ESTIMATION OF ANNUAL AVERAGE DAILY TRAFFIC (AADT) FOR INDIAN HIGHWAYS

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ABSTRACT

This study is aimed at estimation of Annual Average Daily Traffic (*AADT*) for Indian highways. It covers estimation of seasonal factors from PTC data and finding out the best duration and frequency of Short Period Traffic Count (SPTC). For SPTC, this study makes an attempt to find out the days of the week and the months of the year in which traffic count is to be done for accurate estimation of *AADT*. Importance has been given to finding out the duration and frequency of SPTC that is good for each site, rather than the best on an average. Analysis has been done separately for total and truck traffic.

Keywords: Short Period Traffic Count (SPTC), Annual Average Daily Traffic (*AADT*), Seasonal Factors, Duration and frequency.

INTRODUCTION

Traffic volume count is an essential part of highway planning program. The data is used for a variety of purposes. Estimation of road revenue, estimation of load for pavement design and maintenance planning, forecasting vehicle emission, etc. are some of the studies that require annual traffic data.

The places where traffic volume data are taken continuously throughout the year are known as Permanent Traffic Counters (PTC). However, installation of a PTC in each and every road section is neither economically feasible, nor required, since every road section is not entirely different from all others. The general practice is to collect annual data from PTCs that are installed in selected sites and short term traffic counts (say, for 7 days, 3 days, etc.) on remaining segments. The short term traffic counts or Short Period Traffic Counts (SPTC) data are then adjusted using seasonal factors (*SF*) obtained from PTC data to predict the Annual Average Daily Traffic (*AADT*).

Unfortunately, seasonal factors are not available for Indian roads even though the Indian guideline (*1*) suggests their use for more accurate prediction of *AADT*. What this code of practice also says is that for non-urban roads, *AADT* can be obtained as an average of two 7-day SPTCs. The basis for such a suggestion is however not mentioned. It is also silent on how to estimate *AADT* for urban roads.

There is an urgent need to improve the procedures for *AADT* estimation on Indian roads. The urgency arises from the following reasons. First, there is a great need to increase the proportion of roads that allow higher speeds of travel (currently only 6% of the vast road network are classified as National Highways (NH), State Highways (SH) and expressways (*2*)). Second, demand for higher speed road travel is increasing (currently, more than 40% of Indian traffic is on expressways and national and state highways (*2*)). Third, India is in the middle of upgrading its road infrastructure through significant allocation of resources.

This study focuses on estimation of *AADT* for Indian highways from SPTC. This study can be broadly divided into three parts. First, seasonal factors of Indian roads are determined from twenty-one locations spread across India. Second, the days and duration for SPTC that is most suitable for Indian traffic is determined through a detailed analysis of the available data. Third, the frequency and months of SPTC that yields greater improvements in the accuracy of *AADT* prediction is also studied. Finally, a recommendation on duration and frequency for SPTC of Indian roads is also made.

While conducting the studies on the second and third aspects of *AADT* estimation as mentioned above, it was noted that global literature was silent on some related issues. These are discussed in the next section on literature review. Some of the gaps indentified in that section are also addressed in this paper using Indian data. The third section describes the estimation of *SF*s for Indian roads. The fourth section concentrates on determining the duration and frequency of SPTC. The fifth and the concluding section summarizes the observation made in this study.

LITERATURE REVIEW AND MOTIVATION

This section gives a brief overview of the past research done for estimation of seasonal factors of traffic and determination of best frequency, duration of SPTC and the motivation for the present work.

Estimation of Seasonal Factors of traffic

A number of methods have been reported in the literature for classifying PTCs into different groups and estimate *SF* for each group. The four most common methods used for this purpose are (a) Cluster Analysis (*3, 4*) (b) Multiple Regression Analysis (*5*-*9*) (c) Neural Networks (*10, 11*) and (d) Genetic Algorithms (*12*). However, no research work has been done to find out seasonal traffic variation on Indian highways. The aim here is to study flow variations on Indian roads with a view to predict *SF* for Indian highways.

Duration and frequency of SPTC

SPTC are used to estimate *AADT* for sites that do not have a PTC. Hence, the duration and frequency of traffic count that can accurately as well as economically estimate *AADT* also need to be determined.

