Recycled Asphalt Pavement – what to look out for?

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Prepared for the Argus Pavement Technology Asia 2018, 17-19 October, Pan Pacific Singapore

Topics

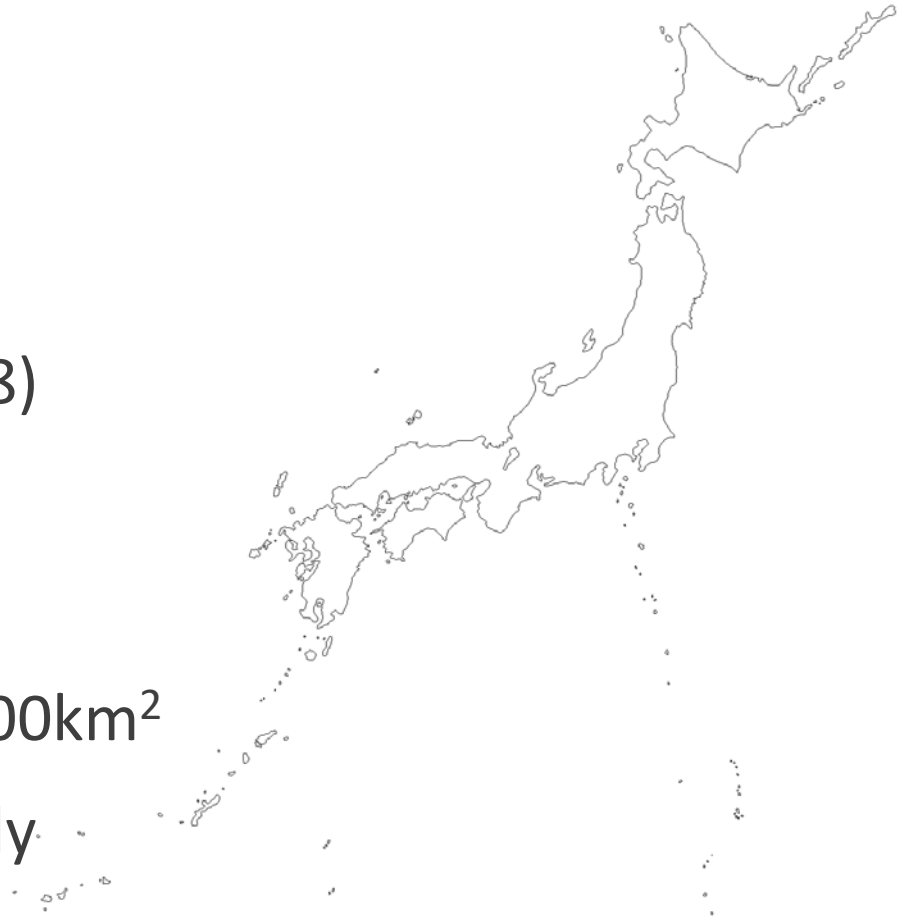
1. Introduction
2. Recycled Asphalt Pavement in Japan
3. Recycled Asphalt Pavement Production
4. Point at Issue – what to look out for
5. Summary and Recommendations

1. Introduction

Statistical Information of Japan

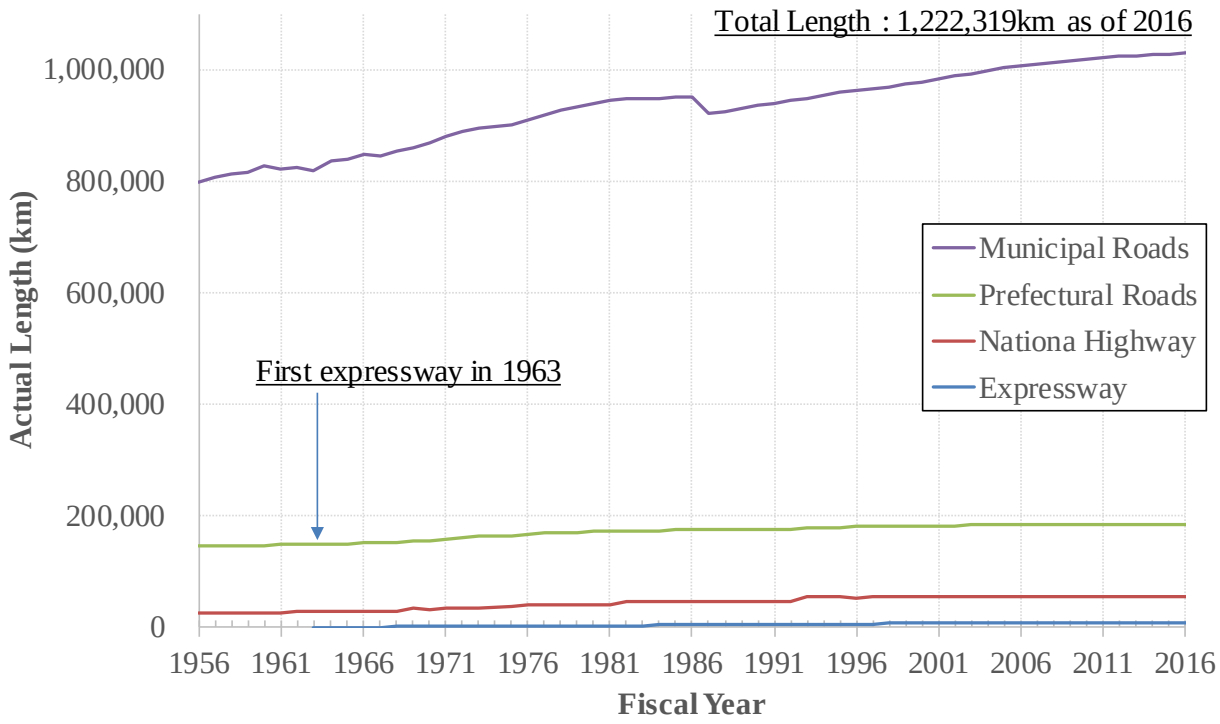
- Area : 378,000km^2
- Population : 127 million (as of 2016)
- Prefectural governments : 47
- Nominal GDP : JPY 555.607 trillion (April 2018)
- Real GDP : JPY 537.849 trillion (April 2018)
- Road network : 1,222,319 km (as of 2016)
- Asphalt plant : 914 (as of 2017) = 1.2 plant/500km^2

