Thickness Design of a Roller-Compacted Concrete Composite Pavement System

Many agencies continue to investigate ways of optimizing pavement designs to save money while still providing a durable pavement structure. One such structure that is gaining popularity is the use of roller-compacted concrete (RCC) base with a hot-mix asphalt (HMA) overlay. The RCC provides the primary structural support with HMA surfacing applied to improve ride quality. Such a pavement structure has been referred to as a composite system. When dealing with a composite pavement, one challenge is in determining the structural contribution of the HMA overlay. The state of the practice for most agencies in designing pavement structure layer thicknesses is through the use of the American Association of State Highway and Transportation Officials (AASHTO) *Guide for the Design of Pavement Structures* ('93 Guide). This methodology in essence utilizes a Structural Number needed and structural layer coefficients associated with certain pavement materials to determine the pavement thickness necessary to support a selected equivalent single axle load (ESAL). RCC is not addressed as a pavement material in the '93 Guide.

RCC-Pave, a pavement design software program developed by the Portland Cement Association (PCA) is widely used in determining the thickness of RCC pavements. However, the program makes no provision for an HMA overlay. By using layer elastic theory and performance models developed by the PCA and the Asphalt Institute, the structural contribution of an HMA overlay with a RCC base can be determined.

Table 1. Material Properties and ESAL Characteristics

Layer	Elastic Modulus (ksi)	Poisson's Ratio	Modulus of Rupture (psi)
RCC	4000	0.15	650
HMA	500	0.35	
Aggregate Base Course	50	0.35	
Low PI Clay	8	0.40	
ESAL Characteristics			
Total Axle Load (kips)	Radius of Loaded Tire (inch)	Tire Contact Pressure (psi)	Distance between Dual Tires (inch)
18	3.78	100	12.0

To illustrate the procedure, the following examples are provided. Material properties and loading conditions used in the examples are given in Table 1. Utilizing layered elastic analysis, the critical stress and strains were determined for various pavement configurations and the results plotted in a set of graphs (Figures 1 through 4). For these examples, a low plasticity index (PI) clay subgrade with a 6.0-inch aggregate base course, and a low PI clay foundation with no base course were two of the structures considered.

