

APPENDIX E
DETERMINATION OF HOURLY TRAFFIC NUMBERS

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DETERMINATION OF HOURLY NUMBER OF TRAFFIC

In order to analyze reflective cracking propagation caused by bending or shearing, hourly number of traffic should be considered in each of the tire length increments within each traffic category. The number of traffic can be calculated from probability density which is determined based on the cumulative distribution on tire length in each category.

Probability Density on Tire Patch Length

The probability density of tire patch length shows the frequency distribution of each tire length on a category, which is required to determine the number of traffic during each hour of each day. The number of traffic for the 1-hour time period in each day for eight traffic categories and tire length increments is used to calculate bending or shearing stress intensity factor. Also, the hourly number of traffic loads is required to calculate the modulus of the overlay at the tip of the crack for each hour of the day. They should be done before doing any reflective crack growth calculation. The calculation of the hourly number of loads for traffic categories and tire length increments will be discussed later in this chapter. The probability density of tire patch lengths for each category can be determined from the cumulative axle load distribution function by differentiating:

$$P(L_j) = \frac{dC(L_j)}{dL_j} \quad (E-1)$$

where

$$P(L)_j = \text{probability density function within category } j$$

For instance, the probability density function for the category 1 of LTPP section 180901 can be determined, as shown in Figure E-1, based on the cumulative axle load distribution of the section shown in Appendix D, Figure D-7. The probability densities for all load categories of the LTPP section are shown at the end of this appendix. Default probability densities for Level 3 data input, presented in Table E-1, are provided in the reflection cracking software, which was computed using the LTPP traffic database.

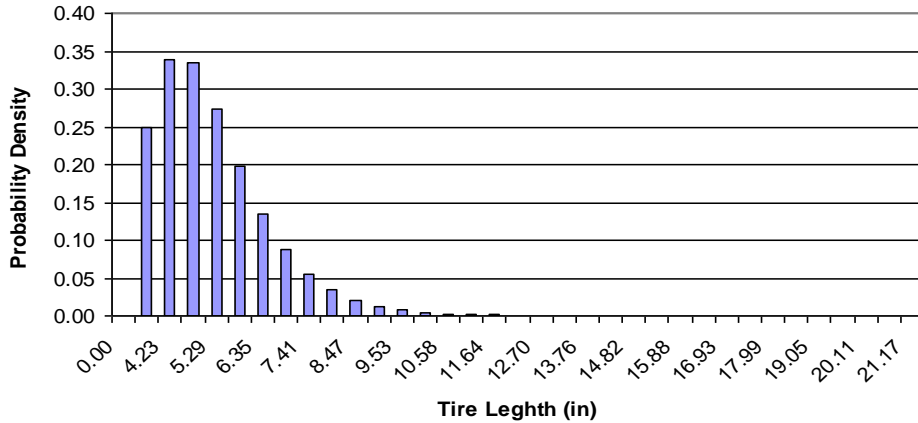


Figure E-1. Probability density function of tire length (category 1, LTPP section 180901).

Calculating Hourly Number of Traffic

As described previously, since the modulus of overlay at the tip of the crack and bending or shearing stress intensity factor are calculated at the 1-hour time periods in each day, hourly number of traffic for each category should be determined. In order to determine the hourly number of traffic using AADTT or the annual number of axle loads of each category, the hourly truck traffic distribution factors which represent the percentage of traffic within each hour of the day should be determined first. The hourly truck traffic distribution factors can be computed using truck traffic data measured continuously over a 24 hours period of time (NCHRP 2004). The reflection crack software provides default values computed from the LTPP traffic database, and the values can be used for Level 3 analysis. The default hourly truck traffic distribution factors are presented in Table E-2.

Table E-1. Default probability density for each load category.

