CE361 Introduction to Transportation Engineering — Out: Monday 1 November 2004
Homework 8 — Due: Monday 8 November 2004

PAVEMENT DESIGN

Dear Consultant:

Although pavements throughout Mythaca County are subject to increasing traffic and heavier loads, nowhere is the problem more acute than on the Portland Cement concrete access road to The Port of Shoridan. The Port of Shoridan handles container shipments that arrive and depart by ships on Murdoch Bay. Please complete the exercises below completely and clearly. You may submit your assignment as a member of a group of CE361 students not to exceed three in size. Signatures of all group members must appear on the top page of the work submitted.

1. **ESAL calculations.** During a typical week last year, 988 containers (each about 20-feet long) were carried to and from the Shoridan port facility on modified "flatbed" versions of the 3-S2 trucks shown in FTE Figure 9.9. Empty containers weigh 4000 lbs and full containers can weigh up to 53,000 lbs. Truck operators and the Port Authority of Shoridan want the state to permit use of 3-S2-4 Turnpike Doubles to and from the Port. 3-S2-4's, like 3-S2's, can be operated with a single driver, who represents the largest single component of operating cost. Thus, being able to haul twice the payload at only a modest increase in operating cost translates into the potential for significant savings in shipping costs. The truckers also claim that the life of the Portland Cement concrete access road's pavement will be extended if 3-S2-4's are used. The relevant data for both trucks are shown in the table below.

Truck type	Unloaded weight	Max. Gross Weight	Steering axle load	Max. number of containers	
3-S2	30,000 lbs	80,000 lbs.	12,000 lbs.	1	
3-S2-4	47,000 lbs.	148,000 lbs.*	12,000 lbs.	2	

* Only in states where these trucks are permitted.

In the problems below, assume that the truck's load is distributed equally over all non-steering axles. Use the fourth power formula to estimate ESALs per axle. (A tandem axle counts as one axle in these calculations.) Because some trucks manage to haul loaded containers in both directions, assume that 55 percent of the containers being hauled to/from the Port are loaded to 50,000 lbs. The other containers are hauled empty. Summarize your calculations using a five-column table with the headings: kips/axle, axle type (S or T), frequency/week, ESAL/axle, and ESAL/week for each axle.

   A. (10 points) If all containers are now carried by 3-S2's, how many ESALs per week are applied to the concrete access road to the port?

   B. (10 points) If all containers were instead carried by 3-S2-4's, how many ESALs per week would be applied to the concrete access road?

2. **Flexible pavement design.** An asphalt supplier approaches the Port Authority with a proposal to replace its approach road with a three-layer flexible pavement. The Port Authority sets the following specifications: Lifetime ESALs = 6.1 million, Reliability = 95 percent, S.D. = 0.35, ΔPSI = 1.9, M_R values of 18,580 psi (base), 14,590 psi (subbase), and 2300 psi (subgrade).

   A. (15 points) Find SN_1, SN_2, and SN_3 using the design chart in FTE Figure 9.15. Attach the design chart to your solutions.

   B. (15 points) Using the material coefficients a_1 =0.43, a_2=0.13, a_3=0.09, what are d_1, d_2, and d_3? Do not violate the minimum thickness values in FTE Table 9.7.

   C. (10 points) Using the material costs in FTE Table 9.8, calculate the cost per lane-mile-inch for each layer that you designed in Part B, then compute the total pavement cost for one lane-mile. Include excavation and earthwork costs at $3/CY.

   D. (10 points) Using the minimum thicknesses of d_1 and d_2 allowed in FTE Table 9.7, show how to find d_3. How much would this pavement design cost to construct? Include excavation and earthwork costs at $3/CY.

3. (20 points) **Rigid pavement design.** The local concrete supplier hears of the asphalt supplier's offer and wants an opportunity to compete for the job. The Port Authority responds with the same specifications, except as follows: S'_c = 926 psi, J = 3.2, $E_c = 4.1*10^6$ psi, k = 100 pci, and C_d = 1.0. Using the design charts in FTE Figures 9.26 and 9.27, how thick must the concrete slab be? Attach the design chart to your solutions.