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Investigation of reclaimed asphalt pavement batching process in an asphalt mixing plant

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International Conference ASPHALT PAVEMENTS 2015

24th – 25th November 2015, České Budějovice, Czech Republic

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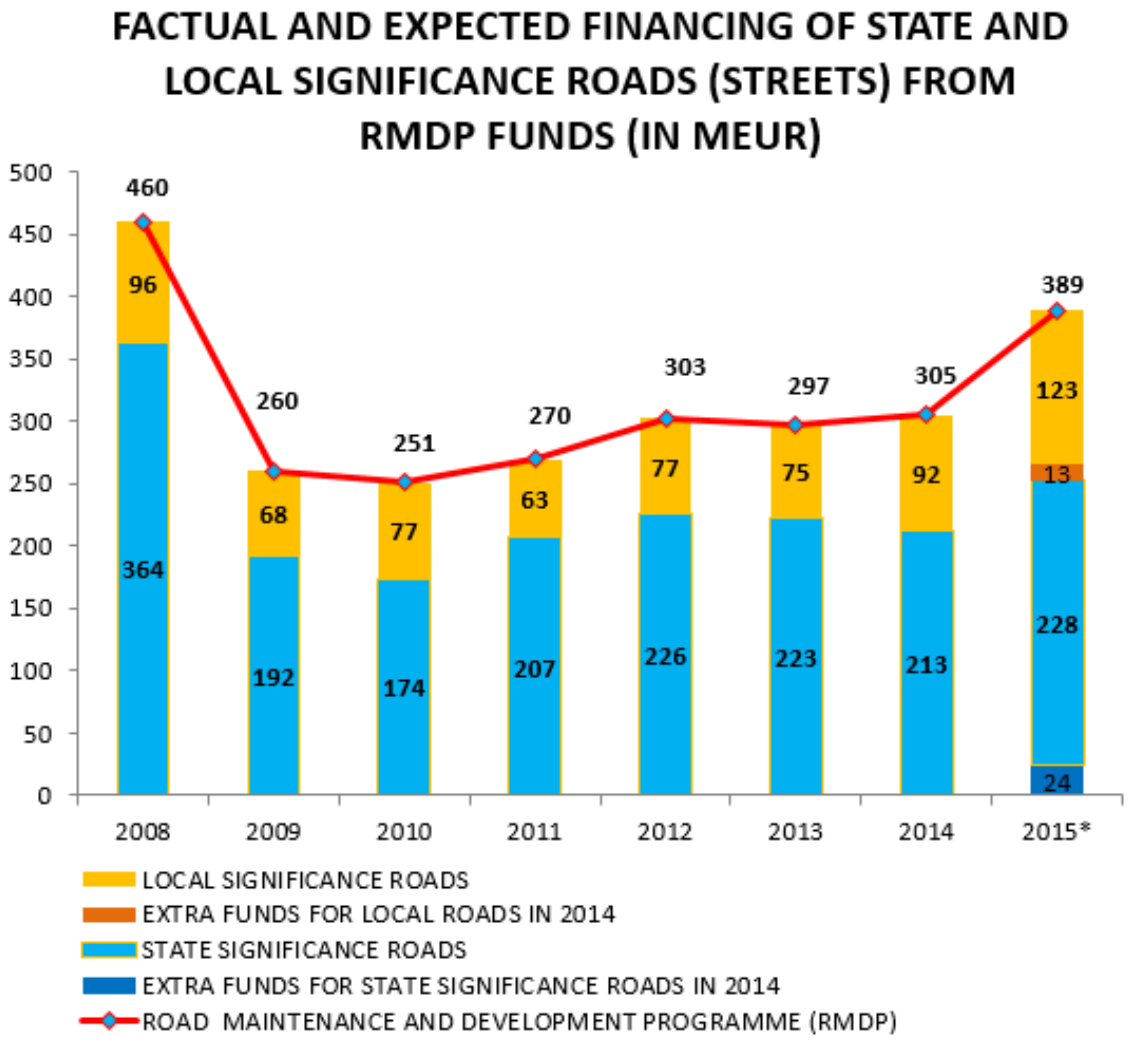
Relevance of the problem

- 13.984 km of asphalt concrete pavement roads in Lithuania

- 7.198 km of gravel roads in Lithuania



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Asphalt – 100% recyclable

- Arguments to increase / promote recycling are:
- it saves virgin materials;
- it saves limited natural resources, minimizing environmental impact;
- it contributes to sustainability;
- the quality of asphalt containing RAP is (at least) as adequate as asphalt containing virgin materials only;
- it is (or can be) financial attractive;
- it avoids landfill and a burden for future generations;
- it is good for the image of the industry
- European standards give the possibility to use RAP in the asphalt mixtures
- there is a European standard for RAP
- some countries have already more than 30 years of experience - asphalt is 100% recyclable / re-usable