Sharma et al. (1996) compared 1-day, 2-day and 3-day traffic count on weekdays to determine the best duration (*13*). They concluded that error for 2-day duration is quite similar to a 3-day duration, except for recreational roads. But, it does not specify which two days in a week are best for traffic count. This issue has been analyzed by Hallenbeck and Kim (1993) who found that truck traffic count on Thursday is better compared to Tuesday and Wednesday (*5*). This conclusion was drawn by combining the data from all sites, and hence do not reflect whether the conclusion is valid for every site in their database. Combining data from every site may create a situation where a particular strategy may seem good for one site, but not so good for others, while another strategy which is reasonable for many sites may not be chosen. Since *AADT* estimates are site specific, a strategy that is good for individual sites should be chosen rather than a strategy that may be good for some sites, while not good for many others.

Traffic counts can also be done multiple number of times in a year. Lingras (1998) used neural networks to show that two 2-day counts (in July and December) is better than a single 7-day count (in July or December) (*14*). Other researchers have also tried to determine the number of times in a year traffic count needs to be done for accurate estimation of *AADT* (*15, 16*). They used traffic counts equally spaced over the year. For example, for counting traffic twice a year, the two counts should be separated by 182 days (365/2 or approximately 6 months). These past works, however do not report any statistical justification for choosing the months in which data is to be collected.

This motivated the authors to determine the days of the week that are best for traffic count, number of days traffic count is to be done, number of times traffic count is to be done in a year and the months that are best for counting traffic multiple times in a year.

Before leaving this section, it may be pointed out that Hallenbeck and Kim (1993) had noted that, seasonal factors for truck traffic and automobile traffic are not necessarily the same (*5*). Hence, it makes sense to calculate their seasonal factors separately. In this paper, however, instead of considering truck traffic and car traffic separately, analysis have been done separately for truck traffic and total traffic. The reason for doing this is that predictions on truck traffic data are often required for pavement design and maintenance studies, while information of total traffic is required for traffic engineering and planning purpose.

STUDY DATA

Traffic volume data from toll plazas located in different parts of India have been used in this analysis. Since these toll plazas collect the data throughout the year and no PTCs exist for Indian roads, these toll plazas are considered as PTCs.

Traffic data of twenty-one PTCs have been used in this paper. All the sites are multi-lane roads located either on national highways (NH) or state highways (SH) of India. They include both rural and urban sites. Rural sites mean those places which are located more than 50 km away from any habitation with population more than 1 million. Daily traffic data was available for five sites only, with duration of 1 year for each site. For the rest sixteen sites, only monthly traffic data was available. Out of that, seven sites had 3 year traffic count data. While 1, 2 and 4 years traffic count data was available for three sites each.

ESTIMATION OF SEASONAL FACTORS OF TRAFFIC

Seasonal factors (*SF*) are required to estimate *AADT* of a site from its SPTC. *SF* of Month *m*, Site *j* in Year *k* is defined as the ratio of Monthly Average Daily Traffic ($MADT_j^{m,k}$) to Annual Average Daily Traffic ($AADT_j^{k}$). It depicts seasonal variation of traffic over the year.

$$SF_j^{m,k} = \frac{MADT_j^{m,k}}{AADT_j^{k}} \qquad (1)$$

Till now, no research work has been reported regarding estimatation of seasonal factors for Indian traffic. So, three methods have been used to predict *SF* of any site from the PTC data. Monthly traffic data of all twenty-one PTCs have been used for this study. The methods used for estimation of *SF* of traffic are:

1. Average Seasonal Factors
2. Cluster Analysis
3. Multiple Regression Analysis

In Average Seasonal Factor method, it is proposed that the seasonal factors on any road for Month *m* can be estimated with reasonable accuracy by the average seasonal factors for that month obtained from all the PTCs. The average seasonal factor (ASF^m) for Month *m* can be obtained as:

$$ASF^m = \frac{\sum_{j=1}^{N}\sum_{k=1}^{K_j} SF_j^{m,k}}{\sum_{j=1}^{N} K_j} \qquad (2)$$

where, *N* is the total number of PTCs (twenty-one in this study) and K_j is the number of years for which traffic data is available at the *j* -th PTC.

The seasonal factors obtained from this method for total and truck traffic are given in Table 1.