No.*	Category							
	1	2	3	4	5	6	7	8
1	0.1974	0.3502	0.1109	0.1014	0.3486	0.1993	0.3608	0.0429
2	0.2570	0.5155	0.1457	0.1753	0.2462	0.2733	0.3282	0.1103
3	0.2709	0.5924	0.1696	0.2542	0.1564	0.3320	0.2713	0.2140
4	0.2473	0.5753	0.1797	0.3216	0.0936	0.3668	0.2102	0.3344
5	0.2050	0.4984	0.1771	0.3659	0.0543	0.3762	0.1558	0.4426
6	0.1591	0.3994	0.1651	0.3831	0.0309	0.3640	0.1122	0.5158
7	0.1181	0.3037	0.1474	0.3759	0.0174	0.3365	0.0792	0.5453
8	0.0851	0.2227	0.1273	0.3508	0.0097	0.3002	0.0551	0.5349
9	0.0601	0.1594	0.1071	0.3146	0.0054	0.2604	0.0380	0.4954
10	0.0418	0.1122	0.0884	0.2736	0.0030	0.2209	0.0260	0.4392
11	0.0289	0.0781	0.0719	0.2324	0.0017	0.1842	0.0178	0.3763
12	0.0198	0.0540	0.0577	0.1937	0.0009	0.1516	0.0121	0.3143
13	0.0135	0.0371	0.0459	0.1591	0.0005	0.1234	0.0082	0.2573
14	0.0092	0.0254	0.0363	0.1292	0.0003	0.0997	0.0056	0.2074
15	0.0062	0.0174	0.0285	0.1040	0.0002	0.0800	0.0038	0.1653
16	0.0042	0.0118	0.0223	0.0831	0.0001	0.0638	0.0026	0.1306
17	0.0029	0.0081	0.0174	0.0661	0.0000	0.0507	0.0017	0.1024
18	0.0019	0.0055	0.0136	0.0523	0.0000	0.0402	0.0012	0.0799
19	0.0013	0.0037	0.0105	0.0413	0.0000	0.0318	0.0008	0.0621
20	0.0009	0.0025	0.0082	0.0325	0.0000	0.0251	0.0005	0.0481
21	0.0006	0.0017	0.0063	0.0255	0.0000	0.0198	0.0004	0.0372

* Number represents the tire patch length increment listed in Table D-2.

Table E-1. Default probability density for each load category (continued).

No.*	Category							
	1	2	3	4	5	6	7	8
22	0.0004	0.0012	0.0049	0.0200	0.0000	0.0156	0.0002	0.0287
23	0.0003	0.0008	0.0038	0.0157	0.0000	0.0122	0.0002	0.0221
24	0.0002	0.0005	0.0029	0.0123	0.0000	0.0096	0.0001	0.0170
25	0.0001	0.0004	0.0023	0.0096	0.0000	0.0075	0.0001	0.0131
26	0.0001	0.0003	0.0018	0.0075	0.0000	0.0059	0.0001	0.0101
27	0.0001	0.0002	0.0014	0.0059	0.0000	0.0046	0.0000	0.0077
28	0.0000	0.0001	0.0010	0.0046	0.0000	0.0036	0.0000	0.0059
29	0.0000	0.0001	0.0008	0.0036	0.0000	0.0029	0.0000	0.0046
30	0.0000	0.0001	0.0006	0.0028	0.0000	0.0022	0.0000	0.0035
31	0.0000	0.0000	0.0005	0.0022	0.0000	0.0018	0.0000	0.0027
32	0.0000	0.0000	0.0004	0.0017	0.0000	0.0014	0.0000	0.0021
33	0.0000	0.0000	0.0003	0.0013	0.0000	0.0011	0.0000	0.0016
34	0.0000	0.0000	0.0002	0.0010	0.0000	0.0008	0.0000	0.0012
35			0.0002	0.0008	0.0000	0.0007	0.0000	0.0008
36			0.0001	0.0005	0.0000	0.0004	0.0000	0.0005
37			0.0001	0.0004	0.0000	0.0000	0.0000	0.0000
38			0.0000	0.0000				

*Number represents the tire patch length increment listed in Table D-2.

