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Establishment of Seasonal Correction Factor for Traffic- a Case study of Gujarat

Reema Shah, Tejas Thaker and Sagar Deshmukh

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Reema shah[1],Tejas Thaker[2],Sagar Deshmukh[3]

[1,2] Department of Civil Enginering,School of Technology,Pandit Deendayal Energy University,Raisan,Gandhinagar,Gujarat,India

[3]Associate Director,LASA

Abstract

Assessment of base year traffic is the fundamental and foundation of any project's intervention, let it be for either planning or design. Traffic counts and their projection plays an essential role in the development of Infrastructure. It typically varies across timelines and seasons. Seasonal Correction/Adjustment Factors are used to remove the seasonal bias by converting the Average Daily Traffic (ADT) into Annual Average Daily Traffic (AADT). Seasonal Correction Factor (SCF) plays an essential role in base year traffic analysis. Also, its accuracy influences long-term projections and decisions thereon. Such seasonal variations, we address through our principles. Some concepts are given in theory, some of them are direct, and some are indirect. Appreciating traffic analysis accuracy, it is intended to work out the SCF-seasonal correction factor with different methods. The comparative analysis is thought out to give specific known as well unknown dimensions. The study area will be considered Gujarat for analysis. However, concepts and literature study practices will be dug out from all possible resources. The way SCF's are being worked out will be gathered, and inferences will be drawn through comparative analysis. It is set to provide a way-forward direction for the right kind of applications.

keywords: Seasonal Correction Factor; Annual Average Daily Traffic; Fuel Sales; Toll able traffic at toll plaza; Automatic Traffic Counter and Classifier

1.Introduction

In several highway engineering projects, the daily total number of vehicles on the road is used. Entry to correct annual average daily traffic (AADT) knowledge is critical to many applications, including roadway construction, transportation planning, traffic safety research, highway development decision making, highway maintenance, air quality enforcement reports, and travel demand modeling. Average daily traffic (ADT) is often used for certain decision-making forms, such as funding distribution or assessment and collection of options for highway upgrades. In the past, the previous Method of measuring vehicle traffic was in volumes. Traffic volume count and usage of all services are the most fundamental of all requirements in preparing, constructing, regulating, utilizing, and maintaining a road network. The traffic counts and their forecasts are critical in where roads and traffic lanes can be strengthened. The weather is usually unpredictable throughout time and the season.

Proper monitoring is essential to reliably forecast transit times and traffic levels through our nation's transportation network. Accurate tracking is necessary to reliably predict transit times and traffic levels through our nation's transportation networks. Nevertheless, it is a costly method for us since it needs a great deal of manpower. The regular annual traffic (AADT) may be determined for every ATR venue using traffic control stations or automated traffic recorders. Many mechanical sensor systems are used to capture traffic data at some places 24 hours per day over the entire year.
Nevertheless, the implementation of ATR at the thousands of locations to count vehicles over the year is not feasible since ATR is positioned at a small range of strategic locations. To have a substitute, traffic counts conducted (i.e., a 24-hour count, a 48-hour count, etc.) are completed. The data obtained at these locations are used for calculating annual average daily traffic (AADT). At individual short-term count stations, the data collection frequency is irregular, indicating that the data is obtained at various periods in different nations. Few states collect short-term counts every year, while other states still collect short-term counts every few years. For locations without active or absolute stations, the AADT is determined dependent on the constant growth coefficient (i.e., seasonal, daily, monthly, growth, and axle factors).

After gathering data from a specific location, this data is then modified using seasonal variables derived from their PTC data to estimate the annual average daily traffic (AADT) at that site by a separate analysis process. By normalizing traffic data on a seasonal basis, the Seasonal Correction Factor (SCF) plays an important function. It is also relevant for long-term forecasts and decisions about the situation. Expected Average Daily Traffic (ADT) is used to counterbalance and eliminate the seasonal prejudice by translating the Average Daily Traffic (ADT) into Annual Average Daily Traffic. (AADT).

An accurate estimate of seasonal correction and its variance plays a significant role in Forecasting base year traffic (AADT) and its predictions. Traditionally or in a more natural manner, the procedure, etc. After some of the literature is analyzed and checked, some tools/techniques can be used. However, it is understood that due to the lack of substantial effort to estimate the study state's statistical characteristics and for all other states in India, no such estimates can be produced.

2. Literature Review

The traffic variation has been observed throughout the year due to various factors, one of the main reasons being season change. Hence, it is essential to find seasonal correction factors (SCF) to see fluctuation in traffic count in state and country. Traffic is different at different time scales according to the time of day, day of the week. The year between known traffic-related fluctuation is the most critical task in traffic monitoring (Li, Zhao, and Wu, 2004).

2.1 Importance Of Seasonal Correction

The seasonal factor plays a vital role in estimating the annual average daily traffic (AADT). The seasonal correction factors can be used as a coefficient for calculating AADT. With the help of SCF, one can understand how much traffic is being fluctuated throughout the year and can find out the seasonal variation in traffic count. Moreover, this can provide valuable insights for calculating accurate AADT. The accurate Estimation of AADT can further help in various future planning and proposals. It is also beneficial for geometrics design and all transportation projects. With Accurate AADT one can forecast future need and demand more precisely for different traffic studies.

2.2 The Approach of Different Countries for Finding Seasonal Correction Factor

Many countries and states know the importance of finding seasonal correction/seasonal adjustment factors for the traffic. They are concerned about the traffic monitoring count fluctuation in countries. One of the surveys conducted in 1997 in Kentucky via questionnaire observed that only nine states used seasonal adjustment to know the seasonal, temporal change in traffic, and 23 states do not use any seasonal adjustment factor. From this survey, very few states use the seasonal adjustment factor. This study also reveals that the traffic variations have been studied for only truck traffic (Stamatiadis & Allen, 1997).

The United States (US) transport department is more concerned about its traffic monitoring program for estimating AADT. They want a comparatively accurate traffic survey for the project; thus, the federal highway administration provides a fund to the states for implementing the same. The FHWA recommended 14 countries, namely California, Florida, Georgia, Indiana, Kentucky, Maryland, New York, North Carolina, Ohio, Tennessee, Texas, Utah, Virginia, and Washington, to find seasonal factors. Selecting these states is because they have already participated in traffic monitoring earlier (Monney, Badoe, and Lee, 2020).

In our country, India, and state Gujarat, not much study is conducted to find seasonal correction factors and seasonal adjustment factors. Our government does not take any initiative and generate any organization as FHWA to find seasonal factors for finding seasonal factors. Some consultants and designers take it randomly in our country, suggesting some secondary data methods for finding seasonal factors for accurate Estimation of the seasonal factor AADT.

2.3 The Different Method Used for The Accurate AADT Calculation

AADT estimation is used for continuous traffic monitoring, permanent traffic count (PTC), or automatic traffic recorder (ATR). From continuous traffic monitoring, know the monthly and seasonal variation characteristics. However, it is not possible because of cost constrain and the limitation of permanent traffic count (PTC) or automatic traffic recorder (ATR). Furthermore, it is elementary to find seasonal correction factors to convert short-term counts into AADT. So, for this reason, Short Term Traffic Count data collection is performed and used to estimate AADT. However, from this use of short-term traffic count, accurate AADT is not estimated.

2.3.1 The Different Method Used for Grouping of Short-Term Traffic Count

To estimate accurate AADT or increase the accuracy of AADT from short-term traffic count, various methods, models, and different strategies are used. For the annual average daily traffic estimation process, converting the short-term traffic count into the seasonal adjustment factor grouping is an evaluative task. Following are the different methods that are found relevant based on the literature review.