(EAPA, 2015)

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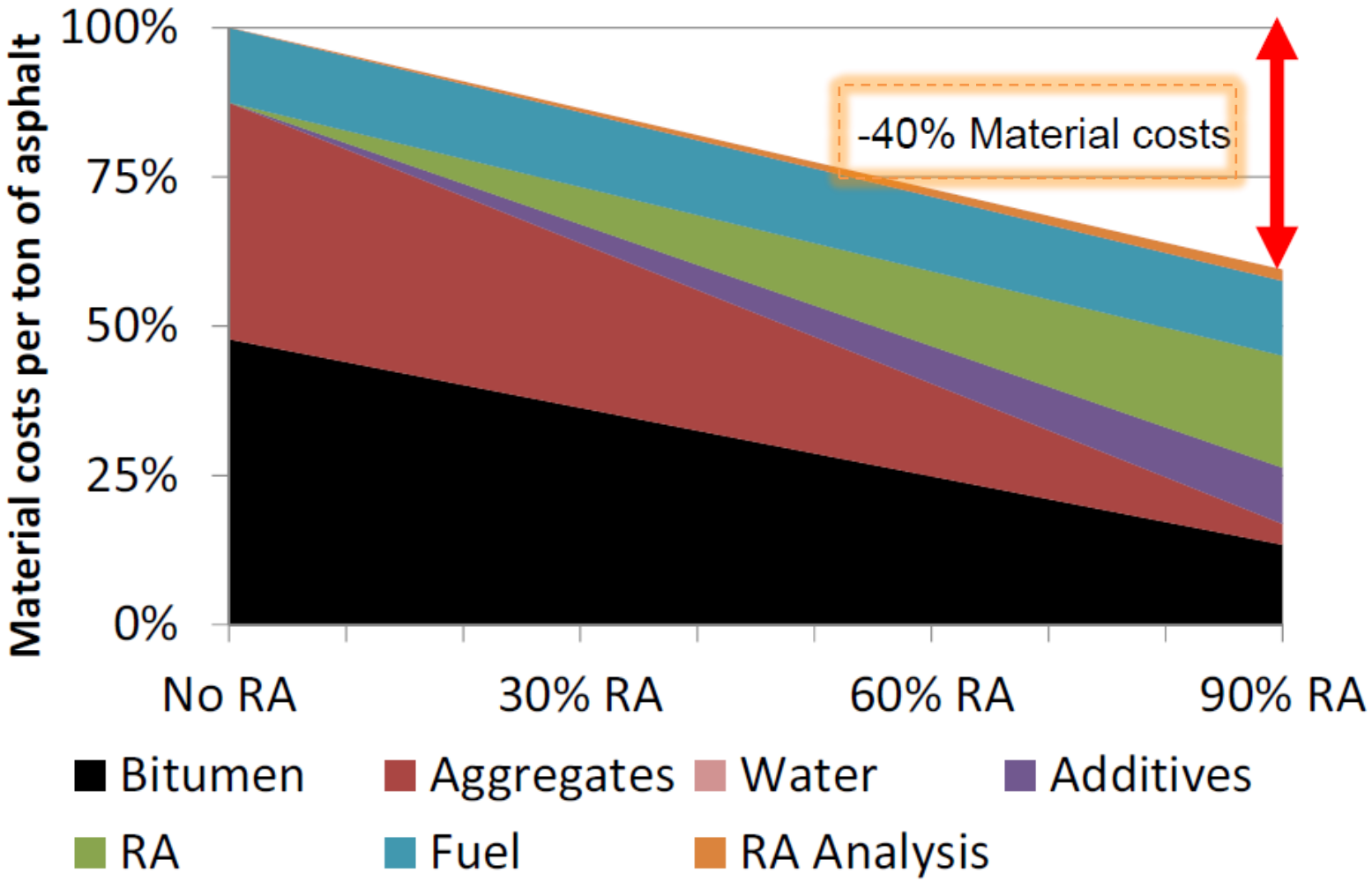
Cost Benefits from Recycling Asphalt



(Ammann, 2013)