  - 805 member firms of JAMA only



Changes in Actual Road Length

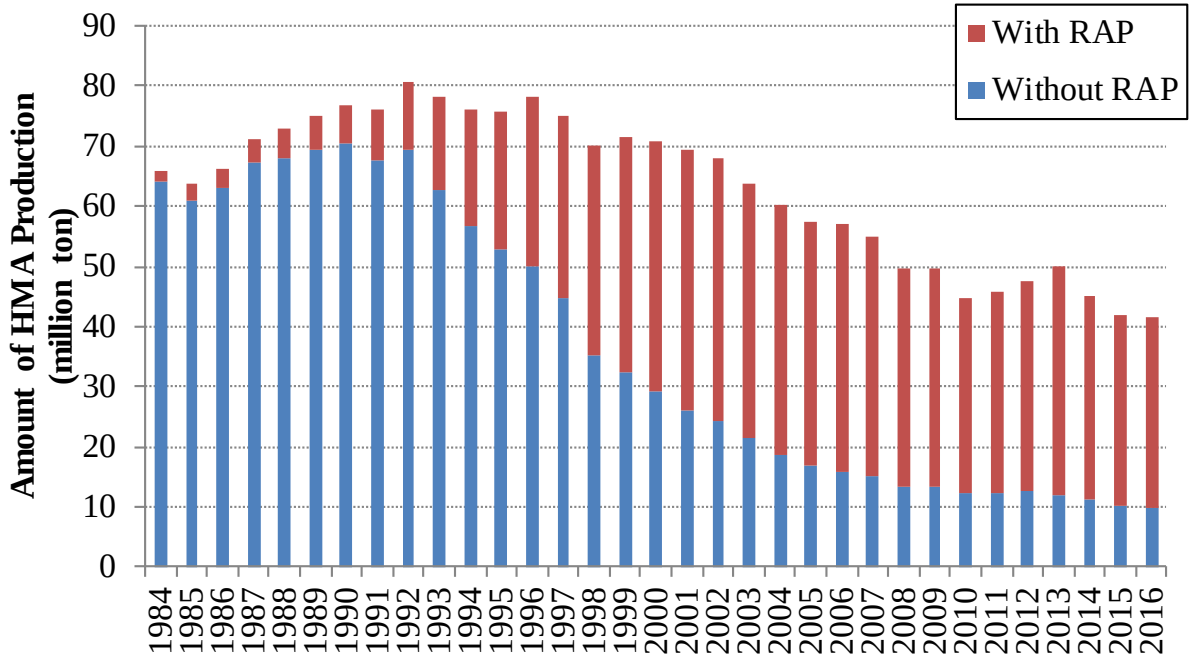
- Total actual road length : 1,222,319 km (as of 2016)
  - ✓Expressway : 8,776 km
  - ✓National highway : 55,565 km
  - ✓Prefectural road : 185,168 km
  - ✓Municipal road : 1,028,375 km
- Road length keeps increasing
- Asphalt pavement is about 95%



Source : Ministry of Land, Infrastructure, Transport and Tourism, Japan

Changes in HMA Production

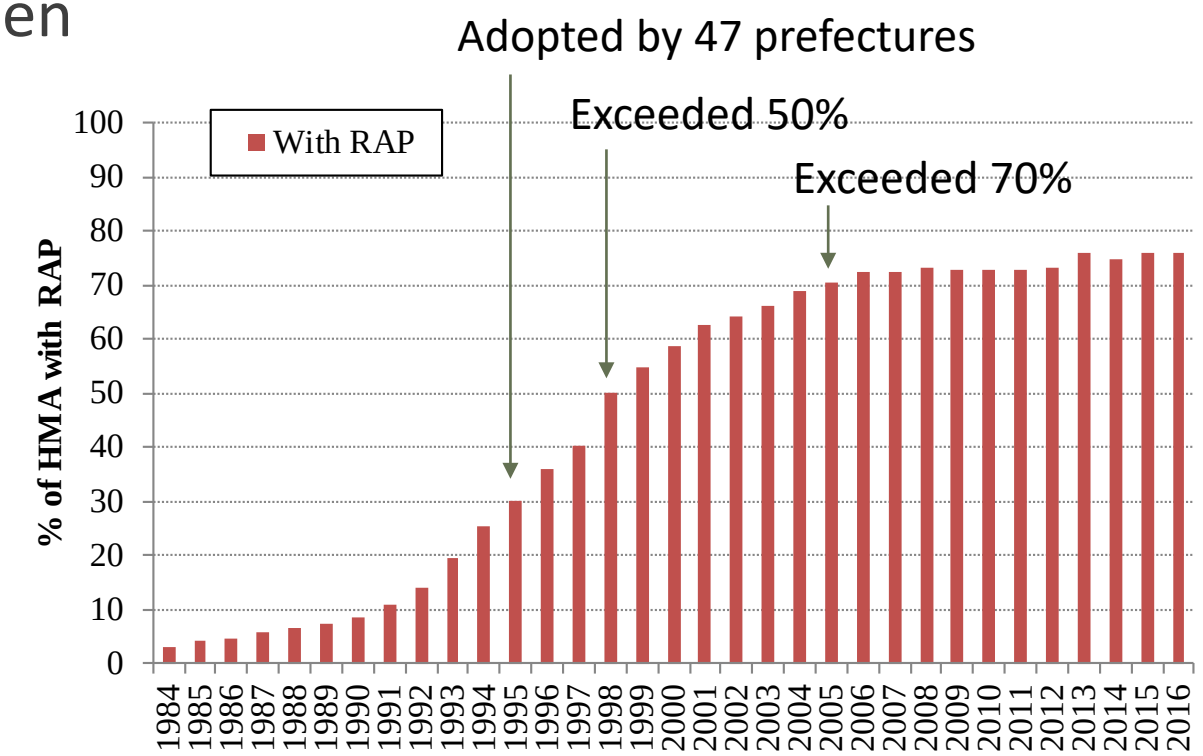
- Total HMA Production
  - ✓ Peak was 80,838 million tons at 1992
  - ✓ 41,640 million tons at 2016
- Recycled Asphalt Pavement (HMA with RAP) Production
  - ✓ Increased after 1992



Source : Japan Asphalt Mixture Association

Changes in Recycled Asphalt Pavement Production

- Recycled Asphalt Pavement has been used as one of the road pavement materials since late 1970s in Japan
- It has been used by every 47 prefectures since 1995
- Its amount was exceeded 50% in 1998
- Its amount was exceeded 70% in 2005
- Its amount is about 76%



Source : Japan Asphalt Mixture Association

Why Recycled Asphalt Pavement Used?