Table E-2. Default hourly truck traffic distribution values (NCHRP 2004).

Time Period	Distribution (%)	Time Period	Distribution (%)
12:00AM – 1:00AM	2.3	12:00PM – 1:00PM	5.9
1:00AM – 2:00AM	2.3	1:00PM – 2:00PM	5.9
2:00AM – 3:00AM	2.3	2:00PM – 3:00PM	5.9
3:00AM – 4:00AM	2.3	3:00PM – 4:00PM	5.9
4:00AM – 5:00AM	2.3	4:00PM – 5:00PM	4.6
5:00AM – 6:00AM	2.3	5:00PM – 6:00PM	4.6
6:00AM – 7:00AM	5.0	6:00PM – 7:00PM	4.6
7:00AM – 8:00AM	5.0	7:00PM – 8:00PM	4.6
8:00AM – 9:00AM	5.0	8:00PM – 9:00PM	3.1
9:00AM – 10:00AM	5.0	9:00PM – 10:00PM	3.1
10:00AM – 11:00AM	5.9	10:00PM – 11:00PM	3.1
11:00AM – 12:00PM	5.9	11:00PM – 12:00AM	3.1

Hourly number of traffic for each category is the final traffic input required for the analysis of reflection cracking on asphalt overlay. To obtain the final traffic input, the daily number of axle is multiplied by the probability density factor and the hourly truck traffic distribution factors within each category for a specific axle type and vehicle class, as follows:

$$HNT_j = DNA_j \times P(L_i)_j \times HDF \quad (E-2)$$

where

HNT_j = hourly number of traffic within a category j

DNA_j = daily number of axle loads within a category j

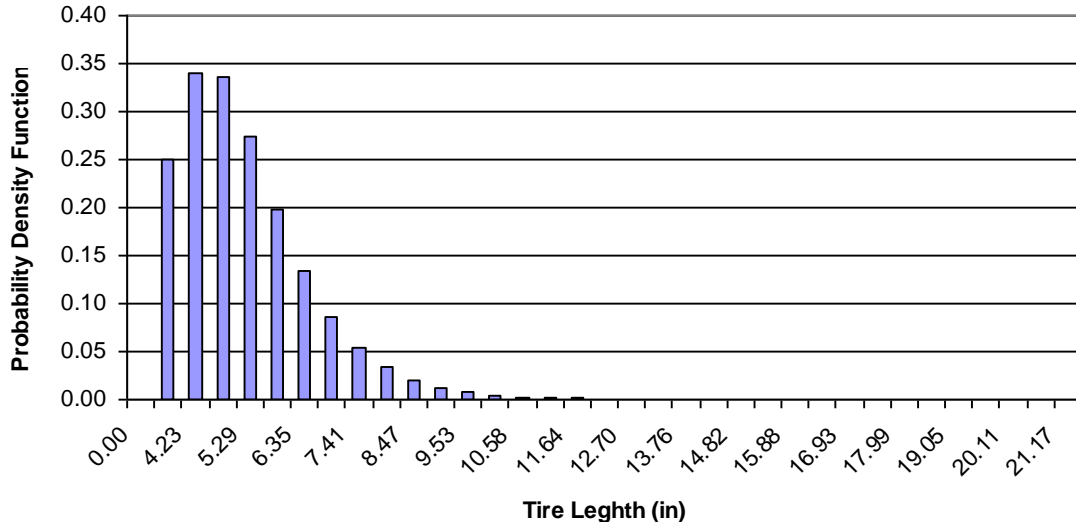
HDF = hourly truck traffic distribution factors

The hourly number of traffic within category 1 of LTPP section 080901 is listed in Table E-3 as an example. It should be noted that if the traffic increases with time then the number of vehicles and tire length increments will also increase with time. In addition, the number of axle application of each traffic category for each time increment is used to predict the distress of reflective cracking related to traffic load with time.