1) Discriminant analysis - The seasonal adjustment factor is depending on traffic fluctuation in a particular road, particular sites, etc. Discriminant analysis is used for short-term grouping count into the seasonal adjustment factor grouping. From this, a different type of algorithm is used for variable selection for grouping. Evaluation with MAE (Mean Absolute Error) and SDAE (Standard Deviation Absolute Error) indicates that the average decline in MAE by 58% and; in the SDAE 70% is estimated over traditional functional roadway classification. This study found that the time of day factor is more accurate than the average daily traffic in a similar short-term count pattern (Tsapakis et al., 2011).
2) Clustering analysis - The seasonal adjustment factor is depending on traffic fluctuation in a particular road, particular sites, etc. Discriminant analysis is used for short-term grouping count into the seasonal adjustment factor grouping. From this, a different type of algorithm is used for variable selection for grouping. Evaluation with MAE (Mean

Absolute Error) and SDAE (Standard Deviation Absolute Error) indicates that the average decline in MAE by 58% and; in the SDAE 70% is estimated over traditional functional roadway classification. This study found that the time of day factor is more accurate than the average daily traffic in a similar short-term count pattern (Tsapakis et al., 2011).

3) Fuzzy C means - The cluster analysis method is not accurate if one road belongs to more than one group. The fuzzy c mean method is used for improvement in grouping and considering characteristics as per road. This method considers where road segment appears to belong to more than one group and provides a degree to belonging to each group (Gastaldi *et al.*, 2013).
4) Artificial Neural Network- Artificial Neural Network has been used extensively in studying driver behavior, pavement maintenance, vehicle classification traffic forecasting, and patterns analysis. A well-framed ANN model can model the complex relationship of hourly traffic volume data finding the traffic patterns and estimating the AADT.
5) Support vector regression- Support vector regression has also been used for a similar application as ANN. It is beneficial for predicting and comparing travel time with baseline travel time prediction using real-time traffic data. A study indicated that SVR had more significant learning potential than ANN. The SVR models were used for the hourly volume data, days of the week, and month of year categorical factors in estimating AADT for short-term count stations.

2.3.2 Proxy Method for Estimating the Seasonal Factor

A study of the above literature found that many different and comparative analysis methods were used to improve the AADT. However, at some point, it is found that not much accuracy was generated from all methods observed. For this reason, the researcher tries to found the proxy method for traffic count; in this, they studied the effectiveness of fuel sales as a proxy for estimating the seasonal factor of traffic count. This study was conducted in India. For this study, the data collected from the toll plazas (that collects the traffic volume data throughout the year) is considered as a permeant traffic volume count, and the fuel sales data collected from the selected toll plaza's nearby petrol pump. For fuel sales data, seasonal factor is found similarly to find traffic volume count. Error is an estimate of fuel sales in terms of root mean square error. It first found an error for the seasonal factor of traffic from fuel sales and analysis of the error accuracy if raw fuel sales data directly used as a seasonal factor. The analysis observed that the error occurs between 3% to 7%, which is quite acceptable (Chakraborty and Chakroborty, 2015).

When no accurate traffic volume count instrument exists for counting the traffic volume for different purposes of designing, operation, traffic volume data collected from toll plaza located in other parts of India have been used for the analysis. Toll plaza traffic volume data considered as an Accurate traffic volume count. (Chakroborty, 2015)

IRC 108:2015 suggest that for finding accurate AADT use appropriate seasonal factor because year may be split into three to four weather periods depend on the season. The distribution of seasonal changes depends on the region and geographic location of the project highway. For finding seasonal changes, seasonal traffic factor should be generated using secondary data such as monthly fuel sale data for at least three years, authentic vehicle category wise traffic data from any nearby toll plaza, or data from any permanent traffic count station in the area, etc.(IRC, 2015).

Seasonal correction factor can find by using secondary data discussed above based on the following equation:

$$seasonal\ factor(SF) = \frac{Average\ traffic\ volume\ count\ for\ 12\ months}{traffic\ volume\ count\ for\ a\ specific\ month} \quad (1)$$

the equation (1) is derived from the (Khanna, 2011)

2.4 Comparative Analysis for Different Method Used for The Estimation of Accurate AADT

The FHWA (Federal Highway Administration) and AASHTO (American Association of State Highway and Transportation Officials) have provided some guidelines and methods for traffic monitoring and traffic data programs. Highway agencies widely use the FHWA (Federal Highway Administration) factoring method to estimate AADT for a wide range of roads, which cannot be covered by permanent counters. In the AASTHO guideline, SIX types of traffic data applications are identified, like project selection, pavement design, capacity analysis, safety analysis, air quality, and traffic simulation.

Comparative analysis for the different Method used for the Estimation of accurate AADT			
Sr.no	Methods/comparative factors	Errors	Results
1	Improving group assignment short-term traffic counts using historical seasonal pattern • MSE method • COV ratio method • FHWA method	10.48 8.41 62.11	From these two methods, a significant improvement in the AADT estimation in comparison to FHWA
2	AADT estimation by applying the different adjustment factor • Monthly • Weekly • Daily	8.3 7.9 7.5	The daily adjustment factor proposed in this study is expected to improve the accuracy of AADT
3	Alternatively, methods for estimating seasonal factor • FHWA method • TDOT's Method • weighted-factored Method	12.1 11.3 9.4	W.F.M has the lowest MAPE Values across the three datasets.
4	Improved AADT estimation process • Simple Average • AASHTO • AASTHO with adjustment • HPSJB	If the Method is not modified, AADT generated 25% greater than the actual values.	Using the HPSJB method, AADT estimation improves 40% to 50%

After the study, some literature review suggests many known and unknown facts related to the estimation of the seasonal correction factor. In most of the literature main aim is to convert short-term traffic count into seasonal adjustment factor/seasonal correction factor with grouping and analysis of the different methods. After applying different methods, compare this method and find the accuracy with different error finding methods. This suggests the most accurate method for finding AADT. Also, some literature found alternatives methods for collecting the data, and IRC also suggests some secondary data collection methods for finding seasonal factors. To Estimate the seasonal correction factor for the Gujarat state from the literature, we collect the data with IRC suggested Method; in this, the data included was continuous yearly data of toll able traffic, fuel sales, and ATCC data. Different data collection methods will be compared, and the most accurate method will be suggested for the Gujarat state.

3. Data Collection

A seasonal correction factor is an important factor for the estimation of AADT. Some methods for collecting data sets generated from literature and also some ways are suggested by **IRC 108:2015.** IRC suggested that factors may be developed using secondary data such as monthly fuel sales data for **at least three years,** authentic vehicle category-wise traffic data from any nearby toll plaza, or data from any permanent traffic counts in the area. Etc. Based on the research study collected three kinds of data set.

1) Fuel sales data -As mentioned in the literature review and as per IRC 108:2015, fuel sales data is collected to estimate SCF. In this study, our research area is GUJARAT state. So, district-wise monthly fuel sales data was collected for the last three financial years (APRIL 2017-MARCH 2018, APRIL 2018 -MARCH 2019, APRIL-2019 -MARCH 2020).

Data was collected from the Indian Oil Corporation Ltd (IOCL) organization. This organization offers a combined volume of six oil marketing companies' retail outlet data in Kilo Litters.

2) The toll plaza traffic data collection method is selected from the literature review and as suggested by **IRC 108:2015.** criteria for collecting the data, mention below
   - Toll plaza traffic data should have complete the last three financial year data month-wise, with no data gaps.
   - The operation of the toll plaza should be adequately maintained to avoid any data discrepancy.
   - All the toll plazas should be arranging the data properly vehicle category-wise.