- Small national area and very limited landfill
- Limited good quality of natural resources, i.e. virgin aggregates
- ‘Waste Management and Public Cleansing Act’ in 1970
  - ✓Severe regulation of industrial waste including used asphalt concrete
  - ✓3R (Reduce, Reuse, Recycle) policies
- ‘Law for Promotion of Effective Utilization of Resources’ in 1991
- ‘Construction Material Recycling Act’ in 2000

- ‘Law Concerning the Promotion of Procurement of Eco-Friendly Goods and Services by the State and Other Entities’ (Green Purchasing Law) in 2001
  - ✓Recycled Asphalt Pavement is one of the procured goods
- Very limited and severe budget
  - ✓Recycled Asphalt Pavement is cheaper than virgin HMA

2. Recycled Asphalt Pavement in Japan

Recycled Asphalt Pavement

- RAP (Reclaimed asphalt pavement)
- Virgin aggregates
- Virgin asphalt
- Rejuvenator
  - ✓ Sometimes not used when virgin asphalt has higher penetration value

Note : RAS (Recycled Asphalt Shingles) is not used in Japan

RAP (Reclaimed Asphalt Pavement)

- Existing asphalt pavement is removed by milling or removal works
- Removed material is hauled to a recycling plant and temporary stored in a stockpile
  - ✓Stockpiles usually do not have roofs

- The stored material is crushed and screened, then stored in other stockpiles again
  - ✓ Such stockpiles usually <u>have roofs</u>
  - ✓ Most maximum size is 13mm in Japan
    - R13-0 : aggregate size is 13mm to 0mm
    - R13-5 : aggregate size is 13mm to 5mm
    - R5-0 : aggregate size is 5mm to 0mm

Specification of RAP in Japan

- ‘Old’ asphalt content : 3.8% or higher by weight
- Percentage of fine aggregate passes 0.075mm sieve : 5% or less by weight
- Penetration value of ‘old’ asphalt at 25^{o}C : 20 (1/10mm) or greater

  or

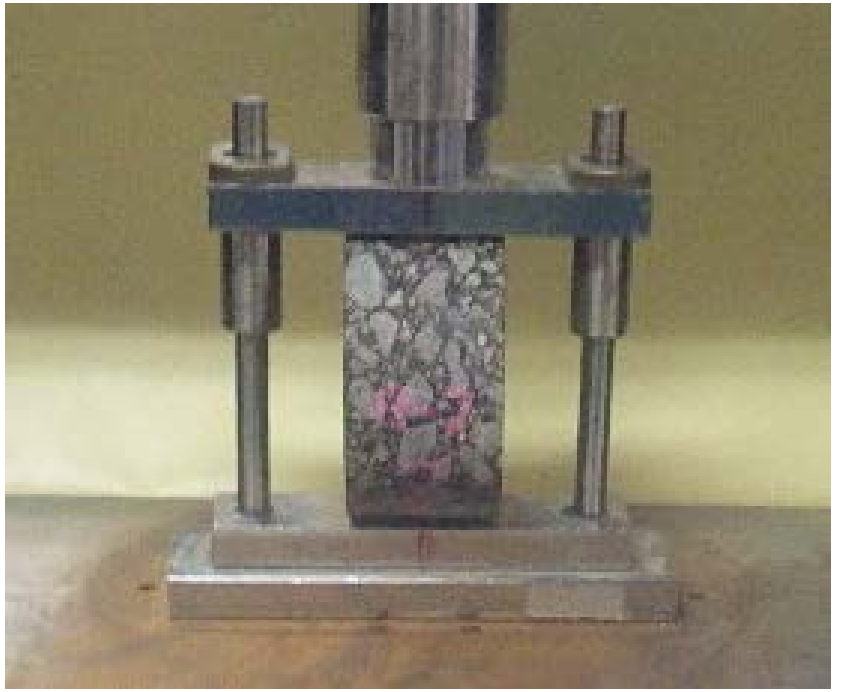
  Splitting strength ratio at 20^{o}C : 1.70 MPa/mm or less

  Note: Splitting strength ratio has been specified since 2010.

Above specifications are for R13-0, and it can be calculated from two values of both R13-5 and R5-0.

Splitting Test

- Cylindrical specimen : 100 mm in diameter and 63.5mm in thickness
- Test temperature : 20°C
- Loading speed : 50mm/min
- Test must be completed within 30 second
- Splitting strength : $\sigma_t = \frac{2P}{\pi dL}$
- Splitting strength ratio : $R_{ss} = \frac{\sigma_t}{x}$



P : maximum load (N), d : thickness of specimen (mm), L : diameter of specimen (mm), x : specimen displacement at maximum load applied (mm)

Note : This is a similar test method to determine tensile strength of specimen

Rejuvenator

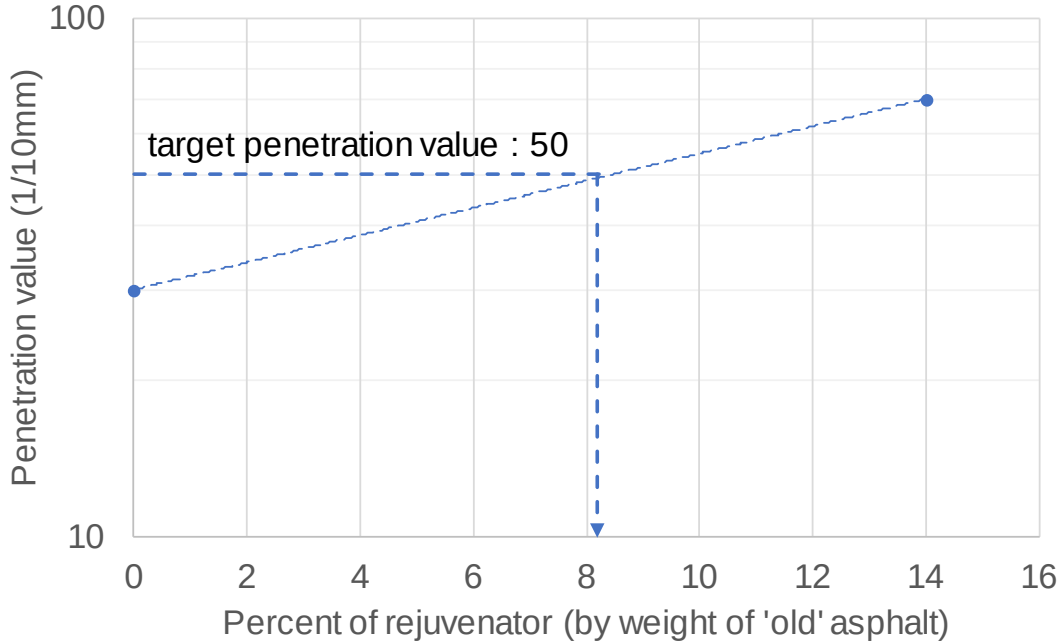
- Used to restore aged asphalt to original property
  - ✓Totally true ?
  - ✓Effective in second, third, fourth, … generation recycling ?
- Various compounds including oil-based materials