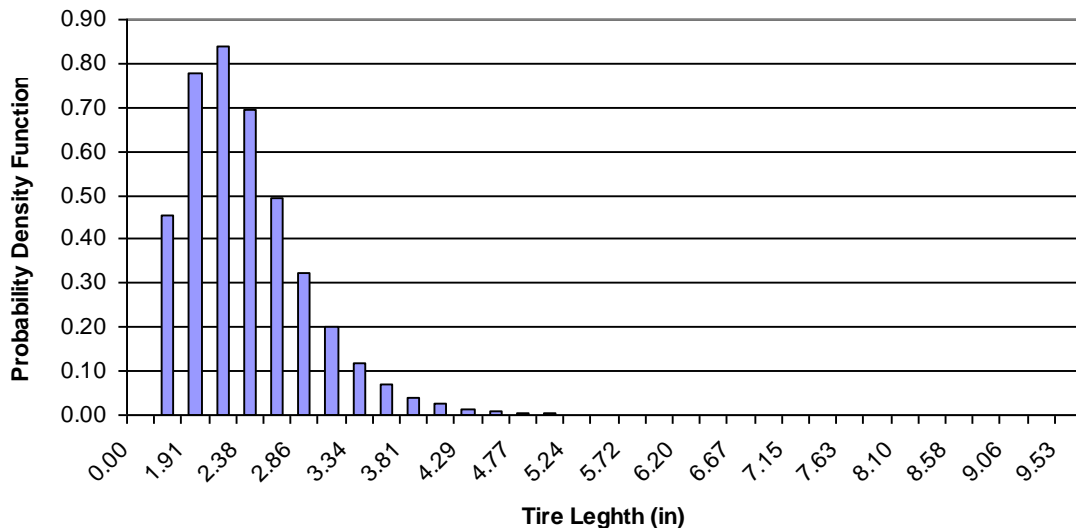
Table E-3. Hourly number of traffic for LTPP section 180901 within category 1.

Tire Length (in.)	Hourly Number of Traffic																							
	12a m	1	2	3	4	5	6	7	8	9	10	11	12pm	1	2	3	4	5	6	7	8	9	10	11
3.704	6	6	6	6	6	6	14	14	14	14	16	16	16	16	16	16	13	13	13	13	9	9	9	9
4.233	9	9	9	9	9	9	19	19	19	19	22	22	22	22	22	22	17	17	17	17	12	12	12	12
4.763	9	9	9	9	9	9	19	19	19	19	22	22	22	22	22	22	17	17	17	17	12	12	12	12
5.292	7	7	7	7	7	7	15	15	15	15	18	18	18	18	18	18	14	14	14	14	10	10	10	10
5.821	5	5	5	5	5	5	11	11	11	11	13	13	13	13	13	13	10	10	10	10	7	7	7	7
6.350	3	3	3	3	3	3	8	8	8	8	9	9	9	9	9	9	7	7	7	7	5	5	5	5
6.879	2	2	2	2	2	2	5	5	5	5	6	6	6	6	6	6	4	4	4	4	3	3	3	3
7.408	1	1	1	1	1	1	3	3	3	3	4	4	4	4	4	4	3	3	3	3	2	2	2	2
7.938	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	1
8.467	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
8.996	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0
9.525	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0	0	0	0	0
10.054	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

The complete set of probability density functions for tire patch length for all eight traffic load categories for LTPP Section 180901 are shown in the following Figures E-2.

