

October 11, 1999

TO: All Holders of the City of Salem Design Standards

EFFECTIVE DATE: January 1, 2000

SUBJECT: **DEVELOPMENT BULLETIN #33**

The following information is distributed as a public service to the Salem development community of engineers, architects, contractors, builders, and developers to make them aware of any changes in the City permit and plan approval process, design standards, or construction standards which may have an impact on their operations:

## **ASPHALT CONCRETE PAVEMENT DESIGN STANDARD**

**PURPOSE: NOTICE OF CHANGE IN THE CITY'S DESIGN PROCEDURE FOR  
ASPHALT CONCRETE PAVEMENT DESIGN**

### **BACKGROUND:**

The City's flexible pavement design procedure is shown in Section 2.13 of the Street Design Standards. The process is a modification of a 1981 Oregon State Highway Division design procedure that is based upon subgrade R-value, truck traffic 18-kip axle loads, and crushed base equivalencies. In lieu of requiring custom pavement designs for each project, designers could use the City's Standard Plan 312 Typical Flexible Pavement Structure. Most projects that have been constructed since 1980 have used the values on former Standard Plan 312.

The City has recently been noticing that many of our streets are not lasting the 20-year design period without significant deterioration. The most noticeable early deteriorations have been on local streets with transit bus routes, collector streets and arterial streets. Many of these are only lasting about 10 years until there is significant deterioration.

During the past five years the City has constructed, resurfaced or reconstructed approximately forty street segments that have been funded by general obligation bonds. For the pavement structure design, we have hired consulting pavement engineering firms. Two firms from the Portland metro area have done most of the work. In general the City has supplied the traffic count information, and the consultant has done non-destructive pavement testing and calculated a recommended pavement structure. The results we have been receiving have been consistently stronger sections than shown on former Standard Plan 312. Attached is a table and a graph showing the results of these forty

projects. The individual projects are plotted along with the City's standard per Standard Plan 312. From the graph one can readily see that the requirements per Standard Plan 312 are at the very lower part of the range for soil conditions and axle loadings for local, collector and arterial streets.

Based upon the above two observations, the City felt it was time to re-evaluate our flexible pavement design procedure.

There are many factors that can effect the longevity of a pavement. Factors may include, but are not limited to: accuracy of traffic predictions and changes in legal truck weights, overloaded vehicles, quality of subgrade soils and uniformity thereof, conversion factors for rock and asphalt concrete, quality of construction, preventative maintenance, etc. One of the things shown on Standard Plan 312 is a planned future overlay for collector and arterial streets. The City has not had the funds to do these planned overlays and as a consequence, in many cases they have not occurred..

#### **POLICY:**

The City's flexible design standard, as shown in Section 2.13 of the Street Design Standards and on former Standard Plan 312, are hereby deleted.

The City's new procedure for flexible pavement design shall conform to the AASHTO GUIDE FOR DESIGN OF PAVEMENT STRUCTURES, 1993.

The Asphalt Pavement Association of Oregon (APAO) in conjunction with Oregon State University have published a Asphalt Paving Design Guide dated December 30,1998. This guide conforms to the criteria in the AASHTO Guide. The APAO Guide contains Tables 4.1 and 4.2 for Thickness Design of local, collector and minor arterial streets. Attached are copies of both of these tables. In order to use these tables, the designer must determine the equivalent 18 kip axle loads and the soil strength. If the designer does not desire to determine the axle loads and soils information, The City of Salem has added default values on the bottom of each table. The APAO Guide does not provide information on the design of higher volume arterial streets. The APAO Guide recommends the use of pavement design consultants for the higher volume arterial streets. The City of Salem has extrapolated the APAO information to develop the attached table for higher volume arterial streets. We feel this is necessary for the boundary street widenings associated with subdivisions and commercial developments. The designer can adjust the thickness of asphalt concrete and aggregate base by using the ratio of 1" of asphalt concrete = 4" of aggregate base. In no cases shall the asphalt concrete thickness be less than 6" for major and minor arterial streets; nor less than 4" for collector, local and cul-de-sac streets. In no cases shall the aggregate thickness be less than 8" for major arterial, minor arterial and collector streets; nor less than 6" for local streets or cul-de-sacs.