Seasonal factors were also obtained from cluster analysis and multiple regression analysis. However, the results from these two methods did not give any significant improvement in comparison to those obtained from average seasonal factor method. In cluster analysis, the clusters were difficult to be defined. And in regression analysis, no variable came out to be statistically significant for more than eight months. The only conclusion that could be drawn from the results of these two methods was that sites in South India (i.e., the states of Telengana, Andhra Pradesh, Karnataka, Tamil Nadu and Kerala) behave differently than the rest of India. However, the demarcation was not clear always. Moreover, the errors in estimation of *SF* obtained from average seasonal factor method were found to be of the same order as that obtained in previous literature for their respective dataset. (*6-7, 9-10*). The details of the results can be obtained from Chakraborty, 2014 (*17*).

TABLE 1 Average Seasonal Factors

Traffic type	Month Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Total Traffic	1.03	1.07	1.04	0.98	1.02	1.00	0.94	0.94	0.94	0.98	1.02	1.05
Truck Traffic	1.01	1.07	1.06	0.99	0.99	0.99	0.96	0.94	0.97	0.98	1.00	1.04

Thus, it is proposed that the average seasonal factor method be used to determine the seasonal factors for different months at all sites. The reason for such a recommendation is that, the average seasonal factor method is comparatively simpler than cluster analysis and regression analysis method. Further, using average seasonal factor method allows the use of a single seasonal factor for a given month across all sites, thereby bringing in simplicity into the procedure. However, it may be noted that traffic data of only national and state highways were included in this study. So, it did not include roads that have functionally different characteristics (e.g. arterial roads, recreational roads, etc.). So, average seasonal factors can be said to be sufficient to depict the seasonal variation of Indian highways.

DURATION AND FREQUENCY OF SHORT PERIOD TRAFFIC COUNT

SPTC forms an integral part for estimation of *AADT* of a site that is not a PTC. The principal decisions that need to be taken for a SPTC are (a) duration of the count (i.e., for how long traffic count has to be done) and (b) frequency of the count (i.e., the number of times to be done) to predict *AADT* accurately. This section presents an analysis to determine an effective duration and frequency for total and truck traffic SPTC.

As the duration and frequency of SPTC increase, the error in *AADT* estimation decreases. However, the cost of conducting the survey also increases with increase in duration and frequency of SPTC. The main objective therefore is to find out a duration and frequency of SPTC that is not prohibitively costly and also estimates *AADT* with reasonable accuracy.

Before analysing the most effective duration and frequency of SPTC, the yardsticks used to determine cost of the survey and accuracy of the *AADT* estimates are also presented. The cost of conducting a survey is assumed to increase with the number of days of survey. Hence, lesser the duration, lesser is the cost. The cost increases with increase in frequency of SPTC too. Lesser is the frequency, lesser is the cost. In general, cost can be represented as a weighted sum of frequency and duration, where the weights represent the unit cost of each of these variables. Unfortunately, in this study, these unit costs were not determined.

In order to determine accuracy, the mean squared error of the deviation in estimated *AADT* from the actual *AADT* is used. In the following portion, the procedure to obtain the mean squared error is explained.

The estimated *AADT* value, $EAADT_j^F(d,n)$ for Site j when SPTC has a Frequency of F, a Duration of d and starts on the n-th day of the week, is given by:

$$EAADT_j^F(d,n) = \frac{1}{F}\sum_{f=1}^{F}\frac{ADT_j^f(d,n)}{PSF_A^{m_f}} \quad (3)$$

where, $ADT_j^f(d,n)$ is the average daily traffic obtained for the f-th traffic count of d - day duration starting on day n, $PSF_A^{m_f}$ is the predicted seasonal factor of month m_f (in which f-th traffic count is done) using Average Seasonal Factor method (see Table 1).

The deviation in *AADT* estimation can be defined as:

$$D_j^F(d,n) = \left(\frac{EAADT_j^F(d,n) - AADT_j}{AADT_j}\right)\times 100 \quad (4)$$

where, $AADT_j$ is the actual *AADT* obtained from 12 months traffic count of the same site.