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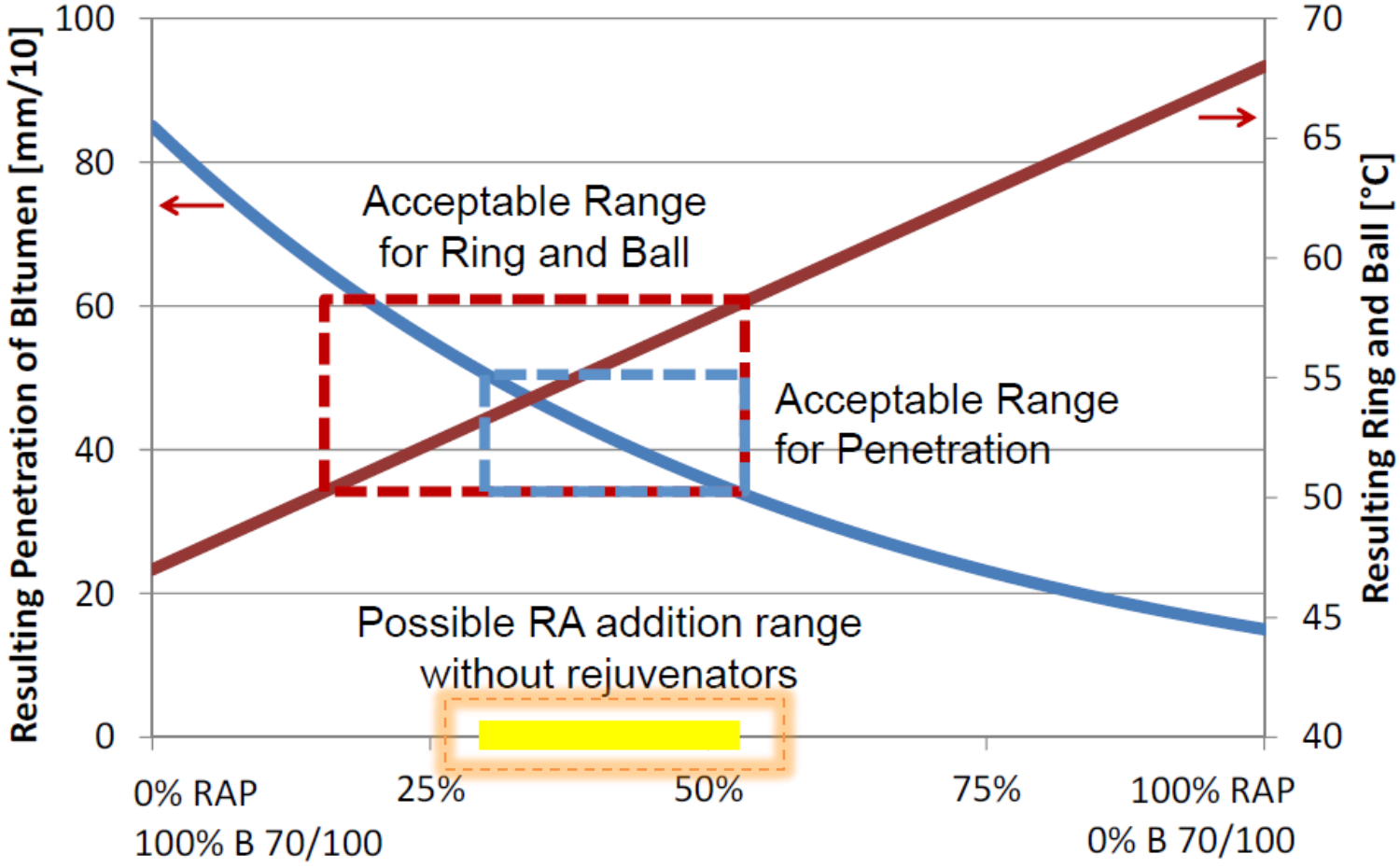
Using RAP = Blending of Bitumen



(Ammann, 2013)

The system of scientific principles of hot asphalt pavement recycling

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The Principles of Asphalt Pavement Hot Recycling

1. Necessity to break up an asphalt pavement course into granules, lumps or slabs (pieces of lumps)
2. Necessity to separate components of the composite physically
3. Decomposing of mechanically or thermo-mechanically impacted RAP through matrix, i.e. a bitumen film and air voids
4. Not damaging the mineral components separable from each other and a bitumen binder
5. Water content removal from the recycled material of asphalt pavement
6. Necessity to blend mechanically: free or/ and forced movement of separate components in space
7. Formation of the largest possible surface of reclaimed bitumen films to be coated with a rejuvenator
8. Capability of a rejuvenator (additive) to cover all mineral particles uniformly and due to diffusive blending to permeate into reclaimed bitumen films
9. Retardation of bitumen oxidized ageing during the technological process of recycling
10. Failure to remove reclaimed bitumen and/ or part of any mineral aggregate‘s fraction from the recycled asphalt mixture
11. Compliance of the designed recycled asphalt mixture (RAM) quality indicators with the design specification requirements
12. Compliance of *in-plant* or *in-place* (on the road) recycled asphalt mixture composition and properties with the job-mix-formula

