the trailing arm to the frame of the car in the standard profilometer. Such high-frequency vibrations produce some error in the double integration of the vertical acceleration. This problem can be avoided by using noncontact probes.

ACKNOWLEDGMENTS

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Estimation of Pavement Loading from Limited Vehicle Volume Sampling

A. T. PAPAGIANAKIS and A. T. BERGAN

ABSTRACT

A method is described for the approximate evaluation of pavement loading (i.e., EAL repetitions) from limited vehicle volume sampling. EAL repetition and truck volume data obtained from a weigh-in-motion (WIM) scale are analyzed. A time series model is fitted to the number of daily EAL repetitions. Strong seasonal trends are proven for the bi-hourly traffic volumes of five-axle semitrailer trucks during a period of 1 week (84 bi-hourly time spans). As a result, the daily traffic volumes of five-axle semitrailer trucks can be approximately determined by sampling five-axle semitrailer truck volumes for several hours only. Total daily EAL repetitions can be calculated from the daily volumes of the five-axle semitrailer trucks by multiplying by appropriate factors. The method of calculation of accumulated EAL involves the evaluation of EAL repetitions for several consecutive days and, subsequently, use of a regressive time series model developed to calculate future EAL repetitions.

Most highway agencies in North America use traffic volume and vehicle weight data as an essential input for their pavement management systems. Vehicle traffic volumes are obtained by sampling the number of vehicle axles through a highway network; axle load data are evaluated by sampling heavy trucks using static weigh scales. Traditionally, pavement loading, indexed by equivalent axle loads (EALs), has been predicted on the basis of vehicle traffic volumes, percentage of heavy trucks, and "weighted" EAL factors representative of the truck population in a jurisdiction (1,pp.1-5; 2). This method of evaluation of pavement loading is not only fairly crude but also extremely inefficient in terms of labor and delay costs. Pavement planning design and management require more accurate and efficient data collection systems.

Recent progress in weigh-in-motion (WIM) technology made WIM scales suitable for nonstop axle load data recording (3,4). Today WIM scales operate successfully in many sites across the United States, Canada, and Britain, recording axle load data on a continuous basis (5,6). The cost associated with WIM scales, however, is relatively high and precludes their installation at every point of interest in a highway network. Various alternative systems based on a limited number of WIM scales have been proposed. These systems provide estimates of axle load data from pertinent vehicle characteristics such as vehicle classification or vehicle length (7, p.III-1). However, the issue of hardware costs arises again when the classifier and monitor site required are considered.

In this paper the idea of estimating pavement loading from limited vehicle volume sampling using statistical methods is presented. The analysis is based on time series modeling of historic traffic volume and axle load data obtained using a WIM scale. The WIM scale data are also processed to obtain representative figures of pavement loading caused by various vehicle classifications.

The analysis is divided into four parts. First, background information is presented related to the pavement loading caused by various vehicle classifications. Second, a time series model is developed to fit total daily EAL repetitions. Third, strong seasonal trends are proven for the hourly traffic volumes of five-axle semitrailer trucks. Fourth, information from the previous steps is combined into an approximate method for EAL estimation. Finally, the proposed methodology is summarized and suggestions for its further refinement are discussed.

BACKGROUND: WIM DATA AND PROPOSED METHODOLOGY

The WIM data are obtained from a scale located in the outside eastbound lane of I-494 in the outskirts of Minneapolis, Minnesota. The WIM scale has been in continuous operation since June 1981. Data from this particular site have been previously presented and their general applications discussed (6,7). The following discussion focuses on representative EAL factors and the proportion of pavement loading caused by various vehicle classes.

The vehicle classification system adopted distinguishes 13 vehicle classes on the basis of axle number and spacing (Table 1). EAL factors for individual vehicles are calculated from axle loads using the EAL versus axle load relationships proposed by the Asphalt Institute (8,p.161). Daily EAL repetitions are calculated by summing EAL factors of individual vehicles. Table 1 gives statistics on EAL factors, EAL repetitions, and truck populations for the various vehicle classifications. It can be seen, for example, that five-axle semitrailer trucks have a mean EAL factor of 0.983, they are responsible for 65 percent of the pavement loading caused by the total truck population, and they comprise 35 percent of the total truck population.

The large number of vehicles sampled suggests that the mean EAL factors computed are fairly representative indexes of the pavement damage caused by individual vehicle classes. The standard deviation of the mean EAL values, however, suggest a fairly large variability in the EAL factors of a given vehicle class, if a normal distribution of EAL factors is assumed. Fortunately, this is not the case. Figures 1 and 2, respectively, show frequency distribution of EAL factors for vehicle Class 4 (i.e., three-axle straight) trucks and Classes 8, 9, and 12 (i.e., 97 percent five-axle semitrailer) trucks. These are approximately F-distributions with the largest population of trucks concentrated around the

