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# ESTIMATION OF FUTURE TRAFFIC DEMAND BY GRAVITY MODEL: A CASE STUDY OF RAMAGUNDAM

**B.SRAVANTHI[1],M.ANVESH KUMAR[2]**

[1]Student, M.Tech, Department of Civil Engineering, Visvodaya Engineering College, Kavali
[2]Assistant Professor, Department of Civil Engineering, Visvodaya Engineering College, Kavali


**ABSTRACT**

In India Power Generation sector is experiencing tremendous growth with the increase in both development and environmental deterioration. Development is taking place in income levels, living standards in all respects of socio economic characteristics. Consequently this leads to increases in the demand for new transportation facilities as well as upgrading of the existing facilities.

Keeping this in view an attempt is now made in the present study to estimate demand for transportation facilities for an area where the power generation sector is expanded. Assuming that the system will have an effective influence only within the premises of colony and industrial area, new zoning scheme has been proposed to identify the travel characteristics among the study area.The traffic volume count has been carried out to know the trips which are going from internal to external at central office and at entrance and exit of the area. The home interview survey was carried out to develop the origin and destination matrix of the trips carried out by the residents of the study area. Travel demand model has been developed using the O-D matrix and is calibrated in which Gravity model is used to develop future traffic O-D matrix. Model validation and sufficiency of lane width is done by loading the traffic volumes of present and forecasted on to the network.



## 1. INTRODUCTION

### 1.1 GENERAL

Transportation plays an important role in the political, economic and social development of any society. As a society grows in terms of population and functions, the need for various components also grows thereby requiring quality and effective transportation systems. In the words of there is no escape from transport even in the most remote and least developed of inhabited regions. It is also opined that “there seems to be no other types of development which can effect so speedily a change in the economic and social conditions of backward nations except transport”.

### 1.2 DEVELOPMENT OF POWER GENERATION SECTOR IN INDIA

Power, being considered as an engine of growth, has always been a focus area for most of the developing countries, including India. The power generation in India has increased from 1362 MW in 1947 to 1, 20,000 MW during 2004-05 and at present total installed capacity is 2,28,722MW and planned to increase 3,00,000 MW by 2017. Global Coal reserves are expected to last another 200 years. India also has a vast coal reserve of 211 billion tones making coal one of the most extensively used fossil fuel for generating power. Hence there is a rapid growth in areas surrounding areas with an increase in power generations.

***1.2.1 TSGENCO***

Telangana Power Generation Corporation (TSGENCO) is the third largest power utility in the country and it is the largest power generating company of T.G. State with installed capacity of 4365.3 MW comprising 2282.5 MW Thermal, 2081.80MW Hydel and 1 MW from Renewable Energy Sources.

In view of proposed projects like Lift Irrigation and Drinking water supply schemes by T.G. government. To meet the needs of demand as a part of it Ramagundam thermal power station with installed capacity of 62.5MW which is increased to 500 MW.

**1.3 DEMAND FOR TRANSPORTATION FACILITIES**

The demand for transportation is known as a "derived demand". This demand is derived from economic activity that is the result of peoples' requirements to earn a living, enjoy leisure activities, and consume goods and services. The production, supply, and distribution of goods and services create the demand for freight movements. Thus, the social, demographic, and economic factors that create the demand for transportation will also determine the type of transportation system that will be necessary in the future. This means that these factors must be considered when developing transportation plans. Some of the major social, demographic, and economic trends that will affect transportation demand and, therefore, future transportation system needs are presented in subsequent chapters.

**1.4 NEED FOR THE STUDY**

By the growth of the industries, urbanization takes place with an increase in demand for transportation facilities especially the road network. To arrive at a better picture for decision making for selection among various transportation alternatives in systems, there is a need to quantify benefits and costs. Travel demand estimation is must for future traffic distribution. This can be used for design of improvements and view its viability. The case study of the existing road network with the proposed improvements gives a better picture about the future road network condition and can view its viability.

**1.5 OBJECTIVES OF THE STUDY**

The present dissertation work is taken up with the following objectives:

1. To review literature on travel demand estimation so as to select appropriate methodology.
2. To evolve a methodology for traffic demand estimation with minimum primary needs.

**2. LITERATURE REVIEW**

**2.1 GENERAL**

In this chapter various travel demand models to estimate future traffic demand and Estimation of OD matrix problem has been presented along with literature on capacities, level of service.

**2.2 SURVEYS TO COLLECT DATA**

The first stage is to form a transportation plan is to collect data on all factors that are likely to influence travel pattern. Surveyors can collect data

1. At home
2. During the trip and
3. At the destination ends of the trip.

Some of the surveys that are usually carried out are,

**(a) Road side interviews** of drivers, usually at the exit of a cordoned area. Sampling fractions of 1 in 5 may be considered typical but they certainly depend on traffic levels and manpower available. They are carried out on different days but at similar times. They tend to be expensive in manpower, delays to vehicles and processing.

**(b) Home interview survey Method.** Although usually not considered reliable enough for a detailed design of, for example, a traffic management scheme, they may be the result of a large study and be available for cross-checking. The method is expensive on manpower and time consuming.

