

1st International Conference on
Sustainable Construction Materials:
Design, Performance and Application
August 10-12, Wuhan, China

Feedback on pavement recycling

Dr. Liantong Mo
State Key Laboratory of Silicate Materials for Architectures
Wuhan University of Technology

Conference Location: Wuhan, China



Yellow crane Tower



First Bridge Cross Yangtze River

Conference Sponsors:



SusCoM2010



Main topics, but not be limited to

- Mix design methodology of concrete
- Hydration of cement and cementitious by-products
- **Processing, testing and application of recycled materials**
- Innovative application of **industrial by-products** in concrete
- High-tech concretes
- Technical durability of concrete
- Performance of bitumen and its modification
- Construction technologies
- Warm Mix Asphalt Technologies
- **Recycled asphalt pavement engineering**
- Functional asphalt pavement
- Constitutive modeling and simulation

Conference information

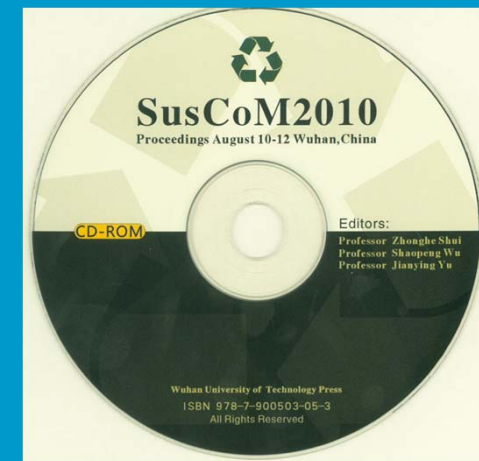
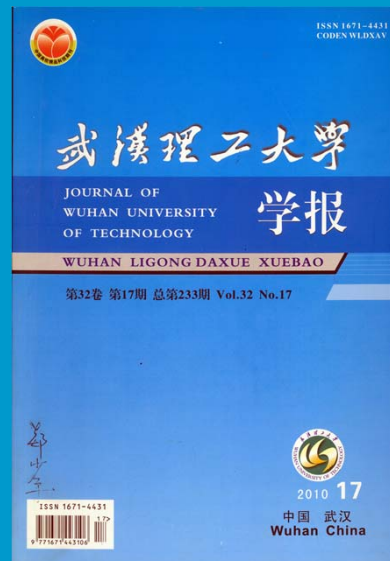
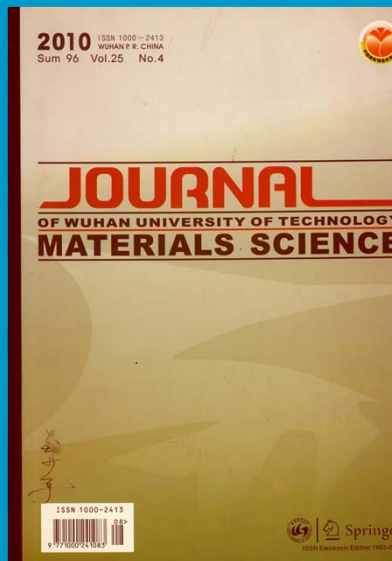
Received abstracts: 207

Accepted papers: 97

Presentations: 56

Supporting Journals: 2

CD: 1



90 delegates

12 different nations and regions



Papers and presentations on recycling and use of so-called waste materials

Institute, Nation/region	Number of Papers
Delft University of Technology, NL:	4
The Hong Kong Polytechnic University:	3
Kingston University, UK:	1
Stellenbosch University, South Africa:	2
Clemson University , USA :	1
Hohai Delft University, CN:	1
Huaiyin Institute of Technology, CN:	1
Wuhan University of Technology, CN:	1
Total:	14

Paper-1

Re-Use and Recycling of so called Waste Materials

Prof. A.A.A. Molenaar, Delft Univer. of Tech.

- Re-use of old asphalt is a well developed technique and much wider applied, but there is still very much to gain.
- Re-use and recycling need firm support from and should be enforced by legislation.
- The recycling and re-use era has just begun in road engineering.
- CDW and RAP are not waste materials but just other types of materials with intrinsically high values.
- CDW and RAP should be treated as “normal” materials.