3) ATCC (Automatic Traffic Counter and Classifier) data- Automatic Traffic Counter and Classifier (ATCC) monitors the real-time traffic flow of a road section, keeps a count of vehicles, and classifies them according to their pre-defined classes.

In GUJARAT state, as a part of the Second Gujarat State Highway Project (GSHP-II), ATCC was installed on Dabhoi-Bodeli (SH-11) corridor and functioning since April 2017. The Data was collected from Project implementation Unit (PIU), Roads & Buildings Department. The data collected was for two financial years, 2017-2018 and 2018-19, but in the year 2018-19, data was observed to have data gaps, so after clearing and checking, April 2017 to March 2018 ATCC traffic data is only used for further analysis.

As the ATCC has collected the data of traffic throughout the year continuously (24x7), it was recently installed, so it was assumed the data is more accurate for estimation of seasonal variation/ seasonal correction factor. Accordingly, this data is also used for estimating SCF and compared with the other two methods.

4. Methodology And Framework for The Study

The seasonal correction factor plays a vital role in planning and designing highways. To implement any project work, many factors are considered. The seasonal correction factor is one of the most important factors for estimating accurate AADT (annual average daily traffic). After the completion of data collection, the adequacy of the data is checked. After all these processes, and as discussed earlier, the data sets 1) Fuel sales data 2) Toll Plaza traffic data 3) ATCC (automatic traffic counter and classifier) data is considered for analysis. The formula is considered from Highway Engineering by Khanna and Justo to find the seasonal correction factor for each data set. And some statistics approaches were used for finding and validate the SCF.

4.1 Development Of Seasonal Correction Factor (SCF)

The approach adopted for addressing the research objective is how SCF varies through three alternative methods and which one is best suited for the state of Gujarat, namely SCF-fuel sales, SCF-toll plaza traffic, and SCF-ATCC.

4.1.1 SCF Based on Fuel Sales

This section describes the procedure for the estimation of seasonal correction factors from fuel sales data of Gujarat state. Fuel sales data combines the sales of petrol and diesel. ($\sum AMF_n$) is average monthly fuel sales ($\sum AMF_n$) for that particular year. For n number of years, the seasonal correction factor for fuel sales (SCF_{in}) is the ratio of average monthly fuel sales data of n^{th} year to monthly fuel sales of the **ith** month. For calculating SCF, first, we need to find the average monthly fuel sales from the equation mentioned below.

$$\sum AMF_n = \frac{Total\ Monthly\ fuel\ sales\ of\ n^{th}\ year\ (i\ 1\ to\ i\ 12)}{12} \tag{2}$$

After finding average monthly fuel sales, seasonal correction factor can be found from the equation below; SCF_{in} for fuel sales is:

$$SCF_{in} = \frac{Average\ monthly\ fuel\ sales\ of\ n^{th}\ year}{Monthly\ fuel\ sales\ of\ the\ i^{th}\ month} \tag{3}$$

$$= \frac{\Sigma AMF_\eta}{MF_i} \tag{4}$$

AMF= Average of monthly fuel sales

MF =Monthly fuel sale

n = 2017, 2018, 2019

i=1……12

4.1.2 SCF Based on Toll Able Traffic

This section describes the procedure for estimating seasonal correction factors from data collection of Toll able traffic at Toll Plaza. In this, the data provided with different vehicle categories. For finding seasonal correction factors, using the total of

all toll-able vehicles at toll plaza. This data considers the average monthly toll able traffic at the toll plaza ($\sum AMT_n$). For n number of the year, the seasonal correction factor for toll able traffic at toll plaza (SCF_{in}) is the ratio of average monthly toll able traffic at the toll plaza of n^{th} year to monthly toll able traffic at the toll plaza of the **i^{th}** month of that n^{th} year. The first step of the average monthly toll able traffic at toll plaza, is calculated from the equation below.

$$\sum AMT_n = \frac{Total\ Monthly\ tollable\ traffic\ at\ toll\ plaza\ data\ of\ n^{th} year}{12} \quad (5)$$

After finding the average monthly toll able traffic of the toll plaza, seasonal correction factor SCF_{in} for the toll plaza for a particular month is calculated from the equation below

$$SCF_{in} = \frac{Average\ monthly\ toll\ able\ traffic\ at\ toll\ plazas\ of\ n^{th}\ year}{Monthly\ tollable\ traffic\ at\ the\ toll\ plaza\ of\ the\ i^{th}\ month} \quad (6)$$

$$= \frac{\sum AMT_n}{MT_i} \quad (7)$$

AMT= Average of monthly toll able traffic at toll plaza

MT =Monthly toll able traffic

n =2017,2018 ,2019

i=1……12

4.1.3 SCF based on ATCC data

This section describes the procedure for estimating seasonal correction factor from Automatic Traffic Counter and Classifier (ATCC) data. For finding SCF, only one year of data has been considered because of the maintenance of ATCC, big data gaps were observed, so the remaining two years of data were not considered.

As discussed in the other two methods, the first average monthly total volume of all vehicles (ΣAMV_η) needs to be calculated. Seasonal correction factor for Automatic Traffic Counter and Classifier (ATCC) (SCF_{in}) is the ratio of the average monthly total volume of all vehicles for *an* n^{th} year to all vehicles' monthly total volume for the i^{th} month.

$$\Sigma AMV_\eta = \frac{Total\ monthly\ volume\ of\ all\ vehicles\ of\ n^{th}\ year}{12} \quad (8)$$

After finding ΣAMV_η find the seasonal correction factor for the ATCC data.

$$SCF_{in} = \frac{Average\ monthly\ total\ volume\ of\ all\ type\ of\ vehicle\ for\ n^{th}\ year}{Monthly\ total\ volume\ of\ all\ type\ of\ vehicle\ for\ the\ i^{th}\ month} \quad (9)$$

