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Estimating Annual Average Daily Traffic Using Daily Adjustment Factor

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ABSTRACT

This study dealt with estimating AADT which serves the important basic data in transportation sector. AADT estimation is fundamental to the analysis of transportation data sets and the management of transportation systems. AADT is estimated using short-term traffic counts at most sites because permanent traffic counts is installed at limited sites. To estimate AADT, an adjustment factor application model was proposed on FHWA's Traffic Monitoring Guide in the United States. This model uses monthly or weekly adjustment factors to estimate AADT. Additionally, grouping with monthly factor, weekly factor and hourly volume pattern was proposed, but these methods don't reflect characteristics of daily pattern. So this study used daily factor to estimate AADT and compared with advanced research. Daily factor is produced 365 factors on one permanent traffic count. Accuracy of AADT was enhanced using daily factor because it reflects daily characteristics as compared to monthly or weekly factors. But it is most important to assign a site to its similar site, because unsimilar assignment carries the greatest potential for significant estimation error. Assigning a short term traffic count to permanent traffic counts to apply adjustment factor will be investigated as a future study.

Keywords: *Annual Average Daily Traffic, Monthly factor, weekly factor, daily factor, grouping*

1. INTRODUCTION

The annual average daily traffic (AADT) is utilized as an important basic data in transportation and road sector. It predicts the future service level of the road based on the planned traffic volume and determines the geometry of new roads. The planned traffic volume serves as the basis of road planning, when AADT is used. In this regard, accurate calculation of AADT is required to construct the roads economically and facilitate traffic flow, while maintaining an appropriate level of traffic service.

To calculate accurate AADT, it is desirable to install permanent traffic counters in all traffic count points. However, due to the limitations such as budget constraints, permanent traffic counters have been installed only in some points, and portable devices have been used in the rest of the point.

The permanent traffic count (hereafter referred to as PTC) can be used to collect traffic volume 365 days a year, which makes it possible to identify time-series properties, including monthly and seasonal characteristics with respect to traffic variations. However, permanent traffic counters have been installed only in some points, and most of traffic surveys have been carried out using portable devices. The short-term traffic count (hereafter referred to as STC) collects traffic data using portable devices, and it surveys 1 to 5 times a year. Therefore, since it is impossible to calculate accurate AADT, AADT estimation is utilized in this case.

There are many ways to estimate AADT of the STC points in which traffic survey is conducted 1 to 5 times a year. Among them, the most widely-known method is to estimate AADT by applying adjustment factors of PTC points with similar traffic patterns to 24-hour volume. In this method, it is very important to find out PTC points with similar traffic patterns to those of STC points. This method is designed to apply adjustment factors which represent the applicable group by grouping all PTC points using monthly factors and weekly factors and assigning STC points to appropriate groups. However, this method cannot reflect all daily variations of PTC points where 365-survey data is collected and poses its limitations: in case AADT is estimated with monthly and weekly variations, monthly and weekly patterns can be reflected, but special characteristics of the survey date (changes in traffic volume due to local events or weather conditions) cannot be reflected. In this regard, this study seeks to investigate methods to increase the accuracy of AADT estimation by applying new adjustment factors that can apply daily variations, and to analyze the results of the comparison between the accuracy of AADT estimation by the proposed method using STC data of national highways and that by other models proposed in previous studies for the verification of the model.

2. STUDY REVIEW

The method to estimate AADT by applying adjustment factors is on the basis of the Traffic Monitoring Guide (FHWA, 2001), and monthly factors and weekly factors are calculated by the following equations.

$$MF_i = \frac{Annual\ Average\ Daily\ Traffic(AADT)}{Monthly\ Average\ Daily\ Traffic(mADT)}$$

$$WF_j = \frac{Annual\ Average\ Daily\ Traffic(AADT)}{Weekly(the\ day\ of\ week)\ Average\ Daily\ Traffic(wADT}$$

wherein, i = January, February, ... , December
j = Monday, Tuesday, ... , Sunday

Joe Flaherty (1993), Lee et al.(2002) and Ha et al(2012) applied adjustment factors by clustering PTC points for AADT estimation. Joe and Lee et al. succeeded in grouping PTC points but failed to present a method for assigning STC points to the classified groups. In the study by Ha et al., the method to assign them to the classified groups was proposed, but it turned out to have a limitation that it cannot reflect daily characteristics by group. Lim et al.(2004) conducted a comparative analysis between the methods based on the grouping of adjustment factors, the same section and the shortest distance to estimate AADT of STC points. The analysis results showed that the method based on the same section has small error. However, since this method applied monthly factors and weekly factors suggested by the TMG, its poses a problem that daily traffic variations cannot be reflected.