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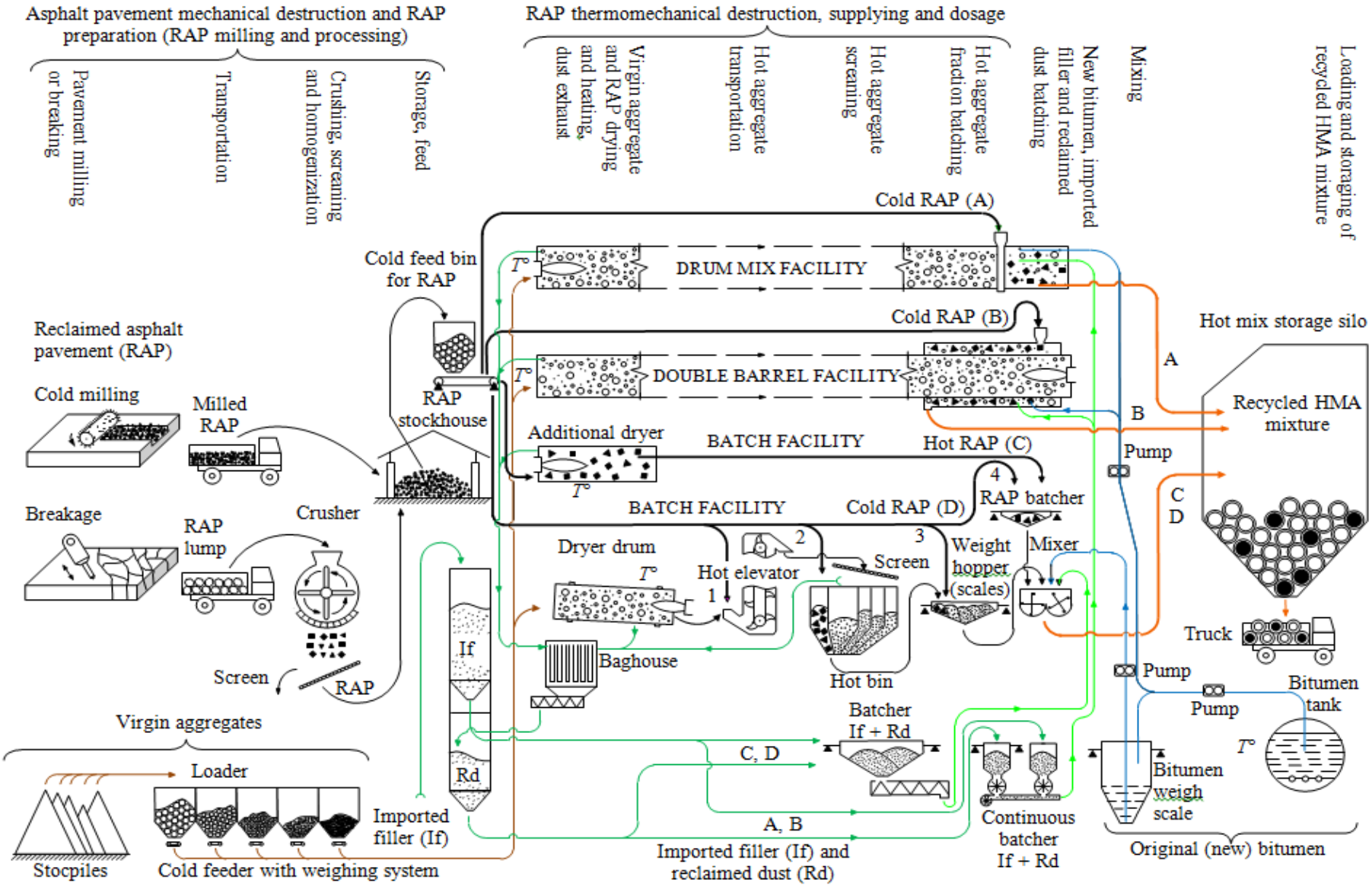
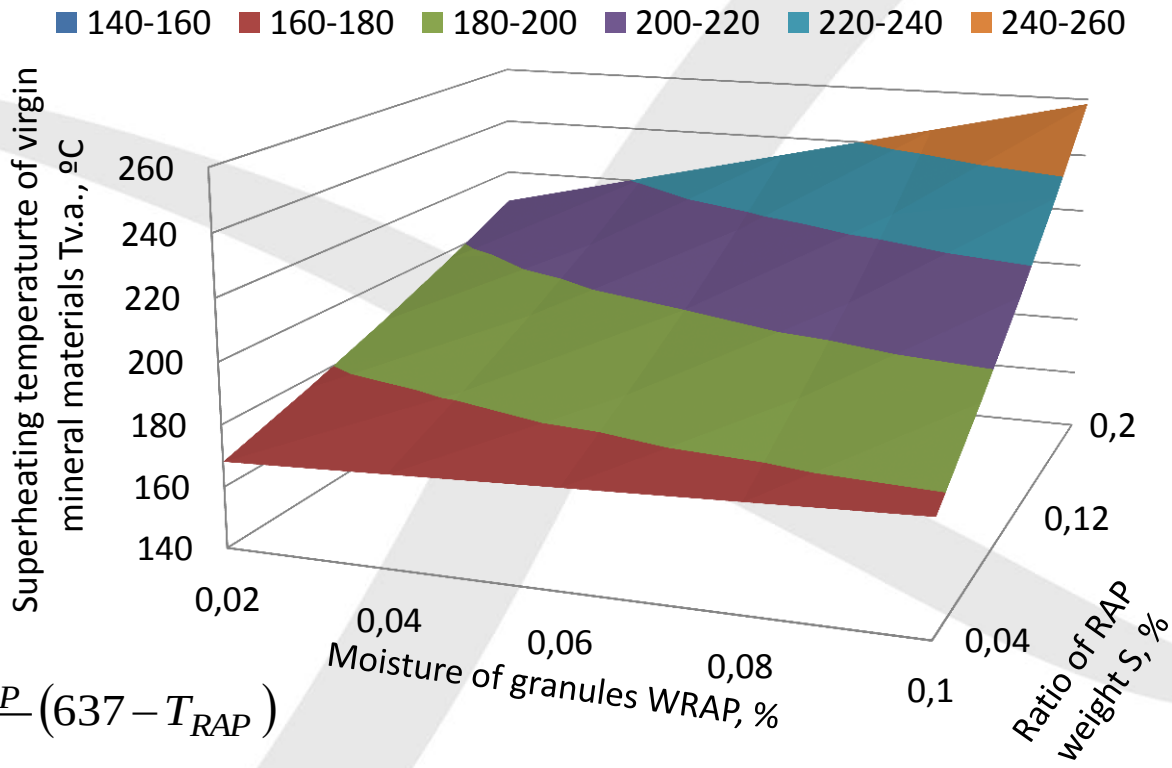
The model of asphalt pavement recycling operations and equipment used in batch plant (C, D), drum mix (A) and a double barrel-drum mix (B) when RAP is supplied and dosed to different places