$$= \frac{\Sigma AMV_\eta}{MV_i} \quad (10)$$

AMV= Average of the monthly total volume of all type of vehicle

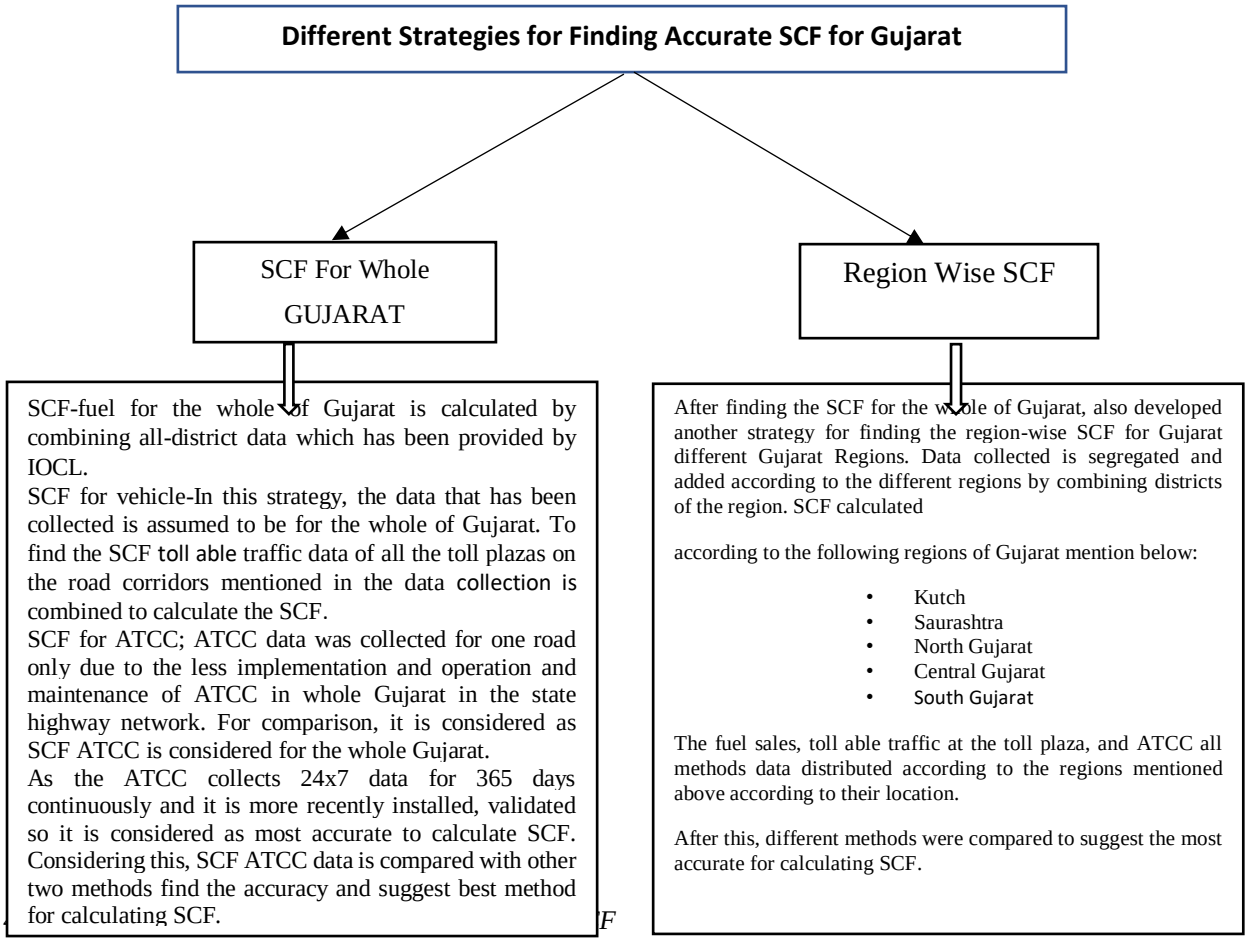
MV =Monthly total volume of the vehicle all type of vehicle

n = 2017

i= 1……12

It has been found from the studies that the seasonal adjustment/seasonal correction factor is used in many countries for different projects. In the case of GUJARAT, it is not appropriately found. From the above formula, the seasonal correction factor is calculated for three types of data set. Furthermore, we compared these methods, analyzed an accurate method is suggested by comparing SCF-ATCC data for Gujarat's future projects.

4.2 Different Strategies for Finding Accurate SCF for Gujarat



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Different statistical approaches are applied to analyse method-wise variation and comparison of two different methods in the estimated SCF. Following statistical tolls were used in finding the variation and accuracy of SCF calculated

- Min, Max, and Range
- Standard Deviation

4.4 Analysis Method for Finding The Accuracy Of The SCF

- Mean Absolute Deviation
- Mean Square Error
- Root Mean Square Error
- Mean Absolute Percentage Error

4.5 Different Methods and How They Affect the Final Outcome

At last for finding the different method outcomes and how they affect the results of any road design and project, effort was made to calculate the actual AADT and projected it to 25 years by using different SCF values calculated from the three different methods discussed above. AADT calculated SCF value is projected by considering the growth rate of 5%. Accordingly, volume by capacity ratio is also calculated to know in which year LOS B is getting achieved to upgrade the road into 4 lanes. By this approach, we can get to know how the final outcome (SCF) is playing a role in kind of investments Government is prior or post of realistic realization. Different methods seasonal correction factor plays a significant role in deciding the authority how many years later this requirement generates when compared with other methods.

4.6 Data validation

ATCC data collected on Dabhoi-Bodeli is validated with short time traffic counts conducted in the year 2016 and 2021. As part of Second Gujarat State Highway Project during the year 2016 and 2021, R&BD has collected the traffic data and same is used for validation of ATCC data.

MONTH	Monthly Traffic in Vehicles
Apr-17	242560
May-17	257737
Jun-17	242560
Jul-17	156285
Aug-17	184366
Sep-17	191069
Oct-17	178081
Nov-17	223109
Dec-17	230138
Jan-18	234252
Feb-18	225268
Mar-18	223972
AVERAGE	**215783**
AADT (Vehicles)	7094
ADT (vehicles in February)	8045
ADT (vehicles in September)	6369

Traffic data on Dabhoi-Bodeli road under Second Gujarat State Highway Project (GSHP-II)

MODES	SH:11-Kundi, km 56+200	
	ADT (SEPTEMBER 2016)	ADT (FEBRUARY 2021)
Sc/Mc	2314	1933
Rickshaw/Chakda	259	156
Car	1531	2512
Mini Bus	26	28
Std Bus	178	205
Tempo/LCV	292	681
2-Axle Trucks	1881	2059
Tractors	100	41
Cycle	103	5
Cycle Rickshaw	5	1
Animal Drawn Vehicles	3	0
Hand Cart	4	0
Others	4	2
Total	**6700**	**7623**

From the tables above, it can be observed that total traffic volume observed in ATCC in line with the short traffic counts conducted on the roads, except minor variation in the month. So, from the short term traffic counts it can be concluded that SCF-ATCC data is correct and ATCC is installed recently by following proper validation protocols.

4.6.1 Validation of SCF

SCF calculated in the research has validated with SCF calculated earlier for the one of the project in R&BD for Project Preparatory works (PPW) for World Bank assisted Project. This project has spread across the state hence it has assumed to be relevant to compare the SCF calculated in the research.

Month	SCF Vehicles	SCF Fuel	SCF ATCC	SCF of R&BD-PPW-2011
Apr-17	0.989	1.003	0.890	1.00
May-17	0.949	0.864	0.837	0.94
Jun-17	1.044	1.000	0.890	1.00
Jul-17	1.184	1.213	1.381	1.05
Aug-17	1.087	1.109	1.170	1.03
Sep-17	1.070	1.103	1.129	1.08

Oct-17	1.002	1.011	1.212	0.97
Nov-17	0.966	0.946	0.967	1.02
Dec-17	0.943	0.970	0.938	0.95
Jan-18	0.912	0.967	0.921	0.98
Feb-18	0.930	0.997	0.958	1.07
Mar-18	0.987	0.912	0.963	1.02

SCF of PPW-2011 was calculated based on the toll plaza revenue of corridors Vadoda-Halol, Bagodara-Vasad, Ahmedabad-Mehsana, Machhu Bridge and Himatnagar bypass for the year 2009-2010.

From the table it can be observed that SCF calculated from three different methods in the research is in line with the study of R&BD, except minor variation because of the data is slightly old and it is calculated with revenue of tollable traffic.

5. Analysis

5.1 SCF for Whole Gujarat

To find out the different data collection methods, SCF accuracy, and different changes in the monthly SCF value for the whole Gujarat monthly, step-by-step comparison is done with different statistical approaches as mention above.