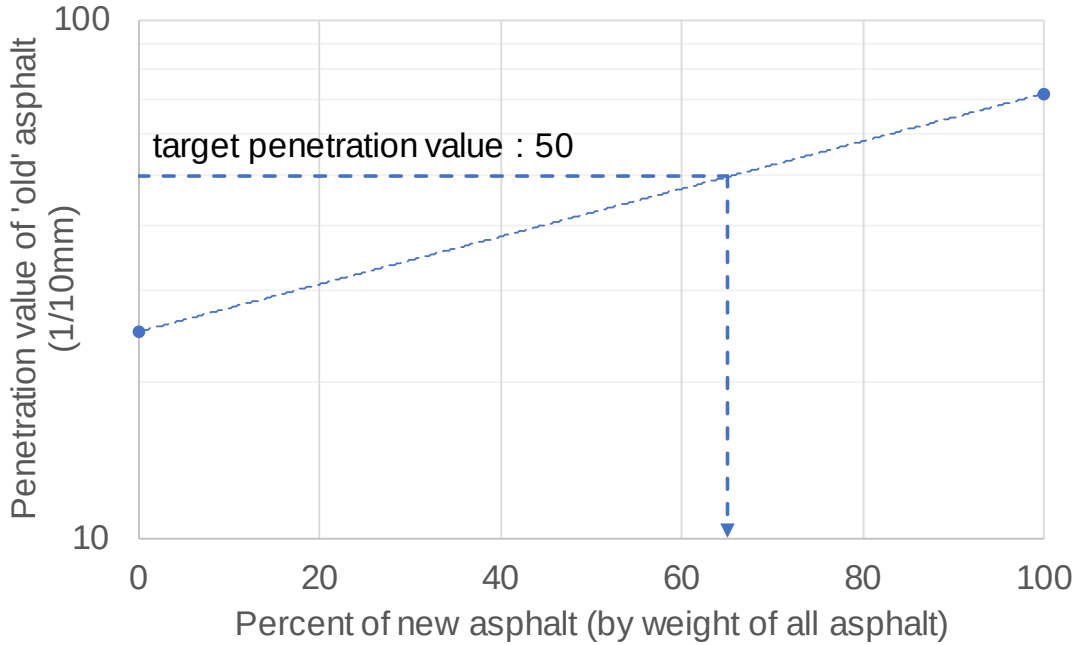
Mixture Design in Japan

- Set the target values of the design penetration value of combined asphalt or the splitting strength ratio value
  - ✓General design penetration value : 50 (1/10mm)
  - ✓General design splitting strength ratio value : 0.75 (MPa/mm)
- Calculate combination ratio of all aggregates including RAP to meet mixture gradation
  - ✓RAP content is usually limited by gradation and/or a plant equipment
- Determine usage of rejuvenator or new soft asphalt
  - ✓Rejuvenator is used when RAP content is relatively high, whereas new soft asphalt is used when RAP content is relatively low

Determine Usage of Rejuvenator or New Soft Asphalt

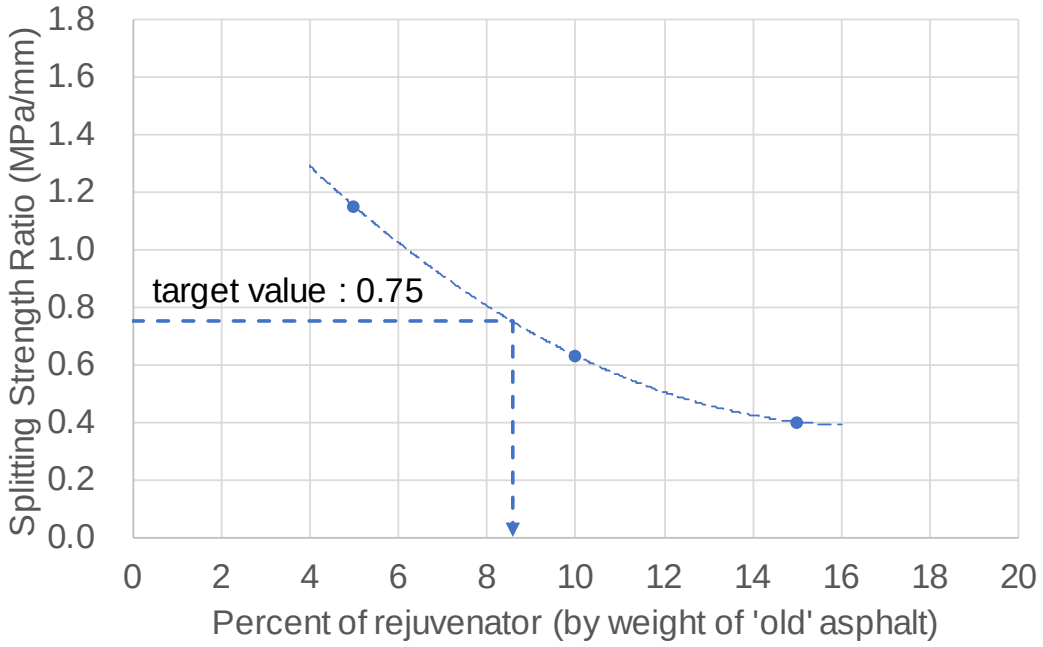
- Penetration Value Method
  - ✓ Usage of rejuvenator or new soft asphalt is determined to meet the design penetration value