TABLE 1 Representative EAL Factor Statistics, June 1981 to June 1982

VEHICLE CLASS	VEHICLE DESCRIPTION	EAL	STANDARD DEVIATION OF MEAN EAL	COEFFICIENT OF VARIATION % OF MEAN EAL	NO. OF VEHICLES	RELATIVE TRUCK POPULATION %	EAL REPETITIONS	% TOTAL EAL REPETITIONS
1	Passenger Vehicle	0.00	--	--	4,243,972		--	--
2	" " w/trailer	0.00	--	--	59,386		--	--
3	O O	0.123	0.033	26.80%	163,453	41.20%	20,105	9.54%
4	O ↓OO	0.639	0.115	18.15%	40,387	10.18%	25,807	12.29%
5	O ↓OOO	1.932	0.997	51.60%	2,183	0.55%	4,218	2.00%
6	O O O	0.133	0.097	72.90%	18,249	4.60%	2,428	1.15%
7	O ↓OO O	0.304	0.066	21.71%	21,307	5.37%	6,477	3.28%
	O O ↓OO	0.191	0.301	157.80%	2,353	0.59%	449	
8	O ↓OO ↓OO	0.983	0.184	18.72%	138,274	34.85%	135,923	64.47%
9	O ↓OO O O	1.741	0.517	29.69%	2,788	0.70%	4,854	2.30%
10	O ↓OO ↓OOO	0.867	0.352	40.62%	3,497	0.88%	3,032	2.50%
	O ↓OOO ↓OO	1.426	--	--	62	0.00%	88	
	O O ↓OOO	0.165	0.118	71.34%	251	0.00%	41	
	O ↓OOO O O	1.820	--	--	1,163	0.29%	2,117	
11	O ↓OOO ↓OOO	3.984	--	--	32	0.00%	128	0.00%
12	O O O O O	6.475	--	--	211	0.00%	1,366	0.66%
	O ↓OO O O O	0.106	--	--	243	0.00%	26	
13	Other	1.642	1.29	78.51%	2,303	0.60%	3,782	1.79%
							210,841	

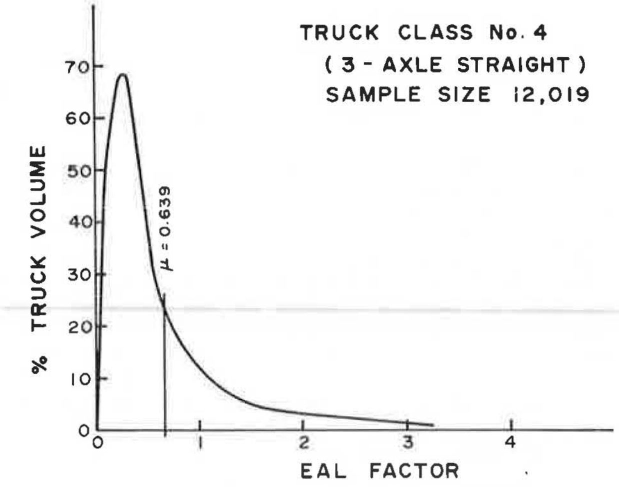


FIGURE 1 Typical frequency distribution of EAL factors: Vehicle Class 4.

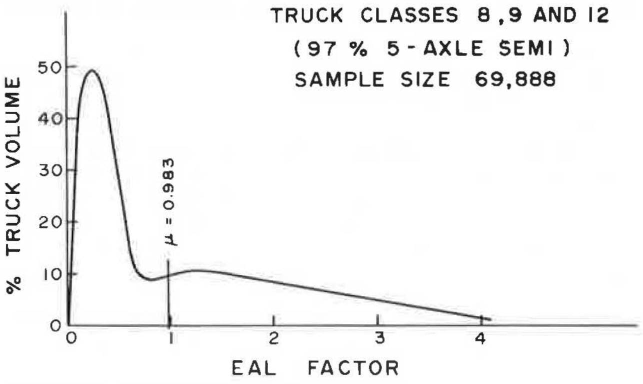


FIGURE 2 Typical frequency distribution of EAL factors: Vehicle Classes 8, 9, and 12.

low EAL factor values. Nevertheless, the calculated mean EAL factors could be regarded as representative only for large vehicle populations.

Estimation of pavement loading, that is, EAL repetitions, is accomplished by sampling traffic volumes of one vehicle class only. The vehicle class selected for sampling should have a relatively low population and be responsible for a large fraction of the pavement loading. It comes as no surprise that Vehicle Class 8 (i.e., five-axle semitrailer trucks) is the most suitable for this purpose.

Calculation of the total EAL repetitions from the EAL repetitions estimated for the Class 8 vehicles is accomplished by applying an appropriate factor. Considering the data given in Table 1, the number of EAL repetitions from five-axle semitrailer trucks must be multiplied by 1/0.6447 to yield the total number of EAL repetitions. A detailed outline of the method of estimation is included at the end of the presentation.

DAILY EAL REPETITIONS AND TIME SERIES MODELING

Analysis of the total daily EAL repetitions experienced at the site reveals interesting trends. In Figure 3, the total daily EAL repetitions are plotted versus the day of the week for a period of 2 typical summer months and 2 typical winter months. The general trend observed here is seasonality; that is, the number of daily EAL repetitions has a weekly pattern that is more or less repeated week after week.

To verify the seasonal trend visually detected, daily EAL repetition data were analyzed using the computer program IDA (9). The autocorrelation function and the partial autocorrelation functions of the daily EAL data are shown in Figures 4 and 5, respectively. Indeed, the autocorrelation function shows a definite pattern with pronounced spikes at gaps of 7, 14, 21, and so forth. This shows clearly a seasonal pattern with a period of 7 days. The par-