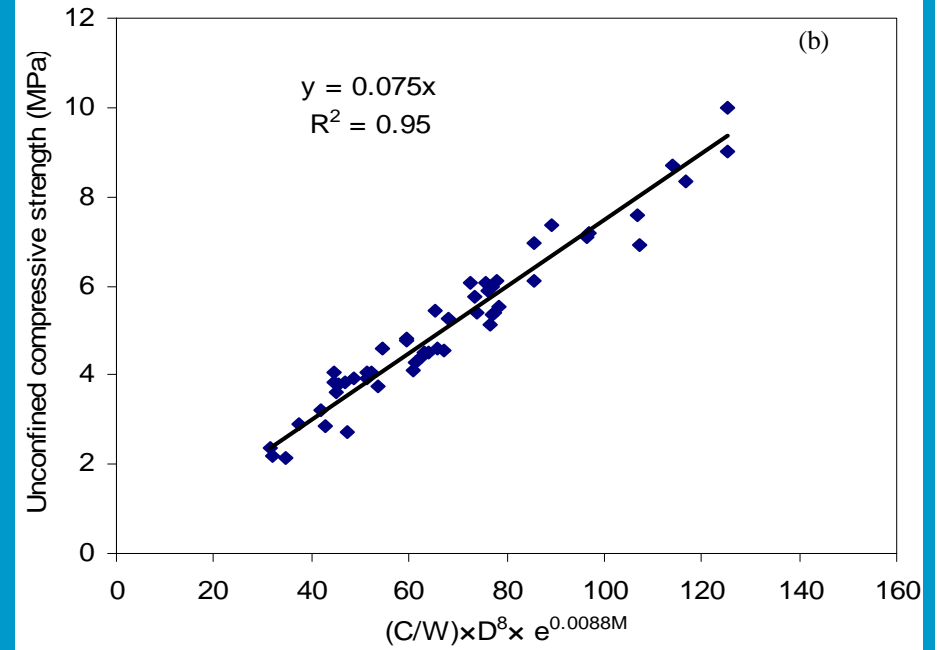
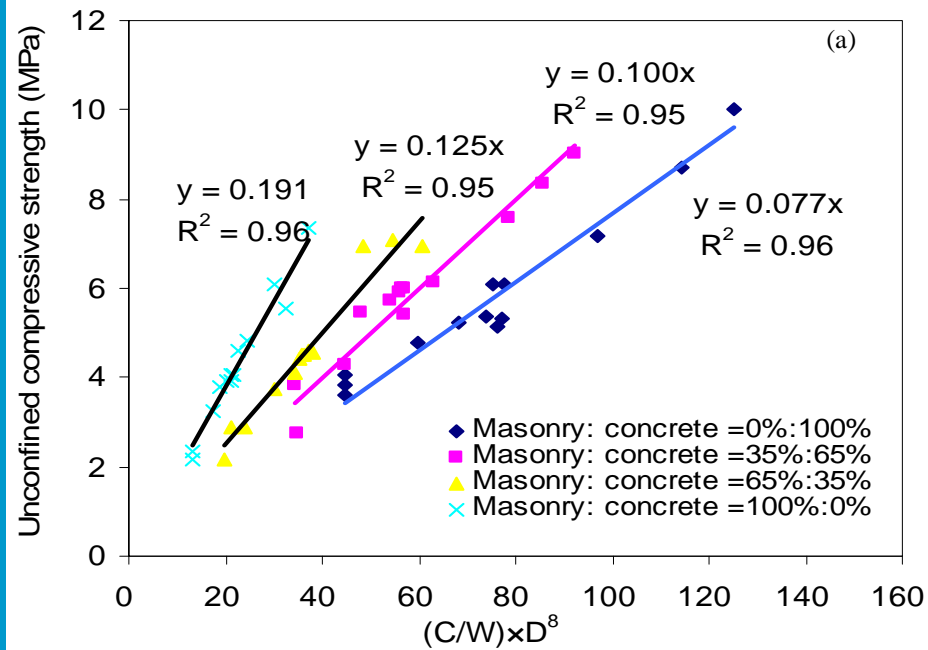
Paper-2

Cement treated recycled demolition waste as a road base material

D.X. Xuan, L.J.M. Houben, A.A.A. Molenaar, Z.H. Shui, Delft Univer. of Tech. NL

- Develop models to predict the mechanical parameters of CTGM which are needed for pavement design from material parameters like composition, cement content etc.
- Show the high potential of CTGM's for use as road base material.

