Large Scale Model Experiments of Recycled Pavement Materials

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Problem Statement

- Roads require continual maintenance and reconstruction, which can be costly and negatively impact the environment.

- Reconstruction with full-depth reclamation (FDR) utilizes existing roadway materials, saving time and money while avoiding landfill disposal and the use of virgin materials.

- Cement or fly ash is often blended with the old roadway materials to improve strength and stiffness

Fig 1: Road reconstruction with FDR

Resilient Modulus (M_r)

- M_r is a key material property for roadway design, where σ_d is the deviator stress and ε_r is the recoverable strain under repeated loading.

$$M_r = \frac{\sigma_d}{\varepsilon_r}$$

- M_r of granular materials varies with the state of stress, and can be described with the relationship:

$$M_r = k_1\left(\frac{\sigma_b}{p_o}\right)^{k_2}$$

where σ_b is the bulk stress, or sum of the 3 principal stresses, p_o is a reference stress, and k_1 and k_2 are empirical constants.

Tested Roadway Materials

- 3 granular base course materials were evaluated:
  - –Class 5 gravel: a typical base course material
  - –Recycled Pavement Material (RPM): 50% pulverized asphalt concrete and 50% granular base material
  - –Road Surface Gravel (RSG): a gravel surface course

Material	D_{50} (mm)	C_u	C_c	G_s	w_{opt} (%)	γ_{dmax} (kN/m^3)	Asphalt Content (%)	LL (%)	PL (%)	Gravel Content (%)	Sand Content (%)	Fine Content (%)	USCS Symbol	AASHTO Symbol
Class 5 base	225	33.3	07	272	50	209	-	NP	NP	366	593	41	SP	A-1-a
RPM	389	89.5	25	264	75	212	46	NP	NP	460	430	106	GW-GM	A-1-a
RSG	080	40.0	10	273	75	226	-	21	14	286	590	124	SG-SM	A-2-4

ash, 10% cement kiln dust (CKD), and 4% cement

Large Scale Model Experiment (LSME)

- The LSME, shown in Fig. 2, measures loads and deflections, from which M_r is backcalculated.

- The LSME incorporates the effect of stress magnitude and strain amplitude on modulus, replicating field conditions more closely than conventional laboratory M_r testing.

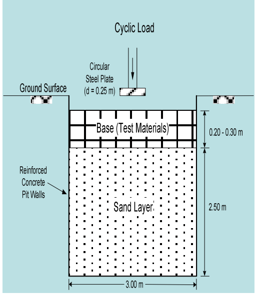


Fig 2: Schematic of LSME

Results

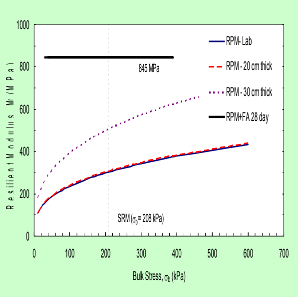
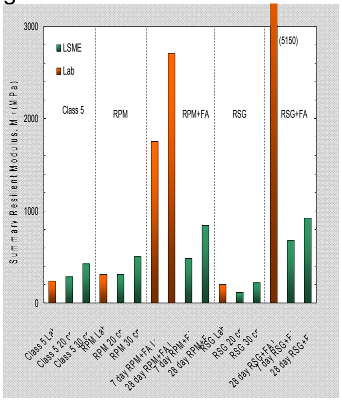


Fig. 3: Mr vs. Bulk Stress for RPM

- M_r of unstabilized granular materials increases with bulk stress and layer thickness.
- Stabilizing the RPM, such as with fly ash (FA), results in a significant increase of M_r
- Stabilized materials are not stress-dependent, as seen from the horizontal line in Fig. 3.

Fig. 4: Comparison of SM_r

- The summary M_r (SM_r) at σ_b = 208 kPa are compared for base materials from the LSME and conventional lab testing.
- A significant increase occurs with fly ash, increasing over a curing time of 28 days.
- Lab tests for stabilized materials result in a higher SM_r than the LSME due to differences in mixing and curing methods.



Conclusions and Applications

$$a_2 = 0.249\log M_r - 0.97$$

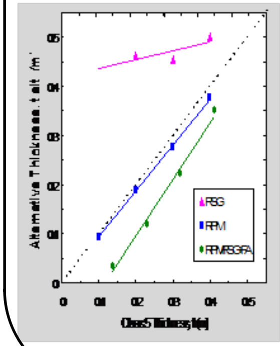


Fig. 5: Gravel Equivalency

- Stabilized recycled materials offer a promising alternative due to increase in Mr.

- Recycled materials can be incorporated into base layer thickness design:
  - –The AASHTO base layer coefficient (a_2) can be calculated from M_r (Rada and Witczak 1981)
  - – The thickness of an alternative recycled material can be determined from the required thickness of Class 5 gravel using Fig. 5.

- A thinner layer of recycled material stabilized with fly ash can be used as an alternative to Class 5 gravel.