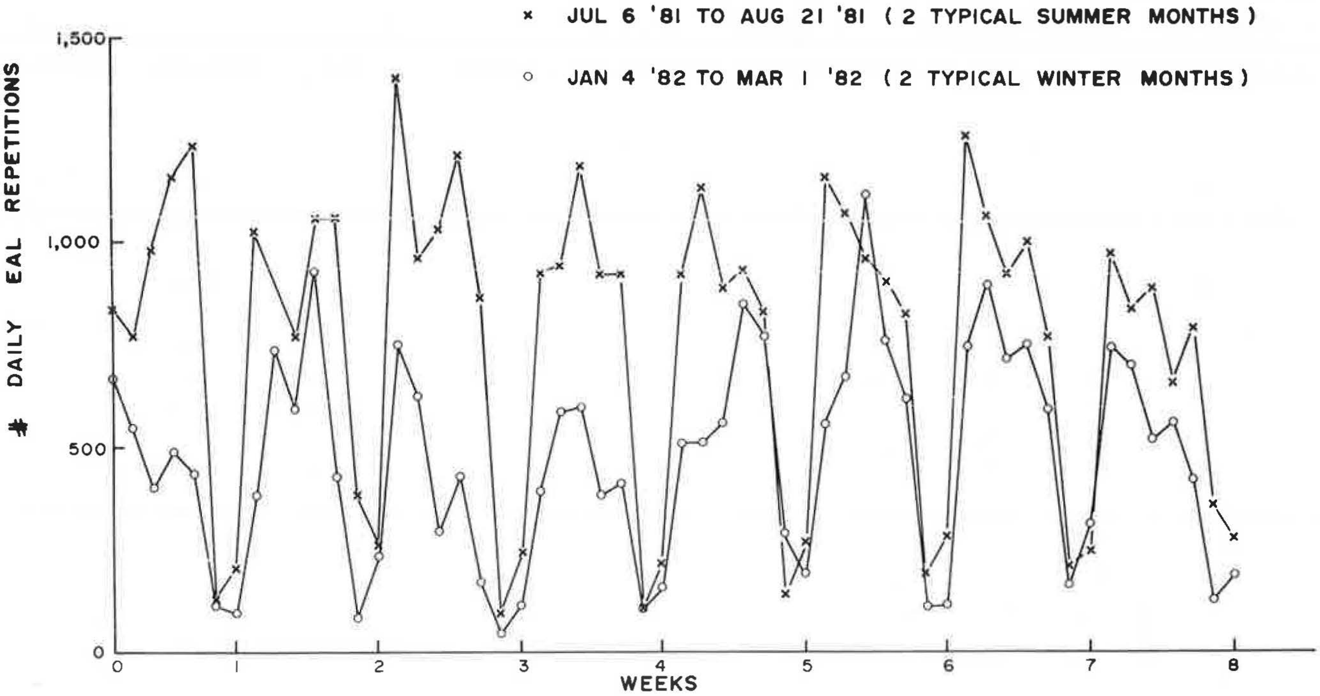
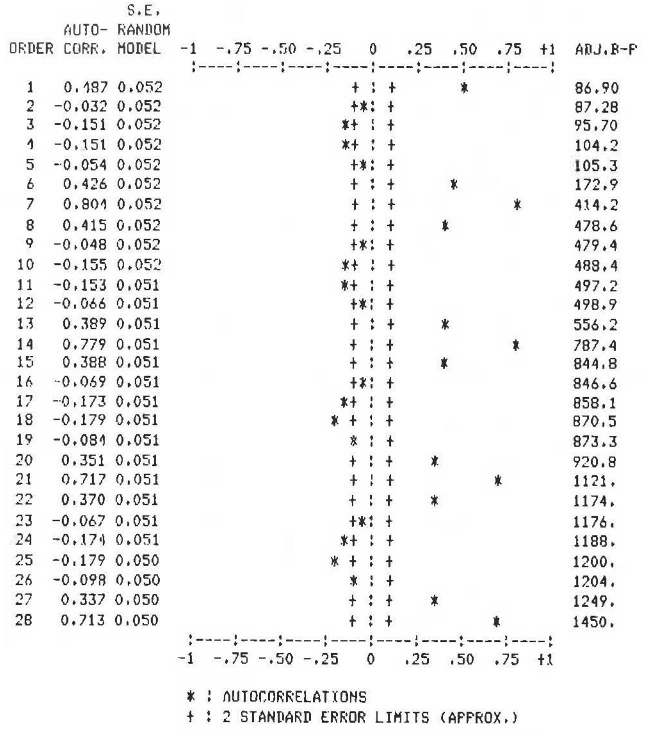


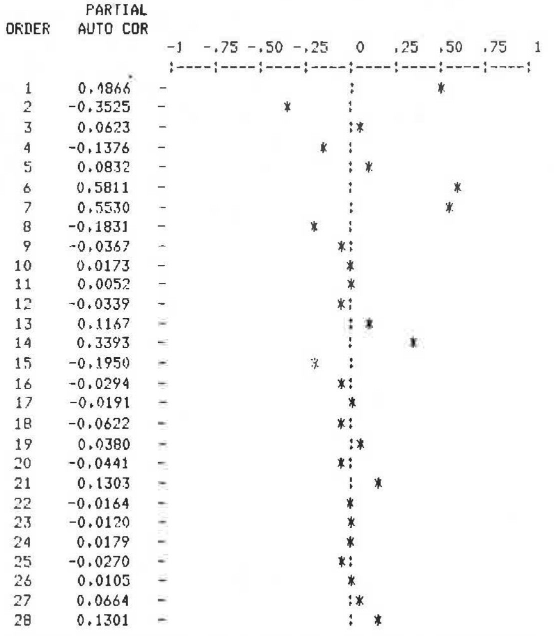
FIGURE 3 Total daily EAL repetitions for 2 summer and 2 winter months.



```
             S.E.
       AUTO- RANDOM
ORDER  CORR. MODEL  -1  -.75 -.50 -.25   0   .25  .50  .75  +1   ADJ.B-F
                    :----:----:----:----:----:----:----:----:
  1    0.487 0.052                    + : +       *             86.90
  2   -0.032 0.052                    +*: +                     87.28
  3   -0.151 0.052                   *+ : +                     95.70
  4   -0.151 0.052                   *+ : +                     104.2
  5   -0.054 0.052                    +*: +                     105.3
  6    0.426 0.052                    + : +     *               172.9
  7    0.804 0.052                    + : +             *       414.2
  8    0.415 0.052                    + : +     *               478.6
  9   -0.048 0.052                    +*: +                     479.4
 10   -0.155 0.052                   *+ : +                     488.4
 11   -0.153 0.051                   *+ : +                     497.2
 12   -0.066 0.051                    +*: +                     498.9
 13    0.389 0.051                    + : +     *               556.2
 14    0.779 0.051                    + : +             *       787.4
 15    0.388 0.051                    + : +     *               844.8
 16   -0.069 0.051                    +*: +                     846.6
 17   -0.173 0.051                   *+ : +                     858.1
 18   -0.179 0.051                  * + : +                     870.5
 19   -0.084 0.051                    * : +                     873.3
 20    0.351 0.051                    + : +    *                920.8
 21    0.717 0.051                    + : +           *         1121.
 22    0.370 0.051                    + : +    *                1174.
 23   -0.067 0.051                    +*: +                     1176.
 24   -0.174 0.051                   *+ : +                     1188.
 25   -0.179 0.050                  * + : +                     1200.
 26   -0.098 0.050                    * : +                     1204.
 27    0.337 0.050                    + : +    *                1249.
 28    0.713 0.050                    + : +           *         1450.
                    :----:----:----:----:----:----:----:----:
                    -1  -.75 -.50 -.25   0   .25  .50  .75  +1

                    * : AUTOCORRELATIONS
                    + : 2 STANDARD ERROR LIMITS (APPROX.)
```

