APPENDIX F

BOWLING GREEN / WARREN COUNTY

PAVEMENT CATALOG

Section F.1 Flexible Pavement Thickness Design Procedures

The procedures for designing flexible (asphalt) pavement are listed below:

1) For a residential street, estimate the number of houses that will be served by the street. For a loop/cul-de-sac/other low volume street, it will equal the number of houses on that street. For a continuing (through) street, it will equal the number of houses that will use the street when entering/exiting the subdivision.

   For developments that are designed in phases, streets shall be designed to reflect the usage they will experience over the life of the proposed development. Therefore, if a street will be a primary access route for construction traffic during a subdivision's site development, this street shall be designed to meet the industrial/commercial standards that reflect its true usage, versus being designed to reflect its eventual usage as a residential street. This standard is required to prevent premature damaging of the street's pavement. Considerations for this requirement will include phasing of subdivisions, number of street connections, density of the development or other factors that may contribute to the projected traffic load on the road network at the time of development.

   In residential subdivisions, there will be a maximum of three (3) street classifications. The hierarchy will be as follows: Low volume streets will be identified. Next, the local streets that serve them will be identified. Finally, the minor collectors that serve the low volume and local streets will be identified. Typically, only one minor collector will exist and serves as the "spine" of the subdivision, channeling traffic to the main entrance. Transition between different classes of pavements shall be done at intersections or over a distance of fifty (50) feet if not at an intersection.

2) For a street that will serve industrial or commercial property, estimate the gross floor area for the development. For hotels and motels, estimate the number of rooms. For a bank, determine if a drive through will be present and number of bays associated with it. For convenience stores, determine the number of gas pumps.

3) Determine the number of Equivalent Axle Loads (ESALs) from Table F-3 for residential streets, and from Table F-4 for commercial/industrial streets.

4) Because the subgrade's type and condition is critical to the final life expectancy of a street proper geotechnical analysis must be completed. In particular testing shall include a California Bearing Ratio (CBR) and a Proctor Test. Based on CBR (determined from ASTM D 1883, current edition), determine the required Structural Number from Table F-5. If rock roadbed, use a CBR value of 7. The minimum structural numbers are shown in Table F-1. Alternate methods of CBR determination must be approved by the Planning Commission staff, in consultation with the developer's geotechnical engineer prior to use. For ASTM D

1883, determine dry unit weight and optimum water content from a Standard Proctor Density Test. The CBR sample shall be within -2% to +1 % of maximum dry density and 0% to +2% of optimum moisture content. It is recommended that the dry density and moisture content of remolded (laboratory compacted) CBR samples should be equivalent to the minimum allowable field compaction criteria (ninety-seven percent (97%) of standard Proctor maximum dry density). The moisture content should be near optimum to ease compaction of the sample as determined by the testing engineer.

Table F-1

Street Classification	SN
Low Volume Street	2.00
Local (Residential) Street	2.40
Neighborhood Collector	3.00
Minor Collector	4.00
Major Collector	4.20
Arterial	4.20
Commercial	4.20
Industrial	4.20

Low volume streets are cul-de-sac streets that serve four hundred (400) ADT (approximately forty (40) dwelling units) or less. In residential subdivisions, the SN for each classification of street will be standardized to provide a maximum of three (3) different pavement designs for the subdivision. Standardization will be based on average SN and adjusted based on good engineering judgment.

5) Determine the required thickness of asphalt, DGA, No. 2 stone, and stabilized subgrade to achieve the required structural number. The layer coefficients are listed below:

Table F-2

Flexible Pavement Layer	Coefficient
Asphalt	0.44 (0.30 for existing asphalt)
DGA / CSB	0.12 (0.10 for existing DGA)
No. 2 Stone	0.08
Geogrids (within aggregate Layer)	Increase DGA coefficient to 0.17
Stabilized Subgrade	0.08

Layer thickness designs may be specified as one of two categories, Maximum Asphalt Design or Maximum Aggregate Design. Maximum Asphalt Designs include a minimum DGA layer of four (4) inches, followed by asphalt base and surface to meet the required structural number. Maximum Aggregate Designs include a ratio of one-third (1/3) asphalt (in inches) to two-thirds (2/3) aggregate (in inches), in thicknesses to meet the required structural number. Maximum

Asphalt Designs are typically used in soil/rock fill, rock cut situations, modified subgrade, and when a wet subgrade is not a factor. Maximum Aggregate Designs are used in soil cut situations, curb and gutter and when wet subgrade will be a factor.

If the asphalt surface course will not be placed immediately after the asphalt base is laid then the asphalt base and DGA courses shall be designed such that the thickness of asphalt base and DGA will meet the design structural number.

Minimum asphalt surface thickness shall be one and one-fourth (1 ¼)-inch and for asphalt base two (2) inches shall be the minimum design thickness used in subdivision design.

DGA is used in the aggregate layer in curb and gutter and shoulder/ditch sections in which the aggregate layer does not "daylight" into the ditch. Alternate materials may be considered on a case by case basis.

If pavements are constructed immediately after compaction of fine-grained soils, then major problems typically will not be encountered when placing and compacting layers of paving materials. Problems arise when surface and subsurface water penetrates compacted fine-grained soils. Water from rainfall, snowmelt and groundwater enters the fine-grained soils subgrade, causing swelling and producing a loss of bearing capacity in the subgrade. When a soil subgrade is exposed to extended wet periods an alternate design may be used where six (6)-inch No. 2 stone is used for the first four (4) inches of DGA, i.e. four (4) inches DGA is structurally equivalent to six (6) inches of No. 2 stone. A filter fabric shall be placed between the No. 2 stone and the subgrade when using the winter design. Fabric shall be placed so that longitudinal edges lap a minimum of eighteen (18) inches.