For a given Site j and a given combination of F, d and n, one can obtain many estimates of *AADT* (since SPTC for the given F, d and n can be done in various week-sets of the year). Assuming the true value of deviation $D_j^F(d,n)$ is zero, the mean squared error of the estimate of $AADT_j$ (given by Equation 3) can be obtained as:

$$MSE_j^F(d,n) = \left(\overline{D_j^F(d,n)}\right)^2 + \frac{1}{R_j^F(d,n)-1}\sum_{r=1}^{R_j^F(d,n)}\left(D_j^F(d,n) - \overline{D_j^F(d,n)}\right)^2 \quad (5)$$

where, $R_j^F(d,n)$ is the number of estimates of $AADT_j$ obtained for Site j for a given combination of F, d and n, $\overline{D_j^F(d,n)}$ is the mean of $D_j^F(d,n)$ (given in Equation 4) and can be obtained as

$$\overline{D_j^F(d,n)} = \frac{1}{R_j^F(d,n)}\sum_{r=1}^{R_j^F(d,n)} D_j^F(d,n) \quad (6)$$

Duration of SPTC

Data sets of five PTCs, having daily traffic data, have been used to find out the best duration of SPTC. The following values of d that have been used in this study: 14, 7, 5, 3 and 2 days. The values of n used in this study for 5-day, 3-day and 2-day SPTCs are, Monday, Tuesday, Wednesday, Thursday, Friday, Saturday and Sunday. For 7-day and 14-day SPTCs, the value of n is always Monday.

Determination of best n

This section describes the methodology to determine the best value of n for total and truck traffic for d = 2, 3 and 5 days. Note that for 7-day and 14-day counts, n is always taken as Monday. Also, during this determination, F is assumed to be 1. That is, the question being asked is: What is the best value of n if SPTC is done once in a year.

To determine the best n -value, two approaches have been used:

1. **Average *MSE*** $AMSE^1(d,n)$: Five data sets, each from a different site, have been used in this study. For a given d and n (F=1), the average MSE [$AMSE^1(d,n)$] is determined as the average of $MSE_j^1(d,n)$. Here j is different for each of the five data sets.

2. Sum of ranks of *MSE* $SrMSE^1(d,n)$: For a given Site j and a given value of d, the $MSE_j^1(d,n)$ are ranked in ascending order over the various values of n. If these ranks are $rMSE^1(d,n)$, then the sum of these ranks over all j's, $SrMSE^1(d,n)$ gives a measure of how well a given value of n fares. The lower the value of $SrMSE^1(d,n)$, the better is the performance of that n for the given d. If for a particular value of n (for a given d), the $MSE_j^1(d,n)$ is the smallest (best) for each site, then $SrMSE^1(d,n)$ takes a value of five (recall that there are five sites in this study). If on the other hand, it is worst for each of the five sites, then $SrMSE^1(d,n)$ takes a value of thirty-five (5×7) because n has seven values.

Table 2 shows the best n (n_b) obtained from the two approaches for all durations of SPTC. The values are analysed for total and truck traffic separately.

TABLE 2 Best *n* for all durations and traffic types

Traffic type	d (days)	$AMSE^1(d, n)$		$SrMSE^1(d, n)$	
		n_b	$AMSE^1(d, n_b)$	n_b	$SrMSE^1(d, n_b)$
Total Traffic	2	Thu	66.4	Thu	7
	3	Thu	61.1	Thu	6
	5	Wed	58.3	Wed	8
Truck Traffic	2	Mon	91.8	Mon	14
	3	Mon	89.6	Sun	13
	5	Sat	84.8	Sun	12

- **Total Traffic**: Table 2 shows that for d = 2, the best value of n is Thursday since it offers the lowest $AMSE^1(2,n)$ and lowest $SrMSE^1(2,n)$. Similarly, for d = 3 and 5-days, the best values of n are Thursday and Wednesday respectively. The analysis indicates that Thursday and Friday are important days for collecting total traffic data since it is a part of the span over which data is to be collected irrespective of whether d = 2, 3 or 5. Interestingly, when the duration is increased by one day, analysis suggests expanding Thursday and Friday by including a weekend day (i.e., Saturday). When two more days are added, the analysis suggests expanding the span Thursday-Saturday by including a day on either side (i.e., Wednesday and Sunday). Moreover, $SrMSE^1(d, n_b)$ for d = 2, 3 and 5-day are seven, six and eight respectively, which are quite close to the minimum it can have (i.e. five since five sites data have been used in this study). Thus, the best starting day (n_b) obtained for the five sites can be said to be good for each of the five sites.
- **Truck Traffic**: Table 2 shows that for d = 2, the best value of n is Monday from both the approaches (Average *MSE* and Sum of Ranks of *MSE*). However, for d = 3 and 5-days, the best n obtained from the two approaches do not match. The n that gives minimum $AMSE^1(3,n)$ and $SrMSE^1(3,n)$ are Monday and Sunday respectively. Thus, for increasing truck traffic count