FIGURE 4 Autocorrelation function of the daily EAL repetitions.



```
          PARTIAL
ORDER    AUTO COR
                        -1  -.75 -.50 -.25   0   .25  .50  .75   1
                        :----:----:----:----:----:----:----:----:
   1    0.4866   -                          :        *
   2   -0.3525   -                   *      :
   3    0.0623   -                          :*
   4   -0.1376   -                       *  :
   5    0.0832   -                          : *
   6    0.5811   -                          :          *
   7    0.5530   -                          :         *
   8   -0.1831   -                      *   :
   9   -0.0367   -                         *:
  10    0.0173   -                          *
  11    0.0052   -                          *
  12   -0.0339   -                         *:
  13    0.1167   -                          : *
  14    0.3393   -                          :     *
  15   -0.1950   -                      *   :
  16   -0.0294   -                         *:
  17   -0.0191   -                          *
  18   -0.0622   -                         *:
  19    0.0380   -                          :*
  20   -0.0441   -                         *:
  21    0.1303   -                          :  *
  22   -0.0164   -                          *
  23   -0.0120   -                          *
  24    0.0179   -                          *
  25   -0.0270   -                         *:
  26    0.0105   -                          *
  27    0.0664   -                          :*
  28    0.1301   -                          :  *
```

FIGURE 5 Partial autocorrelation function of the daily EAL repetitions.

tial autocorrelation function has a damped-sine shape indicating an autoregressive process.

The observed trends allow the time series modeling of the daily EAL data. A seasonal autoregressive process of Order 2 is selected. The coefficients of the model are determined by a Box and Jenkins scheme (10) performed by IDA. The mathematical equation best fitting the data was selected to minimize the residual sum of squares of the prediction errors (ε) is

$$EAL_D = 118.0 + 0.50\ EAL_{D-7} + 0.34\ EAL_{D-14} + \varepsilon \qquad (1)$$

where

EAL_D = EAL repetitions of day D to be determined;
EAL_{D-7}, EAL_{D-14} = EAL repetitions of same day for the 2 previous weeks, respectively; and
ε = prediction error with a mean value equal to zero; the standard deviation of ε for the specific set of data is equal to 204 EAL.

The regressive form of Equation 1 provides a means of calculating daily EAL repetitions provided that initial EAL values are known for each day for the previous 2 consecutive weeks. The prediction error (ε), which has a mean value of zero, is of minor importance in the prediction process. This is because the ultimate goal in predicting daily EAL repetitions is their accumulated number rather than the accuracy of the individual predictions.

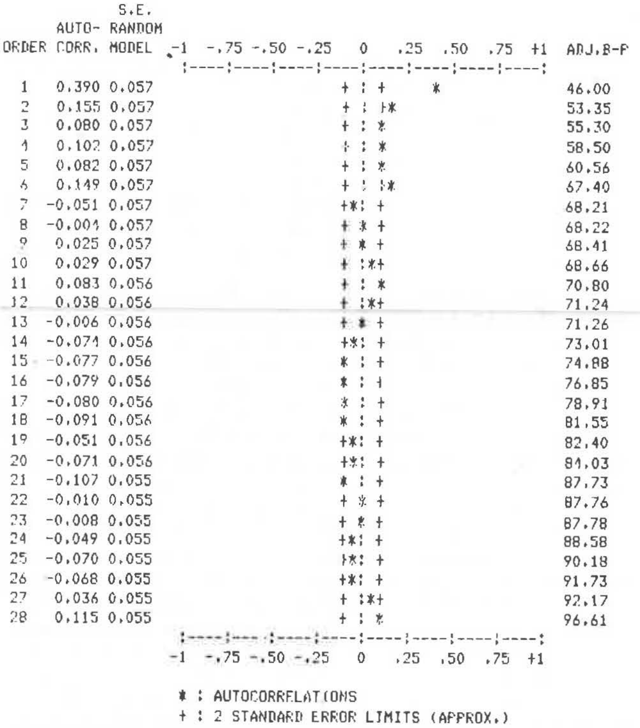
The degree of accuracy of the proposed time series model is given in Table 2, in which the actual daily EAL repetitions, their predicted values, and the prediction errors are tabulated. Table 2 also gives a comparison of the actual accumulated EAL repetitions and the predicted accumulated EAL repetitions. For a sum of 30 observations the difference is close to 10 percent. Furthermore, the autocorrelation function of the prediction residuals (Figure 6) shows no definite pattern. This illustrates the randomness of the prediction error and suggests the suitability of the proposed methodology.