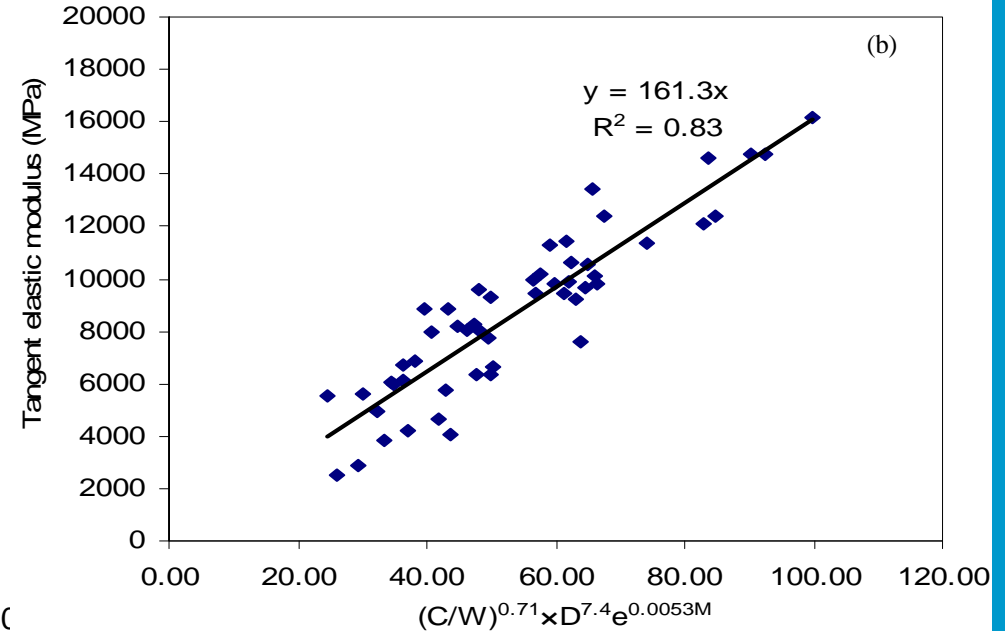
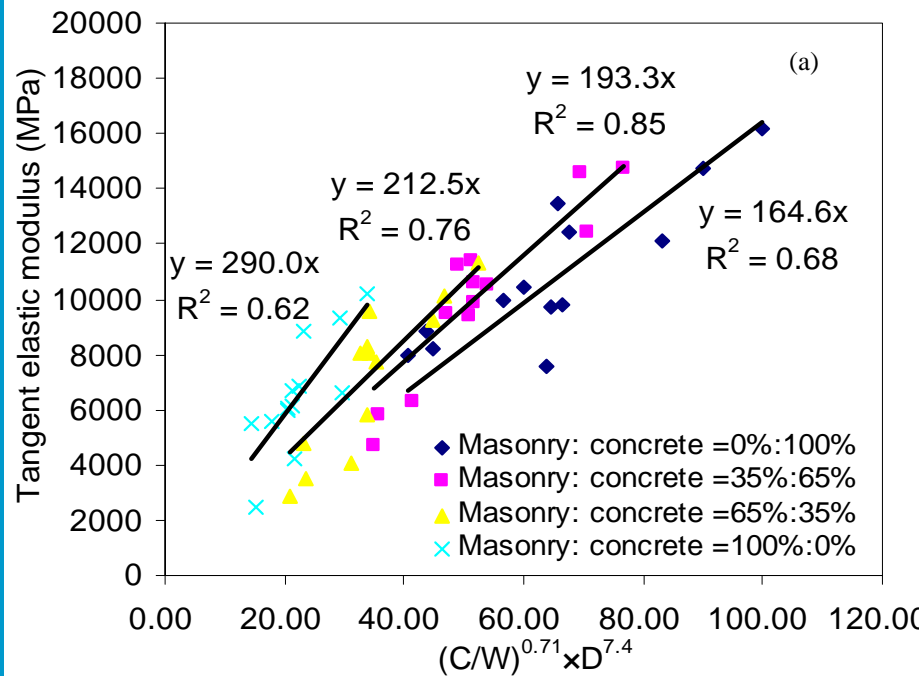
Compressive strength model



$$f_c = 0.0747 \cdot \frac{C}{W} \cdot D^8 \cdot e^{0.0088 \cdot M}$$

C: cement content;
W: water content;
D: dry density;
M: masonry content

Elastic modulus from compression test at 28 days



$$E = 161.3 \cdot \left(\frac{C}{W}\right)^{0.71} \cdot D^{7.4} \cdot e^{0.0053 \cdot M}$$

C: cement content;
 W: water content;
 D: dry density;
 M: masonry content

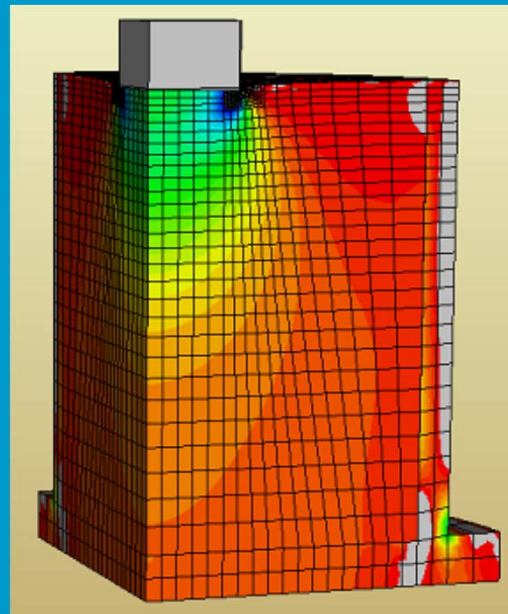
Paper-3

Assessing the resilient behavior of recycled mix-granulate with repeated load CBR testing

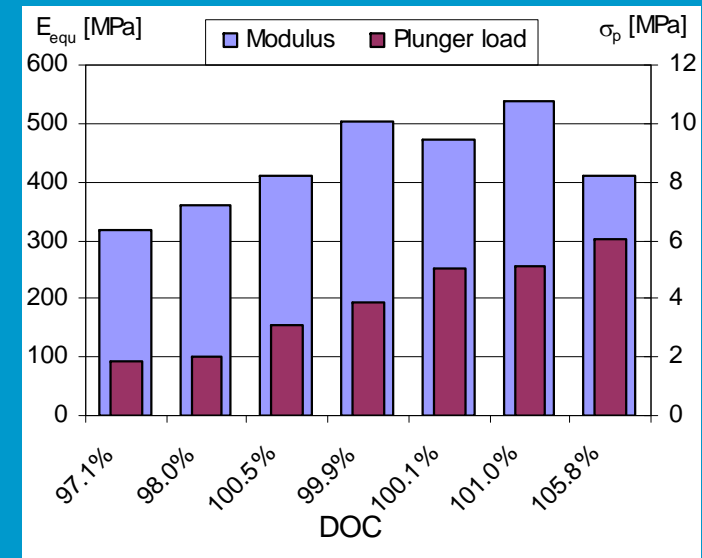
Araya A.A., Molenaar A.A.A., Houben L.J.M., Delft Univer. of Tech. NL