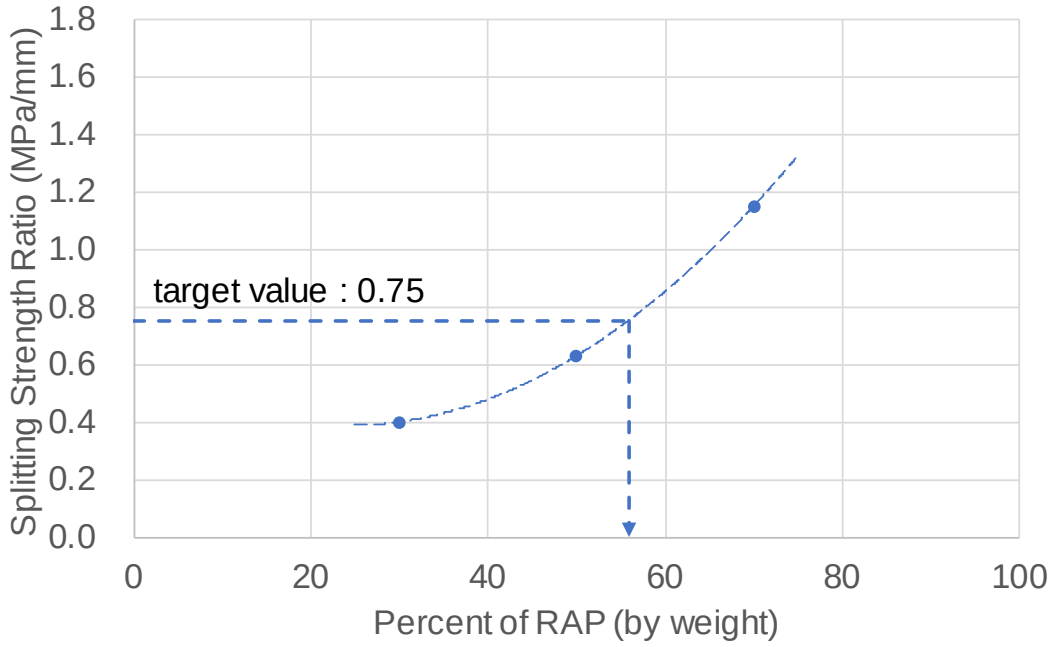




Splitting Test Method

- ✓ Usage of rejuvenator or new soft asphalt is determined to meet the design splitting strength ratio value





- Determine optimum asphalt content by the Marshall volumetric design method to meet mixture specifications
- Confirm mixture property for rutting resistance by the wheel tracking test

- Wheel tracking test
  - Specimen size : 300mm * 300mm * 50mm
  - Tire : 200mm in diameter, 50mm in thickness
  - Load : 686N
  - Loading speed : 42 passes/min
  - Test temperature : 60^{o}C
  - Testing time : 60 minutes or displacement is 25mm

- Recycled asphalt pavement is ascribed to virgin HMA if all performance of recycled asphalt pavement meets specifications for virgin HMA
  - ✓Some properties like rutting resistance from wheel tracking test shows greater result than virgin HMA. Is it acceptable ?

3. Recycled Asphalt Pavement Production

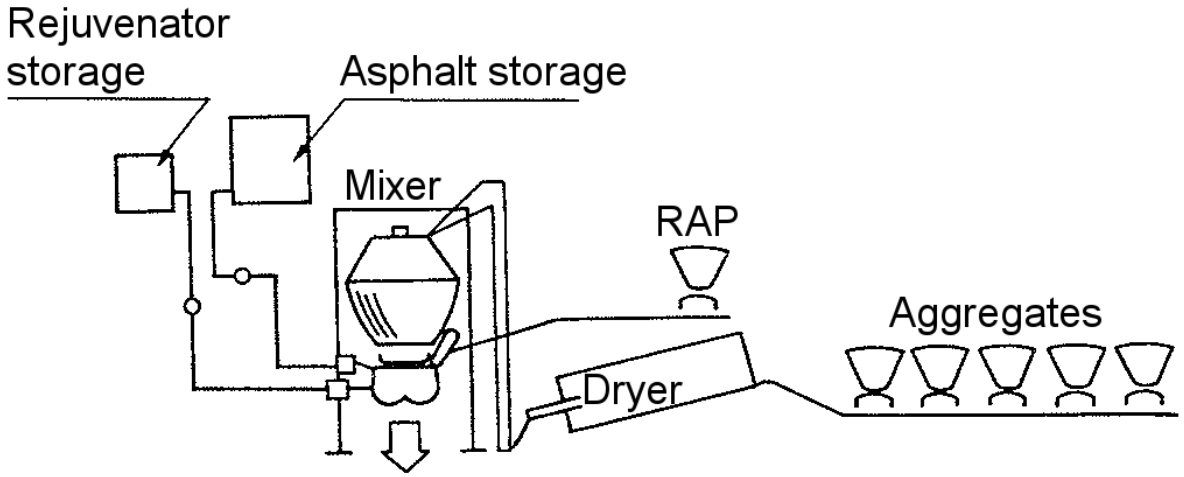
Recycled Asphalt Pavement Production in Japan

- Almost asphalt plants are batch plants in Japan
- Basically three methods
  - ✓Indirect RAP heating method
  - ✓Dual dryer method
  - ✓Drum dryer method