There are other methods to estimate AADT using spatial statistics models, regression analysis and neural network analysis in addition to the method applying adjustment factors. Xia et al (1999) and Zhao et al.(2001) estimated AADT through multi-variate regression analysis using spatial data. For the multi-variate regression analysis, road characteristics and socio-economic variables were applied, and these variables were found to affect AADT. Eom et al. (2006) and Heo et al.(2007) estimated AADT by means of a spatial regression analysis. Eom et al. applied generalized kriging method in the application of spatial regression analysis and used Euclidean distance to estimate the parameters of variogram. Heo et al. applied the shortest path instead of Euclidean distance as in the study of Eom et al. to estimate the parameters of variogram. The analysis results showed that the accuracy of AADT estimation was improved. Kim (2010), Selby et al.(2011) and Ha et al.(2013) estimated AADT using kriging models among spatial statistics models. In Kim's study, traffic volume of nearby roads was utilized as a secondary variable, and the study by Ha et al. utilized the traffic volume of the previous year as a secondary variable. However, these studies pose disadvantages of not utilizing data investigated in the year since they use methods to estimate AADT in case traffic volume of the year is not collected.

This study analyzed methods to estimate AADT using short-term traffic volume survey conducted in the year and investigated methods to reduce the AADT estimation errors by reflecting daily traffic variations, which are more precise units than adjustment factors applied in the previous studies.

3. ANALYSIS METHODS

This study explores ways to reduce estimation errors of AADT using adjustment factors, using traffic flow data of national highways where both PTC's and STC's are performed. Of all PTC points in 2012, the number of points where data were collected for 365 days was 433. Using as much points as possible, this study estimates AADT and conducts comparative analysis on estimation errors. For comparison with previous studies, this study compared AADT estimation errors and analyzed their characteristics: by analyzing three methods: a method based on same sections whereby count points are grouped together in reference to sections, a method that uses adjustment factors of groups where monthly factors and weekly factors, traffic volume patterns analyzed in previous studies are grouped using cluster analysis, and a method using the new adjustment factors proposed in this study.

3.1 Methods to Apply Existing Adjustment Factors

Estimating AADT using adjustment factors require matching PTC points with the points where AADT is to be estimated. The Statistics Yearbook of Traffic Volume suggests a method applying the adjustment factors of adjustment factors in the same sections. The principles of section and spot selection are as follows

- Principle of Section Selection: intersection of national highway or above (as well as local roads and cross sections with exceptionally high traffic. If a section passes through an urban area, the part inside the urban area is excluded)
- Principle of Spot Selection : intersection of local roads or above (as well as sections in Si / Gun with high traffic), national highways passing through leisure facilities or vacation areas with exceptionally severe changes in traffic flow

The method applying previous adjustment factors applies monthly factors and weekly factors of PTC points provided by the Statistics Yearbook of Traffic Volume, and AADT is calculated as shown in the following equation.

$$\widehat{AADT} = volume \times MF_i \times WF_j$$

Where in,

$\widehat{AADT}$: AADT estimates
$volume$: 24-hour traffic invested in STC points
MF_i : Monthly factor of i (month)
WF_j: Weekly factor of j (the day of week)

To estimate AADT using the method applying previous adjustment factors, 101 points where there are more than one PTC points in the same section were selected, and the PTC points in the same section were paired to estimate AADT by applying monthly factors and weekly factors of the other point within the same section. Then, the true value of AADT of the count points were compared with the estimated values to calculate the AADT estimation errors.