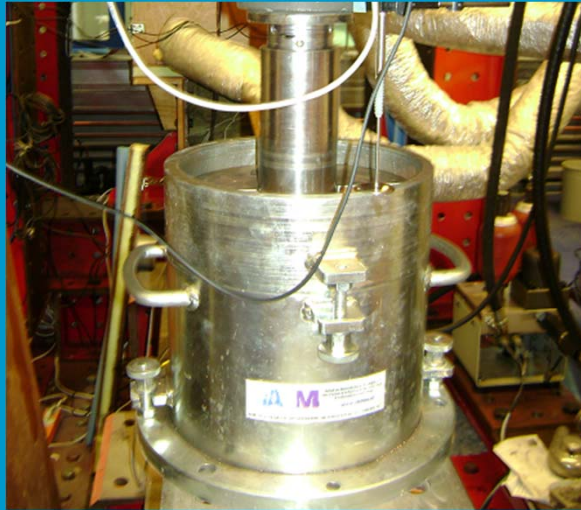
Testing



FE-modelling



Results



- The effect of the DOC on the mix granulate is elaborated in terms of strength property i.e. the penetration load required to penetrate 2.54 mm
- Cyclic triaxial test is not affordable to be used in day-to-day practice particularly in developing countries
- Affordable repeated load CBR test yields good estimate of Resilient Modulus

Paper-4

Recycling Wastes for Use as Construction Materials

Prof. C.S. Poon, The Hong Kong Polytechnic University

- Use of recycled coarse aggregates
- Prescribed grade 20 concrete mix with 100% recycled coarse aggregates
- Designed grade 25-35 concrete mix with 20% recycled coarse aggregates
- Sub-base materials for carriageways (recycled aggregates : virgin aggregates, 6 : 4)

- **Use of recycled fine aggregates is limited**

- limitations: Low workability, reduced strength and high shrinkage
- Feasible use on large scale: Pre-cast bricks and blocks



Eco brick



Recycled Aggregate



Recycled Aggregate + Recycled Glass



Recycled Glass + Recycled Aggregate + Photo-catalyst

Using C&D waste as rendering mortar

- ❖ Feasible use of the sorted construction waste for mortar applications
- ❖ Influence of recycled aggregates on properties of mortar.
- ❖ Long term behavior of mortar produced (e.g. drying shrinkage)
 - Water absorption, porosity and drying shrinkage of hardened mortar increased with increase in recycled aggregate content
 - Higher workability led to improved bond strength between the mortar and the brick

Paper-5

Properties of Cementitious Rendering Mortar Prepared with Recycled Fine Aggregates

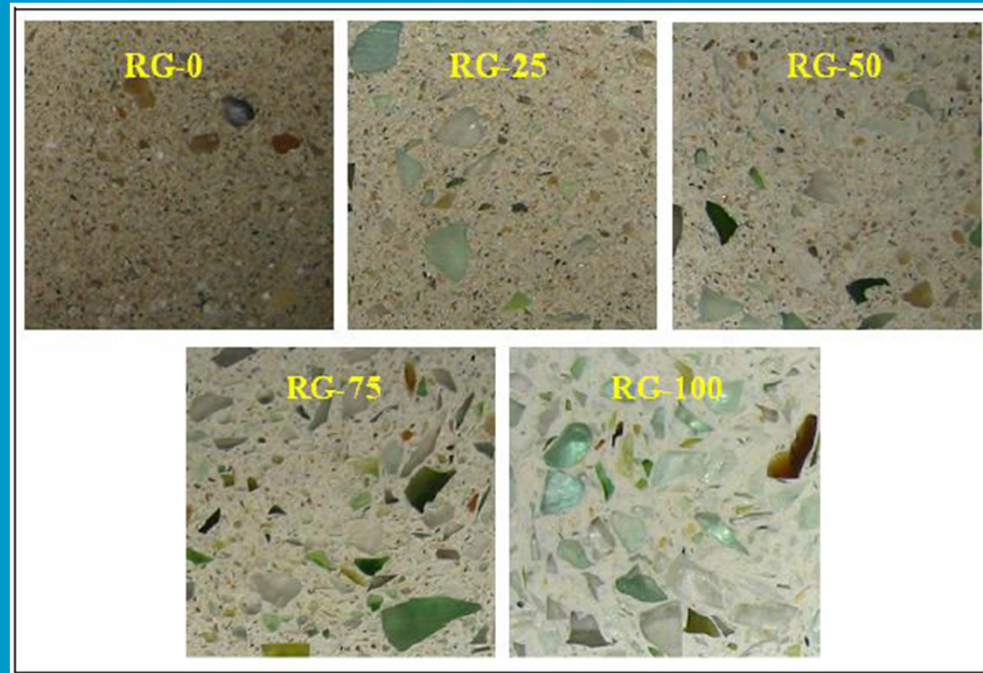
POON Chi-sun, KOU, Shi-cong, The Hong Kong Polytechnic University, Hong Kong

- lower compressive strength and elastic modulus
- Improved bond strength between the mortar and the brick
- Is feasible to use fine recycled aggregate instead of sand and natural crushed fine stone.