**(c) Flagging methods.** It is possible to identify vehicles at cordon and internal points by means of registration numbers, stickers or by asking drivers entering at a given point to switch their lights on. This method has only been tried for very small areas (roundabouts).

**(d) Taxi and Public transport surveys:** Large urban areas usually have sizeable amount of travel by taxis and buses. In order to minimize the delays the interviewer may enter the vehicle and carry out the interviews when the vehicle is in motion.

**(e) Aerial photography.** To a large extent this method is experimental, it requires a good deal of processing to identify cars and track them in a computer readable form. It is only successful for small areas but improvements in the automatic identification of vehicles may increase their applicability. It is the only method which does not necessarily require sampling.

**2.3 TRIP GENERATION**

The first phase of transportation planning process deals with surveys, data collection and inventory. Trip generation understands the trip making behaviour and produce mathematical relationships to synthesize trip making pattern on the basis of observed trips, land use and house hold data. Some of the trip generation models are:

**2.3.1 Multiple Linear Regression Analysis**

**Douglas A.A and Lewis R.J (1962)**[1] proposed this well-known statistical technique for fitting mathematical relationships between dependent and independent variables. In the case of trip generation equations, the dependent variable is number of trips and independent variables are land use and socio economic characteristics.

$Y = a_1X_1 + a_2X_2 + .....a_nX_n + a_0$ .... (2.1)

Where Y = dependent variable, i.e. number of trips

$X_1$ , $X_2$ , $X_3$.... = independent variables like population, employment etc.

$a_o$ , $a_1$ , $a_2$..... = parameters to be calibrated.

Though it is a well known technique the equation derived is purely empirical and the regression coefficients initially established will still remain unchanged which may not be valid in future.

**2.3.2 Category Analysis**

**Watton H.J and Pick G.W (1967)**[2] developed category analysis or cross classification technique which is based on determining the average response or average value of dependent variable for certain defined categories of independent variables. A multi-dimensional matrix defines categories, each dimension in the matrix representing one independent variable. Since the data is directly taken from census, it saves considerable effort, time and money spent on home interview survey. But it cannot test the statistical significance, cannot add new variables and the assumption of income and car ownership changes in future.

**2.4 TRIP DISTRIBUTION**

After having obtained an estimate of the trips generated from and attracted to the various zones, it is necessary to determine the direction of travel. Trip distribution stage determines number of trips from each zone to zone. Some of the trip distribution methods are:

(1) Growth Factor Methods

(2) Synthetic Methods

**T.J Fratar (1954) , K.P. Furness (1965)**[3] proposed some of the growth factor methods which are based on assumption that present travel pattern can be projected to the design year in future by using certain expansion factors. Whereas synthetic models utilise the existing data to discern a relationship between trip making, resistance to travel between zones and relative attractiveness of zone for travel.

**Voorhees A.M (1955)**[4] proposed gravity model which assumes the interchange of trips between zones in an area is dependent upon the relative attraction between zones and and indirectly proportional to some decreasing function of the cost (in time, distance or monetary terms) of travelling between them. This decreasing function is usually called the impedance function of the model.

**R.W. Whitaker and K.E. West (1968)**[5]proposed opportunities model which assumes that trip interchange is the total trips emanating from each zone multiplied by probability that each trip will find an acceptable terminal at the destination.

**2.5 ESTIMATION OF OD MATRIX**

There are also some of the advanced techniques which do not need large data collection unlike conventional methods to estimate OD matrix. OD matrix is directly estimated from traffic counts which are explained below.

**2.5.1 Gravity formulation approach**

**Low (1972)** has used gravity formulation approach in which it is assumed that a gravity model is capable of explaining most of the travel behaviour in the study area. Traffic counts are then used to calibrate the parameters of such model. Largest number of practical applications is reported under this category. Both linear and non-linear models are reported with proportional and capacity restraint for traffic assignment under this technique.

The model suggested by common Wealth Bureau of roads as reported by **Symons et al (1976)**[6] is a special model for state-wide application, in which the nation is divided into zones of economic activity by means of the application of the Central Place theory. The travel phenomenon is explained through the levels of services offered by the hierarchy of growth centres and through the recreational index in the form of rank scores.

**Various Approaches Based On Gravity Model:**

**Linear regression approach**

**Low's model:**

**Low (1972)**[7] suggested the simplified model, which was very effective. This method of approach which was known as internal volume forecasting (IVF), model is suitable for modelling rural or inter-urban transport demand.

$$T_{ij} = ap_i e_{jd}{}^{-2}{}_{ij} \qquad (2.2)$$

Pi, ej = population, employment in zones i and j

dij =distance or travel time between i and j

a is the parameter for calibration.

$$V_a = b_o + \sum_{ij} t_{ij}\, p_{ij}^{a} \qquad .(2.3)$$

Va = flow in link a

$p_{ij}^{a}$ =0 if trips from i to j do not use link 'a'

= 1 if they do so

**Overgrad's model:**

**Overgrads(1976)**[8] suggested this model which can be considered as an improved version of Low's model. External trips are calculated in same way as Low's model. The main difference lies in expressing trip generation or trip attraction and it may be represented as

$$O_i = b_1E_i + b_2P_i + b_3(P_i d) \qquad (2.4)$$

$O_i$ is generation or attraction force in zones i.