The pavement designer is strongly encouraged to use the services of traffic engineers, geotechnical engineers or pavement design consultants in order to obtain the most economical pavement design for the project.

The City will require a project specific pavement design for any street section in which the City has reason to suspect unsuitable soil conditions, subsurface water problems, high percentage of trucks, or any other conditions that may significantly affect the pavement structure design. Local streets in industrial subdivisions shall be designed as arterial streets.

The City realizes that changing from our past procedure to the AASHTO design procedure will increase the initial costs of asphalt concrete pavement street construction. However the City cannot afford to continue constructing streets that fail prematurely. The AASHTO procedure is the current state of the art and will produce street pavement structures that more closely meet the needs of the City.

### **DELAY OF FINAL LIFT PAVING IN NEW SUBDIVISIONS**

The City is also instituting a new policy of delaying the final lift of asphalt concrete pavement on internal streets within new subdivisions. (Boundary streets are not affected by this new policy.) The final lift shall be 1 ½ -inch thickness. For streets constructed in one calendar year, the final lift of paving shall be installed between July 1<sup>st</sup> and September 30<sup>th</sup> of the following calendar year. Placement of the final lift of paving shall not be done until authorized by the City. The contractor shall notify the City at least seven calendar days in advance of final lift paving to obtain the City's authorization. Implementing this new policy will provide the following advantages:

- Provides a fail safe if an under pavement utility repair must be done in the first year.
- Any settlements in the pavement can be fixed prior to final paving.
- Provides a safeguard against late season marginal top lift paving weather.
- Provides a good looking street after homebuilding and franchise utility construction equipment ding up the pavement in the first year.
- Reduces the amount of construction debris that enters into the storm drainage system.

Manhole lids can be either set to final grade initially or placed even with the first lift and adjusted to final grade later. Temporary ramping will be required at manholes that are initially set to final grade. Water valve covers shall be placed even with the first lift and adjusted to final grade with the final lift of paving. At boundary street intersections, sufficient final lift paving shall be done to accommodate ADA requirements at sidewalk ramp locations. Water puddles will be allowed to exist at storm drainage inlets until the final lift of paving is placed.

The developer and/or his paving contractor shall be responsible to notify all affected property owners 72 hours in advance of the date and time of the final lift of paving.

A construction security deposit will be retained for the amount of the final lift of paving until the paving is completed. A one year maintenance security deposit for the final lift of paving will be retained for one year after completion of the final lift of paving.

The City will make appropriate revisions to our project improvement agreements to reflect the above policy of delaying the final lift of asphalt concrete pavement.

All Holders of the City of Salem Design Standards  
October 11, 1999  
Page 4

For more information, please contact the Public Works Department Permit Application Center, at (503) 588-6211 or (503) 588-6292 (TTY).

Karl D. Goertzen, P.E.  
City Engineer

Enclosures:

1. Summary of Pavement Designs Table
2. Plot of Pavement Designs
3. Thickness Design Tables for Local, Collector and Arterial Streets (3)
4. Worksheet for Calculating 18-kip Axle Loads
5. City of Salem AC Pavement Design Criteria
6. 8", 12", 16" Aggregate Design Charts (3)

City of Salem  
Asphalt Concrete Pavement Design Procedure Criteria

The City's procedure for flexible pavement design shall conform to the AASHTO GUIDE FOR DESIGN OF PAVEMENT STRUCTURES, 1993.

The following values shall be used for the AASHTO design formulas:

Design Life (years)	20 arterials and collectors; 25 locals
Initial Serviceability	4.2
Terminal Serviceability	2.5
Reliability Level (%)	90
Asphalt Structural Coefficient	0.41
Aggregate Structural Coefficient	0.10
Drainage Coefficient-Asphalt	1.0
Drainage Coefficient-Aggregate	0.8

The "design life" is the period of time between initial construction and the need for a structural overlay. This is defined by the serviceability indices shown above. Note that from the structural coefficients shown above, that the conversion factor for asphalt to rock is 1" of asphalt concrete = 4" of aggregate base.