TABLE 2 Actual Versus Fitted Daily EAL Repetitions

ROW	EAL	BOXFIT	ERRORS
* 1 *	893.00000	810.99322	82.00678
* 2 *	850.00000	826.24389	23.75611
* 3 *	942.00000	796.85158	145.14842
* 4 *	880.00000	710.36604	169.63396
* 5 *	722.00000	558.75148	163.24852
* 6 *	129.00000	267.61560	-138.61560
* 7 *	208.00000	308.68178	-100.68178
* 8 *	959.00000	835.93543	123.06457
* 9 *	1111.00000	824.69701	286.30299
* 10 *	800.00000	850.38468	-50.38468
* 11 *	543.00000	779.13309	-236.13309
* 12 *	190.00000	632.46207	-442.46207
* 13 *	85.00000	223.00575	-138.00575
* 14 *	109.00000	278.71132	-169.71132
* 15 *	738.00000	877.72121	-139.72121
* 16 *	766.00000	939.10177	-173.10177
* 17 *	978.00000	814.88065	163.11935
* 18 *	1161.00000	665.29848	495.70152
* 19 *	1230.00000	435.07484	794.92516
* 20 *	119.00000	180.94880	-61.94880
* 21 *	204.00000	219.80966	-15.80966
* 22 *	1022.00000	789.66042	232.33958
* 23 *	878.00000	855.34198	22.65802
* 24 *	767.00000	855.60048	-88.60048
* 25 *	1054.00000	859.71928	194.28072
* 26 *	1055.00000	774.19651	280.80349
* 27 *	382.00000	182.98861	199.01139
* 28 *	262.00000	233.64936	28.35064
* 29 *	1395.00000	856.52019	538.47981
* 30 *	957.00000	794.03954	162.96046
SUM	21389.00	19022.00	2367.00

PREDICTION OF DAILY EAL AND TRENDS IN HOURLY TRUCK VOLUMES

The analysis presented so far demonstrates the need for actual prediction of EAL repetitions for several consecutive days. It will be shown that it is possible to obtain this information from a limited vehicle volume sampling. To develop a methodology for



```
            S.E.
      AUTO- RANDOM
ORDER CORR. MODEL -1   -.75 -.50 -.25  0   .25  .50  .75  +1  ADJ.B-P
                   :----:----:----:----:----:----:----:----:
   1  0.390 0.057                    + : +     *              46.00
   2  0.155 0.057                    + : +*                   53.35
   3  0.080 0.057                    + : *                    55.30
   4  0.102 0.057                    + : *                    58.50
   5  0.082 0.057                    + : *                    60.56
   6  0.149 0.057                    + : +*                   67.40
   7 -0.051 0.057                    +*: +                    68.21
   8 -0.004 0.057                    + * +                    68.22
   9  0.025 0.057                    + * +                    68.41
  10  0.029 0.057                    + :*+                    68.66
  11  0.083 0.056                    + : *                    70.80
  12  0.038 0.056                    + :*+                    71.24
  13 -0.006 0.056                    + * +                    71.26
  14 -0.074 0.056                    +*: +                    73.01
  15 -0.077 0.056                    * : +                    74.88
  16 -0.079 0.056                    * : +                    76.85
  17 -0.080 0.056                    * : +                    78.91
  18 -0.091 0.056                    * : +                    81.55
  19 -0.051 0.056                    +*: +                    82.40
  20 -0.071 0.056                    +*: +                    84.03
  21 -0.107 0.055                    * : +                    87.73
  22 -0.010 0.055                    + * +                    87.76
  23 -0.008 0.055                    + * +                    87.78
  24 -0.049 0.055                    +*: +                    88.58
  25 -0.070 0.055                    +*: +                    90.18
  26 -0.068 0.055                    +*: +                    91.73
  27  0.036 0.055                    + :*+                    92.17
  28  0.115 0.055                    + : *                    96.61
                   :----:----:----:----:----:----:----:----:
                  -1   -.75 -.50 -.25  0   .25  .50  .75  +1

                   * : AUTOCORRELATIONS
                   + : 2 STANDARD ERROR LIMITS (APPROX.)
```

FIGURE 6 Autocorrelation function of the residuals ϵ of Equation 1.

this purpose, the trends in the hourly volumes of five-axle semitrailer trucks are studied.

The seasonality of the truck volumes is apparent (Figure 7). In this case, however, the autocorrelation function reveals a textbook-type example of a seasonal time series (Figure 8). Strong correlation can be seen at gaps of 84, 168, and so forth 2-hr periods (i.e., 84 = 12 2-hr periods x 7 days); that is, the weekly pattern of the hourly volumes of the five-axle semitrailer trucks is repeated week after week. This implies that, for a given site, the distribution of the truck population within a day is approximately repeated week after week. Furthermore, for a given site, the truck traffic volume in a certain time period (e.g., 2 hr) will be approximately a constant proportion of the total truck volume in this day. A typical distribution of the number of five-axle semitrailer trucks for 2-hr time intervals is shown in Figure 9 for 7 consecutive days of the week. Considering the seasonal trends demonstrated, the distributions shown in Figure 9 are assumed to be representative for the given site.

Availability of representative distributions such as those presented in Figure 9 allows the calculation of the total volumes of five-axle semitrailer trucks from vehicle counts of several hours only. For example, the number of trucks counted Monday between 8 a.m. and 10 a.m. is 14 percent of the total number of vehicles on Monday. Truck volumes estimated in this manner can be translated into EAL repetitions by multiplying by the EAL factor representative of the truck class in question. Daily EAL repetitions thus obtained are used as starting values for the regressive model proposed (Equation 1). The methodology is outlined and discussed in the next section.