$E_i$, $P_i$ is employment and population in zones i.

d the percentage of population in one family houses.

**Non-Linear regression approach: Robillard's model:** Robillard (I975)[9]created a model as follows

$$T_{ij}=R_i S_j f(Cij) \qquad (2.5)$$

Where $T_{ij}$ = trips of zone i to j

$R_i$, $S_j$ = trip generation and attraction parameters.

$C_{ij}$ = deterrence function = $C_{ij}$-d

Again, the traffic volume on link 'a' is given by

$$Va= \sum_{ij} R_i S_j f(C_{ij}) P_{ij}^{a} + \varepsilon a \ (2.6)$$

**Hogberg's model**

**Hogberg(1976)**[10] considered three types of trips, home - work home-home and work- work trips. Hogberg assumed that the joint generation-distribution model is of the form,

$$T_{ij} = b_iO_i^1A_i^1D_j^1f(C_{ij}) + b_2O_i^1A_i^2D_j^2f(C_{ij}) + b_3O_i^2A_i^2D_j^2f(C_{ij}) \ (2.7)$$

$O_i^1$ , $O_i^2$ trip generation parameters

$D_i^1$,$D_j^2$ trip attraction parameters

$$A_i^1 =[\Sigma D_j^1 f(C_{ij})]^{-1} \qquad .(2.8)$$

And

$$f(C_{ij}) = cij^{b4}\exp(b^5(\log_e(cij)^2)) \qquad (2.9)$$

The volume of the link 'a' is given by

$$Va = \sum_{ij} p_{ij}^{a}\, T_{ij} \qquad .(2.10)$$

## 3. METHODOLOGY

### 3.1 GENERAL

As city expands to accommodate the growth in population and activities, the spatial separation between the population and employment locations increase, increasing needs for travel modes are felt. In order to understand the travel behaviour for transportation planning and management, the patronage has to be estimated. Once the patronage is estimated, suitable planning models could be developed and relevant management policies can be adopted to tackle many of traffic problems. The patronage was estimated using four step planning process which gives the demand directly by way of the desire line diagram for a specified purpose for each route serving a particular land use.

Transportation demand modelling is a process which consists of development of a mathematical model to forecast future travel demand. The past studies and network in the area are just based on the agrarian population rather than the Industrial population. As the Growth is towards the Rapid Industrialization and a predominant increase in basic standard living condition, it is necessary to estimate the transit demand utilizing socio economic characteristics of the zones to develop trip generations/attractions and estimate O-D matrix based on Gravity models.

Traffic volume counts and the future traffic demand are linked to provide and make improvement in Transportation for the existing Network. Design of intersection and parking are done. The present study has been aimed to utilize these data source for the present selected Transportation Network analysis.