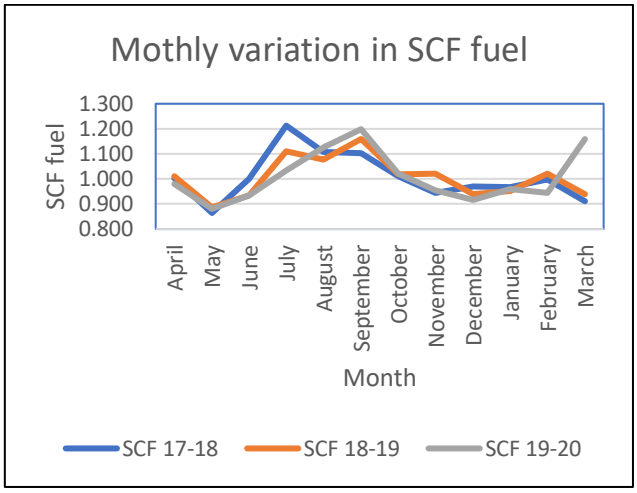


Figure 1 Monthly SCF fuel variation

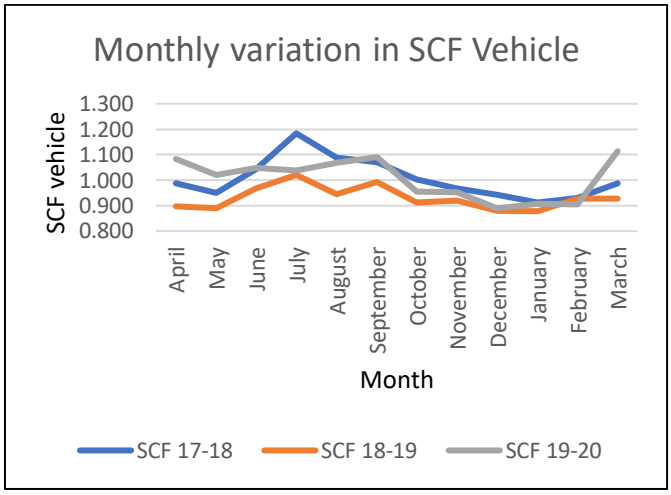


Figure 2 Monthly SCF vehicle variation

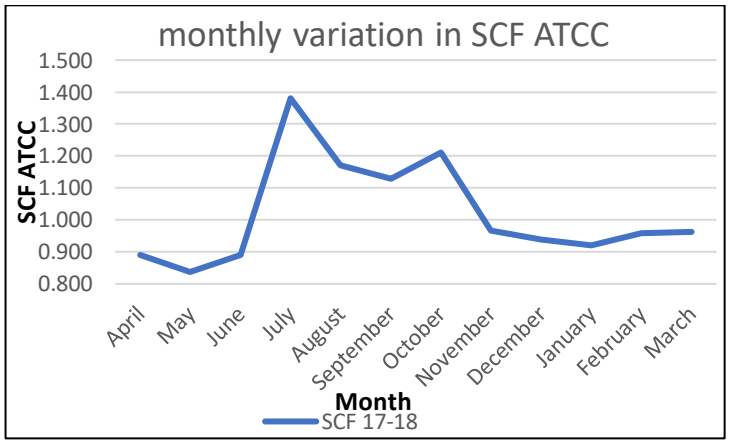


Figure 3 Monthly SCF ATCC variation

From the SCF fuel it is observed that high monthly variation is found in the Year 2017-2018 in July month. Variation in March 2020 is also more compared to the other two years in the same month. Otherwise, it can be observed that SCF is varying for different seasons of the year. , it can also be observed that the variation among months is varying from 27% to 35% in three years.

In the standard deviation for SCF fuel it is observed that the standard deviation value is less during the Year 2018-19 compared to years 2017-2018 and 2019-2020.

From the SCF vehicle it is observed that the variation is more in all years from month April to September. High variation is observed in the July month in the Year 2017 -2018 compared to the other two years. It is also observed that variation in March 2020 is more compared to other years. it can also observe that the variation among months is varying from 14% to 27% in three years. As compared to SCF fuel variation among months are minimum in SCF vehicle.

In the standard deviation for SCF vehicle it is observed that the standard deviation value is less during the Year 2018-19 compared to years 2017-2018 and 2019-2020. Tiny variation among the years 2017-2018 and 2019-2020

As per the data presented above, SCF varies among months based on the various seasons in the year. SCF is observed maximum in July and minimum in May. Variation among different months in the year is more SCF-ATCC.

5.1.2 Comparison and Accuracy of Two Different Methods

As per assumption and data collection, SCF-ATCC data is a more accurate method for calculating SCF because continuous 24x7, 365 days were captured for the year, and variation was also clearly visible in the data.

Considering this, SCF-ATCC data is compared with SCF fuel, and SCF-vehicle and errors were calculated to find the most accurate method for finding SCF in the absence of ATC data for the state of Gujarat. Accordingly, as discussed in the methodology chapter, different methods were used to calculate the error compared to SCF-ATCC with other method**s.**

5.1.2.1 Comparison of SCF ATCC with SCF Vehicle

TABLE 1 SCF-ATCC WITH SCF-VEHICLE ALONG WITH VARIOUS ERROR VALUES

MODEL A Accuracy estimation of SCF ATCC and SCF vehicle for whole Gujarat						
	ACTUAL VALUE	PREDICTED VALUE	ACTUAL VALUE-PREDICTED VALUE	|ACTUAL VALUE-PREDICTED VALUE|		((|ACTUAL VALUE-PREDICTED VALUE|)/ACTUAL VALUE)
MONTH	SCF ATCC	SCF VEHICLE	ERROR	ABSOLUTE VALUE OF ERROR	SQUARE OF ERROR	ABSOLUTE VALUE OF ERRORS DIVIDED BY ACTUAL VALUES
Apr-17	0.890	0.989	-0.099	0.099	0.010	0.1114
May-17	0.837	0.949	-0.112	0.112	0.012	0.1335
Jun-17	0.890	1.044	-0.154	0.154	0.024	0.1735
Jul-17	1.381	1.184	0.197	0.197	0.039	0.1425
Aug-17	1.170	1.087	0.083	0.083	0.007	0.0709
Sep-17	1.129	1.070	0.059	0.059	0.003	0.0523
Oct-17	1.212	1.002	0.210	0.210	0.044	0.1731
Nov-17	0.967	0.966	0.001	0.001	0.000	0.0008
Dec-17	0.938	0.943	-0.005	0.005	0.000	0.0055
Jan-18	0.921	0.912	0.009	0.009	0.000	0.0096
Feb-18	0.958	0.930	0.028	0.028	0.001	0.0296
Mar-18	0.963	0.987	-0.024	0.024	0.001	0.0248
TOTAL			**0.192**	**0.981**	**0.141**	**0.9275**
	N	**12**				

MEAN ABSOLUTE DEVIATION	**0.016**
MEAN SQUARE ERROR	**0.012**
ROOT MEAN SQUARE ERROR	**0.108**
MEAN ABSOLUTE PERCENTAGE ERROR	**7.729**

TABLE 2 SCF-ATCC WITH SCF-FUEL ALONG WITH VARIOUS ERROR VALUES.

MODEL B Accuracy estimation of SCF ATCC and SCF FUEL for whole Gujarat						
	ACTUAL VALUE	PREDICTED VALUE	ACTUAL VALUE-PREDICTED VALUE	|ACTUAL VALUE-PREDICTED VALUE|		((|ACTUAL VALUE-PREDICTED VALUE|)/ACTUAL VALUE)
MONTH	SCF ATCC	SCF FUEL	ERROR	ABSOLUTE VALUE OF ERROR	SQUARE OF ERROR	ABSOLUTE VALUE OF ERRORS DIVIDED BY ACTUAL VALUES
Apr-17	0.890	1.003	-0.113	0.113	0.013	0.1270
May-17	0.837	0.864	-0.027	0.027	0.001	0.0324
Jun-17	0.890	1.000	-0.110	0.110	0.012	0.1241
Jul-17	1.381	1.213	0.168	0.168	0.028	0.1216
Aug-17	1.170	1.109	0.062	0.062	0.004	0.0528
Sep-17	1.129	1.103	0.027	0.027	0.001	0.0236
Oct-17	1.212	1.011	0.201	0.201	0.040	0.1656
Nov-17	0.967	0.946	0.022	0.022	0.000	0.0223
Dec-17	0.938	0.970	-0.032	0.032	0.001	0.0341
Jan-18	0.921	0.967	-0.046	0.046	0.002	0.0495
Feb-18	0.958	0.997	-0.039	0.039	0.002	0.0410
Mar-18	0.963	0.912	0.052	0.052	0.003	0.0539
TOTAL			**0.163**	**0.898**	**0.106**	**0.8478**
	N	**12**				

MEAN ABSOLUTE DEVIATION	**0.014**
MEAN SQUARE ERROR	**0.009**
ROOT MEAN SQUARE ERROR	**0.094**
MEAN ABSOLUTE PERCENTAGE ERROR	**7.065**

From the tables above, when SCF ATCC with SCF Vehicle and SCF ATCC with SCF fuel is compared, it is noted that in SCF fuel much lower errors were generated. Based on the analysis, it can be concluded that the SCF fuel accuracy is more as compared to the SCF vehicle, but the error difference is not much between these two methods.