6) Subgrade shall be constructed and compacted per Article 6 of the Subdivision Regulations. Subgrade shall be compacted or stabilized. Soils that fail to compact, have high moisture content or a CBR less than four (4) may be stabilized by undercutting eight (8) inches and replacing with No. 2 stone on filter fabric using geo-fabrics, hydrated lime or Portland cement as approved by the Planning Commission representative. If unstable areas are discovered during the subgrade proof roll test, then the areas must be stabilized. There are various stabilization techniques available; whichever method the contractor chooses must be approved by the Planning Commission representative. In the event that placing rock is chosen, then the contractor shall remove at least twelve (12") inches (or as directed by the Planning Commission representative) of the unstable material and replace it with No. 2 stone, separated from the subgrade with filter fabric.

7) Pavement at medians, traffic circles, islands and other obstacles in the road shall have fifteen (15) foot lanes, or three (3) feet more width per lane in such entry areas, and corner radius of 35' at entrances providing multiple wheel path opportunity which would lessen the constant isolated pavement loading associated with single lane travel ways. Also, the structural number shall be

increased by adding twenty percent (20%) to the calculated structural number for that street. Increased structural number would provide additional strength in these areas which will receive the constant isolated pavement loading. A distance of fifty (50) feet will be used to transition from median section to road section.

8) Pavement drainage shall be required. The goal is to provide drainage of water that infiltrates the pavement structure. Acceptable methods include but are not limited to:

- lowering the inlet elevation of curb inlets one and one-fourth (1 1/4)-inch and sloping concrete gutter and asphalt surface to match
- adding weep holes in the upper section of the curb inlets
- edge drain systems
- scratch course of asphalt surface at curb inlet locations to direct water to the inlet; this method shall require milling to remove the scratch course prior to final surface course.

Pavement drainage shall be shown on the construction plans and approved prior to construction.

Table F-3
Equivalent Single Axle Loads for Residential Streets

	Equivalent Single Axle Loads				
Number of Houses Served by Street	Construction Trucks	Moving Vans	Garbage Trucks	School Buses	Total
0	0	0	6240	12000	18240
20	600	240	6240	12000	19080
40	1200	480	6240	12000	19920
60	1800	720	6240	12000	20760
80	2400	960	6240	12000	21600
100	3000	1200	6240	12000	22440
120	3600	1440	6240	12000	23280
140	4200	1680	6240	12000	24120
160	4800	1920	6240	12000	24960
180	5400	2160	6240	12000	25800
200	6000	2400	6240	12000	26640
220	6600	2640	6240	12000	27480
240	7200	2880	6240	12000	28320
260	7800	3120	6240	12000	29160
280	8400	3360	6240	12000	30000
300	9000	3600	6240	12000	30840
320	9600	3840	6240	12000	31680
340	10200	4080	6240	12000	32520
360	10800	4320	6240	12000	33360
380	11400	4560	6240	12000	34200
400	12000	4800	6240	12000	35040
420	12600	5040	6240	12000	35880
440	13200	5280	6240	12000	36720
460	13800	5520	6240	12000	37560
480	14400	5760	6240	12000	38400
500	15000	6000	6240	12000	39240

Notes:
Number of Houses Served by Street - For a loop/cul-de-sac/other low volume street, it will equal the number of houses on that street. For a continuing (through) street, it will equal the number of houses that will use the street when entering/exiting the subdivision.

Construction Trucks - Based on twenty (20) loaded supply trucks per house and 1.5 ESALs per truck, for a total of thirty (30) ESALs per house. Construction Trucks may be reduced or deleted if the engineer provides a separate construction entrance into the subdivision that does not utilize the permanent streets.

Moving Vans - Based on each house selling four (4) times in twenty (20) years and each transaction involving one (1) loaded moving van for the seller and buyer, for a total of eight (8) trucks per house. It assumes 1.5 ESALs per turck for a total of 12 ESALs per house.

Garbage Trucks - Based on the following for a 20-year design life:
2 garbage trucks/street/wk x 52 wks/yr x 20 yrs x 1.5 ESALs/truck = 3120 ESALs
1 recycling truck/street/wk x 52 wks/yr x 20 yrs x 1.5 ESALs/truck = 1560 ESALs
1 yard waste recycling truck/street/wk x 52 wks/yr x 20 yrs x 1.5 ESALs/truck = 1560 ESALs
Total of above = 6240 ESALs per street for garbage trucks

School Buses - Based on the following for a 20-year design life: 2 school buses/day/street x 200days/yr x 20 yrs x 1.5 ESALs/bus = 12000 ESALs per street

Table F-4
20-Year ESALs for Various Industrial and Commercial Developments

Land Use	Gross Floor Area (Sq. Ft.) x 1000											
	1	5	10	20	40	60	80	100	200	300	500	1,000
General Light Industrial (15% Trucks)	80,000	115,000	159,000	246,000	418,000	586,000	752,000	915,000	1,681,000	2,370,000	3,515,000	5,020,000
General Heavy Industrial (20% Trucks)	3,000	16,000	31,000	63,000	126,000	188,000	251,000	314,000	628,000	942,000	1,570,000	3,414,000
Warehousing (25% Trucks)	32,000	123,000	219,000	389,000	692,000	968,000	1,229,000	1,479,000	2,629,000	3,681,000	5,623,000	9,994,000
General Office Building (2% Trucks)	1,000	8,000	17,000	35,000	70,000	105,000	141,000	176,000	354,000	531,000	885,000	1,771,000
Retail (2% Trucks)	21,000	102,000	201,000	393,000	745,000	1,056,000	1,327,000	1,557,000	2,100,000	2,840,000	3,923,000	6,630,000