Paper-6

Use of Recycled Glass in Architectural Mortars

POON Chi-sun, KOU, Shi-cong, The Hong Kong Polytechnic University, Hong Kong



- self-compacting method is suitable to produce architectural mortar containing up to 100% recycled glass.
- recycled glass can be used in architectural mortar.

Paper-7

Recycled Aggregates: Production, Properties and Value-added Sustainable Applications

LIMBACHIYA M C , Kingston University, UK

- An extensive scientific research and full-scale site trials
- quality recycled concrete aggregates can be produced and can be used successfully in a range of concrete applications.
- The effects of up to 100% coarse recycled concrete aggregate (RCA) on fresh, engineering and durability related properties have been established
- is suitable for use in a range of sustainable applications.

Paper-8

Test Study on the Recycled Aggregate and Concrete Regenerated from Worn Cement Concrete Pavement

Yun DONG, Weizhong HE, Huaiyin Institute of Technology, CN

- Fine Fraction is about 26% of recycled aggregate after secondary broken
- High water-absorbing ratio: 4%~11%
- High Los-angle weared stone value 32.7, crushed stone value 26.5
- Reasonable content of recycled aggregate: 60%

Paper-9

Why Life Cycle Costing Is Needed for Realistic Comparisons in Pavement Rehabilitation Selection

Jenkins KJ, Stellenbosch University, South Africa

- Utilising whole-of-life costs highlights the benefits of pavement recycling.
- Maximizing the reuse of existing materials and minimizing the consumption of new materials provides both economic and environmental benefits.
- Combining these factors optimally by enhancing the recycled materials using bitumen stabilization for flexibility and durability provides an attractive technology for cost-effective pavements.

Paper-10

Durability of bitumen stabilised materials

Twagira ME, Jenkins KJ, Stellenbosch University, South Africa

- Circulation time at elevated temperature before foaming influences age hardening;
- Short term age hardening of foamed bitumen might occur during mixing.
- The effect on ageing is more notable for soft (80/100) bitumen than hard (60/70) bitumen;
- The foaming process does not alter the bitumen properties;
- Long term binder ageing in the field is very difficult to determine conclusively;
- MIST is a useful tool for simulating moisture damage of BSMs realistically, followed by triaxial testing

Paper-11

USA's Status of Utilization of By-Products in Flexible Pavements

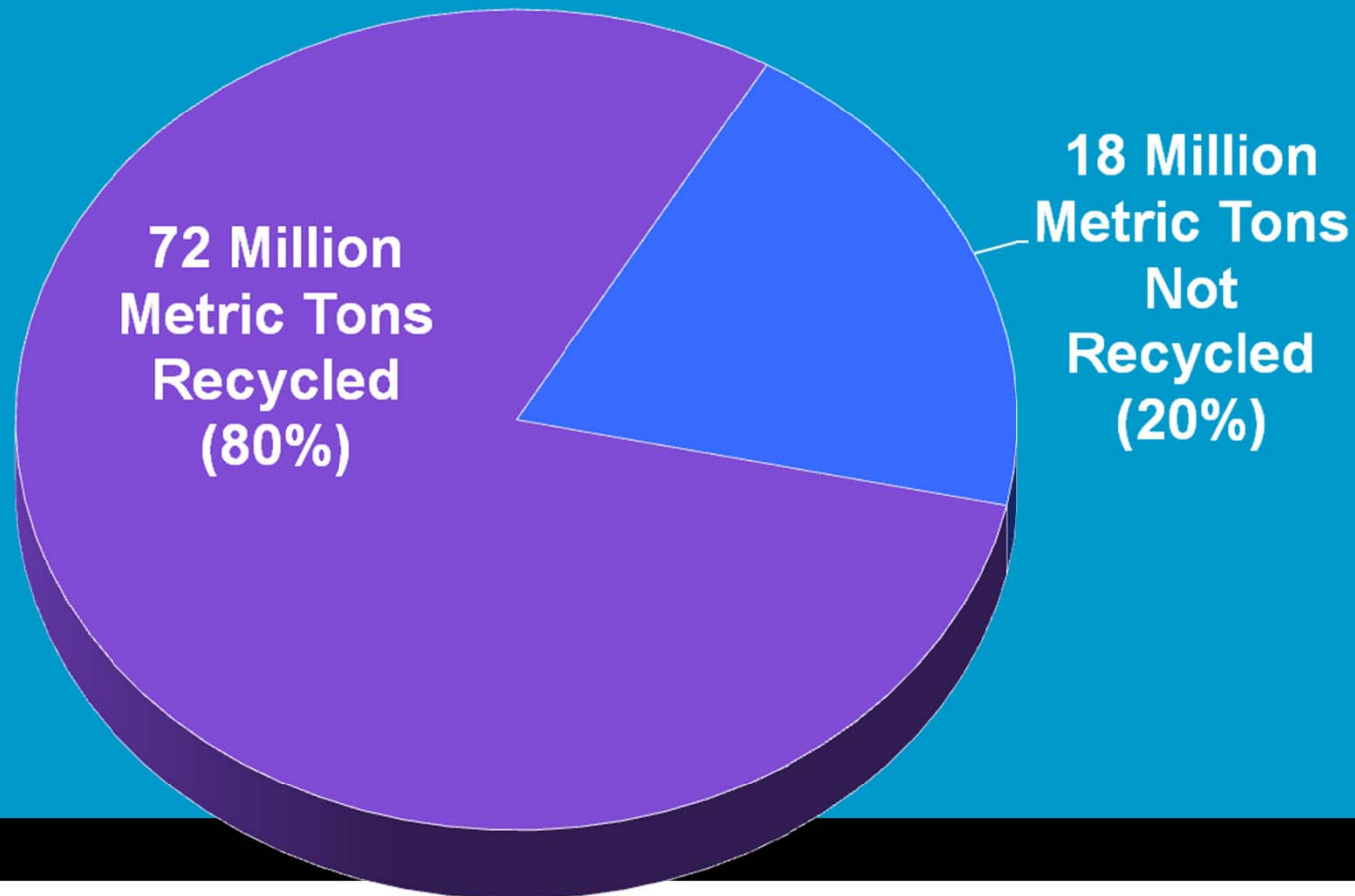
Serji Amirkhanian, Clemson University , USA