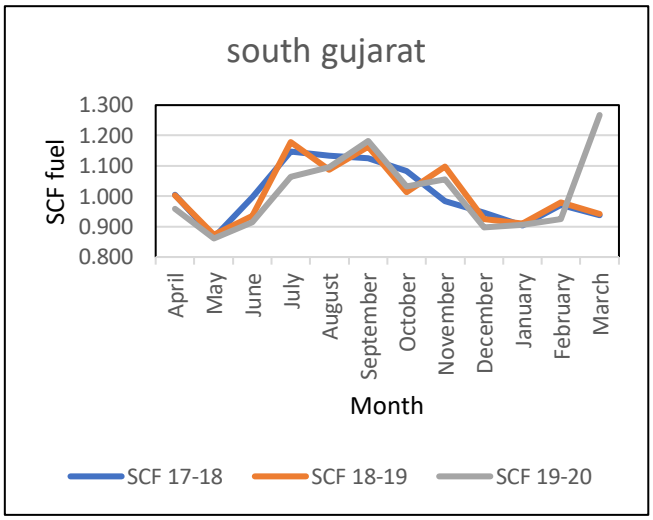
5.2 *SCF Analysis Region Wise*

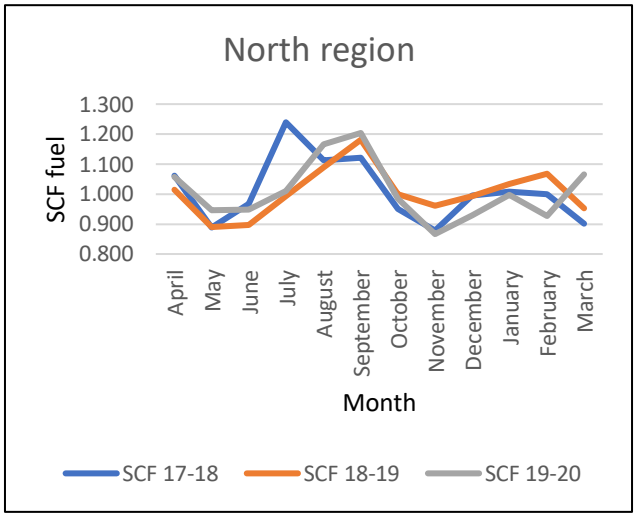
As mentioned earlier, the effort has also been made to find the SCF among different regions of Gujarat. SCF region-wise is calculated based on two methods, SCF vehicles and SCF fuel, and compared the two methods. Indeed, the SCF will vary among different regions based on the region's land use and geographical conditions. Accordingly, the effort was made to analyze the variation among different regions and which method can be best suited to find the accuracy of SCF.

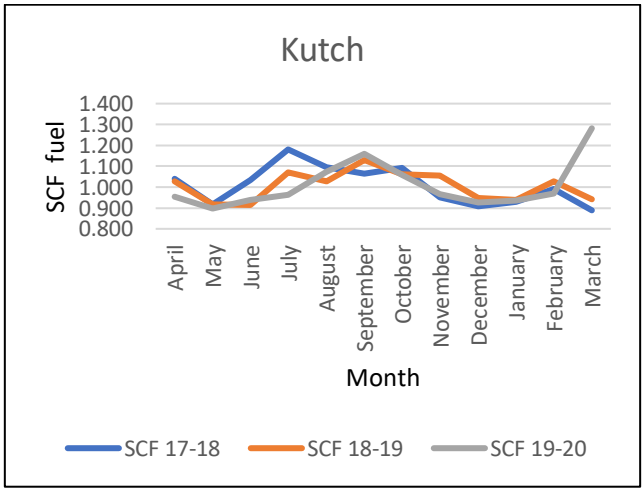
As mentioned earlier, SCF ATCC data was only one road, and it from the central region for comparison and analysis; it was considered in central Gujrat only.

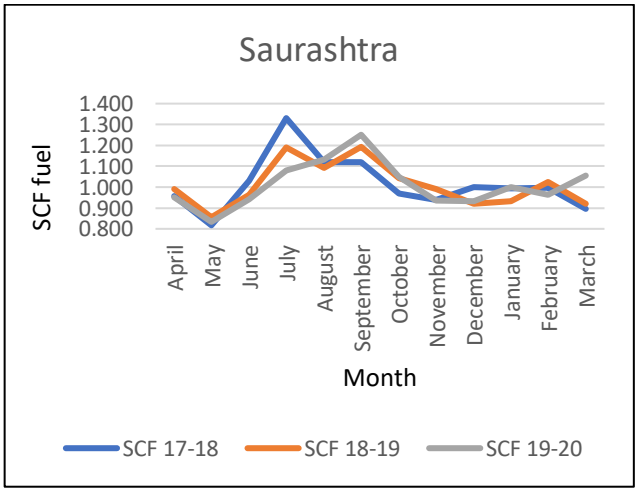
5.2.1 SCF Fuel-Region Wise

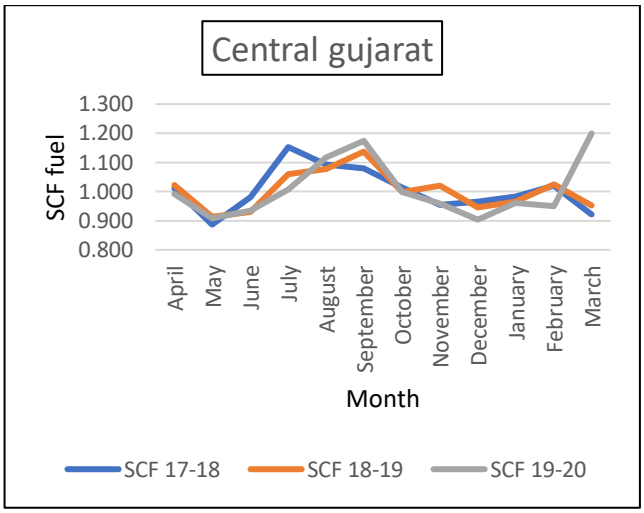
As mentioned in district-wise data collected is used to calculated fuel-wise SCF for different regions. The same is discussed in ensuing sub-sections











