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Flexible Pavement Evaluation

For

Proposed Jake Road Residential Driveway Rapid City, South Dakota

12/4/06

PREPARED FOR:

City of Rapid City, SD

By:

Joel Brannan

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Rapid City Growth
Management Department

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1. Introduction

The City of Rapid City, SD has requested the owners of the residential driveway leading to two homes off Jake Road be paved to city specifications. City specifications according to drawings provided indicate that 2" asphalt pavement be placed over a 2" compacted sub base consisting of recycled asphalt pavement for approximately 965' of mainline. Remaining mainline equaling approximately 275' is to consist of 4" of asphalt pavement placed over 6" of compacted sub base consisting of aggregate base course. Additionally, 5,063 square feet of turnaround area is to be paved at 2" depth over 2" of recycled asphalt sub base and 4,534 square feet of cul-de-sac area is to be paved at 4" depth over 6" of aggregate base course sub base. The owners have the option of continuing any pavement work past the cul-de-sac, which would finish the driveway work up to the two homes. If required construction or plans interpretation differs significantly from that described above, time should be given to re-evaluate the recommendations contained in this report.

A flexible pavement evaluation was performed to identify alternatives that will create a sufficient pavement section as well as a more economical solution for the owners. The evaluation included the following general scope of activities:

1. An alternative design evaluation for life and design thickness
2. A list of construction procedures and quality controls
3. A review of similar projects
4. A cost take-off based on city specifications
5. A cost take-off based on the alternative design

Flexible pavement evaluation for life and design thickness was accomplished in accordance with the AASHTO Guide for Design of Pavement Structures. This report presents an alternative pavement section consisting entirely of recycled asphalt pavement at an appropriate thickness treated with a CSS-1H seal coat. Sub base recommendations are also presented. A discussion of construction procedures is also included as well as quality control.

2. Alternative Design

The alternative design being recommended in this report consists of a final pavement thickness of 4". This thickness is to be placed over a 6" thick sub base consisting of limestone base course, which is already in place. The final pavement section will be sealed with a CSS-1h emulsion seal coat. Actual application rates and construction details will be presented in the construction procedures section.

The above-mentioned design produces a structural number equal to 1.64, which was conservatively rounded up to 2 for the design's purposes. This value was found as shown below in Table 1. The layer coefficient for the wearing service is extremely conservative but does not significantly change the outcome for pavement life. A typical coefficient for hot-mix asphalt concrete would be 0.44, which would increase the structural number. A value of 0.2 was selected because recycled asphalt will behave like a hot mix concrete but is closer to aggregate base course when considering drainage. The conservative approach increases daily traffic loads and decreases pavement life results.

		inches	**structural *layer coef***		
recycled asphalt pavement	pavement	4	0.2	0.8	
crushed stone	subbase	6	0.14	0.84	
				1.64	**SN**

Table 1 – Jake Road Structural Number Calculation

Daily traffic levels applied at a conservatively high rate can be predicted at 10 passes per day. These vehicles are never above a level of that of a car or light truck equivalent to a 2 kip applied load. This rate of traffic results in an equivalent 18 kip single axel load of 0.004 as shown below in Table 2. The factor used equaling 0.0004 is based on a 2 kip load applied to a pavement section with a structural number equaling 2 as presented in Figure 1.

	frequency	kips	factor	
Car/Pickup	10	2	0.0004	0.004
				0.004 **daily W18 ESAL**

Table 2 – Jake Road Daily 18-kip ESAL

Remaining design values included design standard deviation, serviceability loss, resilient modulus, California Bearing Ratio of sub base, serviceability probability and reliability.

The design standard deviation selected was 0.5, which is conservatively high considering the known future traffic loads. The serviceability loss selected was 1.2, which is the equivalent to that of an interstate highway system.

The resilient modulus calculated was near 15,000 psi, which was calculated using a CBR value for the sub base equal to 10. A CBR value equal to 10 applied to the situation found on Jake Road is extremely conservative when considering the quality of

base course applied to the road in place. This value is based on the relationship between the soil sub base and the aggregate bearing capacity, which indicates that, the soil is 10% as strong as the base course in the situation found on Jake Road. This value is more than likely higher in actuality but conservatism is the goal of this evaluation.

A serviceability probability value equal to –1.645 was used based on an again conservative design value similar to that of an interstate highway where a low occurrence of reconstruction and maintenance is necessary.

The information presented above was used in equation 1 below to arrive at a total pavement life ESAL value equal to 31,278.35. This value when applied with the daily ESAL's calculated in Figure 2 indicates that the pavement will have a life of over 20,000 years.