Land Use	Number of Rooms							
	10	50	100	200	400	600	800	1,000
Hotel (1% Trucks)	3,000	38,000	83,000	171,000	348,000	525,000	702,000	879,000
Motel (1% Trucks)	8,000	47,000	99,000	207,000	433,000	667,000	906,000	1,149,000

Land Use	Number of Drive Through Lanes (including ATM)					
	1	2	3	4	6	8
Banks with Drive Throughs (0.5% Trucks) (8)	23,000	45,000	68,000	90,000	135,000	180,000

Land Use	Gross Floor Area (Sq. Ft.) x 1000				
	1	2	3	4	1
Restaurants 1.5% Trucks) (8)	22,000	43,000	64,000	86,000	107,000

Land Use	Number of Pumps					
	2	4	6	8	10	12
Convenience Stores w/ Gas pumps (1.0% Trucks) (8)	119,000	238,000	356,000	475,000	594,000	713,000

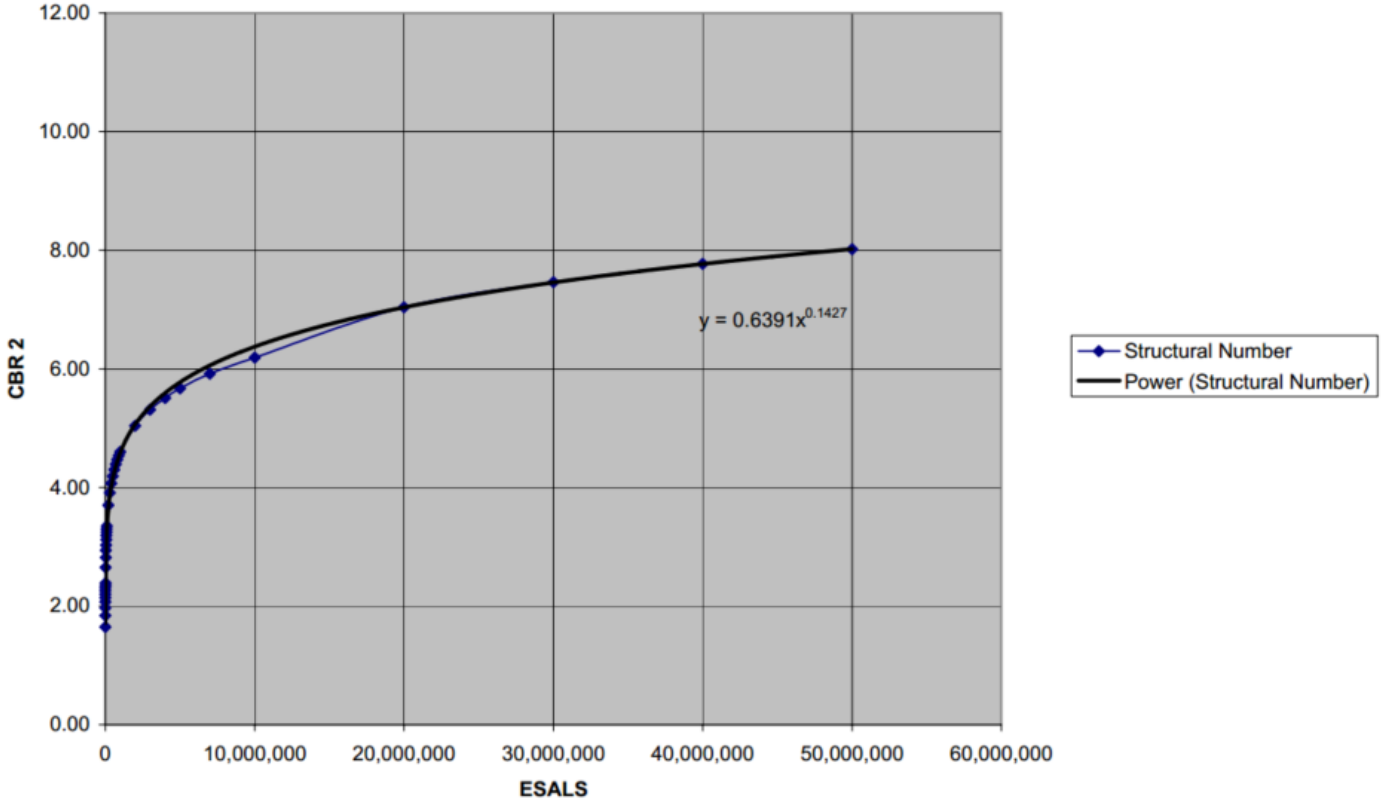
Notes:
1.Number of trips generated for each type of development calculated from the Manual of Trip Generation published by the Institute of Transportation Engineers.
2.ESALs calculated by the computer program PAS 5 developed by the American Concrete Pavement Association, or as noted.
3.Trucks were assumed to be 50% C5As (TYPE 9) and 50% SU3As (TYPE 6)
4.Loaded TYPE 9s were assumed to weigh 80,000 lbs. Empty or nearly empty TYPE 9s were assumed to weigh 50,000 lbs.
5.Loaded TYPE 6s were assumed to weigh 46,000 lbs. Empty or nearly empty TYPE 6s were assumed to weigh 30,000 lbs.
6.50% of both TYPE 9s and TYPE 6s were assumed to be empty.
7.The numbers in the table have been rounded to the nearest 1000.
8.Based on ADT x % Trucks x 365 days/yr x 20 yrs x 1.5 ESAL/truck = # ESAL

