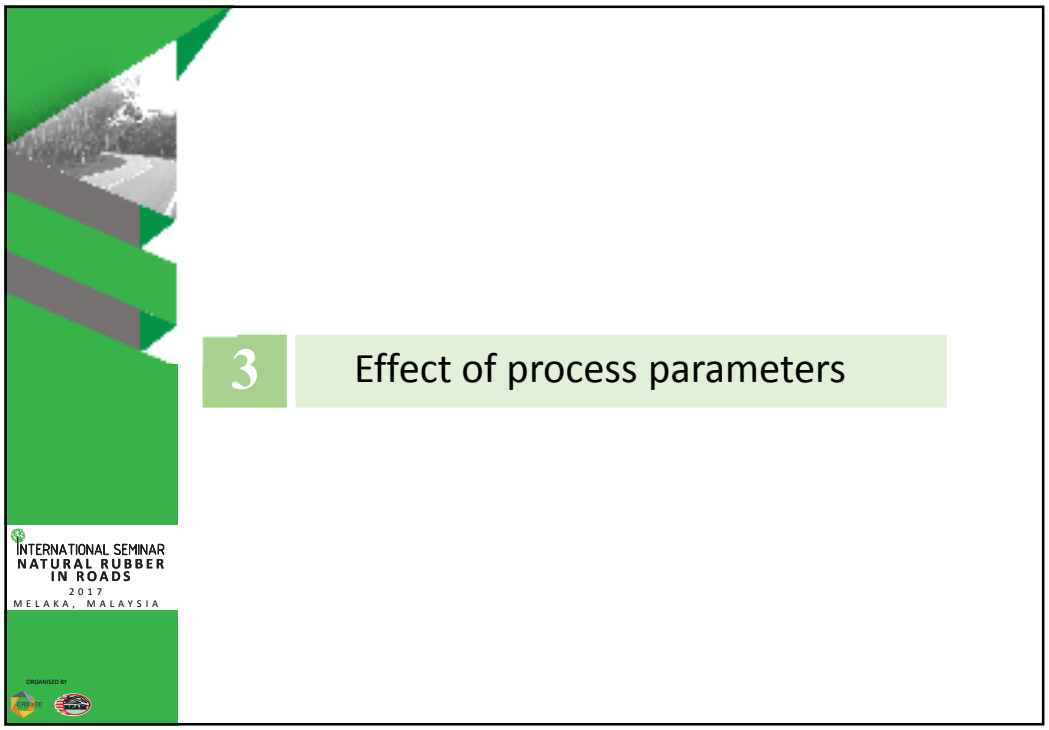

3 Effect of process parameters

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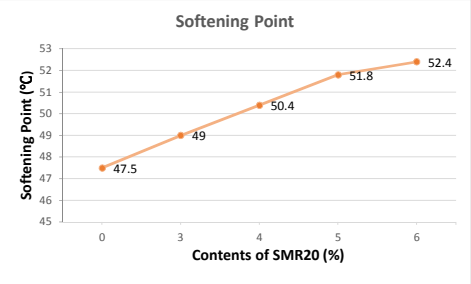
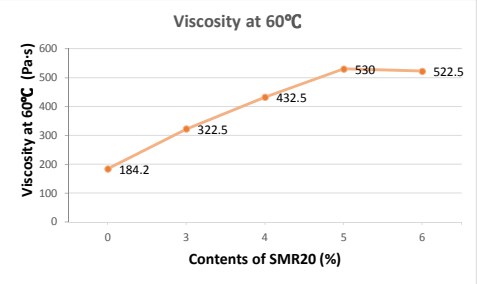
3. Effect of process parameters

- Effect of SMR20 contents
  - 3% of stabilizer by weight of base asphalt
  - High temperature performance