Types of Recycled Materials

- Reclaimed asphalt pavement (RAP)
- Scrap tires (crumb rubber)
- Shingle scraps
- Ash (fly ash, bottom ash, and MSW combustor ash)
- Slag (blast furnace, coal boiler, nonferrous, and steel)

U.S. RAP Production

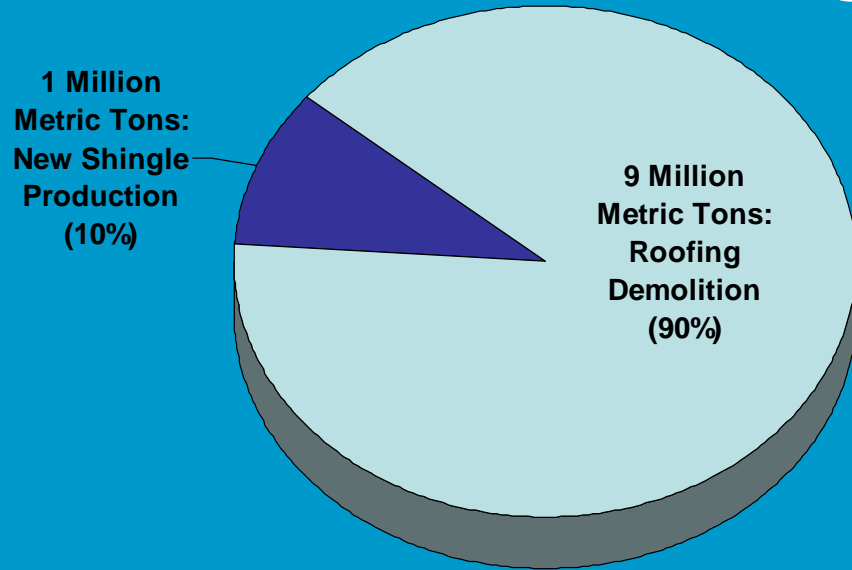
- 90 million metric tons of RAP are produced in the U.S. each year