Table F-5
Structural Numbers

ESALs	CBR 1	CBR 2	CBR 3	CBR 4	CBR 5	CBR 6	CBR 7
1,000	2.15	1.65	1.39	1.23	1.09	1.01	1.00
2,000	2.38	1.84	1.58	1.39	1.27	1.17	1.08
3,000	2.54	1.97	1.69	1.50	1.36	1.26	1.17
4,000	2.65	2.07	1.77	1.58	1.44	1.33	1.24
5,000	2.74	2.14	1.84	1.64	1.50	1.39	1.30
6,000	2.81	2.20	1.89	1.69	1.55	1.43	1.34
7,000	2.88	2.26	1.94	1.74	1.59	1.47	1.38
8,000	2.94	2.31	1.99	1.78	1.63	1.51	1.42
9,000	2.99	2.35	2.02	1.81	1.66	1.54	1.45
10,000	3.03	2.39	2.06	1.85	1.69	1.57	1.47
20,000	3.35	2.65	2.30	2.07	1.90	1.77	1.67
30,000	3.55	2.82	2.44	2.20	2.03	1.89	1.79
40,000	3.70	2.94	2.55	2.31	2.13	1.99	1.87
50,000	3.81	3.03	2.64	2.39	2.20	2.06	1.94
60,000	3.91	3.12	2.71	2.45	2.27	2.12	2.00
70,000	3.99	3.19	2.78	2.51	2.32	2.17	2.05
80,000	4.07	3.25	2.83	2.56	2.37	2.22	2.10
90,000	4.13	3.30	2.88	2.61	2.41	2.26	2.14
100,000	4.19	3.35	2.93	2.65	2.45	2.30	2.17
200,000	4.60	3.70	3.24	2.94	2.72	2.55	2.42
300,000	4.86	3.91	3.43	3.12	2.89	2.71	2.57
400,000	5.04	4.07	3.57	3.25	3.01	2.83	2.69
500,000	5.19	4.19	3.68	3.35	3.11	2.93	2.78
600,000	5.31	4.30	3.78	3.44	3.20	3.01	2.85
700,000	5.42	4.39	3.86	3.52	3.27	3.08	2.92
800,000	5.51	4.47	3.93	3.58	3.33	3.13	2.98
900,000	5.60	4.54	4.00	3.64	3.39	3.19	3.03
1,000,000	5.67	4.60	4.06	3.70	3.44	3.24	3.07
2,000,000	6.19	5.04	4.45	4.07	3.79	3.57	3.40
3,000,000	6.51	5.31	4.70	4.30	4.01	3.78	3.60
4,000,000	6.75	5.51	4.88	4.47	4.17	3.93	3.74
5,000,000	6.93	5.67	5.03	4.60	4.30	4.06	3.86
7,000,000	7.23	5.92	5.25	4.81	4.49	4.25	4.04
10,000,000	7.55	6.19	5.50	5.04	4.71	4.45	4.24
20,000,000	8.49	7.04	6.29	5.80	5.46	5.18	4.94
30,000,000	8.98	7.46	6.67	6.17	5.81	5.52	5.27
40,000,000	9.33	7.77	6.96	6.44	6.08	5.78	5.52
50,000,000	9.62	8.02	7.20	6.66	6.29	5.99	5.72

Minimum Low Volume Street
Minimum Local (Residential) Street
Minimum Minor Collector Street
Minimum Major Collector, Arterial, Commercial, Industrial Street