Note : Above expressions may not be correct

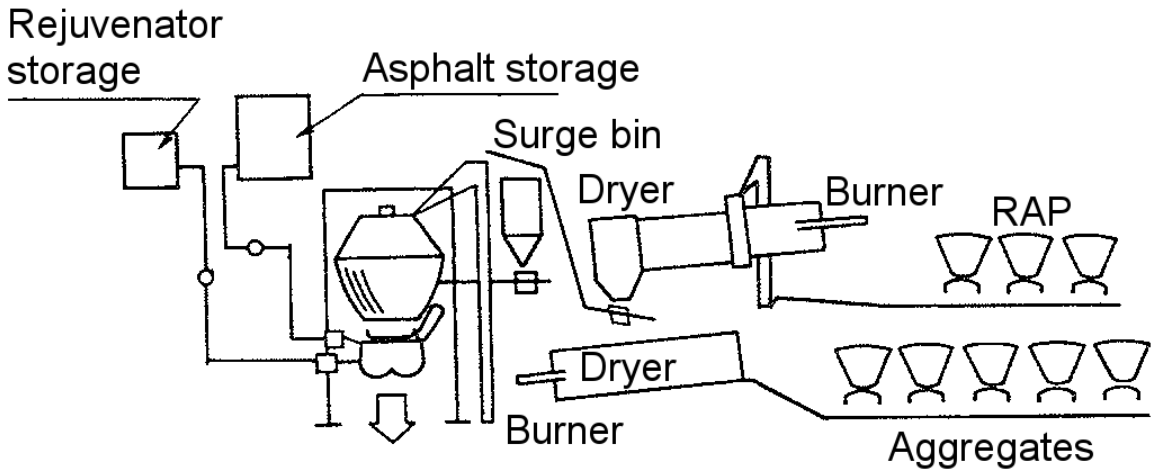
Indirect RAP Heating Method

- Virgin aggregates : Heated by a dryer
- RAP : Mixed with heated virgin aggregates, asphalt and rejuvenator in the mixer
  - ✓Heat-exchange mechanism
- General RAP content is 30% or less
  - ✓The higher RAP content, the higher temperature of virgin aggregates required. This leads to deterioration of recycled asphalt pavement.



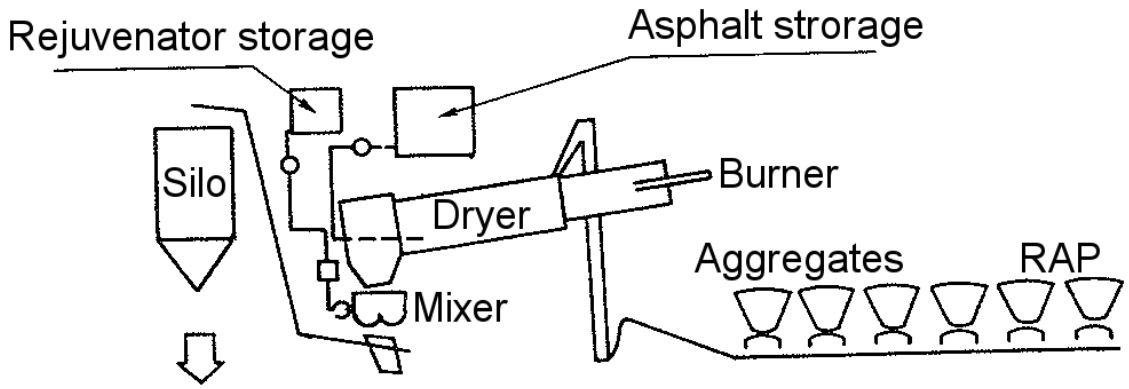
Dual Dryer Method

- Virgin aggregates : Heated by a dryer
- RAP : Heated by another dryer
- General RAP content is 30 – 60%



Drum Dryer Method

- Virgin aggregates : Heated by a dryer
- RAP : Heated by same dryer together
- General RAP content is 60% or more



4. Point at Issue – what to look out for

a. Mixture design
b. Rejuvenator or soft asphalt
c. Recycled asphalt pavement production

Mixture Design

- Penetration value of RAP is decreasing
  - ✓Recycled several times
  - ✓Increasing polymer modified asphalt (PMA)
    - Separating removed asphalt material using PMA from all material is impossible
- This is one of the reasons the splitting test method has been introduced
  - ✓Sometimes hard to recover aged asphalt to a target penetration value
- The splitting test method is under revising currently in Japan

Rejuvenator or soft asphalt

- Penetration value is the only performance index for recovered asphalt in Japan
  - ✓Does rejuvenator work well after only tens of seconds of wet-mixing and/or tens of minutes of hauling?
  - ✓Recovering compounds of asphalt (alkanes, aromatic hydrocarbons, resins and asphaltenes) is expected in the U.S.A. and other countries
  - ✓Some rejuvenators to recover asphalt compounds are commercially available

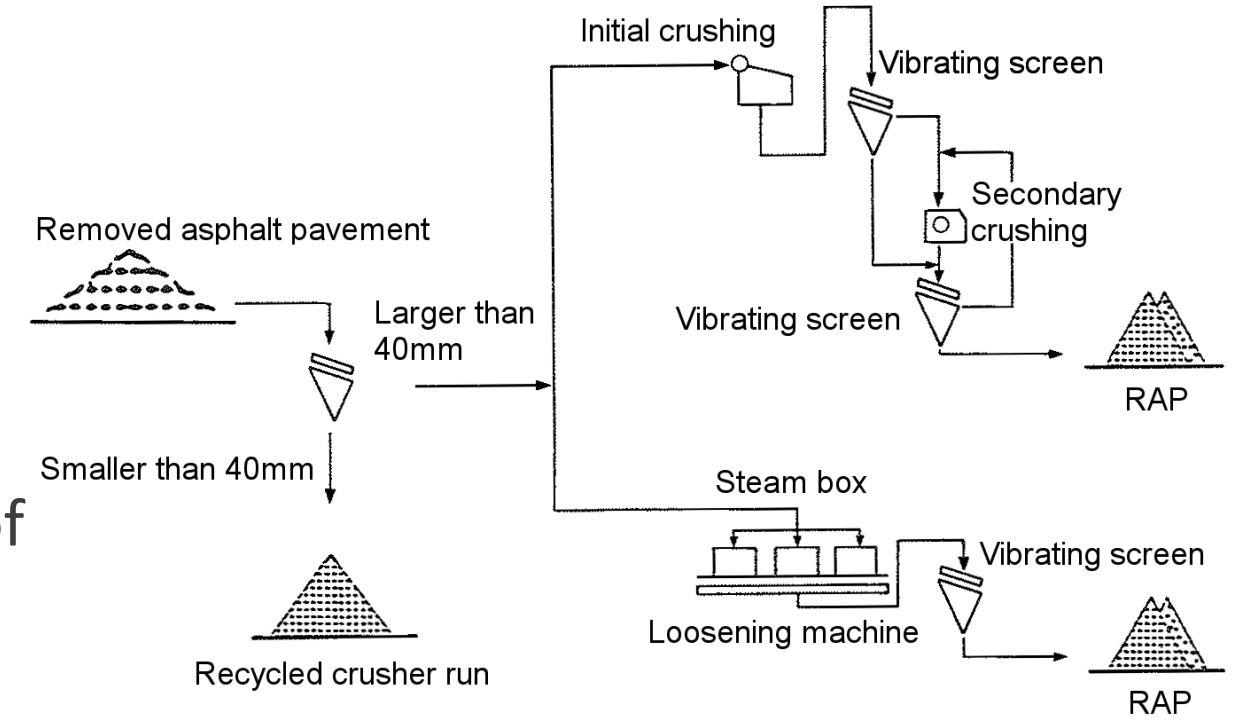
- Is there any problem if RAP is considered as ‘black’ aggregate ?
  - ✓The splitting strength ratio is thought to follow this concept
  - ✓A chemical agent has been developed and used. This agent does not affect to asphalt property but acts like rejuvenator with very small dosage
    - Katsura Endo et.al. : STUDY ON QUALITY IMPROVEMENT OF RECYCLED ASPHALT PAVEMENT, 8th International Conference on Maintenance and Rehabilitation of Pavements (MAIREPAV8), Singapore, 27–29 July 2016