duration by one day, the span can be expanded by adding an additional day on either side of the best 2-day count (i.e., Monday and Tuesday). Similarly, the *n* that gives minimum $AMSE^1(5,n)$ and $SrMSE^1(5,n)$ are Saturday and Sunday respectively. Thus, it is evident that Monday and Tuesday are the important days for truck traffic count of d = 2, 3 or 5-days. However, $SrMSE^1(d, n_b)$ for d = 2, 3 and 5-day durations for truck traffic comes out to be 14, 13 and 12 respectively. And for five sites, the minimum $SrMSE^1(d,n)$ can be five. Thus, it indicates that the best *n* is not actually the best for most of the sites. One probable reason can be that it depend on the type of road or its geographical location (i.e. Urban or Rural, North or South India, etc). But, since traffic data of only five sites are used in this study, such distinctive analysis for determining best *n* for different types of roads is not possible. Hence, further analysis with data of more sites is required in this field.

Determination of best d

In this section, the best values of *d* for total and truck traffic are determined separately. In order to determine the best value of *d*, the improvement in $AMSE^1(d,n)$ per extra day of data collection is used. For a given value of *d*, the value of *n* used in this analysis is that which gave lowest $SrMSE^1(d,n)$ in Table 2. The results are given in Table 3. The first column in the table gives the different values of *d*. The total and truck traffic columns are each divided into two sub-columns. The first gives the $AMSE^1(d,n)$ values. The second column gives the improvement in $AMSE^1(d,n)$ per extra day of data collection.

TABLE 3 Improvement in $AMSE^1(d,n)$ per extra day of data collection

Duration (d)	Total Traffic		Truck Traffic	
	$AMSE^1(d,n)$	Improvement	$AMSE^1(d,n)$	Improvement
2	66.4	-	91.8	-
3	61.1	8.0	89.6	2.4
5	58.3	2.3	84.8	2.7
7	56.5	1.5	76.5	4.9
14	45.7	2.7	61.7	2.8

As can be seen from Table 3, for total traffic, substantial improvement in accuracy is obtained by moving from duration of two days to duration of three days. Subsequent addition of days do not yield commensurate improvement in $AMSE^1(d,n)$. Hence, it is suggested that for total traffic, one should collect data for three days starting with Thursday.

For truck traffic, however, the data indicates that reasonable improvement is obtained by adding days till *d* is equal to seven days. Beyond seven days, collecting data on additional days does not yield significant improvement. Hence, it is suggested that for truck traffic, seven days data be collected starting with Monday.

It may be noted that, as expected, with increase in value of *d*, $AMSE^1(d,n)$ improves. Hence, if there are no resource constraints, the duration of SPTC may be made as long as feasible to obtain better *AADT* estimates.

Frequency of SPTC

As discussed earlier, the estimated *AADT* is impacted by how many times the SPTC is done in a year. In this section, this dependence of $EAADT_j^F(d,n)$ on *F* for every value of *d* is analysed in detail. *F* = 1 means SPTC is carried out on any month. *F* = 2 means SPTCs are carried out in two different months and so on. Data sets of four PTCs, having daily traffic of at least one complete year, are used to find out the best frequency of SPTC. Traffic data of at least one year is required for this study because determination of best *F* also involves determination of the months in which traffic count is to be done.The value of *n* used (for the given *d*) in this analysis is that which gave minimum $SrMSE^1(d,n)$.

The values of $AMSE^F(d,n)$ for different values of *F* and *d* are calculated. In order to see which value of *F* is most desirable, the rate of improvement in $AMSE^F(d,n)$ for every additional repetition of SPTC is calculated. Such reductions in *AMSE* obtained by using a frequency of *F* instead of a frequency of (*F* - 1) for every value of *d* are given in Table 4. The table has three columns. The first column gives different values of *F* (two to six). The second and third column give the reduction of $AMSE^F(d,n)$ for *d* = 2, 3, 5, 7 and 14 for total and truck traffic respectively.