CBR 2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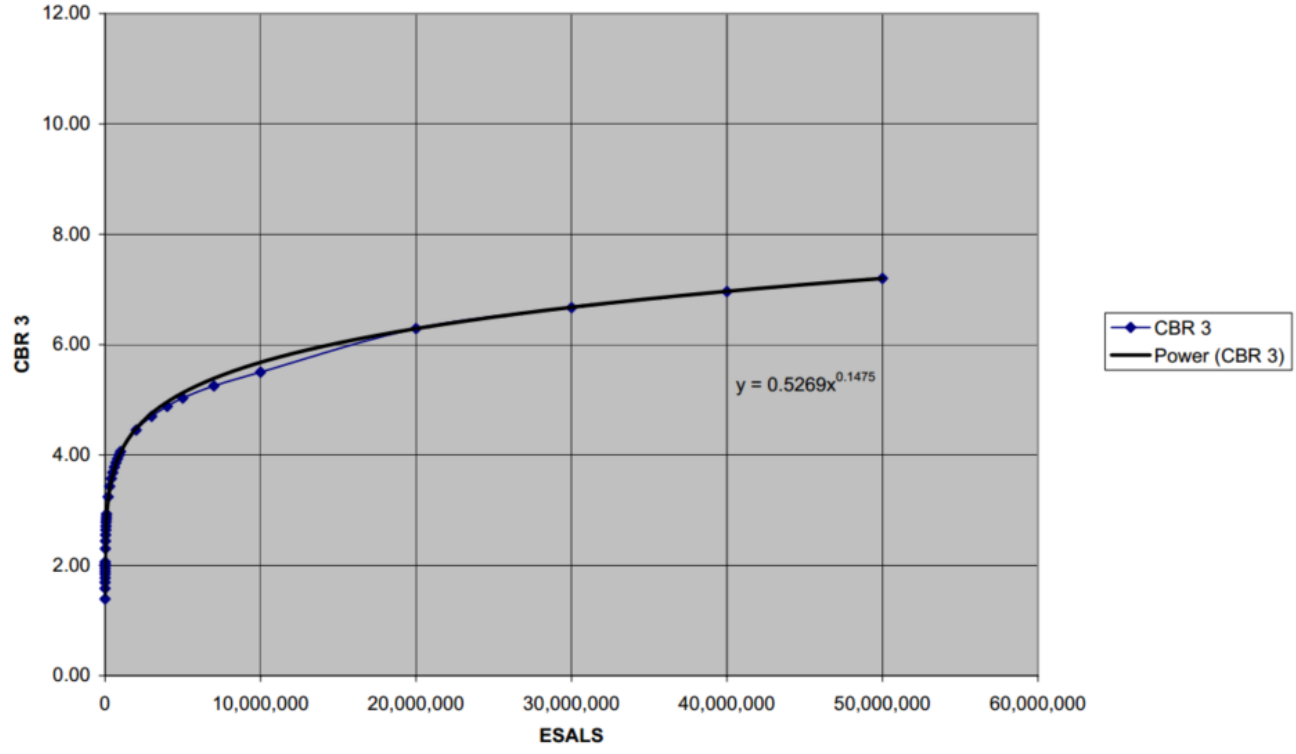
Structural Number
Power (Structural Number)

CBR 3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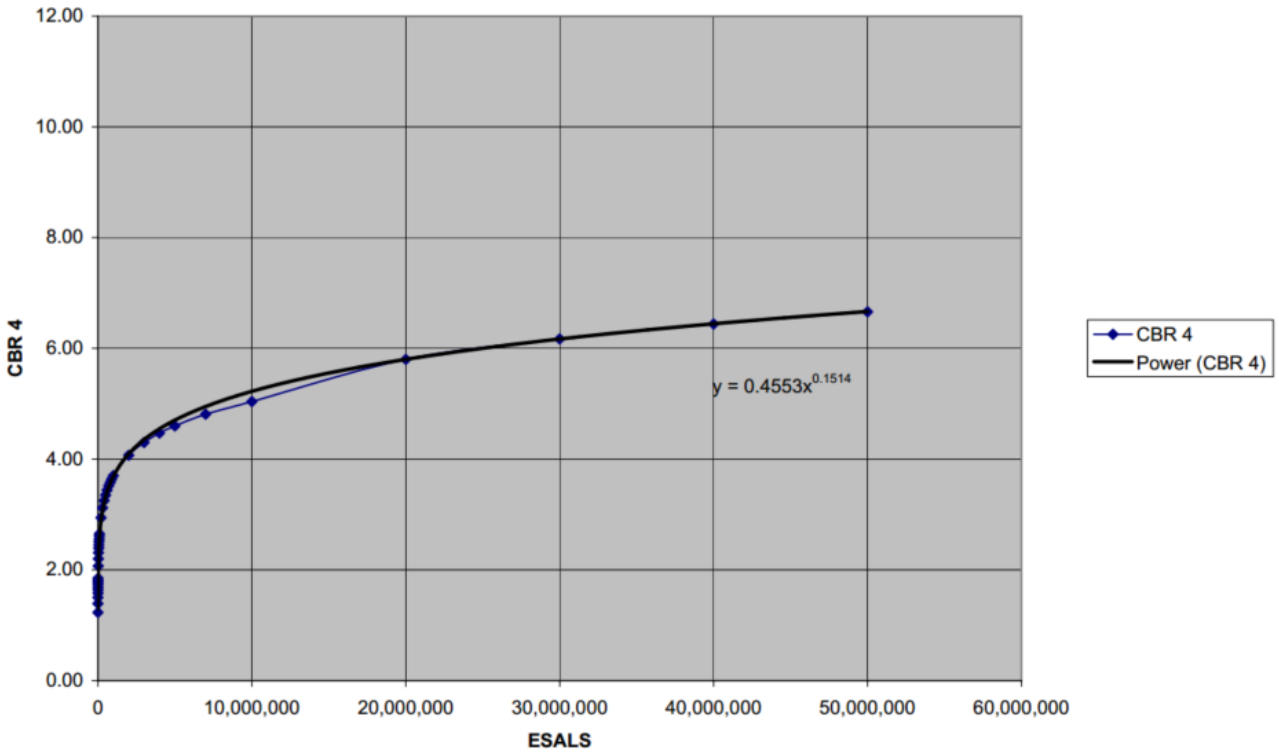
CBR 3
Power (CBR 3)