### Soils

The subgrade resilient modulus shall be determined by back calculation from non-destructive testing (falling weight deflectometer) as described in the AASHTO Guide whenever possible. In instances of not being able to determine the subgrade resilient modulus by non-destructive testing methods, the City may approve obtaining the modulus by other testing methods, such as CBR and R-value, as described in the AASHTO manual. For any of the test methods, appropriate correction factors must be applied in order to obtain a resilient modulus in the range specified in the AASHTO Guide. The tests must be done in such a manner as to provide the resilient modulus at the roadway subgrade elevation, especially in cut and fill areas. A sufficient number of test locations shall be utilized to provide an understanding of the soil strength on as many sides of the project site as possible. The non-destructive tests will need to be done on existing pavement on boundary streets or streets that stub into the proposed development. Unless certified by a pavement design consultant or geotechnical engineer, the City will consider non-destructive testing results to be representative for an area 500 feet from the test location, and will require one test for each five acres or portion thereof, or for each 1,000 lineal feet of street or portion thereof being designed. A minimum of two test locations shall be required on any project. The tests shall be located to provide soil strength information for necessary widenings of existing streets, and information for the proposed new streets. The designer may desire to do additional testing to develop a better understanding of the uniformity of the soils and consequently be able to save construction costs.

The weakest soil strength shall be used for the pavement structure design. If there is an isolated weak spot, it can have a stronger pavement design, or over-excavation and backfill, while the remainder of the streets are designed using a subgrade modulus more representative of the area. The designer may want to consider the use of cement or lime treatment to increase the subgrade strength. The AASHTO Guide does not allow for a reduction in base thickness for the use of geosynthetic subgrade separation layers.

It is highly recommended that the designer utilize the services of a pavement design consultant or a geotechnical engineering consultant to determine the subgrade resilient modulus for use in the AASHTO pavement design procedure.

Unless a pavement design consultant or a geotechnical engineering design consultant is used to determine the subgrade resilient modulus, a subgrade resilient modulus of 3,000 psi shall be used.

### Traffic

Equivalent 18-kip axle loads shall be determined from classified truck traffic counts, and the design period shown above per calculation methods as shown in the AASHTO Guide. Traffic count information and truck information can be obtained from the City Traffic Engineer’s office, or from consulting licensed traffic engineers. Traffic count information from the City is limited to information that is readily available from our traffic count program on existing major streets. Traffic information may also be available from a traffic impact analysis that may have been done for the development. For dead end streets in subdivisions, the traffic projections shall consider anticipated traffic from future extensions of the street into adjacent currently unsubdivided areas. Street Classifications (arterial, collector, local) are per the Salem Transportation System Plan. The growth factor for arterial, collector and local streets shall be 2% per year, compounded annually. The directional factor shall be 0.5. The lane distribution factor shall be 0.9 for major arterials, and 1.0 for all other street categories. If project specific truck traffic information is not determined, the following shall be used:

Street Classification	ADT	Percent Trucks
Major Arterial	50,000	8
Minor Arterial	20,000	8
Collector	10,000	6
Local	1,600	4
Cul-de-sac	400	3

If classified traffic count information is not available, the following values shall be used for the classification of the traffic:

Vehicle Type	Arterial	Collector	Local	Cul-de-sac
Passenger Cars	92%	94%	96%	97%
Buses	1%	0.5%	1%	--
Panel & Pickup Trucks	2%	2%	2%	2%
2-Axle/6-Tire Trucks	1%	1%	0.5%	0.5%
3 or More Axle Trucks	1%	0.5%	--	--
3 Axle Tractor Semi-Trailers	1%	1%	0.5%	0.5%
4 Axle Tractor Semi-Trailers	1%	1%	--	--
5 Axle Tractor Semi-Trailers	1%	--	--	--

Attached is a worksheet for the calculation of 18-kip Equivalent Single Axle Loads Applications. If project specific 18-kip equivalent single axle loads are not computed, then the project design will be based upon the following:

Street Classification	Design Lane 18-Kip E.S.A.L.
Major Arterial	10,000,000
Minor Arterial	4,000,000
Collector	1,000,000
Local	100,000
Cul-de-sac	10,000

Local or collector streets in and adjacent to industrial subdivisions shall be designed as arterials.