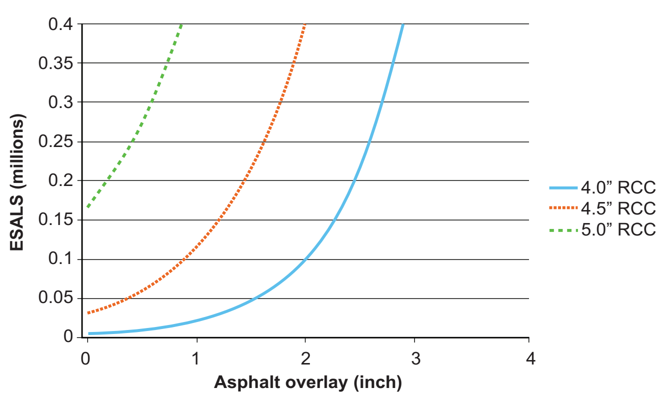

Figure 1. RCC with 6.0-inch aggregate base course and low PI clay subgrade

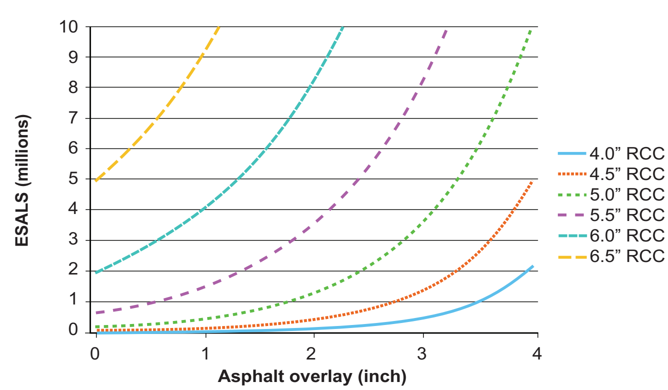

Figure 2. RCC with 6.0-inch aggregate base course and low PI clay subgrade

PCA
Portland Cement Association

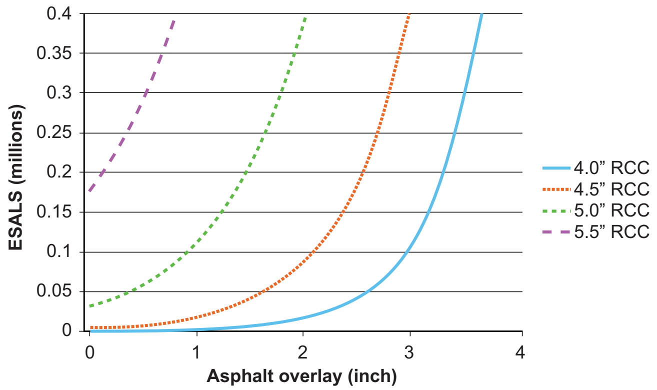

Figure 3. RCC with low PI clay foundation

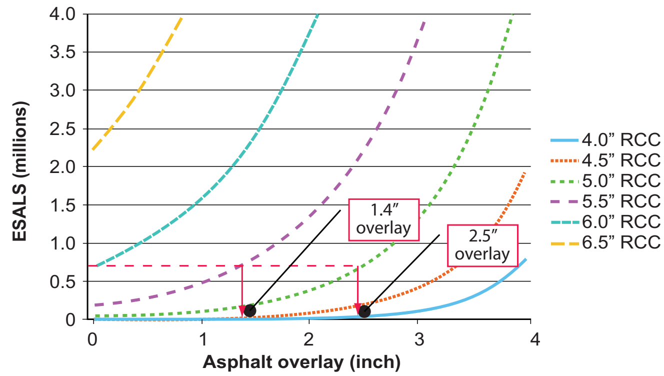

Figure 4. Equivalent sections of RCC with low PI clay foundation

Table 2. Traffic Scenarios

Residential ESAL Traffic	Layer	Thickness (inch)	ESAL Design Life
	RCC Low PI Clay	4.5 Infinite	4,100
	HMA Aggregate Base Low PI Clay	1.5 6.0 Infinite	5,100
	HMA RCC Low PI Clay	1.5 4.0 Infinite	5,800
Collector ESAL Traffic	**Layer**	**Thickness (inch)**	**ESAL Design Life**
	RCC Low PI Clay	6.0 Infinite	795,000
	HMA Aggregate Base Low PI Clay	6.75 6.0 Infinite	810,000
	HMA RCC Low PI Clay	1.5 5.5 Infinite	860,000
Minor Arterial ESAL Traffic	**Layer**	**Thickness (inch)**	**ESAL Design Life**
	RCC Aggregate Base Low PI Clay	6.5 6.0 Infinite	5.5 million
	HMA Aggregate Base Low PI Clay	8.0 10.0 Infinite	5.8 million
	HMA RCC Aggregate Base Low PI Clay	1.5 6.0 6.0 Infinite	6.0 million

Using Figure 4 and assuming a traffic loading of 700,000 ESAL, a 6.0-inch RCC pavement without an HMA overlay is equal to a 5.5-inch RCC pavement with an approximately 1.4-inch HMA overlay. Also from Figure 4, a 5.0-inch RCC pavement with an approximately 2.5-inch HMA overlay is equal to the unsurfaced 6.0-inch RCC pavement.

Finally, Table 2 gives various design options for traffic conditions representative of three typical roadway classifications. These examples show an HMA surface can provide some structural capacity in a RCC composite design. By utilizing the RCC-Pave software program and layer elastic theory and performance models developed by the PCA and the Asphalt Institute, a designer can equate pavement sections of RCC with and without an HMA overlay.

It's important to recognize that these examples are for illustration purposes only and should not be used for design. The figures generated are based on material properties and loading conditions given in Table 1 and the curves in the figures will vary depending on changes in material properties and loading characteristics. In addition, it is assumed a rut resistant asphalt layer will be used and that ride quality will be acceptable upon application of the calculated asphalt overlay.

More Information

PCA offers a broad range of resources on cement-based applications for pavements. Visit our Web site at **www.cement.org/pavements** for design and construction guidelines, technical support, and research on conventional concrete, roller-compacted concrete, pervious concrete, cement-modified soil, cement-treated base, and full-depth reclamation.

For local support, tap into the cement industry's network of regional groups covering the United States. Contact information is available at **www.cement.org/local.**

PCA

Portland Cement Association
5420 Old Orchard Road
Skokie, Illinois 60077-1083
847.966.6200 Fax 847.966.9781
www.cement.org

An organization of cement companies to improve and extend the uses of portland cement and concrete through market development, engineering, research, education, and public affairs work.

PL633