CBR 4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ESALS
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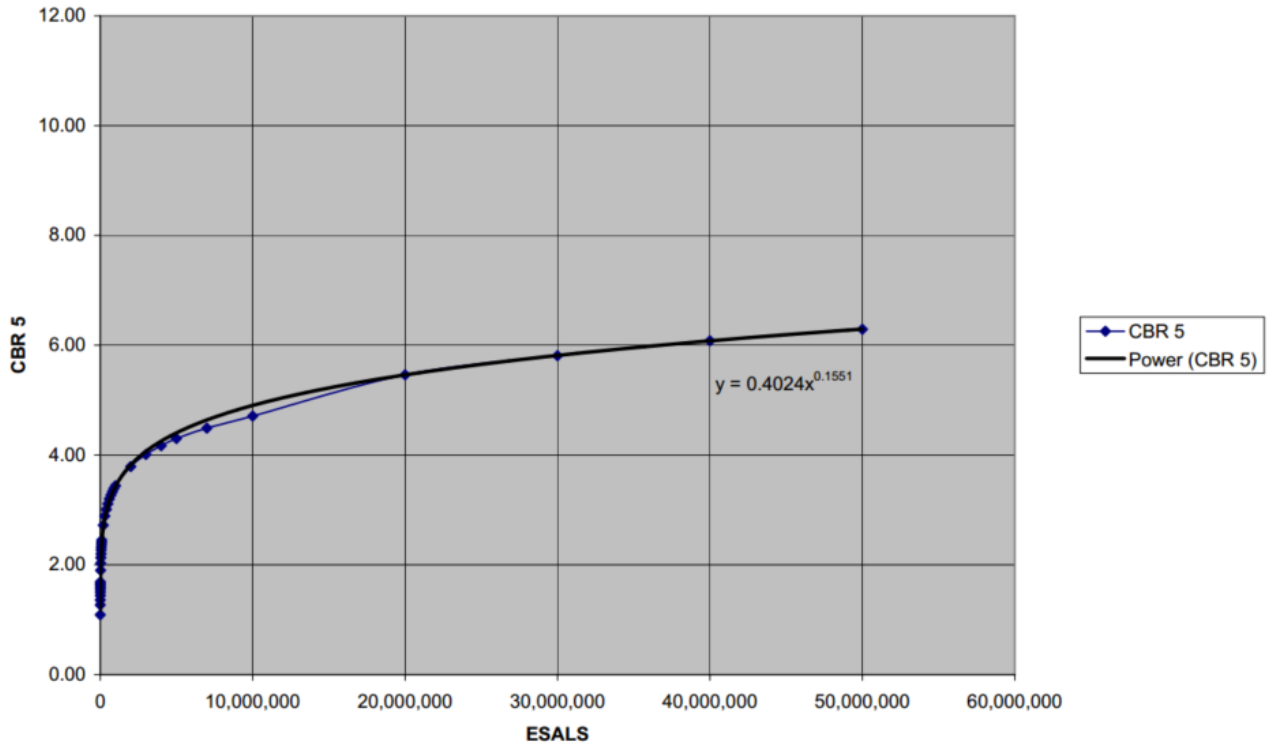
CBR 4
Power (CBR 4)

CBR 5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60,000,000
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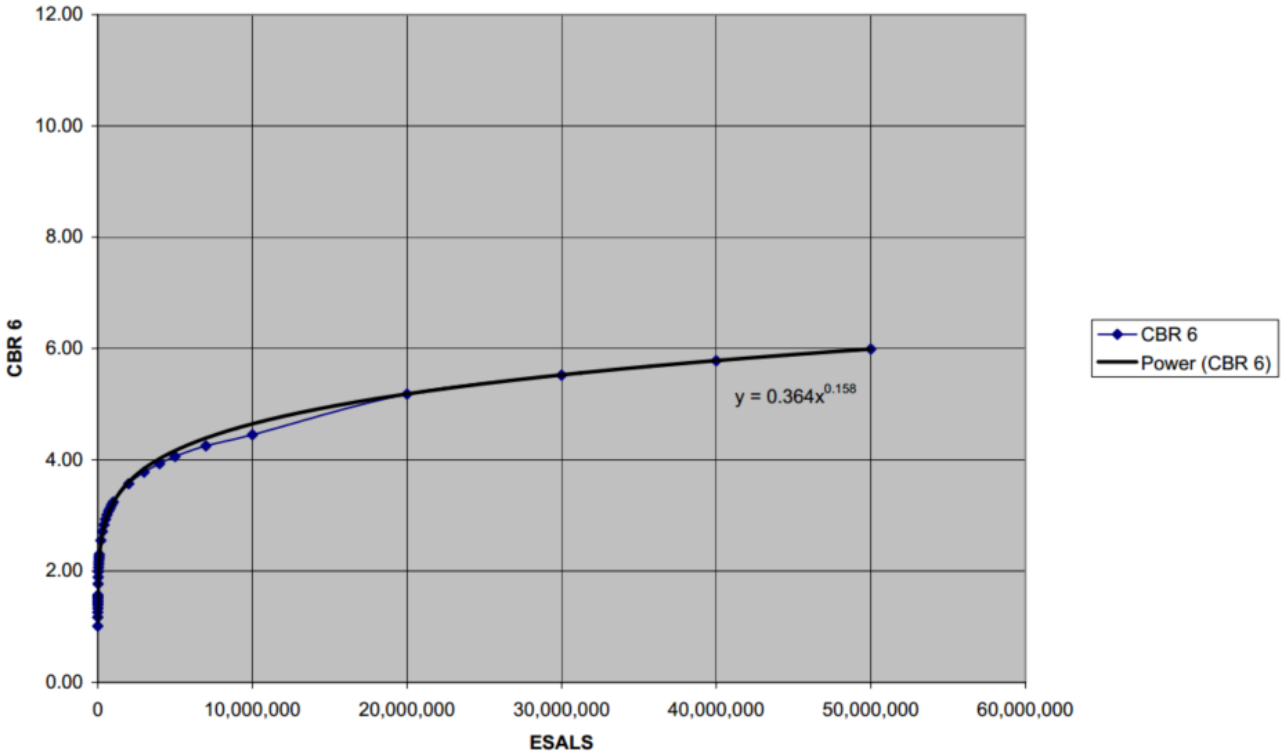
CBR 5
Power (CBR 5)