3.2 Methods to Apply Adjustment Factors of the Group Using Adjustment Factor Grouping

When estimating AADT by grouping adjustment factors and applying the factors of a group, the result produced by such groups may vary depending on which

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variables are used for grouping. Joe Flaherty (1993) conducted cluster analysis on monthly factors of a 5-year period, and Lee et al. (2002) conducted cluster analysis using only monthly factors. Ha et al. (2012) included and grouped monthly factor, weekly factor as well as traffic ratio across hourly traffic volume in their cluster analysis. This method proposed an objective criteria to determine to which group PTC points counted across hourly traffic volume should be allocated to for application of adjustment factors. The analysis showed that this method produces less AADT estimation errors than the previous method applying monthly factors and weekly factors of the same section. Therefore, this study estimated AADT of the count points subject to analyses of this study and conducted comparative analyses with other methods.

For adjustment factors grouping, PTC points were grouped through factor analysis and cluster analysis using monthly factors, weekly factors and traffic ratios across hourly traffic volume. The grouping showed that the adequate number of clusters was 5, and the characteristics of each group are as follows.

Table 1: Road type and characteristic of each group

Group	Road Type	Characteristic
1	Recreation Road 1	Spring peak
2	Urban Road	-
3	Rural Road	-
4	Recreation Road 2	Winter Peak
5	Recreation Road 3	Summer Peak

By grouping adjustment factors and traffic ratios across hourly traffic volume, the mean monthly factor, weekly factor and traffic ratios can be calculated for each group. Then, STC points are assigned to each group through goodness of fit test performed on the mean of the traffic ratios across hourly traffic volume of STC points and the traffic ratios across traffic volumes of each group, and AADT is calculated by applying adjustment factors of the relevant group.

3.3 Methods Applying Daily Factors

This study improved the previous method applying adjustment factors described in section 3.1 above, to propose a new adjustment factor. The new factor is created by specifying monthly factors and weekly factors using the ratio of actual daily traffic volume against AADT. It can be calculated as shown in the following equation.

$$DF_{mmdd} = \frac{Annual\ Average\ Daily\ Traffic(AADT)}{m\ month\ \ and\ d\ day\ Traffic\ volume(ADT_{ij})}$$

Where in, $mmdd$: date of survey(month/day)

This new adjustment factor is created by dividing daily traffic with AADT, and is called 'daily factor' in this study. Use of this daily factor is expected to reduce errors, as it allows considering the characteristics of the specific day when the count was performed as well as monthly and weekly characteristics. Estimating AADT with monthly and weekly factors may result in errors due to traffic differences between the 4 weeks included in a month. Also, bad weather during STC may affect traffic volume, and reduce accuracy of AADT estimation. The distance between points in a same section does not exceed 30km on average: thus, the factors affecting traffic changes including weather condition of surrounding points are expected to be not much different during the same day, which will result in reduced errors compared with existing adjustment factors. To verify the relationship between daily traffic, observed traffic and monthly, daily and weekly factors, of the points analyzed, those with high traffic variation were compared with those with low traffic variation. The monthly factor, weekly factor and monthly/weekly factor were defined as follows.

$$MF_i = \frac{Annual\ Average\ Daily\ Traffic(AADT)}{Monthly\ Average\ Daily\ Traffic(mADT)}$$

$$WF_j = \frac{Annual\ Average\ Daily\ Traffic(AADT)}{Weekly(the\ day\ of\ week)\ Average\ Daily\ Traffic(wADT)}$$

$$MWF_{ij} = \frac{Annual\ Average\ Daily\ Traffic(AADT)}{i\ month\ \ and\ \ j\ day(the\ day\ of\ week)\ Traffic\ volume(Ai}$$

Where in, i = January, February ,... , December
j = Monday, Tuesday, ... , Sunday

Table 2: Estimation of AADT and Error of estimation at each adjustment factor (which has a small variation)

Month/day	Aadt	Adjusted by Monthly factor Only		Adjusted by Weekly factor Only		Adjusted by Monthly & weekly Only		Daily traffic	
		Volume	Error (%)	Volume	Error (%)	Volume	Error (%)	Volume	Error (%)
10/15 (MON)	54,767	56,418	3.01	56,418	3.01	57,461	4.92	57,546	5.07
10/16 (TUE)		56,798	3.71	57,360	4.73	55,759	1.81	57,934	5.78
10/17 (WED)		58,175	6.22	58,750	7.27	57,214	4.47	59,338	8.35
10/18 (THU)		56,063	2.37	56,063	2.37	55,256	0.89	57,184	4.41