Dependence of superheating temperature of virgin mineral materials on the ratio of RAP weight and moisture of RAP granules

When applying the first heat transfer method, superheating temperature of virgin mineral materials (aggregate) is calculated according to the following empirical formula applied in practice:



$$T_{v.a.} = \frac{T_{RHMA} - S \cdot T_{RAP}}{1 - S} + \frac{4 \cdot S \cdot W_{RAP}}{1 - S}\left(637 - T_{RAP}\right)$$

where $T_{v.a.}$ – superheating temperature of virgin mineral materials (aggregates), °C; T_{RHMA} – required temperature of RHMA, which depends on the grade of the bitumen binder, °C; S – ratio of RAP granules' batching mass in the RHMA mixture, in units; T_{RAP} – temperature of RAP granules °C; W_{RAP} – moisture (water content) of RAP granules, in units.

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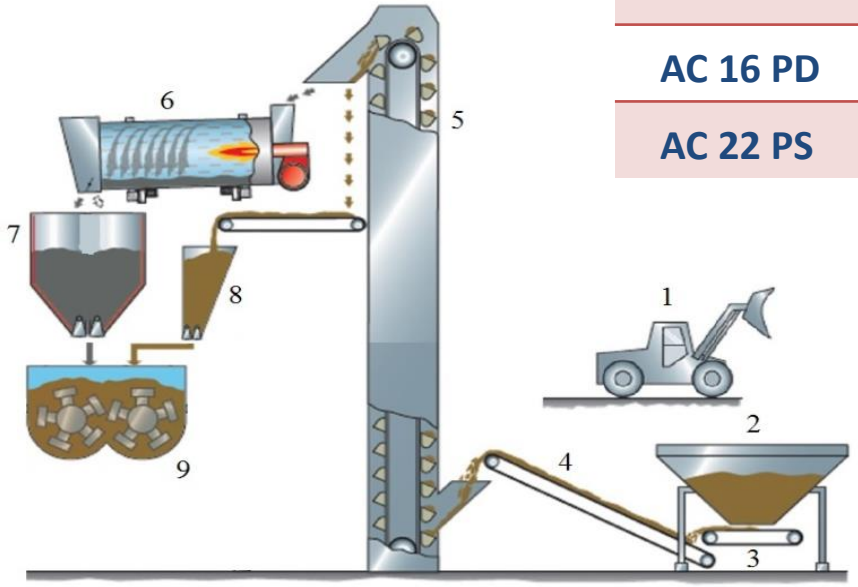
RAP batching accuracy and precision

Sample sizes of the data used in the investigation

Type of HMA	Days	Total sample size	Sample size without outliers
AC 16 PD	10	1424	1324
AC 22 PS	12	1617	1569



The technological scheme of RAP hot and cold recycling in batch type AMP

The following mixture for a road pavement binder course of two types was produced in a batch-type AMP with preheated RAP: with 25 % and 50 % of RAP.