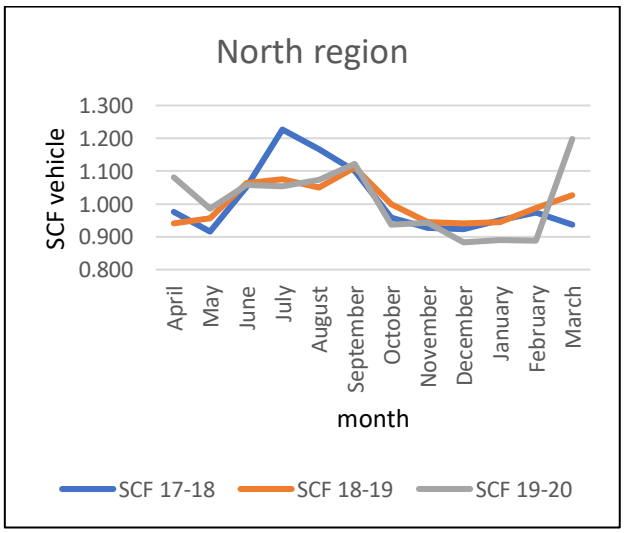
In the south region, from the figure it can be observed that the variation is less in the year 2017-2018, and the variation is more in the year 2018-2019. It is found that March month has more variation in the year 2019-2020. In the north region, variation is less slightly less in year 2018-2019. Year 2018-19 and Year 2019-20 is showing similarity by month. In the Kutch region, the lower variation is examined in the year 2018-2019, and the high variation is observed in the year 2019-2020.The graph surveyed that in the Kutch region, the lines are moving parallel to each other, not much variation is observed only in march month during the year 2019-2020; vast variation is examined. The above graph observed that SCF more in the month of July in the year 2017-18. In the Saurashtra region, minor variation is found in the year 2018-2019, but the higher variation was observed in 2017-2018. In table central Gujarat region, not much variation was found in SCF values. From three years, minor variation is observed in the year 2018-2019, except in the month of March in 2019-20.

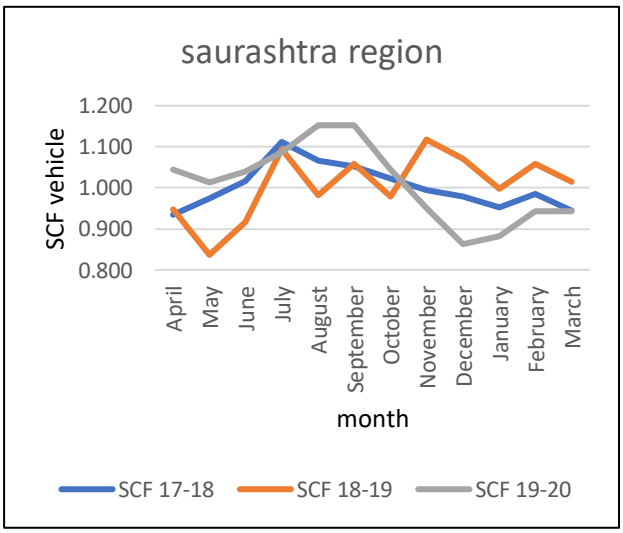
From the standard deviation comparison observed that the high variation observed yearly in the region-wise sometimes yearly variation is high, and sometimes yearly variation is low. And the region-wise also observed that the in south region variation is low during the year 2017-2018, but in Saurashtra region year 2017-2018 has high variation. In comparing yearly variation in standard deviation, find out that in the south Gujarat region, lower variation is found in the year 2017-2018, and high variation is found in the year 2019-2020. In the north region, the lower variation is found in the year 2018-2019, and higher variation is observed in the year 2017-2018.from this observed that the results for lower variation is the same for Kutch, Saurashtra, and central Gujarat region in the year 2018-2019.

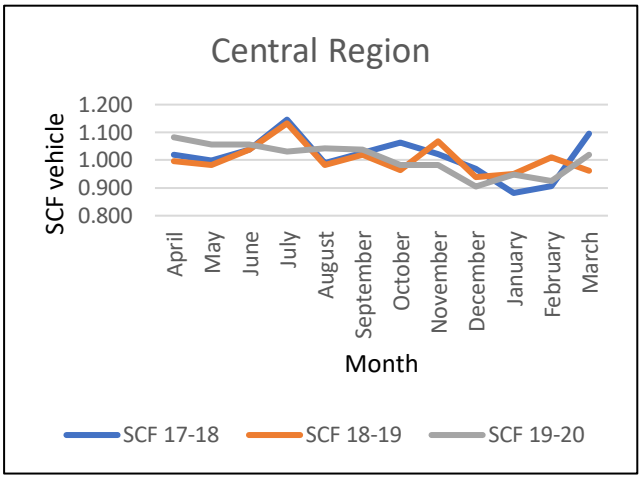
From all the observations, it was finding out that the significant variation is observed in region-wise SCF.

5.2.2 Region Wise-SCF Vehicle

Region wise SCF vehicle is calculated for the three regions only, because the roads selected and data collected are spread across in these regions only. Which are North region, Saurashtra region, and central region. The variation between these three regions is presented below.







In the north region it was observed that in the year 2017-2018, the variation is high in July and 2019-2020 variation is high found in the march month. In the Saurashtra region it was observed that significant variation is observed in different months and among the years also. 2018-19 variation among different months are low compared to other two years.IN 2019–2020-month wise variation is more.

From the SCF vehicle standard deviation comparison examines that the north region in the year 2018-2019 variation is low, but the variation is almost the same in the year 2017-2018 and the year 2019-2020. In the Saurashtra region, the year 2018-2019, the variation is the same, and again in the northern region, the variation for the year 2017-2018 and year 2019-2020 is the same. And in the Saurashtra region, the year 2017-2018 and the year 2019-2020 are the same. In the central region, the higher variation is found in the year 2017-2018, and in the year 2018-2019 and the year 2019-2020, the variation is the same, and it is lower.

From this found out that in the north and central region, the variation is lower in the year 2018-2019, and in the Saurashtra region, the variation is high in the year 2018-2019.

5.2.3 Comparison and Accuracy of Two Different Methods

TABLE 3 SCF-ATCC WITH SCF-VEHICLE ALONG WITH VARIOUS ERROR VALUES

CENTERAL REGION						
MODEL A Accuracy estimation of SCF ATCC and SCF vehicle for whole Gujarat						
	ACTUAL VALUE	PREDICTED VALUE	ACTUAL VALUE-PREDICTED VALUE	|ACTUAL VALUE-PREDICTED VALUE|		((|ACTUAL VALUE-PREDICTED VALUE|)/ACTUAL VALUE)
MONTH	SCF ATCC	SCF VEHICLE	ERROR	ABSOLUTE VALUE OF ERROR	SQUARE OF ERROR	ABSOLUTE VALUE OF ERRORS DIVIDED BY ACTUAL VALUES
Apr-17	0.890	1.019	-0.129	0.129	0.017	0.1456
May-17	0.837	0.999	-0.162	0.162	0.026	0.1938
Jun-17	0.890	1.039	-0.149	0.149	0.022	0.1678
Jul-17	1.381	1.146	0.235	0.235	0.055	0.1700
Aug-17	1.170	0.990	0.180	0.180	0.033	0.1541
Sep-17	1.129	1.025	0.104	0.104	0.011	0.0923
Oct-17	1.212	1.064	0.148	0.148	0.022	0.1218
Nov-17	0.967	1.022	-0.055	0.055	0.003	0.0567
Dec-17	0.938	0.968	-0.030	0.030	0.001	0.0323
Jan-18	0.921	0.882	0.039	0.039	0.002	0.0428
Feb-18	0.958	0.907	0.051	0.051	0.003	0.0536
Mar-18	0.963	1.097	-0.133	0.133	0.018	0.1381
TOTAL			0.098		0.211	1.3688
		N	12			

MEAN ABSOLUTE DEVIATION	**0.008**
MEAN SQUARE ERROR	**0.018**
ROOT MEAN SQUARE ERROR	**0.133**
MEAN ABSOLUTE PERCENTAGE ERROR	**11.4067**