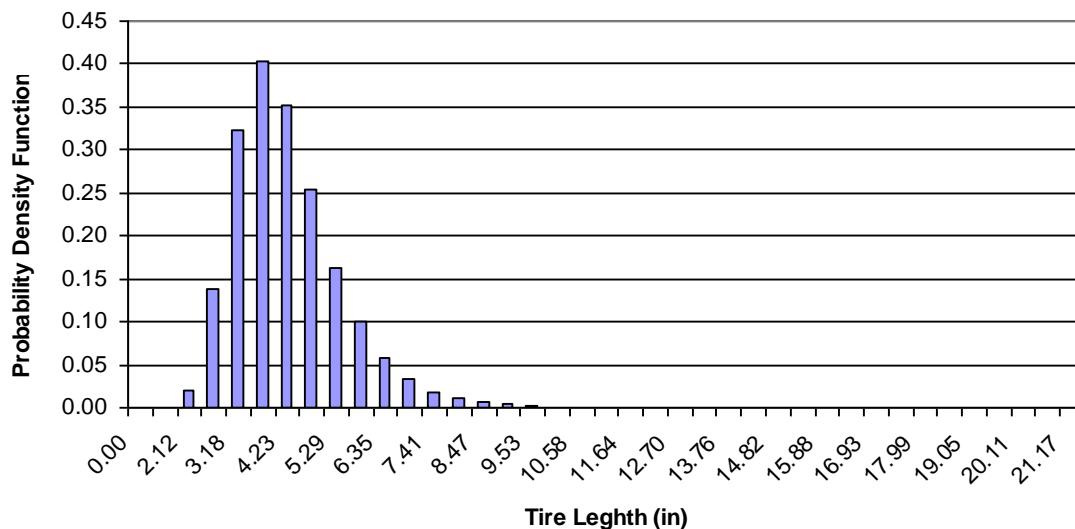


(a) Category 1 (Single axle/single tire)

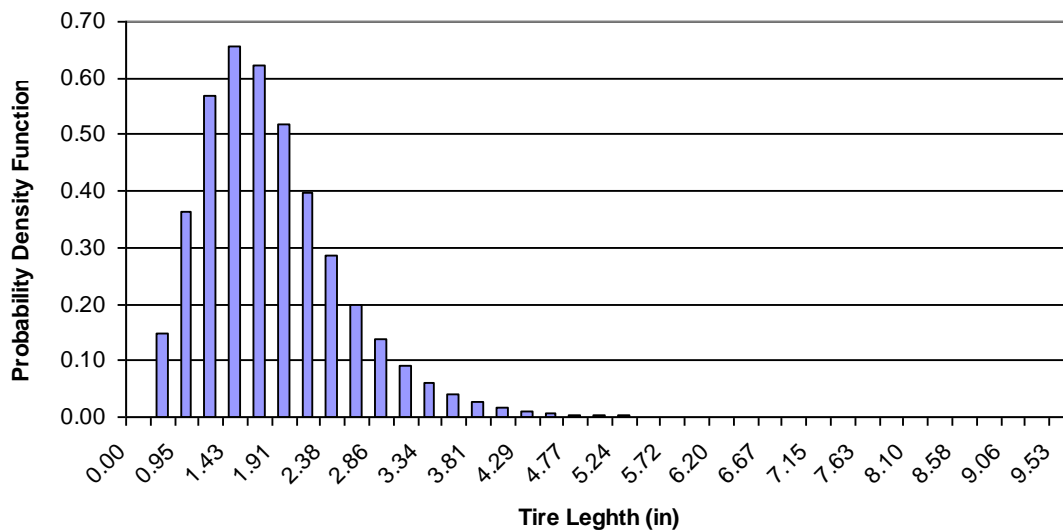


(b) Category 2 (Single axle/dual tires)

Figure E-2. Probability density functions for LTPP section 180901 (2004).