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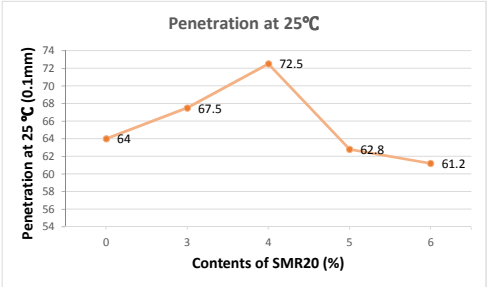
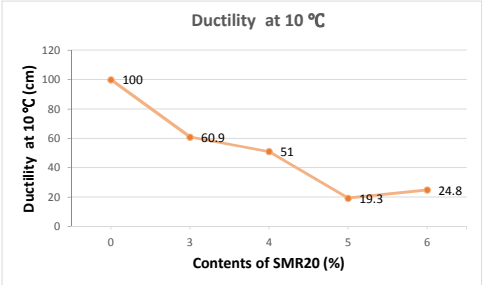
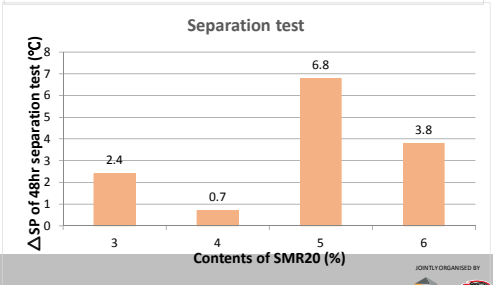
3. Effect of process parameters

- Effect of SMR20 contents
  - Low temperature performance
  - Asphalt consistency
  - Storage stability

3% of Stabilizer by weight of base asphalt







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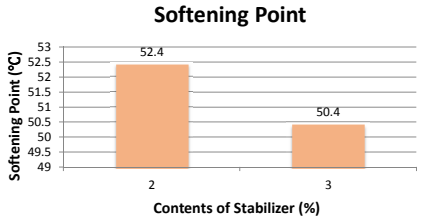
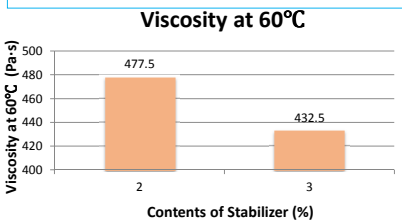
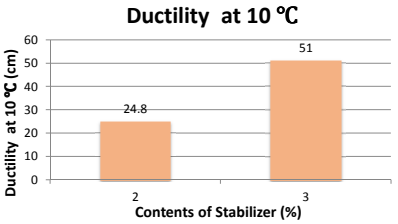
3. Effect of process parameters

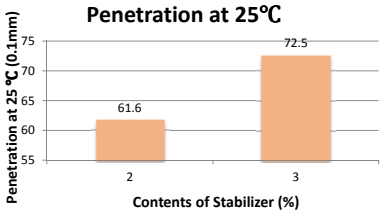
- Effect of stabilizer contents

4% of SMR by weight of base asphalt









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3. Effect of process parameters

- The high temperature performance of asphalt would increase with increasing SMR20 contents.
- The penetration of asphalt is to a certain rise up by the addition of stabilizer.
- Based on this experiment, the most effective ratio of SMR20 and stabilizer are 4% and 2% by weight of base asphalt separately.