SUMMARY AND SUGGESTIONS

The proposed method of estimation of pavement loading from limited vehicle volume sampling requires two types of data. First, information is required on the pavement loading caused by various vehicle classifications. An up-to-date table similar to Table 1 must be available. This type of information can be effectively obtained only by a WIM scale and it is expected to be quite unique for a given jurisdiction and traffic composition. Second, information is required on the distribution of truck volumes on an hourly or bi-hourly basis. As explained, this infor-

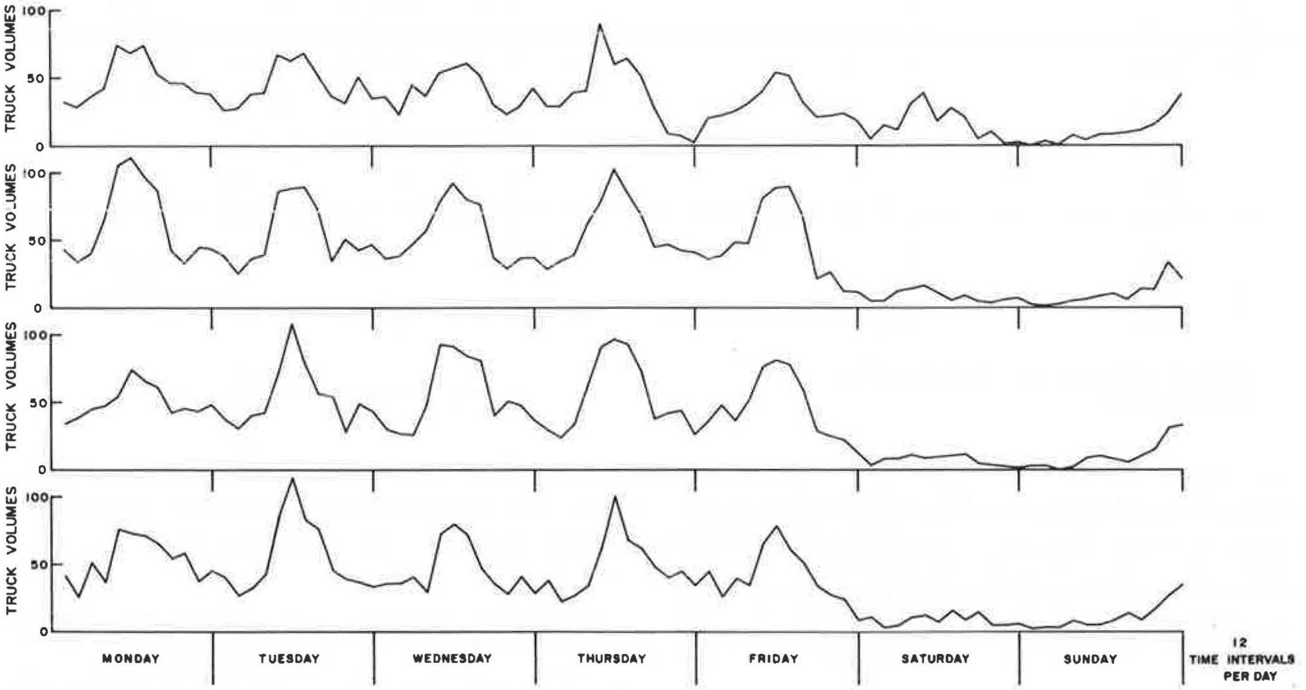


FIGURE 7 Fluctuation of bihourly traffic volumes of five-axle semitrailer trucks for 4 consecutive summer weeks.

```
            S.E.
      AUTO- RANDOM
ORDER CORR. MODEL   -1 -.75 -.50 -.25   0   .25  .50  .75  +1   ADJ.B-P
                    :----:----:----:----:----:----:----:----:

    1  0.852 0.045                    + : +              *      365.4
    2  0.678 0.045                    + : +           *         597.3
    3  0.488 0.044                    + : +       *             717.6
    4  0.340 0.044                    + : +    *                776.0
    5  0.271 0.044                    + : +  *                  813.1
    6  0.219 0.044                    + : + *                   837.4
    7  0.197 0.044                    + : + *                   857.2
    8  0.205 0.044                    + : + *                   878.7
    9  0.268 0.044                    + : +  *                  915.3
   10  0.376 0.044                    + : +     *               987.9
   11  0.479 0.044                    + : +       *             1106.
   12  0.518 0.044                    + : +       *             1244.
   13  0.424 0.044                    + : +     *               1336.
   14  0.265 0.044                    + : +  *                  1372.
   15  0.092 0.044                    + : *                     1377.
   16 -0.034 0.044                    +*: +                     1377.
   17 -0.099 0.044                    * : +                     1382.
   18 -0.137 0.044                   *+ : +                     1392.
   19 -0.153 0.044                   *+ : +                     1404.
   20 -0.153 0.044                   *+ : +                     1417.
   21 -0.105 0.044                    * : +                     1422.
   22 -0.013 0.044                    + * +                     1422.
   23  0.069 0.044                    + :*+                     1425.
   24  0.103 0.044                    + : *                     1431.
   25  0.031 0.044                    + :*+                     1431.
   26 -0.073 0.043                    +*: +                     1434.
   27 -0.194 0.043                  * + : +                     1454.
   28 -0.281 0.043                *   + : +                     1496.
   29 -0.311 0.043                *   + : +                     1547.
   30 -0.327 0.043               *    + : +                     1604.
   31 -0.315 0.043                *   + : +                     1657.
   32 -0.293 0.043                *   + : +                     1703.
   33 -0.239 0.043                 *  + : +                     1734.
   34 -0.143 0.043                   *+ : +                     1745.
   35 -0.051 0.043                    +*: +                     1747.
   36 -0.009 0.043                    + * +                     1747.
   37 -0.056 0.043                    +*: +                     1748.
   38 -0.145 0.043                   *+ : +                     1760.
   39 -0.241 0.043                 *  + : +                     1791.
   40 -0.313 0.043                *   + : +                     1845.
   41 -0.333 0.043               *    + : +                     1905.
   42 -0.347 0.043               *    + : +                     1972.
   43 -0.336 0.043               *    + : +                     2034.
   44 -0.310 0.043                *   + : +                     2087.
   45 -0.246 0.043                 *  + : +                     2120.
   46 -0.152 0.043                   *+ : +                     2133.
   47 -0.058 0.042                    +*: +                     2135.
   48 -0.009 0.042                    + * +                     2135.
   49 -0.046 0.042                    +*: +                     2136.
   50 -0.133 0.042                   *+ : +                     2146.
   51 -0.227 0.042                 *  + : +                     2175.
   52 -0.289 0.042                *   + : +                     2222.
   53 -0.319 0.042                *   + : +                     2279.
   54 -0.329 0.042               *    + : +                     2340.
   55 -0.327 0.042               *    + : +                     2400.
   56 -0.303 0.042                *   + : +                     2452.
   57 -0.230 0.042                 *  + : +                     2482.
   58 -0.134 0.042                   *+ : +                     2492.
   59 -0.042 0.042                    +*: +                     2493.
   60  0.021 0.042                    + * +                     2493.
   61 -0.010 0.042                    + * +                     2493.
   62 -0.072 0.042                    +*: +                     2496.
   63 -0.133 0.042                   *+ : +                     2506.
   64 -0.171 0.042                   *+ : +                     2523.
   65 -0.166 0.042                   *+ : +                     2539.
   66 -0.153 0.042                   *+ : +                     2553.
   67 -0.118 0.042                    * : +                     2561.
   68 -0.071 0.041                    +*: +                     2564.
   69  0.037 0.041                    + :*+                     2565.
   70  0.180 0.041                    + : + *                   2584.
   71  0.299 0.041                    + : +   *                 2636.
   72  0.369 0.041                    + : +    *                2716.
   73  0.335 0.041                    + : +    *                2782.
   74  0.256 0.041                    + : +  *                  2820.
   75  0.173 0.041                    + : +*                    2838.
   76  0.118 0.041                    + : *                     2846.
   77  0.109 0.041                    + : *                     2854.
   78  0.132 0.041                    + : +*                    2864.
   79  0.171 0.041                    + : +*                    2881.
   80  0.225 0.041                    + : +  *                  2912.