10/19 (FRI)		59,477	8.60	57,233	4.50	55,906	2.08	60,667	10.77
average	-		4.78		4.38		2.83		6.88

Fig 1. Shows the traffic volume of a point with low traffic variation near Gwangju, Gyeonggi-do, on National Highway No. 3. STC on regular national highways are performed from March to November, only on weekdays. However, as STC on local roads are performed on Thursdays on the third week of every October, the graph was drawn based on the traffic data of the third week of October.

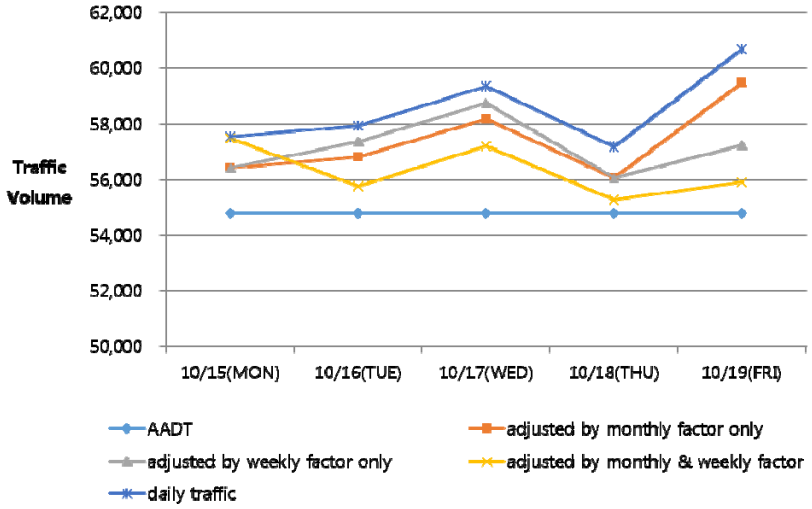


Fig 1: Estimation of AADT at each adjustment factor (which has a low variation)

The traffic volume of the point shown in **Fig 1** in October was slightly higher than AADT. And the AADT estimated with monthly and weekly factors was the closest to the AADT. In addition, regardless of adjustment factors applied, the traffic volume estimated with adjustment factors showed less difference with AADT compared with the actually observed daily traffic volume.

Table 3: Estimation of AADT and Error of estimation at each adjustment factor (which has a large variation)

Month /day	Aadt	Adjusted by Monthly factor Only		Adjusted by Weekly factor Only		Adjusted by Monthly & weekly Only		Daily traffic	
		Volume	Error (%)	Volume	Error (%)	Volume	Error (%)	Volume	Error (%)
10/15 (MON)	3,009	1,692	43.8	1,949	35.2	1,821	39.5	1,540	48.8
10/16 (TUE)		2,022	32.8	2,486	17.4	2,187	27.3	1,840	38.9
10/17 (WED)		1,788	40.5	2,260	24.9	2,463	18.2	1,627	46.0
10/18 (THU)		1,926	36.0	2,435	19.1	3,035	0.9	1,753	41.7
10/19 (FRI)		2,334	22.4	2,758	8.3	3,047	1.3	2,124	29.4
average	-		35.1		21.0		17.4		41.0

Fig 2. shows the traffic volume of a point with high traffic variation near Geoje, Gyeongsangnam-do on National Highway No. 14. The traffic volume shown in the graph is that of the third week of October, which is

known to have low traffic variation, and the traffic volume at this point in October was found to be lower than AADT. Estimation of AADT at this point with monthly factor, weekly factor and monthly and weekly factor, the value estimated with weekly factor and the value estimated with monthly and weekly factor was found to be the closest to AADT. In addition, like the previous point, regardless of adjustment factors applied, the traffic volume estimated with adjustment factors showed less difference with AADT compared with the actually observed daily traffic volume.