Types of Applications of Scrap Tires

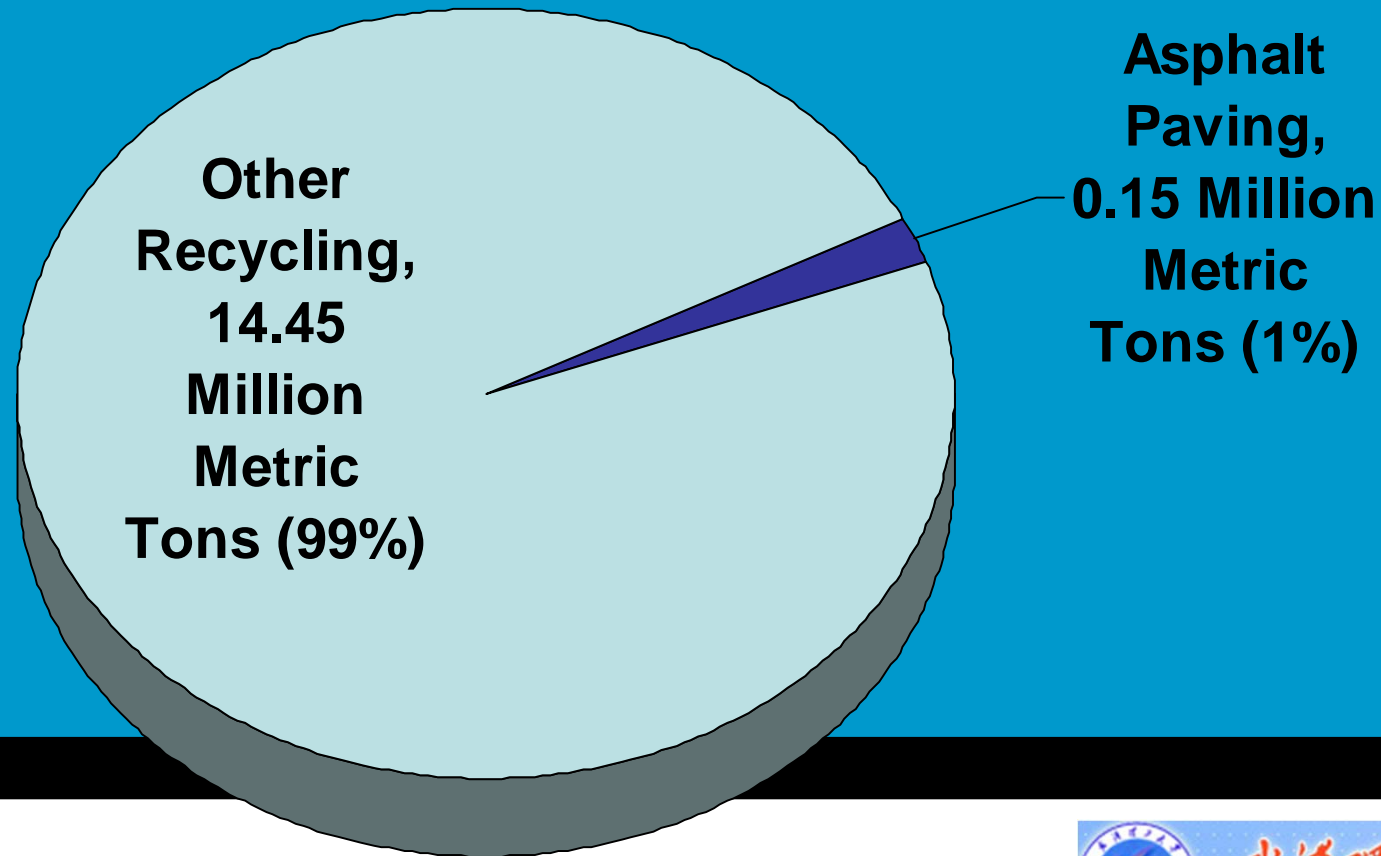
- Rubber-modified surface course (R-M SC)
- Rubber-modified open-graded friction course (R-M OGFC)
 - Dense-graded friction course (DGFC)
 - Gap graded friction course (GGFC)
- Stress absorbing membrane interlayer (SAMI)