TABLE 4 Improvement in $AMSE^F(d,n)$ with increase in frequency of SPTC

Freq. (*F*)	Total Traffic *d* (days)					Truck Traffic *d* (days)				
	2	3	5	7	14	2	3	5	7	14
2	36.7	33.7	32.1	30.2	26.8	44.1	39.8	38	32.7	25.9
3	11.6	10.6	10.1	9.5	8	14.2	12.1	12.2	10	7.5
4	5.8	5.3	5	4.7	4	7.1	6	6.1	5	3.7
5	3.5	3.2	3	2.8	2.4	4.2	3.6	3.7	3	2.2
6	2.3	2.1	2	1.9	1.6	2.8	2.4	2.4	2	1.5

The values given in Table 4 suggest that a large improvement (reduction) in $AMSE^F(d,n)$ is obtained (for any value of *d*) by using *F* = 2 instead of *F* = 1. Further increases in *F* do not yield similarly large improvements. Hence, it is suggested that, irrespective of the value of *d*, SPTC repeated twice in a year (i.e., *F* = 2). It should be noted that, as in the case of determining the best value of *d*, so here, one can obtain better estimates of *AADT* by continuing to increase *F*. Such increase will cause increased strain on resources.

Determination of the best two-month combination

Now that the analysis indicates that choosing *F* = 2 is best, the natural question is which two-month combination is the best. In order to answer this question, $AMSE^2(d,n)$ values for different two-month combinations are compared. Note, the $AMSE^2(d,n)$ for a given two-month combination is simply the average over all sites of $MSE_j^1(d,n)$ values obtained for that two-month combination.

The question of which two month-combination is the best is also evaluated by summing the ranks over all sites for the $MSE^1{}_j(d,n)$, obtained for different two-month combinations ($SrMSE^2(d,n)$). The $SrMSE^F(d,n)$ parameter was explained in detail during determination of best *n*. In this case, the best rank a two-month combination can have for a given site is one. Since, there are sixty-six different two-month combinations possible for a given site, the worst rank that a two-month combination can have is sixty-six. Hence the best $SrMSE^2(d,n)$ in this case is four (recall that there are four sites in this study) and the worst $SrMSE^2(d,n)$ is two hundred sixty-four (66 ×4).

Table 5 gives the best two-month combination (denoted by $2M_b$) w.r.t $AMSE^2(d,n)$ as well as $SrMSE^2(d,n)$. The *AMSE* and *SrMSE* of the corresponding $2M_b$ are denoted by $AMSE^2_{2M_b}(d,n)$ and $SrMSE^2_{2M_b}(d,n)$ respectively. The table has four columns. The first column gives the type of traffic (total, truck traffic) and the second column provides the different values of *d* (2, 3, 5, 7 and 14). The third column gives the results obtained from *AMSE* approach. It is subdivided into two sub-columns. The first sub-column shows the best two-month combination ($2M_b$) obtained while the second sub-column gives the value of $AMSE^2_{2M_b}(d,n)$. Similarly, the fourth column provides results obtained from $SrMSE^2(d,n)$.

TABLE 5 Best two-month combination of total and truck traffic

Traffic Type	*d* (days)	$AMSE^2(d,n)$		$SrMSE^2(d,n)$	
		$2M_b$	$AMSE^2_{2Mb}(d,n)$	$2M_b$	$SrMSE^2_{2Mb}(d,n)$
Total Traffic	2	May Oct	9.9	May Oct	19
	3	May Sep	9.3	May Sep	35
	5	May Sep	7.5	May Sep	28
	7	May Oct	10.3	May Oct	36
	14	May Oct	2.7	May Oct	11
Truck Traffic	2	Jan Oct	11.2	Jan Oct	27
	3	Apr May	7.9	Apr May	30
	5	Apr May	8.6	Apr Jun	38
	7	Mar Jun	12.2	Mar Jun	49
	14	Apr Aug	2	Apr Jul	14

The results given in Table 5 are inconclusive in the sense that they fail to identify a particular two-month combination which is good for all sites. Because, $SrMSE^2_{2M_b}(d,n)$ obtained are for all durations and types of traffic are very high from the minimum it can have (i.e., four). However, it may be mentioned that, for a given value of *d*, there is reasonable agreement between best two-month combination w.r.t two approaches.

Since the results failed to identify a particular two-month combination which is good for all the sites, further analysis was done to see whether the data could conclusively indicate how much gap should be maintained between the two SPTCs in order to obtain reasonably good estimates of *AADT*.