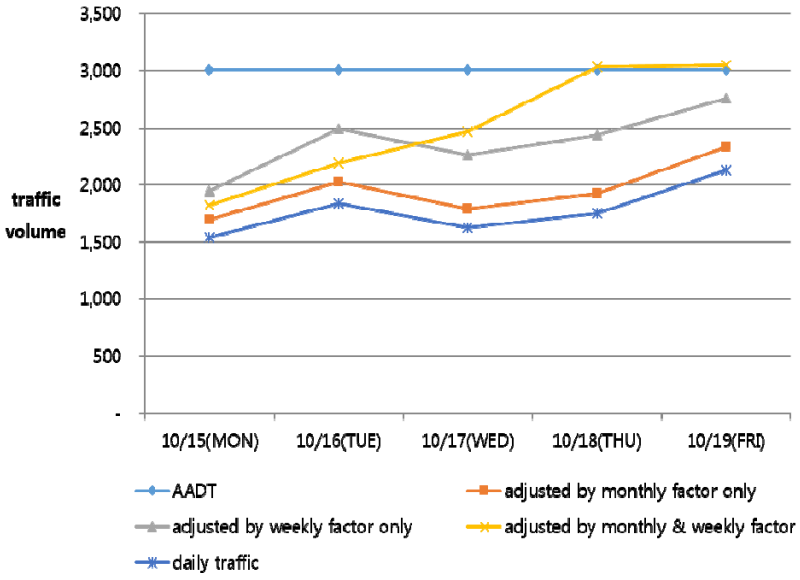


Fig 2: Estimation of AADT at each adjustment factor (which has a high variation)

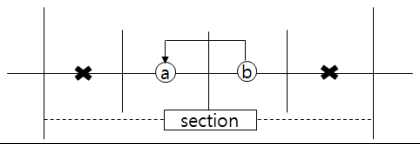
By applying monthly factor, weekly factor and monthly and weekly factor to a point with high traffic variation and a point with low variation, it was found that applying factors with smaller range, such as monthly and weekly factor, reduces estimation error. Estimation with the daily factor proposed in this section results in the value same as the true value of AADT: this estimation was excluded from the graph as its addition would not add any significance. Instead, the daily factor was applied when comparing errors produced by other analysis methods to conduct comparative analysis.

4. ANALYSIS RESULTS

This study applied adjustment factors to estimate AADT at STC points. Estimating AADT at a STC point by applying adjustment factors at other points requires determining the adjustment factor of which point to apply. This study applied adjustment factors of STC points within the same section, based on the sections provided by the Traffic Statistics Yearbook.

* Estimating AADT of a point(STC) using adjustment factors of b point (PTC)

$$\widehat{AADT}_a = ADT_a \times MF_b \times DF_b$$



To estimate AADT based on the same section and compare/analyze errors, a section with more than one

PTC point is required. Assuming a section called A has PTC equipments a and b, and the AADT at point a is unknown, the monthly factor and weekly factor at point b should be applied to point a and the AADT should be compared in order to find out the estimation error.

Table 4: MAPE for each analysis method
(unit : number of locations)

Estimation Error	0 ~5%	5 ~10%	10 ~15%	15 ~20%	20 ~25%	25 ~30%	over 30%	average of MAPE
method 1	32	43	16	6	2	0	2	8.3

method 2	26	55	16	3	0	0	1	7.9
method 3	47	34	11	5	2	0	2	7.5

Analysis was performed on 101 points in sections with more than one PTC points. Comparative analysis on estimation error was conducted using two methods: a method applying existing adjustment factor (method 1) and a method estimating AADT using adjustment factor grouping (method 2), to find out which method estimates AADT more accurately. To compare errors among three methods, this study used Mean Absolute Percentage Error (MAPE), which is widely used as error assessment index. MAPE is calculated as shown in the following equation.

$$MAPE(\%) = \frac{1}{N}\sum_{i=1}^{N}\left|\frac{(y_i-\hat{y}_i)}{y_i}\right| \times 100$$

In the preceding equation, y_i represents true value, and $\hat{y}_i$, the estimated value. As accurate AADT can be calculated using the PTC points subject to analysis, the AADT's of the relevant points are used as true values, and the AADT's estimated using each analysis method is used as estimated values to calculate the errors and analyze accuracy of AADT estimation.