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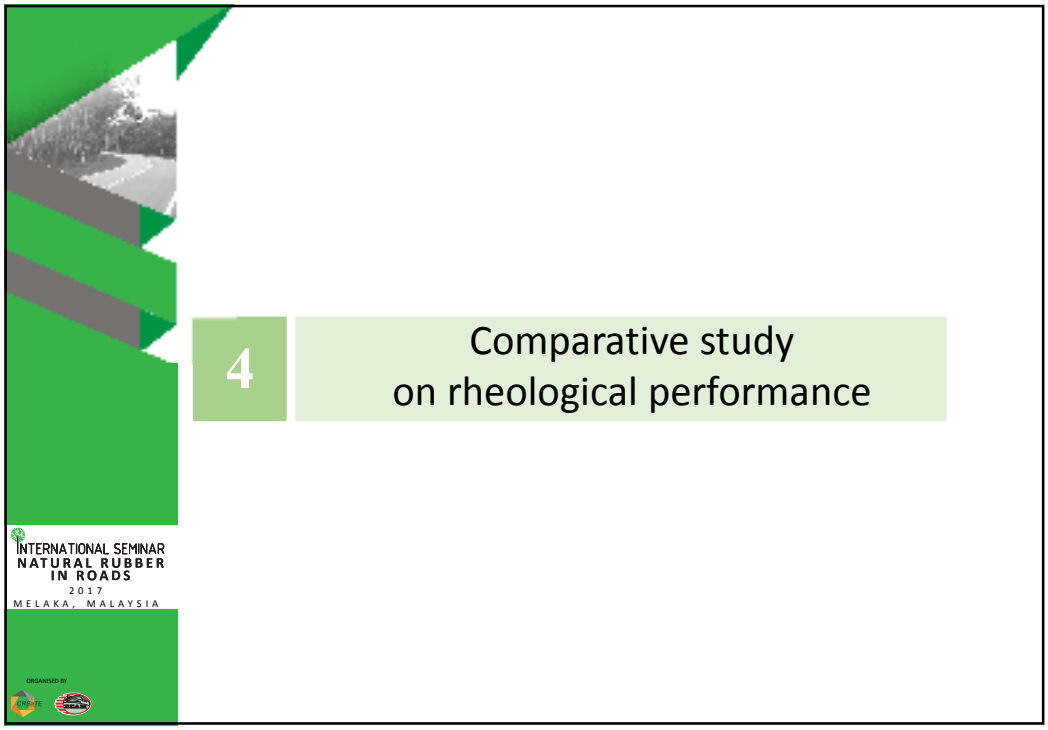

4. Comparative study on rheological performance

- Materials
  - AC: Base asphalt, PEN 60/80

	Penetration (25 ℃， 5s， 100g)(0.1mm)	Softening point (℃)	Ductility (15℃, cm)	Ductility (10℃， cm)	Viscosity (60℃, Pa·s)
Base Asphalt	64	47.5	＞100	＞100	184.2

  - SMR-2: Asphalt modified by 4% of SMR20 and 2% of stabilizer
  - SMR-3: Asphalt modified by 4% of SMR20 and 3% of stabilizer
  - SBS: Asphalt modified by 4% of Styrene-butadiene-styrene block copolymers.
  - AR: Asphalt modified by 18% of Tire crumb rubber

4. Comparative study on rheological performance

- PG grade

Asphalt type	AC	SMR-2	SBS	AR
PG grade	PG64-22	PG64-22	PG76-28	PG82-28

Asphalt type			AC	SMR-2	Superpave standard
DSR	Original asphalt G*/sinδ (kPa)	64℃	1.36	2.64	≥1.0
		70℃	0.639	1.36	
	RTFOT G*/sinδ (kPa)	64℃	2.62	4.39	≥2.2
		70℃	1.20	2.01	
	PAV G*sinδ (kPa)	25℃	3612	3210	≤5000
BBR	-12℃	S (MPa)	239	205	S≤300 m≥0.1
		m	0.327	0.313	
	-18℃	S (Mpa)	466	417	
		m	0.250	0.249	

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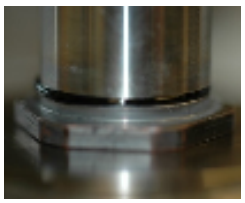
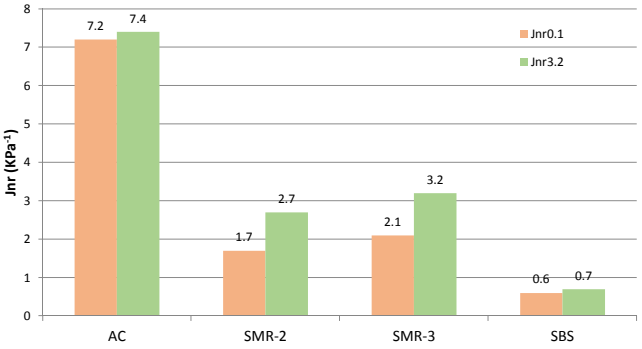
4. Comparative study on rheological performance