Month separation for traffic counts twice in a year

The objective of this section is to determine the month separation that is to be kept for counting traffic twice in a year. In the previous analysis, the $AMSE^2_{2M_b}(d,n)$ values and $SrMSE^2(d,n)$ values are evaluated for a particular two-month combination. In this case, however, $SrMSE^2(d,n)$ values and $AMSE^2(d,n)$ are obtained for cases where SPTCs are conducted in two months separated by the same number of months. Therefore, unlike in the previous case, where January, April and August, November represented two different two-month combinations, in the present analysis, they represent the same case because both January, April and August, November represent the case where SPTCs are obtained in months separated by a two month period.

Analysis was done with cases where *separation* (denoted by S) between the SPTCs were zero months (i.e., SPTCs done in consecutive months), one month (i.e., SPTCs done in January, March; February, April; March, May; etc.) and so on till five months. Thus, $SrMSE^2(d,n)$ for the best separation can be four (recall four sites data are used in this study) and for the worst can be twenty (5×4).

Table 6 gives the results of the best separation (denoted by S_b) to be kept between two SPTCs. Like in Table 5, Table 6 also has four columns. The first two columns show the traffic type (total, truck traffic) and durations (d = 2, 3, 5, 7 and 14). The third column provides the results obtained from Average *MSE* approach. It is divided into two sub-columns. The first sub-column gives the best separation (S_b) and the second one gives the value of $AMSE^2_{S_b}(d,n)$. Similarly, the two sub-columns of the fourth column provide the results obtained from $SrMSE^2_{S_b}(d,n)$ for best separation (S_b).

TABLE 6 Best month-separations between two SPTCs for total and truck traffic

Traffic Type	d (days)	$AMSE^2(d,n)$		$SrMSE^2(d,n)$	
		S_b	$AMSE^2_{Sb}(d,n)$	S_b	$SrMSE^2_{Sb}(d,n)$
Total Traffic	2	2	24.3	2	6
	3	2	22.8	2	6
	5	3	24.3	2	6
	7	3	23.1	2	9
	14	2	15.7	2	8
Truck Traffic	2	1	35.7	1	8
	3	2	28	2	8
	5	2	21.8	2	7
	7	2	11.7	2	8
	14	2	11.5	2	8

Table 6 shows that for total traffic, the S_b obtained from $AMSE^2(d,n)$ and $SrMSE^2(d,n)$ do not match exactly for 7 and 5-day durations. However, for truck traffic, the S_b from both approaches are same for all durations. And, it is noteworthy that for most of the durations, the best separation comes out to be two months from both the approaches. This indicate that, though it is not possible to determine a particular two-month combination which is best for all four sites used in this study, but specifications can be given on the *separation* of months that is to be kept for traffic count twice in a year. So, it can be concluded that SPTCs is to be done twice a year keeping a *separation* of two months between the counts for all durations (d =2, 3, 5, 7 and 14) and types of traffic (total and truck traffic).

CONCLUSIONS

This study gives the guidelines for estimation of *AADT* for Indian highways.It also provides procedures to determine the days and months for conducting SPTCs. These procedures can be adopted by any other highway agency for their datasets. Certain gaps in the global literature on this topic and identified here, have also been addressed.

In the following, some of the observations obtained during the analysis, presented in this paper, are summarized.

1. On Indian roads, for the data used here, there were no discernable differences in *SF* variation. Hence, the *SF* obtained from the Average Seasonal Factor method performs well.
2. As expected, the longer the duration of SPTC, the greater is the accuracy of the predicted *AADT*. Nonetheless, it was found that the best balance between the accuracy of *AADT* estimates and the resource requirement for conducting the SPTCs was achieved when the duration of SPTC was three days (starting from Thursday) and seven days, for total and truck traffic, respectively.
3. The analysis showed that, irrespective of the duration of SPTCs, traffic data on Thursday and Friday was important for total traffic. Similarly, for truck traffic, Monday and Tuesday were important days.
4. As expected, the more the frequency of SPTC, the greater is the accuracy of the predicted *AADT*. Nonetheless, it was found that the best balance between the accuracy of *AADT* estimates and the resource requirement for conducting the SPTCs was achieved if SPTCs are done twice a year. It was observed, that the best two-month combination was when there was a two month *separation* between the SPTCs count.

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