Equation 1

$$Log_{10}W_{18} = Z_rSo + 9.36[log_{10}(SN + 1)] - 0.2 + (log_{10}[\Delta PSI/2.7]/0.4+[1094/(SN+1)5.19]) + 2.32log_{10}Mr - 8.07$$

A life of 20,000 years is obviously a radical result but it does indicate the capabilities of a recycled asphalt pavement when applied to a low volume driveway such as Jake Road. It is for this reason that a redesign of Jake Road consisting of 4" of recycled asphalt pavement applied with a CSS-1h seal coat would more than adequately provide an excellent driving surface and a strong and dependent roadway for many years.

3. Construction Procedures and Quality Control

Construction of the alternative design for Jake Road would follow steps similar to those used on previous applications by Pete Lien & Sons. The steps consist of shaping the current grade, gate spreading recycled asphalt material with end dump trucks, blade-laying material to the desired loose thickness, pneumatically rolling the pavement to the finish thickness and steel drum rolling the pavement for smoothness. The material is placed with approximate moisture of 5% but has been visibly inspected in the past with no physical tests recorded. The CSS-1h would be applied as 3:1 water to oil ratio and at a rate of 0.15 gallons per square yard.

The steps are again presented as follows with controls on quality for pavement thickness, strength and smoothness.

1. Shaping current grade
2. Gate spreading recycled asphalt material with approximately 5% moisture.
    a. Visible inspection of material will occur for moisture. A water truck will be on hand to add moisture if necessary. The material will be equalized and dried if moisture levels appear to be too high.
    b. Thickness and material quantities will be monitored based on tonnage per foot of mainline. With the design proposed, one 15-ton dump truck load will cover 10 feet of mainline.
3. Blade laying of material to approximately 5" loose thickness and 20' wide driving surface.
4. Pneumatically rolling material with 6 passes per section to a thickness of approximately 4 ¼".
    a. No more than 250' will be rolled at one time to ensure that each section receives the proper number of passes.
5. Steel drum rolling material to a final grade of 4" with 6 passes per section.
    a. Steel rolling will cover no more than 250' of mainline per section to ensure proper coverage.
    b. Final compaction of 90% is desired. This can be approximated in the field by back calculating quantity figures but an actual density would be required to find the exact value. It is believed that this value will be achieved with the proper thicknesses and compaction rates.
6. CSS-1h applied one week after final grading at a rate of 0.15 gallons per square yard in a 3 to 1 water to oil ratio.

Construction should occur when an ambient temperature of near 80 degrees Fahrenheit is achieved throughout the day in order to improve compaction.

4. Review of Similar Projects

The alternative presented has been applied to three previous projects. All three projects were constructed and monitored in the methods described and have shown strong results.

The first two applications occurred in 1994 and were completed near the 1st of August when temperatures were well into the 90's. The two driveways were constructed of recycled asphalt pavement at a thickness of 3 to 4 inches and were sealed with one coat of CSS-1h that same month. No sealing has occurred since. The third application was completed in June of 2005 when temperatures were in the 80's during construction. The driveway was constructed of recycled asphalt with a finish thickness of 4 inches and one coat of CSS-1h that same month.

The figures below show the thickness of the pavement today and the overall durability of the finished product. Twelve years of traffic similar to that found on Jake Road have created limited wear on the driving surface and little to no damage to the overall strength of the pavement. Absolutely no signs of rutting are evident which proves that the CBR value equaling 10 is conservative. However, even with conservative values throughout, the design equation still yields an extremely long life for a recycled asphalt driveway. As mentioned, no seal coats were applied were applied over the past 12 years, yet the pavement still weathered extremely well.

Figure 1 - Chuck Lien Driveway – 1994 Completion (Current Appearance)

Figure 2 - Chuck Lien Driveway – 1994 Completion (3-4" Thickness)