- High temperature performance
  - Multi-step creep and recovery test (MSCR)
  - AASHTO T350





High temperature performance: SBS > SMR-2 > SMR-3 > AC

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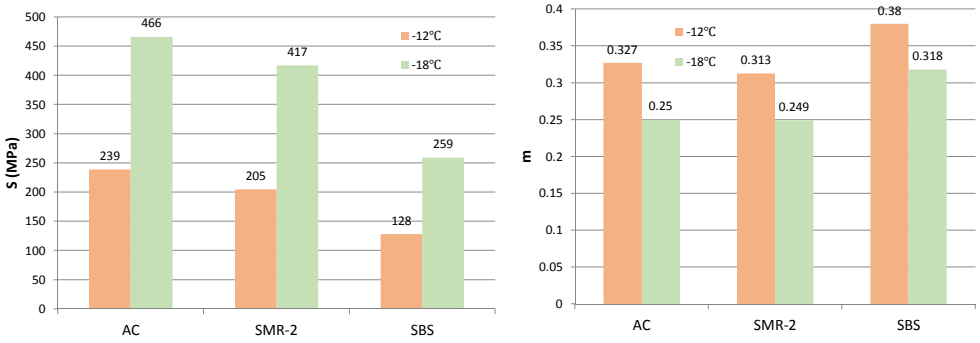
4. Comparative study on rheological performance

- Low temperature performance
  - Bending beam rheometer test (BBR)
  - AASHTO T313



Low temperature performance: SBS > SMR-2 > AC

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4. Comparative study on rheological performance

- Based on this experiment, The PG grade of SMR modified asphalt is the same as base asphalt, much lower than SBS and Tire crumb rubber modified asphalts.
- The rheological performance of base asphalt can be improved by modified with SMR to a certain degree.