Recycled Asphalt Pavement Production

a. Ensuring sufficient supply of RAP
b. RAP size control
c. Moisture control of RAP
d. Cost effective ?

Ensuring Sufficient Supply of RAP

- RAP can not be produced without removed existing asphalt pavement
  - ✓Legislation maybe required
- Producing 1 ton of RAP requires several tons of removed asphalt pavement
  - ✓This leads to a kind of limitation of RAP content



- If you want to increase RAP content to drop in production cost of recycled asphalt pavement, it requires enough RAP storage

RAP Size Control

- It is sometimes difficult to meet a target mixture gradation when uses R13-0
  - ✓R13-0 sometimes has small amount of fine particles passing 2.36mm sieve
  - ✓Using classified RAP ,i.e. R13-5 and R5-0, is one of the solutions, but R13-5 remains after R5-0 is consumed in this case
    - This is also one of the reasons that HMA with higher RAP is difficult to produce

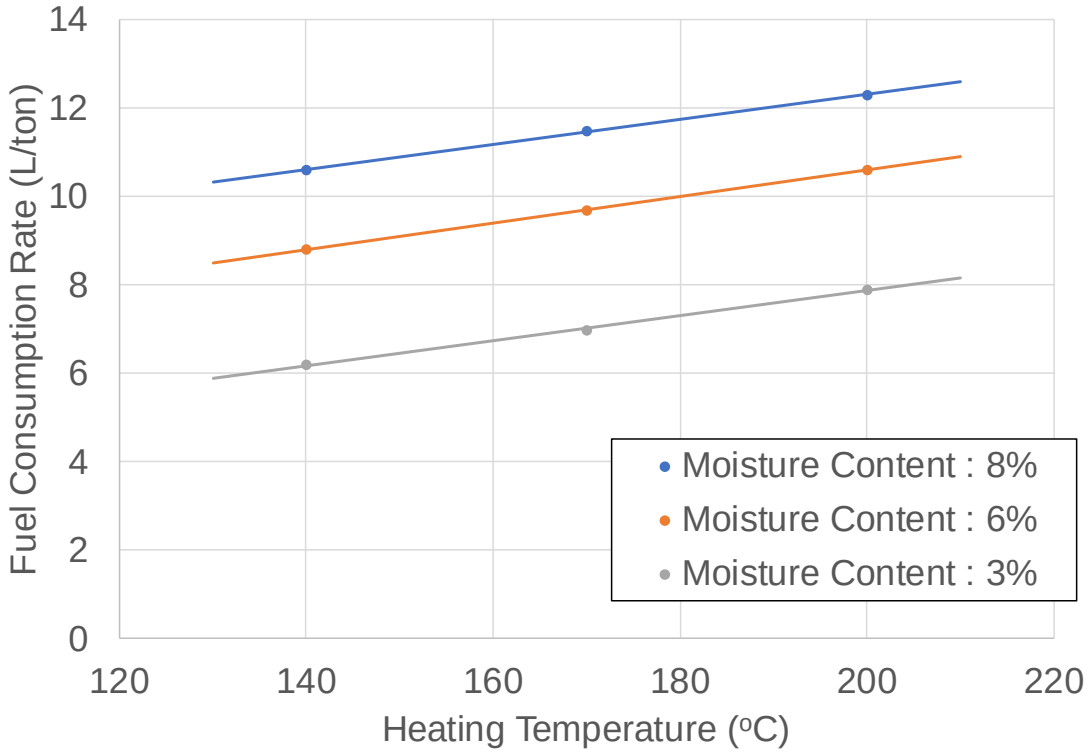
Moisture Control of RAP

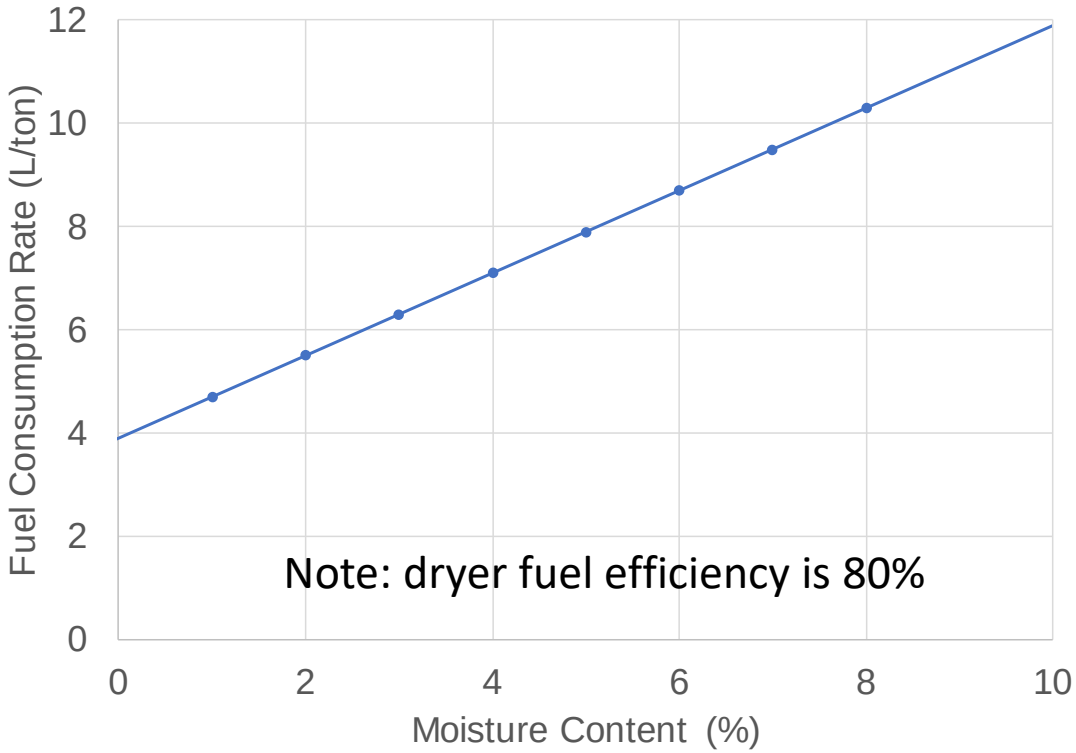
- Moisture content of RAP affects to heating temperature to evaporate water well