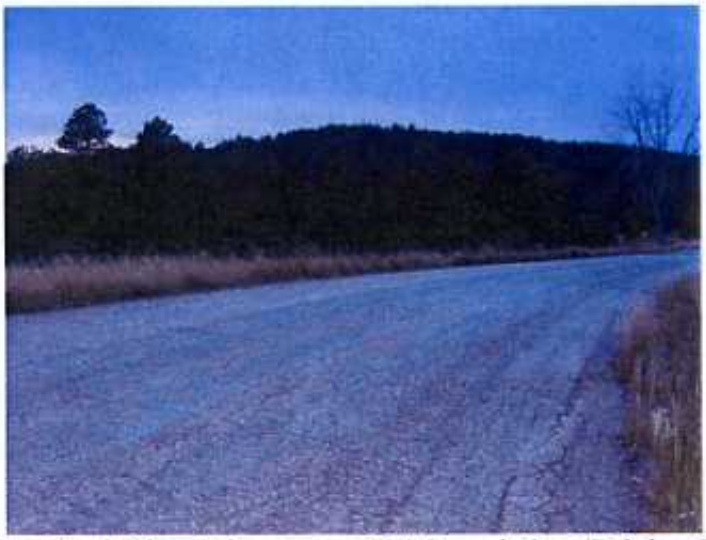

Figure 3 - Chuck Lien Driveway – 1994 Completion (Driving Surface)

Figure 4 - Bruce Lien Driveway – 1994 Completion (Current Appearance)

Figure 5 - Bruce Lien Driveway – 1994 Completion (3-4" Thickness)

Figure 6 - Bruce Lien Driveway – 1994 Completion Date (Driving Surface)

The remaining figures show the most recent project where one year of wear is not evident. The pavement appears as durable and strong as the day that construction was completed.

Figure 7 - Pete Lien Driveway – 2005 Completion Date (Current Appearance)

Figure 8 - Pete Lien Driveway – 2005 Completion Date (4" Thickness)

Figure 9 - Pete Lien Driveway – 2005 Completion Date (Driving Surface)

5. Cost Take-off Based on City Specifications

A cost take-off completed based on the plans provided by the city for the placement of varying thicknesses of asphalt pavement yielded a total tonnage of approximately 518 tons. The required recycled asphalt pavement based on the drawings provided yielded a total of approximately 331 tons. In place and including tax, the total construction of Jake Road would equal approximately $44,015.

Take-off quantity calculations can be found below in Table 3.

2" x 20' section					
Station 12 + 75 to 3 + 10 = 965 feet					
	length (ft)	**width (ft)**	**thickness (in)**	**pcf**	**tons**
AC	965	20	2	140	225
RAP	965	20	2	135	217
Turn-Around					
Area = 5063 square feet					
AC	75	67.5	2	140	59
RAP	75	67.5	4	135	114
4" x 20' section					
Station 15 + 50 to 12 + 75 = 275 feet					
AC	275	20	4	140	128
RAP	275	20	0	135	0
Cul-de-sac					
Area = 4534 square feet					
AC	4534	1	4	140	106
TOTALS					
AC	518				
RAP	331				

Table 3 – Planned Take-off Quantities

6. Cost Take-off Based on Alternative Design

A cost take-off completed based on the alternative design presented yielded a total tonnage of approximately 786 tons of recycled asphalt material. A total tonnage of CSS-1h would equal approximately 2.39 tons. In place and including tax, the total construction of Jake Road would equal approximately $14,906.

Take-off quantity calculations can be found below in Table 4.

4" x 20' section

Station 12 + 75 to 3 + 10 = 965 feet

	length (ft)	width (ft)	thickness (in)	pcf	tons
RAP	965	20	4	135	434
SF	19300				

Turn-Around

Area = 5063 square feet

RAP	75	67.5	8	135	228
SF	5063				

4" x 20' section

Station 15 + 50 to 12 + 75 = 275 feet

RAP	275	20	4	135	124
SF	5500				

Cul-de-sac

Area = 4534 square feet

RAP	4534	1	4	140	106
SF	4534				

TOTALS

RAP	786				
SF	34397				
	SY	*gallon/sy*	*gallons*	*gallons/ton*	*tons*
CSS-1h	3822	0.15	573	240	2.39

Table 4 – Proposed Take-off Quantities

7. Conclusion

A proposed alternative to the designed pavement section designed for Jake Road in Rapid City, SD has been presented. The alternative more than adequately meets the requirements for durability and strength based on the estimated loadings and conditions, and the alternative is more cost effective for the owners.

Similar applications have been applied to other local driveways and have shown little to no effects from equal vehicle loading and weathering. With proper construction and quality control, the construction of Jake Road to the specifications set in the alternative design presented in this report should more than adequately meet the demands of the roadway.

It is for these reasons that it is recommended that an alternative design for Jake Road consisting of a thicker layer of recycled asphalt applied to the area desired by the City of Rapid City be considered. This alternative does not include new asphalt concrete but does include a seal coat consisting of CSS-1h to seal and protect the newly placed material.