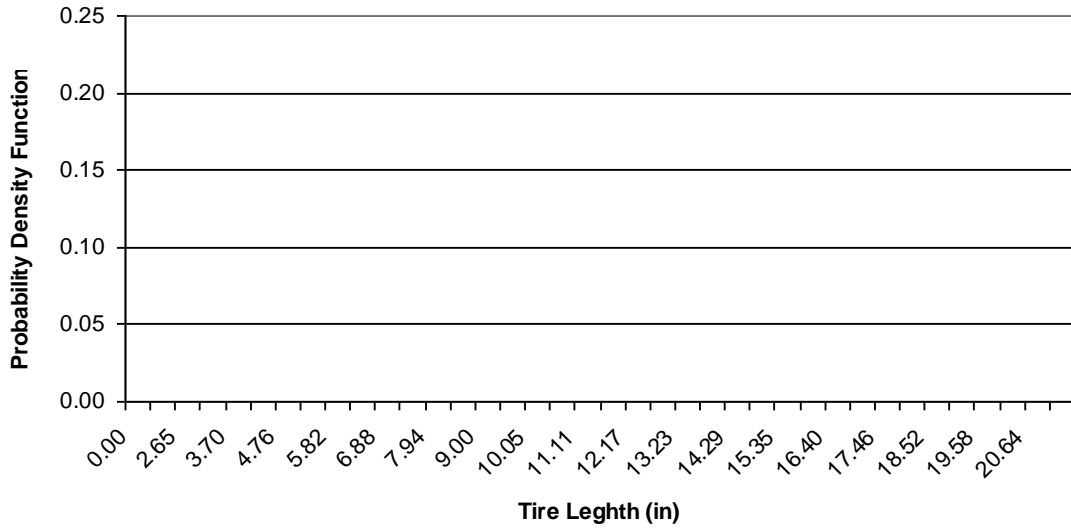


(c) Category 3 (Tandem axle/single tire)

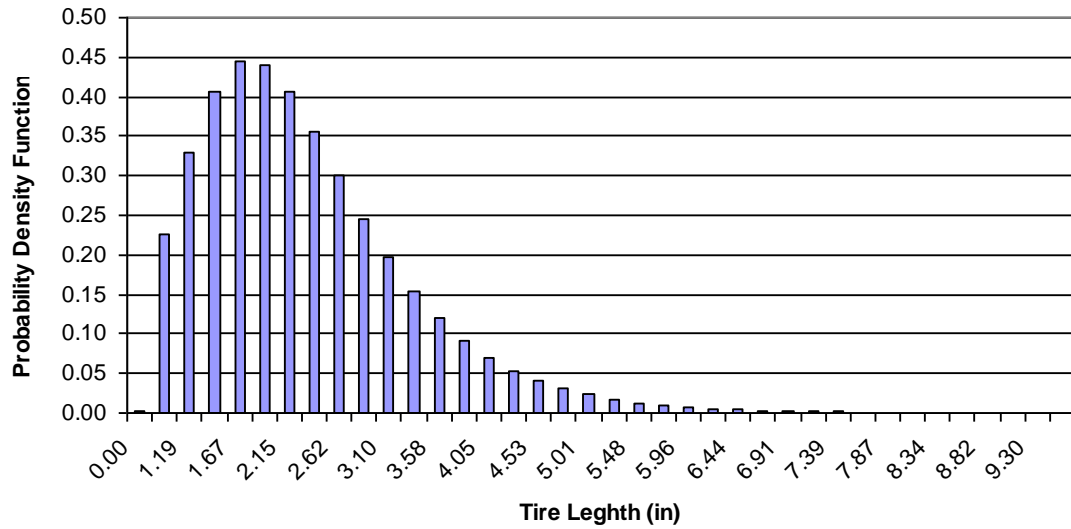


(d) Category 4 (Tandem axle/dual tires)

Figure E-2. Probability density functions for LTPP section 180901 (2004) (continued).

