URS

MEMORANDUM

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From: Nick Landwer, P.E,

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Subject: Pavement Design

Virtually all streets owned and maintained by the City of Arden Hills are bituminous (asphalt) roadways. Therefore, this discussion is based on the design and load characteristics of bituminous pavement. Concrete roadways have different mechanical characteristics, are constructed differently and for economical reason have a different design life.

It is commonly accepted that a 20-year design life for bituminous pavement is the most economical in the state of Minnesota. In Arden Hills a 9-ton pavement design is used for residential streets to account for heavier vehicles such as delivery trucks, buses and garbage trucks. Pavement is designed considering three main factors; 1) pavement base, 2) pavement surface and 3) drainage. With these factors in mind the following information is used:

- The underlying soils are tested to determine the strength and stability properties.
- Traffic loading and the distribution of types of vehicles are projected over the life of the pavement.
- MnDOT design standards are and have been used on all new residential and commercial road design in Arden Hills.

Pavement Base

This portion of pavement design considers the underlying soil for strength and stability. The gravel base thickness is determined this way using MnDOT design charts. The gravel base is the strength of the roadway and is designed to carry most of the traffic load.

Pavement Surface

The pavement surface is the bituminous portion of the road section and, although it does contribute to the strength of the pavement, its primary purpose is to create a watertight and smooth surface. The projected amount of traffic for a section of roadway determines the pavement thickness and the aggregate and binder oils to be used in the bituminous mixture. The binder oils used in Minnesota are typically designed to handle the extreme temperature ranges experienced here.

Drainage

Drainage is accounted for on the surface and in the subsurface of the pavement section. It is extremely important to keep water from saturating and undermining the pavement and base. On the surface the pavement is sloped to get the water out of the roadway and into the storm sewer system. In addition surface cracks are sealed to keep water from draining into the pavement base through them. Typically a 12-inch sand layer is constructed beneath the aggregate base to add strength and to drain the base. In many cases perforated drainpipes are installed in the sand base to route any subsurface water in the pavement base to the storm sewer system. Because water is drained from the sand base the road becomes much less susceptible to freeze thaw cycles.

The main causes for deterioration of bituminous pavement over its life span are the strength and stability of the pavement base, traffic volumes, type of traffic and environmental factors such as water, temperature, sun and pollutants.

Traffic

For design purposes traffic is estimated for the 20-year design life based on traffic counts and projected traffic growth rates averaged over the design life to determine the Average Daily Traffic counts for the roadway. In most cases MnDOT has traffic distribution tables for the percentages of different vehicles that will be using the road. The traffic counts and the distribution of vehicles are used to calculate Equivalent 9-ton (N18) Single Axle Loads (ESALs.) The ESALs are used to determine both the base and surface thickness of the pavement section. For example, using ESALs, a typical garbage truck has the equivalent loading of approximately 1500 passenger cars. Although passenger cars are typically the largest percentage of vehicles to use the road the roadway section is designed to handle the loading of the larger vehicles. Tables H.1 and H.2 from the MnDOT Geotechnical and Pavement Manual are included to show typical vehicle type distributions and the load factors applied to a particular type of vehicle.

Environmental

Water is very hard on the pavement section particularly in cities like Arden Hills where the clay soils under the road can trap water and become a problem during freeze thaw cycles. On pavement with no hard edges such as concrete curb and gutter the water can also contribute to the raveling of the pavement on the edges.

The bituminous pavement itself becomes brittle over time from the effects of temperature, sun and pollutants. Typically most cracking exhibited in properly constructed bituminous roadways is due to temperature changes causing the pavement to expand and contract. For this reason, cracks are sealed and roadways are generally seal coated with a bituminous slurry and covered with a fine aggregate. Seal coating is typically recommend every 7 to 10 years to maintain and possibly extend the life of the pavement.

It has been observed that many of the older streets in Arden Hills, particularly the rural design with no curb and gutter, rely more on the pavement as strength and do not have very good aggregate bases and generally do not have a sand layer. It is assumed that many of these streets began as gravel roads and have been overlaid with a bituminous surface with varying thickness.

A typical newer pavement section in used on residential streets in Arden Hills is:

- 12-inch sand base
- 8 to 12 inches of aggregate base
- 4 to 6 inches of bituminous pavement

Summary

Although vehicle types and loading contribute to the wear of the pavement section, environmental factors also contribute to the deterioration of the pavement section. A properly designed bituminous surface should be able to handle the traffic loading over its design life including heavy truck loadings experienced in Arden Hills. Reducing the number of heavy truck loadings should have positive effects on the lifespan and quality of local streets however, environmental factors are generally responsible for the majority of pavement wear and deterioration for Arden Hills streets and therefore significant extensions of pavement life are unlikely.

Appendix H.1

Assumed Distribution Factors By Vehicle Type (Table 7–5.03B)

Vehicle Type	Description	Rural Truck Highway % of AADT	Metro % of AADT	Local Rural and CSAH % of AADT**
1	Passenger Cars	78.1	83.5	75.7
2	Panels and Pickups (under 1 ton)	10.0	9.0	16.0
3	Single Unit – 2 axle, 4 tire	1.4	1.6	2.4
4	Single Unit – 2 axle, 6 tire	3.9	1.8	2.6
5	Single Unit – 3 axle & 4 axle	1.3	0.5	1.7
6	Tractor Semitrailer Combination – 3 axle	0.3	0.3	––
7	Tractor Semitrailer Combination – 4 axle	0.5	0.4	0.1
8	Tractor Semitrailer Combination – 5 axle	3.0	2.4	0.5
9	Tractor Semitrailer Combination – 6 axle	*	*	*
10	Trucks with Trailers and Buses	1.5	0.5	1.0

* Too few to establish a value at this time.
** Data for local roads is from 1975 and 1977 County Roads Pilot Project, and these should not be used in preference to current seasonally adjusted classification counts.

This is Table 7–5.03B From Mn/DOT Road Design Manual January 31, 1982, reference 5.

Appendix H.2

Average N18 Factors By Vehicle Type (Table 7–5.03D)

Vehicle Type	Description	Rural T.H. N18 Factor	Metro N18 Factor	Local Rural CSAH and Municipal N18 Factors	Range		
					Max. Legal 10–Ton	Measured	
						Max.	Min.
1	Passenger Cars	0.0004	0.0004	0.0004	--	0.0008	0.0003
2	Panels and Pickups (under 1 ton)	0.007	0.007	0.007	3.0	0.012	0.0006
3	Single Unit – 2 axle, 4 tire	0.01	0.01	0.01	3.0	0.070	0.003
4	Single Unit – 2 axle, 6 tire*	0.24	0.22	0.21	3.0	0.61	0.019
5	Single Unit – 3 axle & 4 axle****	0.41	0.57	0.45	2.61	1.40	0.015
6	Tractor Semitrailer Combination – 3 axle	0.58	0.21	0.15	2.20	2.45	0.028
7	Tractor Semitrailer Combination – 4 axle	0.53	0.41	0.30	2.62	3.91	0.060
8	Tractor Semitrailer Combination – 5 axle	0.88	0.63	0.59	2.20	4.10	0.028
9	Tractor Semitrailer Combination – 6 axle	***	***	***	--	--	--
10	Trucks with Trailers and Buses**	0.42	0.42	0.34	--	--	--

* Use 0.60 for 2 axle garbage trucks.
** Use 1.25 for MTC buses.
*** Too few to establish a value at this time.
**** Use 0.91 for sugar beet trucks.

This is Table 7–5.03D from Mn/DOT Road Design Manual January 31, 1982, reference 5.