### Design

Design Charts are attached to assist in determining the aggregate and asphalt concrete thicknesses once the subgrade resilient modulus and the total 18-kip equivalent axle loads have been determined. Charts are included for 8", 12" and 16" of aggregate. For any given aggregate depth, a person can plot the 18-kip axle loadings and subgrade resilient modulus to determine the required asphalt concrete thickness. Conversion to other equivalent pavement structural sections can be done using the above equivalency factor of 1" of asphalt concrete = 4" of aggregate. In no cases shall the asphalt concrete thickness be less than 6" for major and minor arterial streets; nor less than 4" for collector, local and cul-de-sac streets. In no cases shall the aggregate thickness be less than 8" for major arterial, minor arterial and collector streets; nor less than 6" for local streets or cul-de-sacs.

A licensed professional engineer shall submit all test results and design calculations required to perform the AASHTO design procedure for the City's review and approval.

Asphalt Pavement Association of Oregon  
Asphalt Paving Design Guide

**Table 4.1. Thickness Design - Local Residential Streets<sup>1</sup>**

Traffic	Reliability %	Subgrade Class			
		Poor	Fair	Good	Excellent <sup>2</sup>
a) Asphalt Concrete Over Aggregate Base, inches					
I Up to 10,000 EALs	All Levels	3.0/12.0	3.0/8.0	3.0/6.0	3.0/4.0
II 10-50,000 EALs	75	3.0/15.0	3.0/10.0	3.0/6.0	3.0/6.0
	90	4.0/14.0	4.0/9.0	3.5/6.0	3.5/6.0
III 50-100,000 EALs	75	3.5/14.0	3.5/11.0	3.5/6.0	3.5/6.0
	90	4.5/15.0	4.5/10.0	4.0/6.0	4.0/6.0
b) Full Depth Asphalt Concrete, inches <sup>3</sup>					
I Up to 10,000 EALs	All Levels	5.5	4.5	4.0	4.0
II 10-50,000 EALs	75	6.5	5.5	4.0	4.0
	90	7.5	5.5	4.5	4.0
III 50-100,000 EALs	75	7.5	6.0	4.5	4.0
	90	8.0	6.5	5.0	4.5

<sup>1</sup> 1 inch = 25 mm

<sup>2</sup> Excellent subgrade conditions are ideal for full depth asphalt; however, a minimum of 100 mm (4 inches) of asphalt concrete is recommended. In some cases aggregate is needed to provide material to fine grade and to provide a smooth surface to pave on. If needed, 100 mm (4 inches) of aggregate is recommended as a minimum thickness for this purpose.

<sup>3</sup> Full depth asphalt can be built on poor and fair soils only in dry conditions and when the subgrade soils may be brought up to optimum moisture conditions and compacted to specification density.

Poor soil:  $M_R = 5,000$  psi or lower  
Good soil:  $M_R = 10,000$  to  $15,000$  psi

Fair soil:  $M_R = 5,000$  to  $10,000$  psi  
Excellent soil:  $M_R = 15,000$  psi or greater

For City of Salem:

Reliability shall be 90%.

Unless a soils analysis is done, use "Poor" subgrade class.

Unless a traffic analysis is performed:

Cul-de-sacs = 10,000 EALs

Local streets = 100,000 EALs

For the AC over aggregate alternative, the minimum AC thickness shall be not less than 4", and the minimum rock thickness shall be not less than 6".

Mix Selection - 12.5 mm mix, PBA-5 Asphalt Cement, Marshall method (50 blows - 3% air voids).

Asphalt Pavement Association of Oregon  
Asphalt Paving Design Guide

**Table 4.2. Thickness Design - Collector Streets<sup>1</sup>**

Traffic	Reliability %	Subgrade Class			
		Poor	Fair	Good	Excellent <sup>2</sup>
a) Asphalt Concrete Over Aggregate Base, inches					
IV 100-250,000 EALs	All Levels	4.5/18.0	4.5/12.0	4.5/6.0	4.5/4.0
		5.0/18.0	5.0/11.0	4.5/6.0	4.5/4.0
V 250-500,000 EALs	75	5.5/18.0	5.5/11.0	5.0/6.0	5.0/6.0
	90	6.0/19.0	6.0/12.0	5.5/6.5	5.5/6.0
VI 500,1,000,000 EALs	75	6.0/20.0	6.0/13.0	5.5/6.5	5.5/6.0
	90	7.0/19.0	7.0/12.0	6.0/7.0	6.0/6.0
b) Full Depth Asphalt Concrete, inches <sup>3</sup>					
IV 100-250,000 EALs	All Levels	8.5	7.0	5.5	5.0
		9.0	7.5	6.0	5.5
V 250-500,000 EALs	75	9.5	8.0	6.0	5.5
	90	10.0	8.5	6.5	6.0
VI 500-1,000,000 EALs	75	10.5	8.5	7.0	6.0
	90	11.5	9.5	7.5	6.5