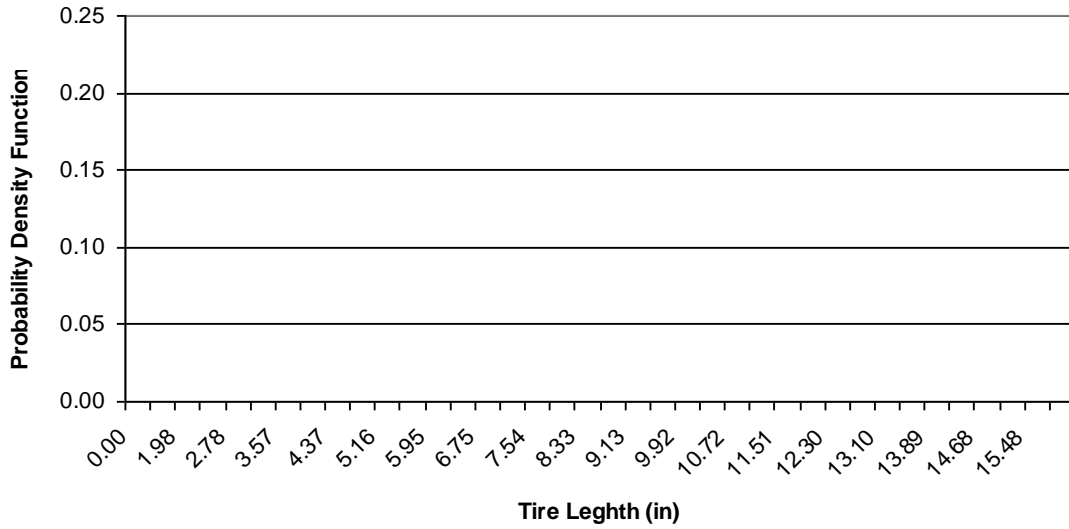


(e) Category 5 (Tridem axle/single tire)

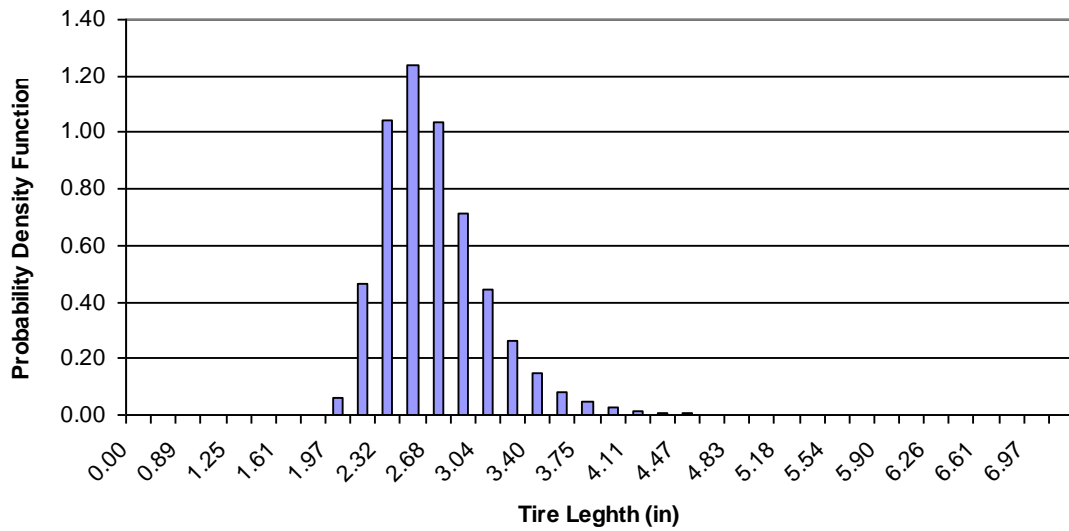


(f) Category 6 (Tridem axle/dual tires)

Figure E-2. Probability density functions for LTPP section 180901 (2004) (continued).



(g) Category 7 (Quadrem axle/single tire)



(h) Category 8 (Quadrem axle/dual tires)

Figure E-2. Probability density functions for LTPP section 180901 (2004) (continued).