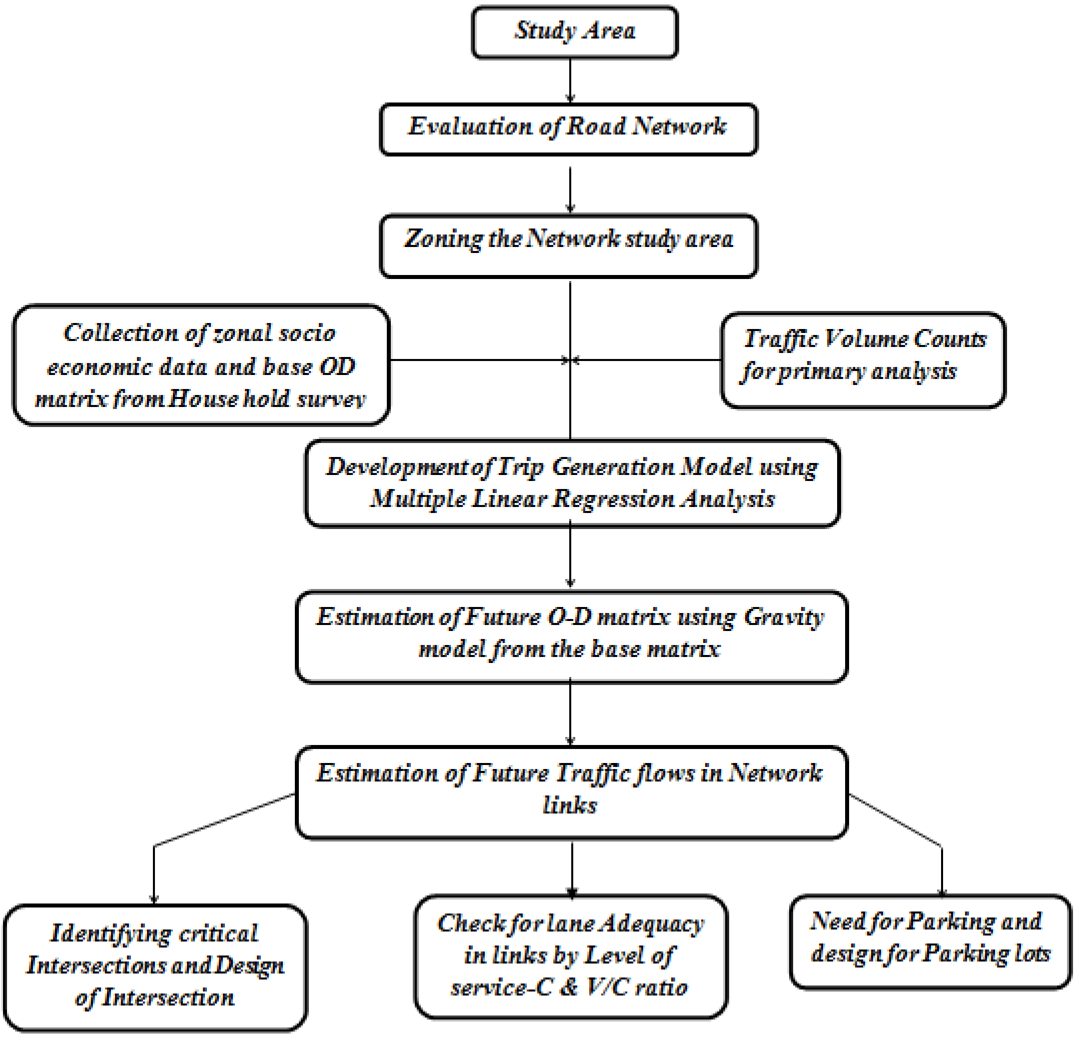


**Figure 3.1: Study Methodology**

**3.2 STUDY METHODOLOGY**

The study methodology adopted in the present dissertation work is presented in the flow chart as shown in the figure 3.1 and the various steps of proposed methodology are discussed in subsequent articles.

**3.3 DEVELOPMENT OF TRIP GENERATION MODEL**

This is the first of sub models in the study process which predicts the number of trips starting and finishing in each zone. The objective of trip generation stage is to understand the reasons behind the trip making behaviour and to produce mathematical relationships to synthesise the trip making pattern on the basis of observed trips, land use data and household characteristics.

Multiple linear Regression analysis is a well-known statistical technique for fitting mathematical relationships between dependent and independent variables. Since this technique exploited fruitfully in many of the transportation studies, this method is used in the present study.

### 3.4 ESTIMATION OF FUTURE OD-MATRIX

After having obtained an estimate of the trips generated from and attracted to the various zones, it is necessary to determine the direction of travel. Trip distribution stage determines number of trips from each zone to zone. As mentioned earlier for the purpose of present study, synthetic or inter area travel formulae methodology has been adopted i.e. gravity model. The generalized relationship is more usually expressed as

$T_{ij} = P_i*A_j*f(t_{ij})*R_i*C_j$ (3.1)

Where

$T_{ij}$ = Number of trips from zone i to j

$P_i$ = Total number of trips produced in zone i

$A_j$ = Total number of trips attracted to zone j

$R_i$ = Row balancing factor

$C_j$ = Column balancing factor

$f(t_{ij})$ = Deterrence function which is based on Generalized cost of the journey from Zone i to j. Some functions that have been used are,

$f(t_{ij}) = tij^{-a}$

Negative power function (3.2)

$f(t_{ij}) = e^{(-b*tij)}$

Negative exponential function (3.3)

$f(t_{ij}) = t_{ij}^{-a}\, e^{(-b*tij)}$ Combined power and exponential function (3.4)

Although often used, the negative exponential has some disadvantage. The same absolute increase in travel impedance at low values of the travel impedance has the same relative effect on the trips as at high travel impedance. Sometimes a deterrence function does not decrease monotonously across the entire range of the travel impedance. In the case of car trips, for example, the value of the deterrence function starts at a low level, reaches a maximum, and only then decreases with increasing travel impedance. The reason is that the tendency to use the car for very short distances will generally be low. In such cases it is sometimes possible to use a combination of power function and exponential function to describe the data.

Comparing all the three curves as shown in the figure 3.2, it is observed that combined negative exponential and power function form has been found to be particularly appropriate for shorter distance, intra urban trips and the curve is in the form of signature of the city.So, for the purpose of the present study, equation (3.4) is used as deterrence function.

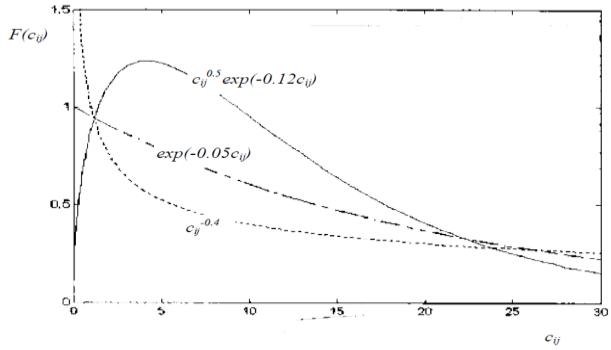


**Figure 3.2** Curves of the deterrence functions

## 4. DATA COLLECTION AND PRELIMNARY ANALYSIS

### 4.1 GENERAL

This chapter covers in detailed data collection process and primary analysis are discussed based on the procedure mentioned in the methodology.