As STCs on national highways in Korea are conducted from March to November only on weekdays(Tue, Wed, Thu), the analysis was performed for the days subject to STC (99 days per year).

Accuracy of AADT estimation based on traffic volume counted at 101 points subject to analysis was compared among three methods: a method applying existing adjustment factor (method 1), a method estimating AADT using adjustment factor grouping (method 2), and a method applying daily factor (method 3). In AADT estimation with adjustment factor, the criterion to determine the factor of which point to apply holds the highest importance. This study applied adjustment factors at PTC points within the sections used in previous studies.

The analysis showed that the method applying daily factor proposed in this study produces the lowest MAPE. And the points with error within 5% accounted for 46.5% of the total points: thus, the method 3 is likely to increase the AADT estimation accuracy. When applying method 2, however, the ratio of points with error within 15% was slightly higher. This is due to the fact that the analysis was performed under the assumption that adjustment factors of points within the same section would be similar to each other: if they are not similar, the AADT estimation error may increase. The AADT estimation error seems to have increased in sections where the adjustment factors are different between count points. And the points with AADT estimation error exceeding 20% accounted for 4% of the total points.

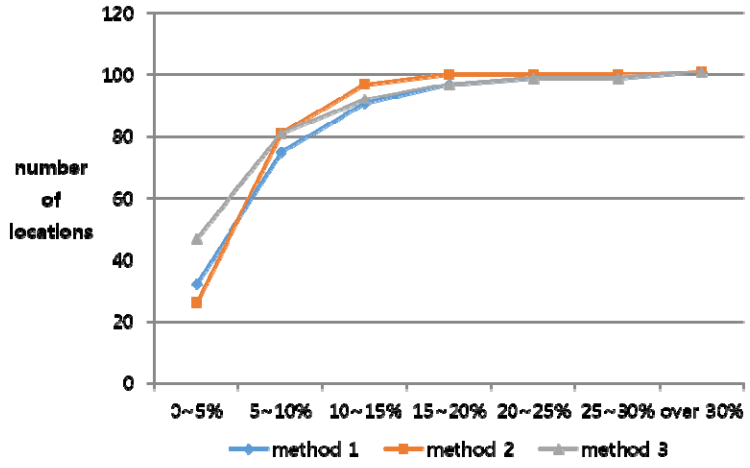


Fig 3: Accumulated distribution MAPE for each method

5. CONCLUSION

In this study, the estimation method applying adjustment factors was investigated among methods to estimate AADT mainly used for planning and designing roads. True values of AADT can be obtained in the point where permanent traffic counters are installed, but AADT is estimated through short-term traffic volume survey in the point where PTC is not installed. The AADT is considered to be very important as basic data for planning and designing roads and accurate AADT estimation is needed because its overestimation can lead to the waste in

the use of the budget and its underestimation results in poor level of road services. In this regard, this study suggested to investigate AADT estimation methods applying adjustment factors, and to compare the accuracy of estimated values.

To estimate AADT by applying adjustment factors, it is very important to determine PTC point from which adjustment factors are extracted. This study used a method to apply adjustment factors of PTC point within the section with high accuracy according to the analysis in the previous studies and conducted a comparative analysis between AADT estimation methods by grouping through the use of adjustment factors and changes in hourly traffic ratio and applying representative adjustment factors of each group. The current method of applying adjustment factors uses monthly factors, weekly factors and monthly/daily adjustment factors. Monthly factors are values obtained by applying the rate of average daily traffic by the month with respect to AADT, and 12 factors were calculated for each point. In the case of weekly factors, average daily traffic by the day of the week is applied with respect to AADT, and 7 factors were calculated for each point. Monthly/daily adjustment factors are used to calculate weekly factors for each month, and thus 84(=12×7) factors were calculated. Under the assumption that as the unit of adjustment factors becomes more detailed, the accuracy of AADT estimation is higher, this study developed daily adjustment factors calculated through the division of daily traffic volume by AADT and compared its accuracy with the existing adjustment factors. The comparison results showed that as the unit of adjustment factors is divided in detail, the accuracy of AADT estimation is improved, which indicates that its accuracy is further improved than that of values from AADT estimation using adjustment factor groupings. The distance between points within the same section turned out to be 30km on average, suggesting that factors affecting traffic variations in nearby points on the same day are similar to each other, and these factors cannot be identified by daily and weekly factors. Thus, the daily adjustment factors proposed in this study is expected to improve the accuracy of AADT estimation since they can reflect the characteristics of daily traffic volume which affects traffic variations.