To investigate the accuracy and precision of RAP batching, technological data about RHMA mixtures produced in 2014 were used. AMP handling software presents rated (target) and factual data on the name and number of job-mix formula (JMF), weight, mixing time and temperature of each RHMA mix batch.

RAP batching accuracy and precision

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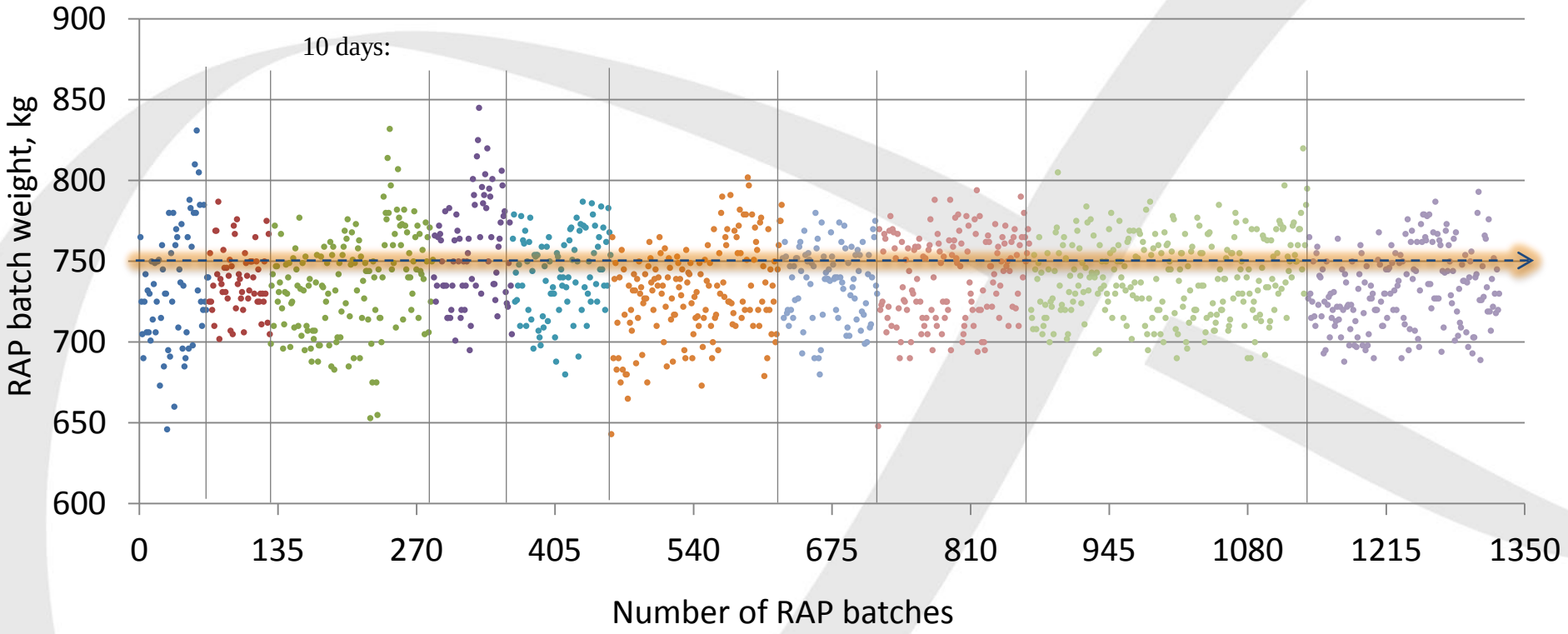

Distribution of RAP separate batch masses. when its job mix formula (JMF) is 750 kg