### 4.2 DESCRIPTION OF THE STUDY AREA

The Present study is done in Ramagundam B Super Thermal Power Plant colonies, which is located at Ramagundam in Telangana. The power plant is one of the coal based power plants of TSGENCO with an installed capacity of 62.5 MW (single unit). The plant was established in the year of 1971. Now the surrounding Rural population is settled in and around the colony premises.

Due to availability of land, water resources and fuel material (Coal) in the near vicinity TSGENCO has proposed for extension of power plant from an installed capacity of 62.5 MW to 500 MW within the next two years. However the existing road network and transportation facilities are designed in 1970 modified and developed in the 1990's. Hence the present area is being selected for study purpose. The present study area is as shown in the figure 4.1

### 4.3 ZONING THE STUDY AREA

The entire region of Ramagundam TSGENCO power plant and the surrounding area is sub divided in to seven zones based on the land use characterises. These zones are as shown in the figure 4.1

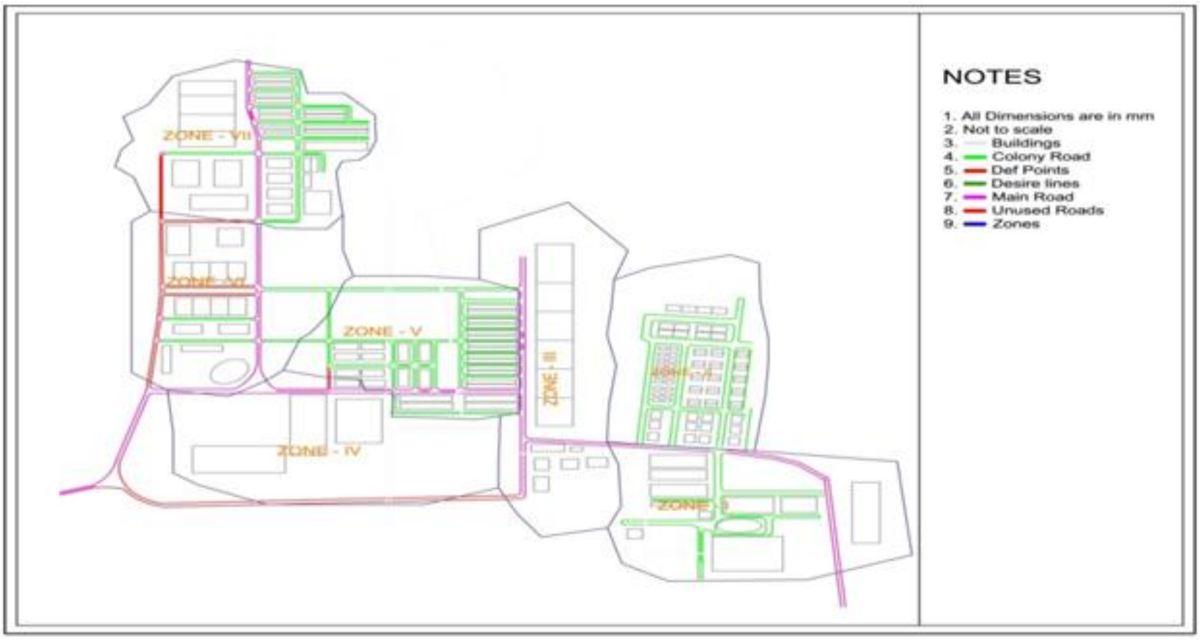


**Figure 4.1** Study area indicating zones and road Network

While dividing the study area into zones the following guide lines are must have to be followed.

1. Zone should be homogeneous in land use as far as possible.
2. The zone boundaries should match with administrative boundaries.
3. The zone should match with manmade and natural boundaries as far as possible.

Table 4.1 shows population and employment details of the zones collected from previous and censes-2011 studies and information from the local municipality and industries situated in the study areas i.e. TSGENCO. Based on these zone details,one can be able to forecast the future population and employment and are also shown in Table 4.1 only.

**Table 4.1** Zone characteristics of study corridor

| Zone No | Zone Name | Population | | | Employment | | | Characteristics |
|---|---|---|---|---|---|---|---|---|
| | | 2011 | 2015 | 2021 | 2011 | 2015 | 2021 | |
| 1 | Power plant area | 938 | 1313 | 5710 | 653 | 911 | 1218 | Complete industrial area with power plant and low housing |
| 2 | B-colony | 2456 | 2943 | 5616 | 323 | 356 | 471 | Fully Residential area along with small retail shops |
| 3 | Masjid corner & Shopping Area | 2564 | 3123 | 5368 | 872 | 923 | 842 | commercially developing area |
| 4 | Central office Area | 2587 | 3421 | 9201 | 1065 | 1121 | 1840 | Offices area |
| 5 | A-Colony | 2098 | 2937 | 3194 | 564 | 635 | 1295 | Fully Residential area along with small retail shops |
| 6 | Market & School Area | 1987 | 2481 | 2972 | 245 | 332 | 594 | Market, shopping & schools |
| 7 | C- Colony | 2678 | 3349 | 3818 | 123 | 196 | 258 | Fully Residential area along with small retail shops |

**4.3.1 Study area Analysis**

Two approaches can be used to study a corridor. First one is based on developing OD matrix on a regional basis. Second one is to develop a new OD matrix on the specific problem to be solved. If an OD matrix is already available for a region, a proportioning process can be easily used to develop trips between smaller analysis zones in the corridor study. Another alternative procedure is to develop a completely new trip distribution employing revised set of analysis zones. As the OD matrix and actual travel patterns are analysed for the year i.e.2015 and 2021.