<sup>1</sup> 1 inch = 25 mm

<sup>2</sup> Excellent subgrade conditions are ideal for full depth asphalt; however, a minimum of 100 mm (4 inches) of asphalt concrete is recommended. In some cases aggregate is needed to provide material to fine grade and to provide a smooth surface to pave on. If needed, 100 mm (4 inches) of aggregate is recommended as a minimum thickness for this purpose.

<sup>3</sup> Full depth asphalt can be built on poor and fair soils only in dry conditions and when the subgrade soils may be brought up to optimum moisture conditions and compacted to specification density.

Poor soil:  $M_R = 5,000$  psi or lower  
Good soil:  $M_R = 10,000$  to  $15,000$  psi

Fair soil:  $M_R = 5,000$  to  $10,000$  psi  
Excellent soil:  $M_R = 15,000$  psi or greater

**For City of Salem:**

Reliability shall be 90%.

Unless a soils analysis is done, use "Poor" subgrade class.

Unless a traffic analysis is performed:

Collector streets = 1,000,000 EALs

For the AC over aggregate alternative, the minimum AC thickness shall be not less than 4", and the minimum rock thickness shall be not less than 8".

Mix Selection - 19 mm mix, PBA-5 Asphalt Cement, Marshall method (50 blows - 4% air voids).

## APAO Paving Guide Concept Extrapolated for Arterial Streets

### Thickness Design - Arterial Streets<sup>1</sup>

Traffic	Reliability %	Subgrade Class			
		Poor	Fair	Good	Excellent <sup>2</sup>
a) Asphalt Concrete Over Aggregate Base, inches					
1-2,500,000 EALs	90	7.0/26.0	7.0/18.0	7.0/8.0	7.0/8.0
2.5-5,000,000 EALs	90	8.0/28.0	8.0/18.0	8.0/10.0	8.0/8.0
5-10,000,000 EALs	90	9.0/30.0	9.0/18.0	9.0/10.0	9.0/8.0
b) Full Depth Asphalt Concrete, inches <sup>3</sup>					
1-2,500,000 EALs	90	13.0	11.0	8.5	8.0
2.5-5,000,000 EALs	90	15.0	12.0	10.0	9.5
5-10,000,000 EALs	90	16.0	13.0	11.0	10.5

<sup>1</sup> 1 inch = 25 mm

<sup>2</sup> Excellent subgrade conditions are ideal for full depth asphalt; however, a minimum of 100 mm (4 inches) of asphalt concrete is recommended. In some cases aggregate is needed to provide material to fine grade and to provide a smooth surface to pave on. If needed, 100 mm (4 inches) of aggregate is recommended as a minimum thickness for this purpose.

<sup>3</sup> Full depth asphalt can be built on poor and fair soils only in dry conditions and when the subgrade soils may be brought up to optimum moisture conditions and compacted to specification density.

Poor soil:  $M_R = 5,000$  psi or lower  
 Good soil:  $M_R = 10,000$  to  $15,000$  psi

Fair soil:  $M_R = 5,000$  to  $10,000$  psi  
 Excellent soil:  $M_R = 15,000$  psi or greater

For City of Salem:

Reliability shall be 90%.

Unless a soils analysis is done, use "Poor" subgrade class.

Unless a traffic analysis is performed:

Minor arterial streets = 4,000,000 EALs

Major arterial streets = 10,000,000 EALs

For the AC over aggregate alternative, the minimum AC thickness shall be not less than 6", and the minimum rock thickness shall be not less than 8".

Mix Selection - 19 mm mix, PBA-5 Asphalt Cement, Marshall method (50 blows - 4% air voids).