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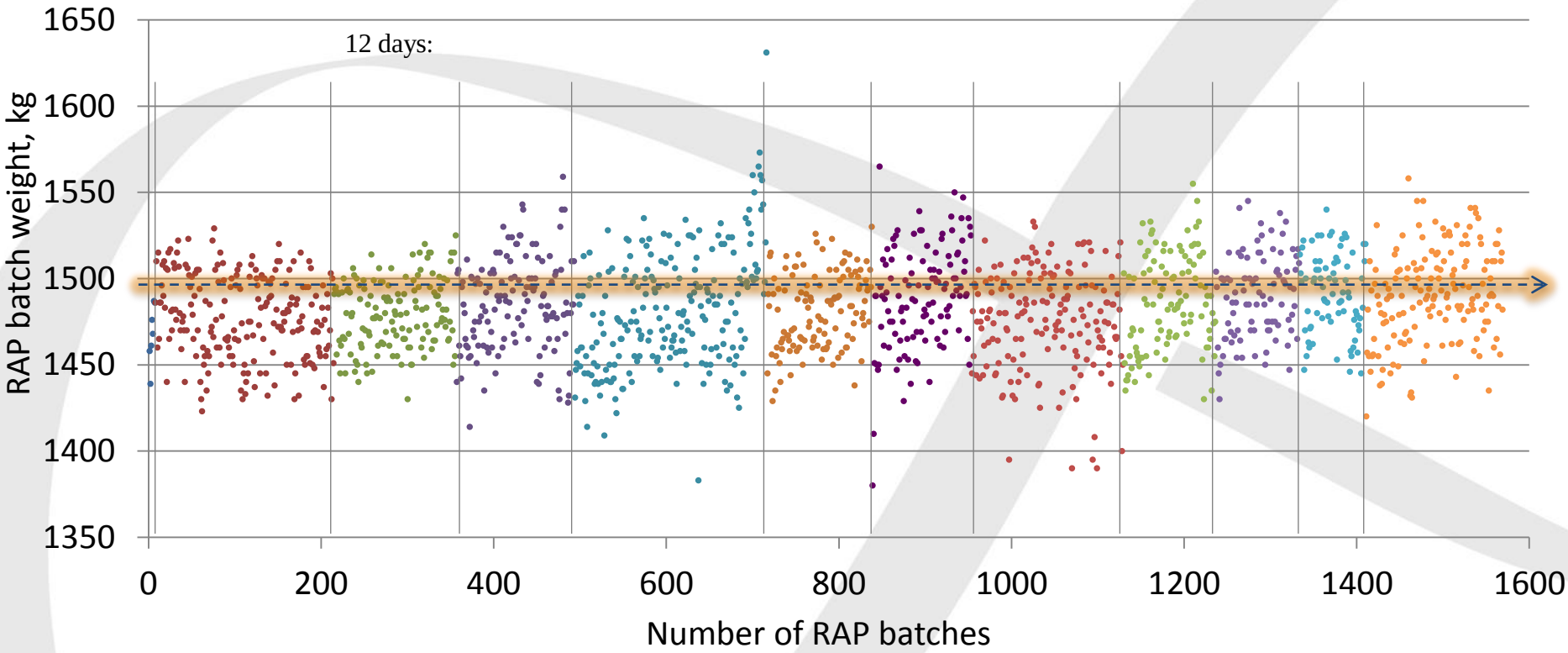
RAP batching accuracy and precision



Distribution of RAP separate batch masses. when its job mix formula (JMF) is 1500 kg