**4.4 DATA COLLECTION AND PRELIMINARY ANALYSIS OF DATA**

The surveys conducted for the present study are

1. Traffic volume count for Preliminary Analysis of Data
2. Home Interview Survey

**4.4.1 TRAFFIC VOLUME COUNTS**

In the present study, manual counts of traffic are conducted at three different locations along the major road link. The three different locations are the entrance of the study area, exit of the study area and near central office where maximum flow is obtained. Surveys are conducted for 16 hours to collect volume in both directions. Traffic volume count Data format sheet is presented in **Appendix A.**

The location of the survey and the corresponding traffic volume for 16 hours is mentioned in the table 4.3. and the total volume is converted into passenger car unit obtained per day trips by multiplying the traffic volume count with Equivalent passenger car unit's factors given in the table 4.2. Passenger car units count obtained is presented in Table 4.3.

**Table 4.2** Equivalent PCU value factors by Vehicle type

| **Vehicle type** | **Equivalent PCU value** |
|---|---|
| Bus | 3 |
| Mini bus/van | 1.5 |
| Car | 1 |
| 2 Wheeler | 0.5 |
| Auto Rickshaw | 1 |
| 2 Axle Truck | 3 |
| 3 Axle Truck | 4.5 |
| MAV | 4.5 |
| LCV | 1.5 |
| Tractor | 4.5 |
| Cycles | 0.5 |
| Hand/Animal drawn carts | 4 |

**Table 4.3** Total traffic volume count for 16 Hours.

| | **Traffic Volume (16 Hours) (vehicles/day)** | | | **Traffic Volume (16 Hours) (PCU/day)** | | |
|---|---|---|---|---|---|---|
| **Location** | External to internal | Internal to external | Total Volume | External to internal | Internal to external | Total Volume |
| Entrance near plant | 5130 | 5879 | 11009 | 5194 | 5747 | 10941 |
| Central office | 6547 | 6634 | 13181 | 6103 | 5812 | 11915 |
| Exit from study zone | 7976 | 8226 | 15709 | 7573 | 7403 | 14476 |

**Calculation of the total internal trips:**

The present study is only the internal zone study and it not influenced by the external surrounding area. For that purpose only the internal trips are calculated as follow:

External to internal trips = Entrance (E to I) +Central office (E to I) –Exit (I to E)

= 5194+6103 – 7403 = 3894 PCU/day

Internal to external trips = Entrance (I to E) +Central office (I to E) –Exit (E to I)

= 5747+5812- 7573 = 3986 PCU/Day

Total Internal trips in both the direction = 3894 +3986 = 7480 PCU/day

### 4.4.2 HOME INTERVIEW SURVEY

#### 4.4.2.1 Preparation of Questionnaire

The questionnaire has been prepared to meet the data requirements of the study. The main aspect of this survey was to identify the personal trips. The questions are very useful for obtaining information about travel origination and destination. The purpose of the trip and all other socio economic characteristics are included in the questionnaire.

#### 4.4.2.2 Data Requirements

The questionnaire was prepared to survey people of all kinds of income levels. A typical format of the Questionnaire is given in plate I

1. Travel related data of passenger covering Origin, Destination and purpose.
2. Socio economic characteristics of passengers covering income, vehicle ownership, age, qualification and employment.
3. Trip data of passenger covering travel time and travel distance.

The Home Interview survey format is presented in **Appendix B.**

#### 4.4.2.3 Data collection of questionnaire

Traffic Surveys were conducted along the major link on both directions in the three locations as mentioned earlier. As per standards the minimum sampling size for Home interview survey is 1 in 10 households for population under 50,000. The total population in the study area is around 15500, with an average family size of 5. Total numbers of samples collected are 312. The expansion factor is obtained by dividing the no. of house hold by the sample households. These studies are conducted in all the zones to collect complete personal trip travelled in past 24 hours. Surveys were conducted at the colonies and zone wise in the households in the month of November 2015.

From the sample collected (312), Preliminary analysis of Home interview survey is carried out to classify the sample based on trip purpose and income groups and the analysis relieved the following details.

**Table 4.4** Primary analysis of Home Interview SurveysClassification based on purpose of trip

| | |
|---|---|
| Work trips | 56.2 % |
| Education trips | 21.6 % |
| Business trips | 12.4 % |
| Recreational trips | 7.7 % |
| Others | 2.7% |

Classification based on Income Groups

| | |
|---|---|
| < 10,000 | 4% |
| 10,000 – 25,000 | 35% |
| 25000 – 50,000 | 56% |
| >50,000 | 5% |

The base year persons trip O-D matrices is obtained from this Home interview survey and it is divided by the average vehicle occupancy factor of 1.2 to obtain the Passenger Car units O-D matrices. The base year O-D matrix is shown as below.