In this study, a method to apply adjustment factors of PTC points within the same section was used for AADT estimation by applying adjustment factors. However, if traffic characteristics within the same section are different from each other, the values obtained by applying daily traffic volume from STC may be more similar to actual AADT than those from AADT estimation by applying adjustment factors. Gadda et al.(2007) identified that the grouping between groups with similar patterns is effective, and misapplication of adjustment factors to AADT estimation contributes to the occurrence of greater errors. The results of this study also demonstrated that an error of more than 20% in four points is due to the difference of traffic characteristics between points between the sections. Accordingly, it is expected that if adjustment factors of PTC points in the applicable section are applied through the introduction of more objective methods for selecting sections, the accuracy of AADT estimation will be further improved.

REFERENCES

[1] FHWA, Traffic Monitoring Guide (2013)

[2] Ajou University, A paper on survey system and computerization of traffic volume (1979)

[3] KRIHS, An improvement of traffic volume survey and management system (1993)

[4] Flaherty J. Cluster analysis of Arizona automatic traffic recorder data, Transportation Research Record Vol.1410 (1993), 93-99.

[5] S.J.Lee, N.C.Baek, H.J.Kwon, A study on the estimation of AADT by short-term traffic volume survey, Journal of Korean Society of Transportation, Vol.20, No.6 (2002), 59-68.

[6] J.A.Ha, S.C.Oh, Estimating annual average daily traffic using hourly traffic pattern and grouping in national highway, The Journal of the Korea Institute of Intelligent Transportation Systems, Vol.11(2012), 2nd, 10-20.

[7] S.H.Lim, J.S.Oh, A study on deriving of adjustment factor to estimate AADT, Journal of Korea Society of Civil Engineers, Vol.24, 1D(2004), 19-29.

[8] Qing Xia, Fang Zhao, Zhenmin Chen, L.David Shen, Diana Ospina, Estimation of annual average daily traffic for nonstate roads iin a Florida county, Transportation Research Record, Vol.1660(1999), 32-40.

[9] Zhao F., S. Chung, Contributing factors of annual average daily traffic in a Florida county: exploration with geographic information system and regression models, Transportation Research Record, Vol.1769 (2001), 113-122.

[10] J.K.Eom, M.S.Park, T.Y.Heo, L.F. untsinger, improving the prediction of annual average daily traffic for nonfreeway facilities by applying a spatial statistical method, Transportation Research Record Vol.1968 (2006), 20-29.

[11] T.Y.Heo, M.S.Park, J.K.Eom, J.S.Oh, A study on the prediction of traffic counts based on shortest travel path, The Korean Journal of Applied Statistics, Vol.20, No.3, 459-473

[12] Kim H.Y., A geostatistical approach for imporved prediction of traffic volume in urban area, Journal of the Korean Association of Geographic Information Studies, Vol.13 No.4 (2010), 138-147

[13] Brent Selby, Kara M. Kockelman, Spatial Prediction of AADT in unmeasured locations by universal kriging, the 90th Annual Meeting of the Transportation Research Board(2011)

[14] J.A.Ha, T.Y.Heo, S.C.Oh, S.H.Lim, Annual average daily traffic estimation using co-kriging, The Journal of the Korea Institute of Intelligent Transportation Systems, Vol.12, No.1(2013), 1-14

[15] MOLIT, Statistical Yearbook of Traffic Volume (2012)

[16] Shashank Gadda, Atul Magoon, Kara M. Kockelman, Estimates of AADT: Quantifying the uncertainty, the 86th Annual Meeting of the Transportation Research Board (2007)

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