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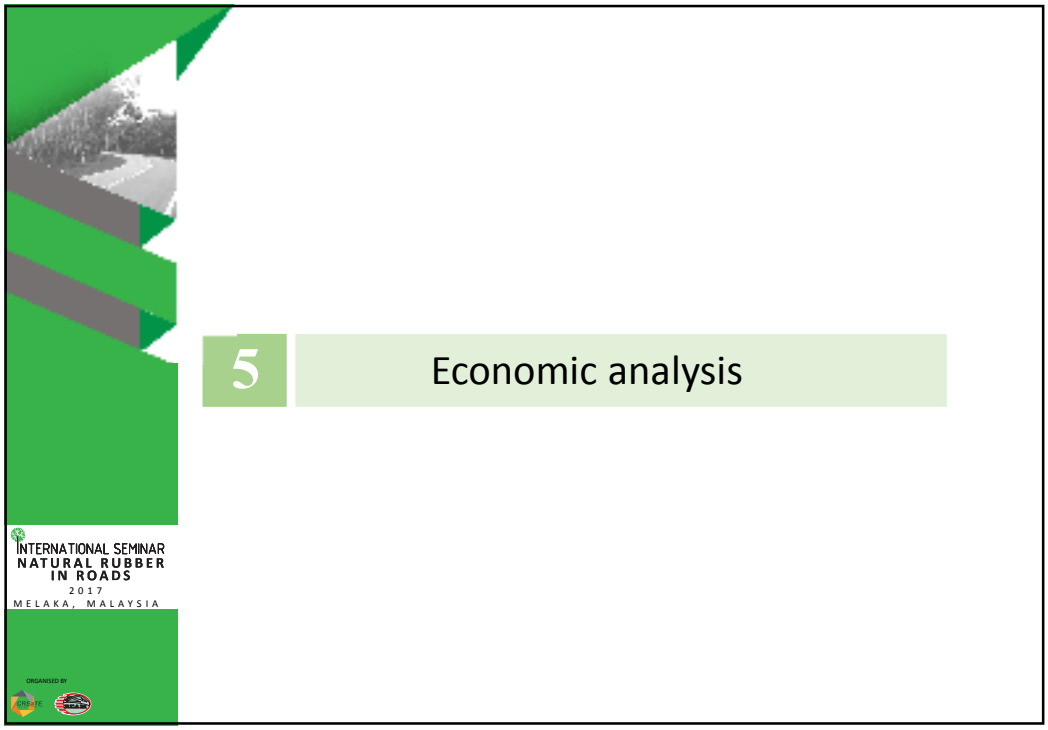
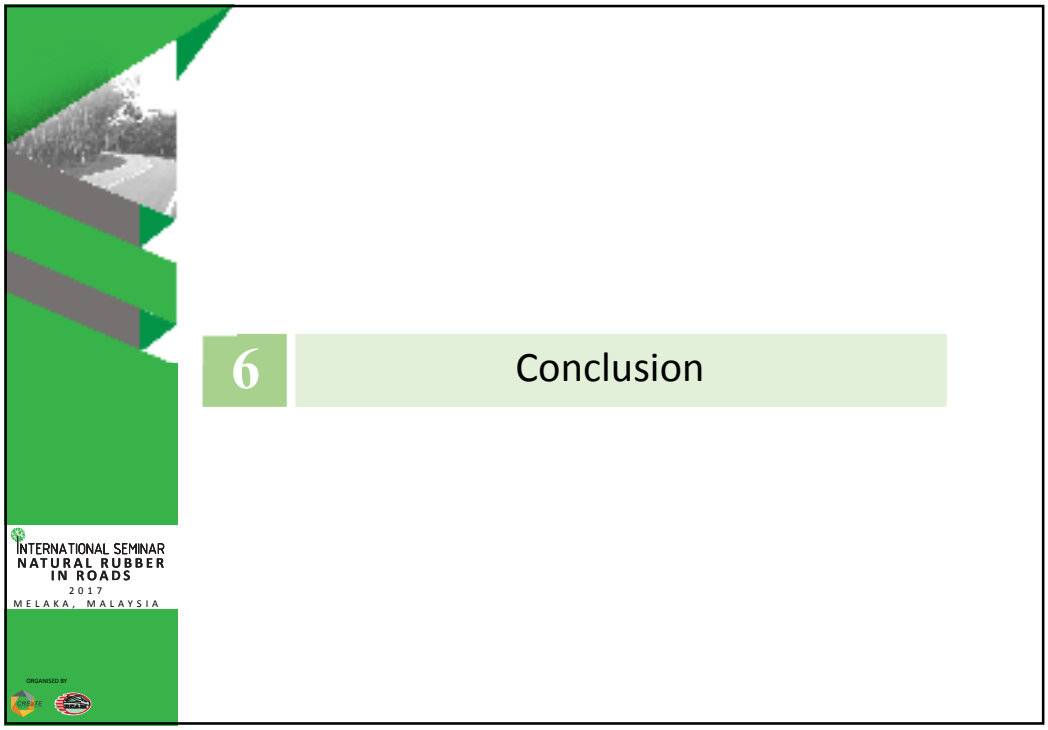


5. Economic analysis

Price estimation

		SMR	SBS	AR
Raw Materials	Base asphalt	1446.5	1446.5	1446.5
	SMR20	7484.25	/	/
	SBS copolymer	/	12500	/
	Tire Crumb rubber	/	/	1000
	Stabilizer	3125	3125	/
	Others	/	625	/
Products		1809	2023	1627

Notes: The formula of each products are estimated as below:
SMR: 100% Asphalt+4% SMR20+2% Stabilizer
SBS: 100% Asphalt+4% SBS copolymer +2.4% Stabilizer+0.12% Others
AR: 100% Asphalt+18% Tire crumb rubber



6. Conclusion

- Conclusion
  - By controlling suitable preparation temperature and adding stabilizing agent, compatible and stable SMR modified asphalt can be prepared.
  - Based on this experiment, The most effective ratio of SMR20 and stabilizer are 4% and 2% by weight of original asphalt separately.
  - Based on this experiment ,the quality of SMR modified asphalt is better than base asphalt, but is not as good as SBS and Tire crumb rubber modified asphalt.
  - The road property of Natural rubber modified asphalt mixture and detail economic analysis should be further investigated.

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Thank you !

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