CBR 6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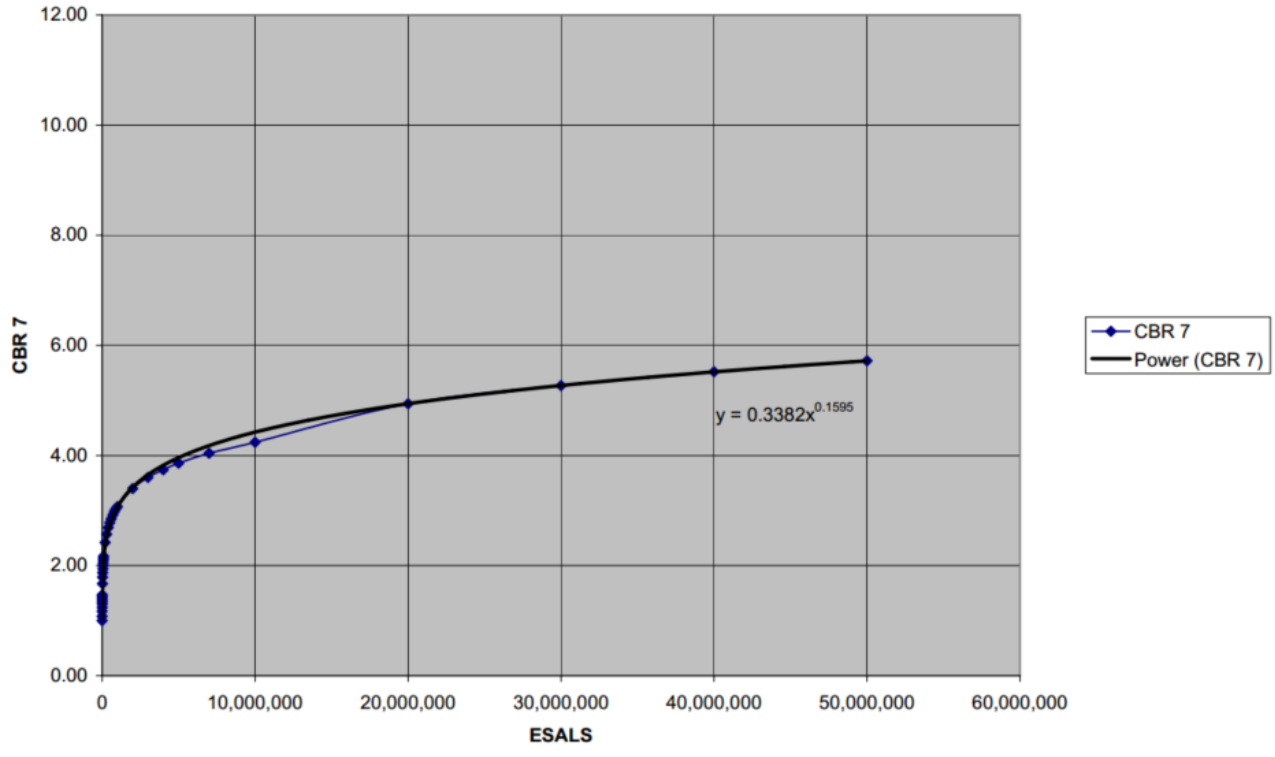
CBR 6
Power (CBR 6)

CBR 7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CBR 7
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40,000,000
50,000,000
60,000,000
ESALS
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CBR 7
Power (CBR 7)

Pavement Catalog Section F.2 Flexible Pavement Mix Design Procedures

All asphalt materials shall meet the specifications for Super Pave mixes as defined by the current Edition of the Kentucky Transportation Cabinet's Standard Specifications for Road and Bridge Construction.

Asphalt surface mixes shall include a three-eighths (3/8)-inch nominal maximum aggregate size.

All aggregate materials shall meet the specifications for such mixes as defined by the current Edition of the Kentucky Transportation Cabinet's Standard Specifications for Road and Bridge Construction.

Section F.3 Flexible Pavement Plant Testing / Inspection Procedures

All asphalt and aggregate materials shall be sampled, tested and reported to the Planning Commission staff per the plant testing requirements of the current edition of the Kentucky Transportation Cabinet's Standard Specifications for Road and Bridge Construction. At a minimum, one test should be performed per project with roadways totaling greater than five hundred (500) feet in length. Testing shall be completed early during production to allow for adjustments and to communicate results to field personnel inspecting placement. The developer, the engineer, contractors, third party testing agencies and suppliers (collectively known as external party agents), shall be responsible for all asphalt and aggregate plant testing and any other testing and paperwork needed for acceptance. At the discretion of the Planning Commission, a quality assurance check of the sampling and testing may be required if deficiencies are suspected. External party agents shall be properly certified by the Kentucky Transportation Cabinet or the appropriate trade organization for the work they are performing. A copy of such certification shall be provided to the Planning Commission staff prior to performing the work.

Section F.4 Flexible Pavement Construction Procedures

All asphalt and aggregate materials shall be placed by methods as defined by the current Edition of the Kentucky Transportation Cabinet's Standard Specifications for Road and Bridge Construction and Article 6.