**Table 4.5** Base O-D Matrix from Home Interview Surveys

| O/D | 1 | 2 | 3 | 4 | 5 | 6 | 7 | $P_i$ |
|---|---|---|---|---|---|---|---|---|
| **1** | 0 | 1329 | 569 | 759 | 524 | 176 | 154 | **3510** |
| **2** | 1501 | 0 | 111 | 165 | 63 | 25 | 62 | **1927** |
| **3** | 578 | 100 | 0 | 1423 | 438 | 126 | 2 | **2667** |
| **4** | 718 | 139 | 1327 | 0 | 2083 | 790 | 323 | **5379** |
| **5** | 462 | 49 | 380 | 1936 | 0 | 312 | 128 | **3267** |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **6** | 169 | 21 | 120 | 805 | 342 | 0 | 303 | **1761** |
| **7** | 173 | 20 | 95 | 384 | 163 | 354 | 0 | **972** |
| **$A_j$** | **3601** | **1658** | **2602** | **5472** | **3613** | **1782** | **972** | |

**5. ESTIMATION OF FUTURE TRAFFIC DEMAND**

**5.1 GENERAL**

Transportation demand modelling is a process that consists of development of a mathematical model to forecast future travel demand and assessment of alternative solutions for handling the future traffic demand. It is a series of interlinked and interrelated models of varying levels of complexity dealing with different facets of travel demand.

**5.2 TRIP GENERATION**

This is the first of sub models in the study process which predicts the number of trips starting and finishing in each zone. Multiple linear Regression analysis is a well-known statistical technique for fitting mathematical relationships between dependent and independent variables. Since this technique exploited fruitfully in many of the transportation studies, this method is used in the present study.

The Base OD matrix of the corridor( OD matrix for the year 2015) is considered and socio economic characteristics of all the zones along the corridors for the year 2011, 2015, 2021 are collected from previous studies and the present and future trips are projected using linest function which is based on linear Regression analysis concept.

The socio economic characteristics of the zones in the Study area is mentioned earlier in table 4.1 and the base OD matrix for the zonal area is provided in table 4.5

**Multiple Linear Regression Analysis Equations**

No. of Trips Produced at that particular zone

= 128.02 + 0.1344 *Population + 4.17 * Employment (5.1)

$R^2$ = 0.906, T-statistic for population = 1.23 , for employment =4.21 ,

F-test = 9.18

No. of Trips Attracted at that particular zone

= 141.36 + 0.094 * Population + 4.34 * Employment (5.2)

$R^2$ = 0.887, T-statistic for population = 1.19 , for employment = 3.82 ,

F-test = 7.668

The Productions and Attractions of each zone for all the years is shown in table 5.1

**Table 5.1** Productions and Attractions for the year 2011, 2015 and 2021

| Location | 2011 $P_i$ | 2011 $A_j$ | 2015 $P_i$ | 2015 $A_j$ | $P_i$ 2021 | $A_j$ 2021 |
|---|---|---|---|---|---|---|
| Power plant area | 3510 | 3601 | 4098 | 4220 | 5969 | 5971 |
| B-colony | 1927 | 1658 | 2007 | 1966 | 2844 | 2717 |
| Masjid corner & Shopping Area | 2667 | 2602 | 4393 | 4445 | 4358 | 4307 |
| Central office Area | 5379 | 5472 | 5258 | 5333 | 9030 | 9003 |
| A-Colony | 3267 | 3613 | 3168 | 3177 | 5953 | 6068 |
| Market & School Area | 1761 | 1782 | 1845 | 1818 | 3004 | 3004 |
| C- Colony | 972 | 972 | 1395 | 1309 | 1714 | 1621 |

**5.3 TRIP DISTRIBUTION**

After having obtained an estimate of the trips generated from and attracted to the various zones, it is necessary to determine the direction of travel. Trip distribution stage determines number of trips from each zone to zone. The output of trip generation model is used as input for trip distribution model.

As mentioned earlier for the purpose of present study, synthetic or inter area travel formulae methodology has been adopted i.e. gravity model. The generalized relationship is more usually expressed as

$T_{ij}= P_i*A_j*f(t_{ij})*R_i*C_j$ (5.3)

Where

$T_{ij}$ =Number of trips from zone i to j

$P_i$ =Total number of trips produced in zone i

$A_j$ =Total number of trips attracted to zone j

$R_i$ =Row balancing factor

$C_j$=Column balancing factor

$f(t_{ij})$ = Deterrence function which is based on Generalized cost of the journey from zone i to j.