Annual U.S. Shingle Scraps



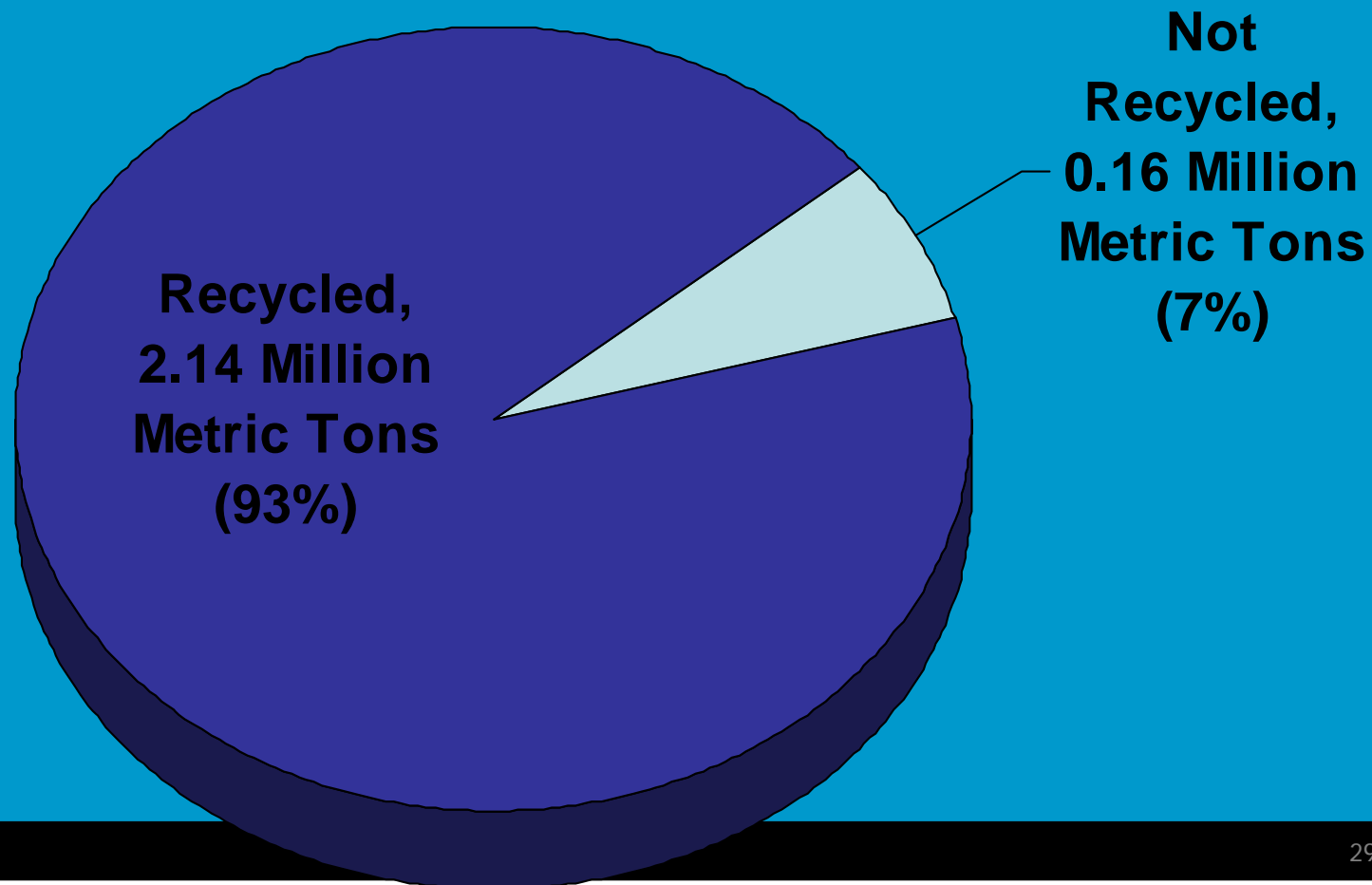
U.S. Recycled Coal Fly Ash

- 53.5 million metric tons produced annually
- 14.6 million metric tons recycled annually (27%)



U.S. Boiler Slag

•2.3 million metric tons produced annually



Paper-12

Study on Optimal Percentage of Reclaimed Asphalt Pavement in Central Plant Hot Recycling Mixture

Prof. Xin Yu, Hohai University, China

- The cracking resistance and fatigue performance are the major indicators in determining the optimal percentage of RAP.
- Binder test results indicated the maximum percentage of the recovered asphalt without regeneration agent was 30%.
- Mixture test results indicated that the percentage of RAP material should be less than 30% without regeneration agent.
- Combined binder and mixture test results: the optimal percentage of RAP material $< 30\%$

Paper-13

Waste Materials to replace Natural Resources??

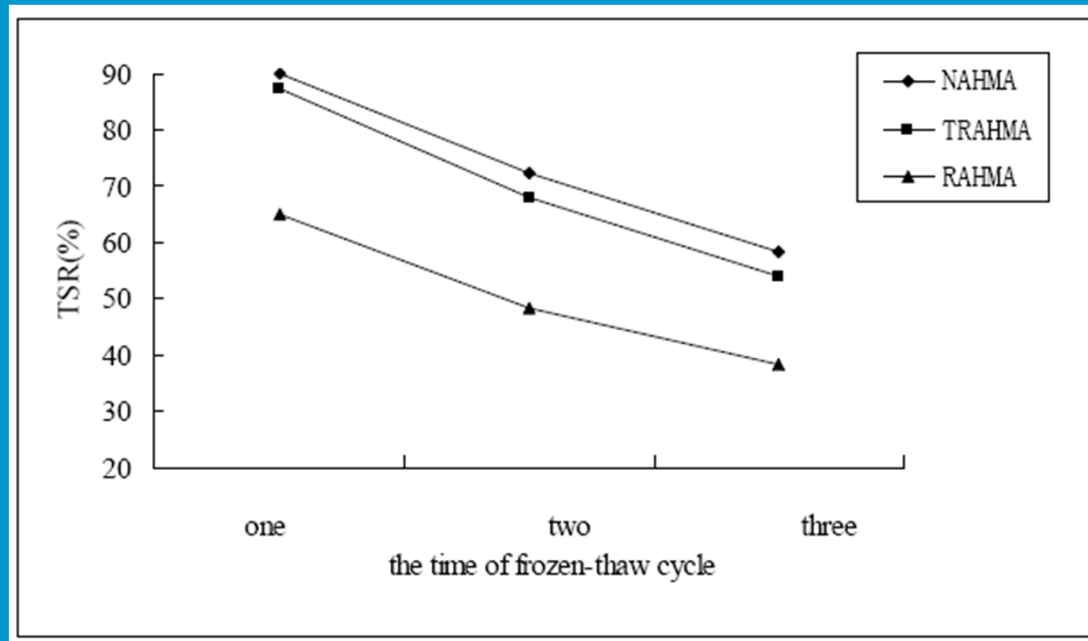
VAN DE VEN M.F.C. , MOLENAAR A.A.A. , POOT M.R, Delft Univer. of Tech.

- Waste materials were studied on their application into asphalt mixtures
- Waste materials: **plastic waste, ceramic waste, foundry sand and sintered granulate**
- The best way to start with waste materials: **use in a base course mixture.**
- Ceramic waste and industrial sand: **relatively easy applicable.**
- Plastic waste requires a very special approach in the mix design: **low density**
- Sintered household waste shows difficulties: **crushing during compaction, high void content and uncertain permanent deformation.**
- use of waste materials is not a straight forward procedure: **Environmental requirements and functional performance**

Paper-14

Investigation of Water Stability of Concrete Wastes in Asphalt Treated Base

W. Wei, M.Z. Chen, S.P. Wu, H. Jiang, Wuhan Univer. of Tech.



- Asphalt mixture with recycled aggregate show poor resistance to moisture damage, but can be improved by surface treatment with organo-silicone

Conclusions

- Waste materials can be widely used in road and pavement engineering.
- Quality recycled aggregate can be produced.
- Good or improved performance has been reported
- Test sections has been constructed for validation
-
-
-

2nd International Conference on
Sustainable Construction Materials:
Design, Performance and Application
October 18-22, Wuhan, China

34