   81  0.334 0.041                    + : +    *                2978.
   82  0.471 0.041                    + : +      *              3111.
   83  0.600 0.041                    + : +         *           3328.
   84  0.658 0.041                    + : +          *          3589.
   85  0.589 0.041                    + : +         *           3799.
   86  0.464 0.041                    + : +      *              3929.
   87  0.319 0.041                    + : +   *                 3991.
```

```
            S.E.
      AUTO- RANDOM
ORDER CORR. MODEL   -1 -.75 -.50 -.25   0   .25  .50  .75  +1   ADJ.B-P
                    :----:----:----:----:----:----:----:----:

   88  0.216 0.041                    + : + *                   4020.
   89  0.168 0.040                    + : +*                    4037.
   90  0.126 0.040                    + : +*                    4047.
   91  0.116 0.040                    + : *                     4055.
   92  0.123 0.040                    + : *                     4064.
   93  0.189 0.040                    + : + *                   4086.
   94  0.285 0.040                    + : +   *                 4137.
   95  0.364 0.040                    + : +    *                4219.
   96  0.400 0.040                    + : +     *               4318.
   97  0.326 0.040                    + : +    *                4384.
   98  0.203 0.040                    + : + *                   4410.
   99  0.064 0.040                    + :*+                     4412.
  100 -0.044 0.040                    +*: +                     4414.
  101 -0.083 0.040                    * : +                     4418.
  102 -0.113 0.040                    * : +                     4426.
  103 -0.132 0.040                   *+ : +                     4437.
  104 -0.132 0.040                   *+ : +                     4448.
  105 -0.082 0.040                    * : +                     4452.
  106 -0.010 0.040                    + * +                     4452.
  107  0.061 0.040                    + :*+                     4455.
  108  0.089 0.040                    + : *                     4460.
  109  0.034 0.039                    + :*+                     4461.
  110 -0.050 0.039                    +*: +                     4462.
  111 -0.147 0.039                   *+ : +                     4476.
  112 -0.209 0.039                  * + : +                     4504.
  113 -0.232 0.039                 *  + : +                     4539.
  114 -0.241 0.039                 *  + : +                     4577.
  115 -0.243 0.039                 *  + : +                     4616.
  116 -0.225 0.039                  * + : +                     4649.
  117 -0.170 0.039                   *+ : +                     4667.
  118 -0.087 0.039                    * : +                     4672.
  119 -0.006 0.039                    + * +                     4672.
  120  0.026 0.039                    + :*+                     4673.
  121 -0.017 0.039                    + * +                     4673.
  122 -0.103 0.039                    * : +                     4680.
  123 -0.195 0.039                  * + : +                     4706.
  124 -0.251 0.039                 *  + : +                     4748.
  125 -0.280 0.039                *   + : +                     4800.
  126 -0.292 0.039                *   + : +                     4857.
  127 -0.290 0.039                *   + : +                     4914.
  128 -0.270 0.038                 *  + : +                     4963.
  129 -0.213 0.038                  * + : +                     4994.
  130 -0.138 0.038                   *+ : +                     5007.
  131 -0.070 0.038                    +*: +                     5010.
  132 -0.036 0.038                    +*: +                     5011.
  133 -0.068 0.038                    +*: +                     5014.
  134 -0.143 0.038                   *+ : +                     5028.
  135 -0.218 0.038                  * + : +                     5061.
  136 -0.273 0.038                 *  + : +                     5113.
  137 -0.291 0.038                *   + : +                     5171.
  138 -0.299 0.038                *   + : +                     5233.
  139 -0.301 0.038                *   + : +                     5296.
  140 -0.286 0.038                *   + : +                     5353.
  141 -0.234 0.038                 *  + : +                     5391.
  142 -0.161 0.038                   *+ : +                     5409.
  143 -0.087 0.038                    * : +                     5415.
  144 -0.050 0.038                    +*: +                     5417.
  145 -0.072 0.038                    +*: +                     5420.
  146 -0.117 0.038                    * : +                     5430.
  147 -0.172 0.038                   *+ : +                     5451.
  148 -0.193 0.037                  *  +:+                      5478.
  149 -0.191 0.037                  *  +:+                      5504.
  150 -0.175 0.037                  *  +:+                      5526.
  151 -0.153 0.037                   * +:+                      5543.
  152 -0.120 0.037                    *+:+                      5553.
  153 -0.031 0.037                     *:+                      5554.
  154  0.069 0.037                     +:*                      5557.
  155  0.168 0.037                     +:+ *                    5578.
  156  0.224 0.037                     +:+  *                   5614.
  157  0.203 0.037                     +:+  *                   5644.
  158  0.160 0.037                     +:+ *                    5663.
  159  0.110 0.037                     +:+*                     5672.
  160  0.081 0.037                     +:+*                     5677.
  161  0.084 0.037                     +:+*                     5682.
  162  0.100 0.037                     +:+*                     5690.
  163  0.126 0.037                     +:+ *                    5701.
  164  0.171 0.037                     +:+ *                    5723.
  165  0.254 0.037                     +:+   *                  5772.
  166  0.365 0.036                     +:+     *                5872.
  167  0.461 0.036                     +:+       *              6032.
  168  0.506 0.036                     +:+        *             6225.
                    :----:----:----:----:----:----:----:----:
                    -1 -.75 -.50 -.25   0   .25  .50  .75  +1

                    * : AUTOCORRELATIONS
                    + : 2 STANDARD ERROR LIMITS (APPROX.)
```