TABLE 4 SCF-ATCC WITH SCF-FUEL ALONG WITH VARIOUS ERROR VALUES

CENTERAL REGION						
MODEL B Accuracy estimation of SCF ATCC and SCF FUEL for whole Gujarat						
	ACTUAL VALUE	PREDICTED VALUE	ACTUAL VALUE-PREDICTED VALUE	|ACTUAL VALUE-PREDICTED VALUE|		(|(|ACTUAL VALUE-PREDICTED VALUE|)/ACTUAL VALUE)
MONTH	SCF ATCC	SCF FUEL	ERROR	ABSOLUTE VALUE OF ERROR	SQUARE OF ERROR	ABSOLUTE VALUE OF ERRORS DIVIDED BY ACTUAL VALUES
Apr-17	0.890	1.004	-0.114	0.114	0.013	0.1285
May-17	0.837	0.884	-0.047	0.047	0.002	0.0564
Jun-17	0.890	0.981	-0.091	0.091	0.008	0.1028
Jul-17	1.381	1.154	0.226	0.226	0.051	0.1639
Aug-17	1.170	1.093	0.078	0.078	0.006	0.0664
Sep-17	1.129	1.086	0.043	0.043	0.002	0.0383
Oct-17	1.212	1.019	0.192	0.192	0.037	0.1586
Nov-17	0.967	0.959	0.008	0.008	0.000	0.0087
Dec-17	0.938	0.967	-0.030	0.030	0.001	0.0315
Jan-18	0.921	0.973	-0.052	0.052	0.003	0.0565
Feb-18	0.958	1.016	-0.059	0.059	0.003	0.0611
Mar-18	0.963	0.924	0.040	0.040	0.002	0.0413
TOTAL			**0.194**	**0.981**	**0.128**	**0.9140**
		N	12			

MEAN ABSOLUTE DEVIATION	**0.016**
MEAN SQUARE ERROR	**0.011**
ROOT MEAN SQUARE ERROR	**0.103**
MEAN ABSOLUTE PERCENTAGE ERROR	**7.6166**

From the tables above, when SCF ATCC with SCF Vehicle and SCF ATCC with SCF fuel is compared, it is noted that SCF fuel much lower errors were generated. Based on the analysis, it can conclude that the SCF fuel accuracy is more than the SCF vehicle, but the error difference is much between these two methods.

5.3 Different Methods and How They Affect the Final Outcome

The outcomes of SCF vehicles, SCF fuel and SCF ATCC and how these methods affect the results of the road design and any road project of Gujarat. From the SCF values short term traffic count (ADT) of road Vallbhipur-Ranghola corridor is converted to ADDT and the same is projected to 25 years. Short term traffic count was taken from the R&BD which was collected for Second Gujarat Project in the year 2017-18. So, 2017-18 may month SCF values were taken into consideration.

As per the standard 5% growth rate was considered to project the traffic for 25 years. Accordingly, Volume Capacity ratio is also calculated to know exactly in which year LOS B is achieved. If this ratio greater than 0.50 after this requirement is generated to convert two-lane road into Four-lane highway. The outcomes are found the results are mention below.

Outcome Based on SCF Vehicle: After projected the traffic as per the procedure mention, it can be observed that in the year 2039 the requirement will be generated for the convert 2-lan road into 4 -lane road.

Outcome Based on SCF Fuel: From this examine that as per the projected traffic according to SCF fuel it was found that in 2041 required convert 2- lane into the 4- lane**.**

Outcome based on SCF ATCC: From this table observed that if the traffic projected as per the value of SCF ATCC it is find out that the on the basis of v/c ratio 0.52 generated in the year 2042 after that it is required to convert two lane road into four lane road.

From the above results, it was noted that based on ATCC requirement for upgradation of road is coming out in the year 2041 based on SCF-ATCC, 2040 based on SCF-Fuel and 2038 based on SCF-Vehicle. It can be concluded that how Department can save the expenditure based on the accurate estimation of SCF and how SCF is influencing in the investment finalisation. Prior investments can be saved and utilised in most appropriate manner.

6. Result and Discussion

To conclude the accurate SCF method for Gujarat, based on the literature review and various guidelines followed three methods were used SCF fuled based on fuled data of Gujarat state, SCF vehicle based on the tollable vehicles of state highways and SCF ATCC based on the traffic volume counted through Automatic Traffic Counter and Classifier (ATCC). Effort were made to compared these three methods, summary and results are placed below:

In the whole of Gujarat, the analysis reveals that the for SCF fuel sales in July and march month variation is observed more. And the variation among months is 27% to 35% in three years data for SCF vehicles. It is observed that from April to

September high variation difference was observed. In SCF vehicles, a value of 14% to 27% variation was observed in three years of data compared to SCF fuel variation among months are minimum in SCF vehicles.

In SCF ATCC, SCF is observed maximum in May and minimum in July

The variation is found less in the year 2018-2019 for both the method SCF fuel and SCF vehicles in the standard deviation variation.

For the whole of Gujarat, comparison was made with SCF ATCC with SCF fuel and SCF vehicles. The result was generated is SCF fuel error is low as compared to SCF vehicle. The SCF fuel error is 7%, and the SCF vehicle error is 7.7%, not much variation found in it. So that it can be concluded that SCF fuel is more accurate.

The second strategy analysis is also done region-wise for SCF fuel and SCF vehicles to determine variation among monthly and yearly region-wise.

In the region-wise comparison of SCF fuel, the variation is more in different regions when it is compared to SCF of fuel for whole Gujarat. In some regions during the year 2017-2018, variation is high. In some region during the year 2018-2019, variation is less from this result observed that more variation fluctuation finds in region wise analysis.

For the region-wise analysis of SCF vehicle it is revealed that July month variation is high in the north region. In the standard deviation comparison, variation difference is more observed than the comparison for the whole of Gujarat.

In comparing yearly variation in standard deviation, it was found that lower variation is found in the south Gujarat region in the year 2017-2018, and high variation is found in the year 2019-2020. In the north region, the lower variation is found in the year 2018-2019, and higher variation is observed in the year 2017-2018.from this observed that the results for lower variation are the same for Kutch, Saurashtra, and central Gujarat region in the year 2018-2019.

The comparison of SCF fuel and SCF vehicle with SCF ATCC again observed that accuracy is more observed for SCF fuel but more variation was in error between SCF fuel and SCF vehicle.SCF fuel error is 7.61%, and SCF vehicle error is 11.41%.

Based on the finalized SCF effort was also made to see the that how SCF values are impacting on designing the road corridor. Accordingly, one two-lane stretch is selected which have short term traffic data, same traffic data is used to calculate AADT by SCF values in the study and same has been project. Results indicates that based on the projected traffic road upgradation is coming out in the year 2041 based on SCF-ATCC, 2040 based on SCF-Fuel and 2038 based on SCF-Vehicle. Based on the results comparison, it can be concluded that how Department can save the expenditure based on the accurate estimation of SCF and how SCF is influencing the investment finalization. Prior investments can be saved and utilized in the most appropriate manner.

Conclusion:

From both the methods and strategies discussed in the thesis the results indicates that SCF fuel is more accurate than SCF vehicles. Because cost constraints implementation, operation and maintenance of ATCC in state Highways is very difficult. From the study it can be concluded that if ATCC data not available, SCF fuel data can be considered for finding the accurate AADT for state highways. It will be more accurate, and SCF found in this study can also be used for forecasting traffic. It was also proved that how SCF is influencing in finalizing AADT and its project traffic accordingly investments finalization, designs, etc. It was also suggested and recommends to implement the ATCC on selected state highways in each region of Gujarat so that R&BD/NHAI/MORTH/GSRDC can use the data in planning, prioritization of the road projects.

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