	Case1	Case2	Case3
Moisture Content of RAP (%)	146.5	154.5	163.0
Heated Temperature of RAP (°C)	3.4	2.6	4.0
Moisture Content of RAP after Heating (%)	2.5	0.4	0.0

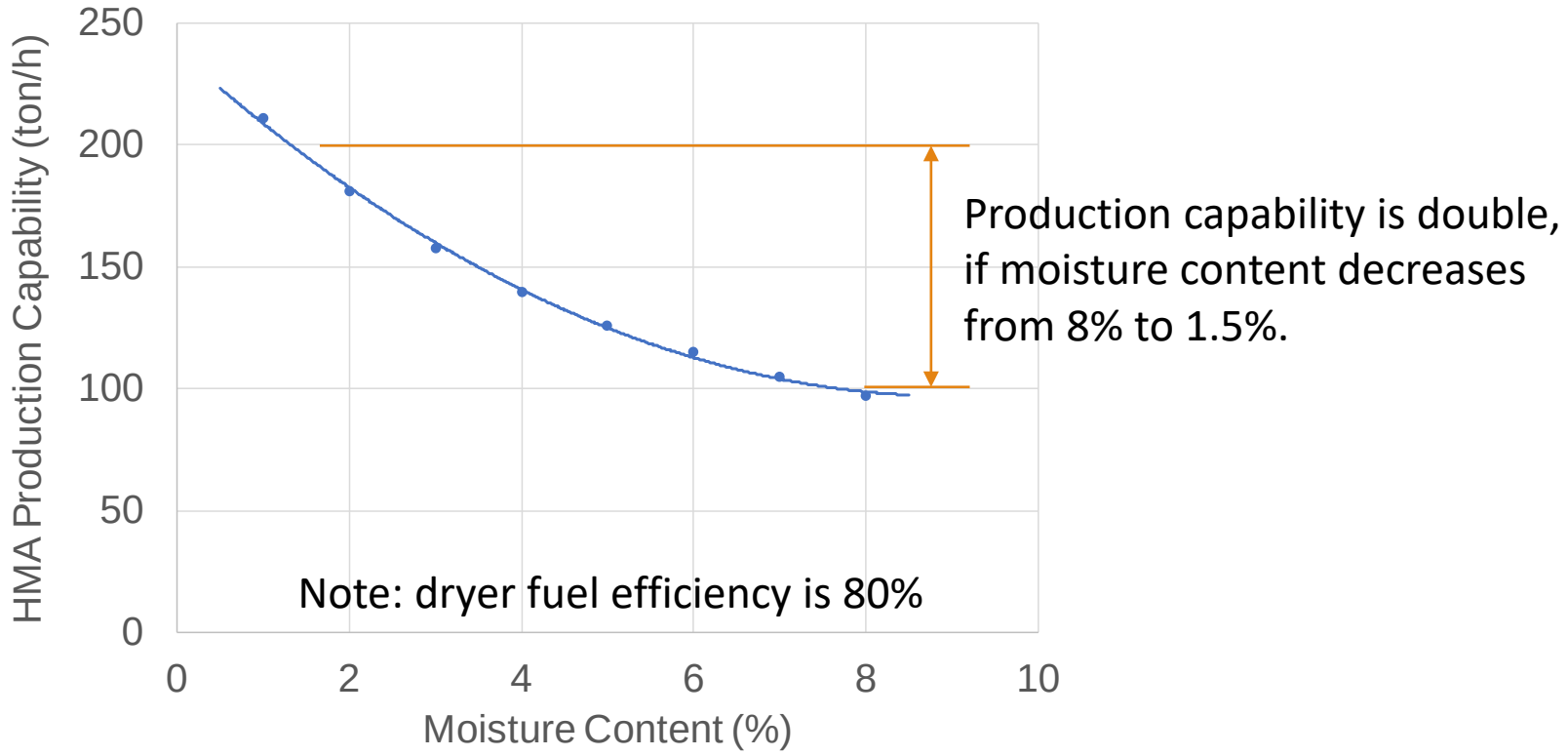
- Remaining water in RAP leads to temperature drop during hauling HMA to construction sites and makes recycled asphalt pavement workability worse

Heating temperature affects to operation cost of a plant





- Moisture content also affects to HMA production capability



Cost Effective ?

- RAP producers get both removed asphalt pavement and its disposal fee from waste generators
  - ✓Then RAP is cheaper than virgin aggregates and recycled asphalt pavement is cheaper than virgin HMA
- Recycled asphalt pavement is more cost effective if well moisture control takes place

Summary and Recommendations

1. Introduction

- Recycled asphalt pavement has been used since late 1970s and now is a major HMA in Japan
- Recycling-related legislation supported popularization of recycled asphalt pavement

2. Recycled Asphalt Pavement in Japan

- Specification of RAP is based on penetration value or splitting strength ratio of ‘old’ asphalt
- Mixture design is base on a concept to determine rejuvenator volume or new soft asphalt content to meet a target penetration value or splitting strength ratio, and it is conducted through the Marshall volumetric design method

- Recycled asphalt pavement is ascribed to virgin HMA if all performance meets specifications for virgin HMA, however some test results are questionable

3. Recycled asphalt Pavement Production

- Most asphalt plants are batch-type and basically three methods in Japan
- General RAP content depends on which method is adopted

4. Point at issue – what to look out for

- Adaptive mix design to increasing RAP content, several generation of recycling and PMA
- How to recover aged asphalt ideally with rejuvenator or soft asphalt ,or using a new agent will be another option
- How to ensure sufficient supply of RAP
- Better moisture control of RAP leads to better quality of recycled asphalt pavement and more cost effective

Thank you for your kind attention.