Section F.5 Flexible Pavement Field Inspection Procedures

Planning Commission staff will provide routine site visits and visual observations of the construction activities throughout the duration of the project. The developer, the engineer, surveyor, contractors, third party testing agencies and suppliers (collectively known as external party agents) shall be responsible for all PQI, coring or nuclear density testing and any other testing and paperwork needed for acceptance. At the discretion of the Planning Commission, a quality assurance check of the sampling and testing may be required if deficiencies are suspected. External party agents shall be properly certified by the Kentucky Transportation Cabinet or the appropriate trade organization for the work they are performing. A copy of such certification shall be provided to the Planning Commission engineer prior to performing the work.

Nuclear density testing shall be required on all DGA courses and PQI, coring, or nuclear density testing shall be required on all asphalt base courses. Asphalt base courses shall be compacted to a density equal to minimum ninety-two percent (92%) solid volume and maximum ninety-six percent (96%) solid volume. Asphalt surface testing will not be required.

Methods further defined in Article 6.

Section F.6 Rigid Pavement Thickness Design Procedures

The procedures for designing rigid (concrete) pavement are listed below:

All concrete pavement designs shall meet the specifications for rigid pavement as defined by the current Edition of the Kentucky Transportation Cabinet's Standard Specifications for Road and Bridge Construction. Designs will be reviewed and approved by the Planning Commission staff on a case by case basis.

Section F.7 Rigid Pavement Mix Design Procedures

All concrete materials shall meet the specifications for such mixes as defined by the current edition of the Kentucky Transportation Cabinet's Standard Specifications for Road and Bridge Construction.

All aggregate materials shall meet the specifications for such mixes as defined by the current edition of the Kentucky Transportation Cabinet's Standard Specifications for Road and Bridge Construction.

Section F.8 Rigid Pavement Plant Testing / Inspection Procedures

All concrete and aggregate materials shall be sampled, tested and reported to the Planning Commission staff per the plant testing requirements of the current edition of the Kentucky Transportation Cabinet's Standard Specifications for Road and Bridge Construction. At a minimum, one (1) test should be performed per project with roadways totaling greater than five hundred (500) feet in length. Testing shall be completed early during production to allow for adjustments and to communicate results to field personnel inspecting placement. The developer, the engineer, contractors, third party testing agencies, and suppliers (collectively known as external party agents) shall be responsible for all concrete and aggregate plant testing and any other testing and paperwork needed for acceptance. At the discretion of the Planning Commission, a quality assurance check of the sampling and testing may be required if deficiencies are suspected. External party agents shall be properly certified by the Kentucky Transportation Cabinet or the appropriate trade organization for the work they are performing. A copy of such certification shall be provided to the Planning Commission staff prior to performing the work.

Section F.9 Rigid Pavement Construction Procedures

All concrete and aggregate materials shall be placed by methods as defined by the current edition of the Kentucky Transportation Cabinet's Standard Specifications for Road and Bridge Construction and Article 6.

Section F.10 Rigid Pavement Field Inspection Procedures

Planning Commission staff will provide routine site visits and visual observations of the construction activities throughout the duration of the project. The developer, the engineer, surveyor, contractors, third party testing agencies, and suppliers (collectively known as external party agents) shall be responsible for all nuclear density testing and any other testing and paperwork needed for acceptance. At the discretion of the Planning Commission, a quality assurance check of the sampling and testing may be required if deficiencies are suspected. External party agents shall be properly certified by the Kentucky Transportation Cabinet or the appropriate trade organization for the work they are performing. A copy of such certification shall be provided to the Planning Commission staff prior to performing the work.

Nuclear density testing shall be required on all DGA courses. Methods are further defined in Article 6.

Section F.11 Other Pavement Types (brick, pavers, etc.)

Other pavement types shall be designed, constructed and approved on a case by case basis by the designer and Planning Commission staff.

Section F.12 Pavement Acceptance

All flexible pavement asphalt and aggregate materials testing and inspection shall be evaluated by the Planning Commission staff per the requirements of the current edition of the Kentucky Transportation Cabinet's Standard Specifications for Road and Bridge Construction. The goal is to produce asphalt and aggregate in place that meets the specification of one hundred percent (100%) lot pay adjustment schedule value ranges for Option A and B mixtures as defined in Section 402 of the current edition of the Kentucky Transportation Cabinet's Standard Specifications for Road and Bridge Construction. However, asphalt and aggregate materials will be considered acceptable if the test results determine the material is within the specifications of ninety percent (90%) lot pay adjustment schedule value ranges. Asphalt and aggregate materials determined during the required testing to be out of specification shall require adjustment at the plant or the field to produce material in place within specification. The materials shall then be retested for compliance. Materials that continue to be out of specification shall be evaluated by the Planning Commission staff, City/County Engineer or Public Works Department, engineer and contractor per the procedures defined in Kentucky Method KM 64-448-04, and/or an extended warranty period shall be negotiated by the developer and City/County Engineer or Public Works Department prior to acceptance. Rigid and other pavements shall be evaluated and accepted by similar methods.

Section F.13 Pavement Design Submittal Folder

A pavement design folder shall be submitted to the Planning Commission staff for approval. The folder shall include the following information: Project Identification, Preparer Qualifications, Design Calculations, Geotechnical Information, Final Pavement Design Summary with Typical Section, and any other information related to the design.