FIGURE 8 Autocorrelation function of bihourly traffic volumes of five-axle semitrailer trucks.

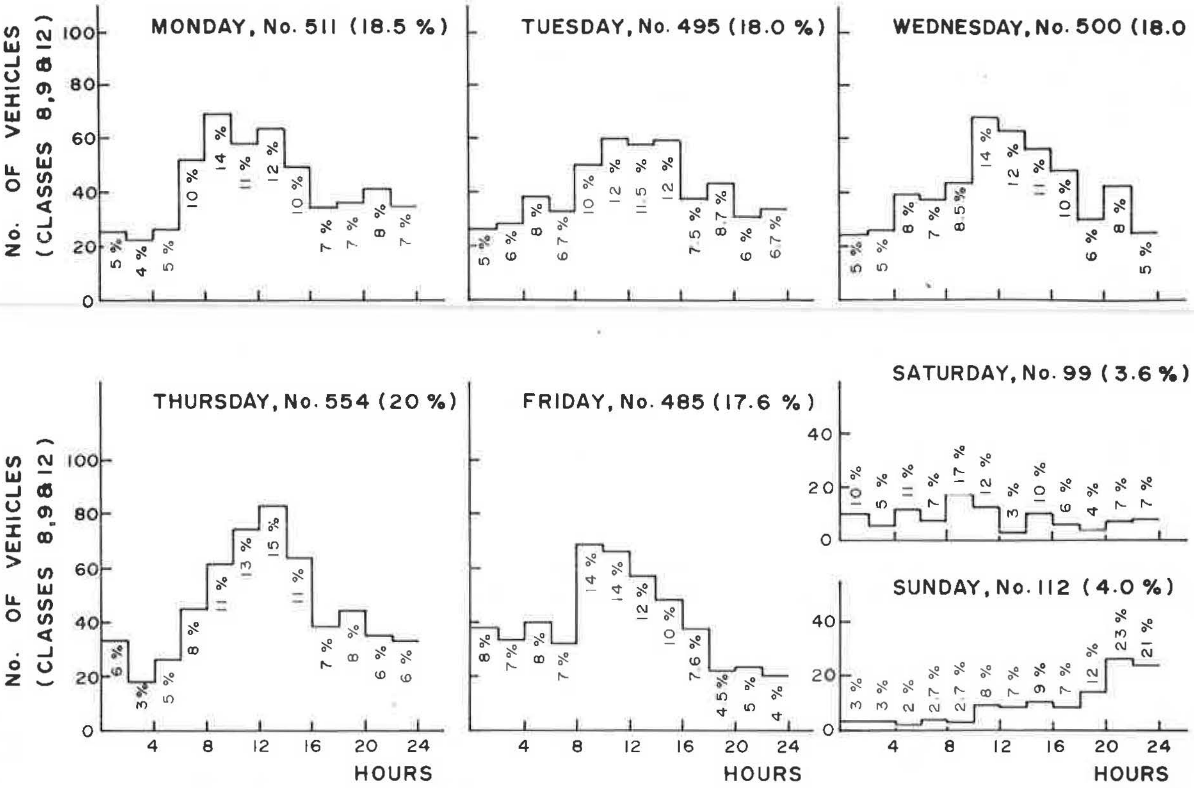


FIGURE 9 Typical distributions of bihourly truck volumes (Classes 8, 9, and 12).

mation is unique to a site, but it is expected to be fairly repetitive over time (Figure 8).

The proposed methodology is summarized as follows:

1. Obtain flow counts of five-axle semitrailer trucks for a period of 2 hr. This number represents a certain percentage of five-axle semitrailer trucks in a given day.
2. Multiply the number of five-axle semitrailer trucks obtained in Step 1 by an appropriate factor (Figure 9) to obtain the total number of five-axle semitrailer trucks in this day.
3. Multiply the outcome of Step 2 by a representative EAL factor for the truck category in question (Table 1) (e.g., for five-axle semitrailers it is 0.983).
4. Multiply the outcome of Step 3 by an appropriate factor related to the percentage of EAL repetitions caused by the truck class in question (Table 1) (e.g., for five-axle semitrailers it is 1/0.6447).
5. Use the obtained daily EAL as initial conditions for Equation 1. Note that the daily EAL repetition of only 2 weeks is required to be computed through Steps 1-4 because Equation 1 is regressive.

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