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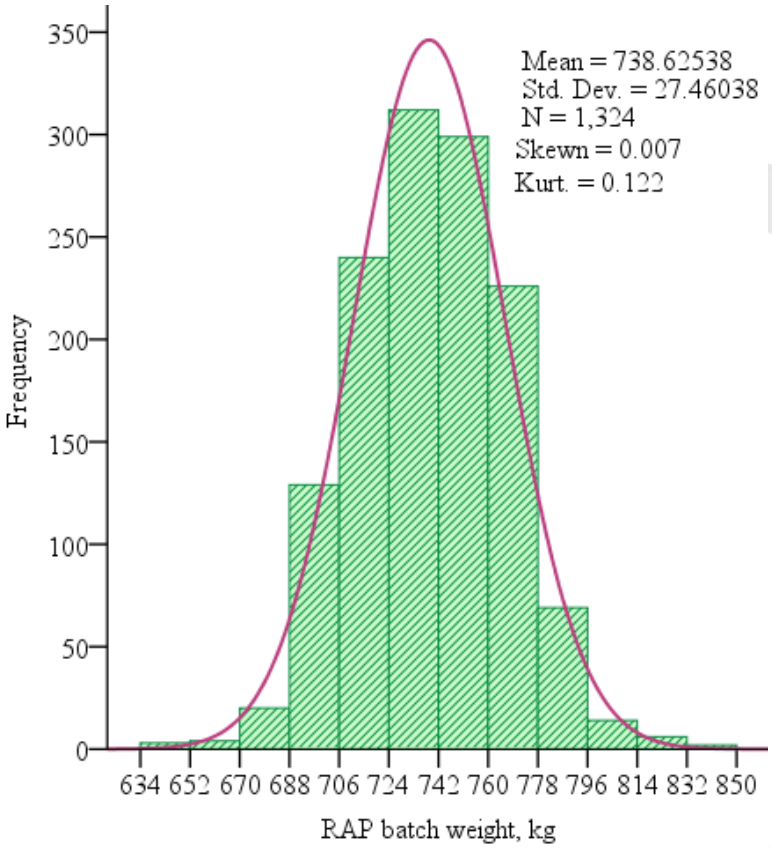
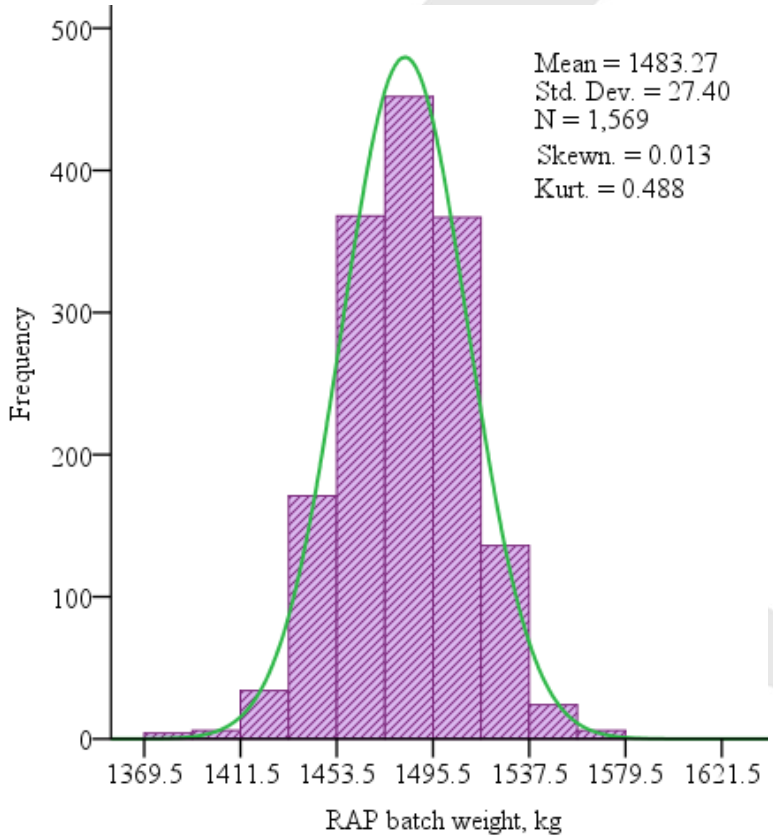
Distribution histograms, theoretical curves of normal distribution and statistical parameters of RAP batch masses in HMA batches of mixtures: a – AC 16 PD (750 kg); b – AC 22 PS (1500 kg).





Only 29 % of them (392 out of 1324) are within the range of permitted tolerances, when the estimated $q_{RAP,JMF} = 750$ kg and 51 % (803 out of 1569) when it was $q_{RAP,JMF} = 1500$ kg.

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Conclusions

- Aged asphalt pavement is recycled by employing the principles based on the latest scientific findings and industrial know-how. Twelve principles are presented and analysed in this paper. The application of these twelve road asphalt pavement hot recycling principles enables to expect the best possible structure and pavement of the reclaimed asphalt pavement course. These principles may be used for asphalt pavement hot-in-place surface recycling and hot-mix in-plant recycling.

- The component composition of HMA mixture with less than 100 % of RAP developed in a laboratory as accurately and precisely as possible shall be guaranteed when producing it in an asphalt mixing plant. Inevitable systematic and random errors of batching RAP increase the deviations of recycled asphalt component content from JMF and their variation. The size of errors depends on AMP structure, technical condition, RAP percentage in recycled asphalt and AMP operator‘s actions when setting the technological parameters of the recycling process and handling them.

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Conclusions

- The factual parameters of RAP batching process may be determined by measuring a rather large sample size of RAP batch mass according to the data collected by AMP software and processing them through the use of mathematical statistical methods. In 2014, one of the Lithuanian companies provided representative data on RAP batches weighed in an AMP batcher equipped with a parallel RAP dryer. According to JMF, RAP content was 25 % (750 kg batch mass, 10 days, n = 1324 batches) and during the investigation, it was 50 % (1500 kg batch mass, 12 days, n = 1569 batches). The mean of 738.6 kg of all AMP batches with its required content of 25 % mass was less than 750 kg by 1.52 %, and with the required RAP content of 50 %, the mean of 1483.3 kg was less than 1500 kg, i.e. by 1.1%. Due to the high variation of the batch mass of separate RAP, the tolerance of ±1.5 % was met only by 29.6 % and 51.5 %, respectively, of all RAP batches. The accuracy and compliance of batch masses with tolerances increases when a higher percentage of RAP is batched.

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Conclusions

- The standard deviation mean calculated from two standard deviations (s_q =27.46 kg and s_q =27.40 kg) was 27.4 kg. The variation coefficient of RAP batch mass was 3.72 % (when RAP batch mass according to JMF was 750 kg) and approximately two times less (1.85 %), when according to JMF RAP batch mass was 1500 kg.

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