As mentioned in the above the $t_{ij}$ matrices is the time distance matrices which is an impedance matrices and is given in the table 5.2

**Table 5.2** Time distance matrices

| $T_{ij}$ | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| **1** | 0 | 0.5 | 1.2 | 1.8 | 1.3 | 2.3 | 2.7 |
| **2** | 0.5 | 0 | 1 | 1.4 | 1.5 | 2.4 | 1.4 |
| **3** | 1.2 | 1 | 0 | 0.4 | 0.5 | 1 | 13 |
| **4** | 1.8 | 1.4 | 0.4 | 0 | 0.3 | 0.5 | 1 |
| **5** | 1.3 | 1.5 | 0.5 | 0.3 | 0 | 0.5 | 1 |
| **6** | 2.3 | 2.4 | 1 | 0.5 | 0.5 | 0 | 0.5 |
| **7** | 2.7 | 2.9 | 1.4 | 1 | 1 | 0.5 | 0 |

As mentioned earlier in the section 3.4, for the purpose of this study, combined power and negative exponential form($tij^{-a}$ $e^{(-b*tij)}$) is used which has been found to be particularly appropriate for shorter distance, intra urban trips and the curve of the function is in the form of signature of the city.

The parameters 'a' and 'b' in the function are calibrated by trial and error method till the observed and estimated data satisfy the maximum error i.e. 10% for daily traffic >50,000 (as per FHWA(Federal Highway Administration), calibration and adjustment of system planning models(1990)). After ten iterations the calibrated parameters are observed to be within the range and the final deterrence function is

$F(t_{ij}) = t_{ij}^{(-1.5)*} \exp^{(-0.05*\, tij)}$ (5.4)

The estimated OD matrix for the year 2015 and 2021 along the corridor is shown in the table 5.3 and 5.4.

**Table 5.3** O-D Matrix along the corridor for the year 2015

| i \ j | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| **1** | 0 | 1814 | 1119 | 852 | 531 | 206 | 239 |
| **2** | 1806 | 0 | 195 | 165 | 57 | 26 | 86 |
| **3** | 1100 | 193 | 0 | 2253 | 626 | 209 | 4 |
| **4** | 812 | 158 | 2185 | 0 | 1766 | 777 | 420 |
| **5** | 518 | 56 | 621 | 1805 | 0 | 304 | 164 |
| **6** | 205 | 26 | 212 | 811 | 311 | 0 | 422 |
| **7** | 234 | 28 | 189 | 433 | 166 | 417 | 0 |

**Table 5.4** O-D Matrix along the corridor for the year 2021

| i \ j | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| **1** | 0 | 3652 | 1580 | 2094 | 1478 | 496 | 430 |
| **2** | 3622 | 0 | 268 | 396 | 155 | 60 | 151 |
| **3** | 1544 | 264 | 0 | 3774 | 1186 | 343 | 5 |
| **4** | 1973 | 376 | 3637 | 0 | 5792 | 2205 | 892 |
| **5** | 1376 | 145 | 1130 | 5727 | 0 | 945 | 382 |
| **6** | 473 | 58 | 334 | 2229 | 966 | 0 | 852 |
| **7** | 408 | 48 | 225 | 898 | 389 | 848 | 0 |

## 6. DISCUSSIONS AND CONCLUSIONS

### 6.1 GENERAL

The chapter presents the summary of work done and conclusions drawn, specific recommendations are made. Limitations of the present study and scope for future work is also presented in this chapter.

### 6.2 DISCUSSIONS

Due to the tremendous growth of vehicle population, the limited lane width, right of way, congestion are the problems to be faced in the near future. To solve all above problems there is a need to develop improvements in the transportation system. In order to plan such system, it is necessary to establish the demand for the transportation System.

The estimation of travel demand for the colony, methodology is proposed. As per proposed methodology, the data collection through preliminary surveys was carried out through traffic volume counts from external to internal and internal to external at entrance and exit and central office of RTS-B Ramagundam and Home interview survey carried out to prepare the origin and destination matrix trips carried out by the residents of the study area. The model development for estimation of O-D matrix for future growth i.e. for 2021 is done and model validation is carried out for the year 2015. Capacity and Level of service for the lanes is estimated.

### 6.3 CONCLUSIONS

Conclusions drawn from the present study are listed below:

1. From the present study of Ramagundam Thermal plant, it is observed to be a rapid growing industrial area which in turn raised the need to upgrade the existing transportation facilities.
2. From the estimated probability matrix for future 2021, one can conclude that the Traffic volume is increased. Are high and the existing system can hold the forecasted traffic hence new designs were proposed based on their capacity.

### 6.4 LIMITATIONS OF THE STUDY

**1.** The following are the limitations of the present study:

2. The present study is limited to the internal area of the Ramagundam Thermal Power plant and analysed by isolation from the external area.
3. While developing Trip generation model only population and employment variables are considered due to lack of data. However other variables like vehicle ownership etc can be considered.

### 6.5 SCOPE OF THE FUTURE WORK

The present study can be further extended by incorporating the following aspects.

1. To estimate the travel demand from all the surrounding areas, there is a necessity to develop new transport demand models. Whereas the present study was carried out through based on internal zone criteria.
2. To predict the actual travel pattern on the existing road network, there is a necessity to consider diverted and generated traffic which will actually predict the decrease in volume and increase in speeds of traffic. Whereas the present study considered existing traffic.

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