Transportation system management for Madurai city using GIS

Dr. S. Moses Santhakumar[1] G. Gokuldas[2] and P. Partheeban[3]

[1]Professor
[2]Post Graduate Student
[3]Research Scholar
Department of Civil Engineering, Regional Engineering College
Tiruchirappalli - 620 015.

Abstract

Urban transportation systems are wilting under the pressure of ever growing demands on inadequate street network. Traffic management is the application of sound management principles and practice to optimise the use of existing road network with a view to improving traffic flow and road safety without impairing environmental quality. With the advent of information technology and its fast changing nature, it has become imperative to make use of better and more efficient techniques of planning. To study the effect of the Transportation System Management (TSM) measures one needs to have a clear view of the flow patterns, locations, as well as existing road network and must be able to analyse the attributes related to them. Geographic Information System (GIS) helps to do these things effectively and efficiently. The Madurai Local Planning Area (LPA) has been selected for study of TSM measures. GIS is used to the study the effect of TSM measures. Madurai LPA road network and location of important places are added as layers. Attributes are added in the form of databases from which one can retrieve data by making queries. Conversion of one-way streets, diversion of traffic, odd-even vehicle restrictions, parking management, effect of ring roads, and overall improvement in the network are studied with the help of GIS. ArcView and Avenue are used for the development of this package.

1. Introduction

It has been the experience of many traffic planners that most transportation plans rarely progress beyond the drawing board due to lack of financial resources and other related constraints. The only recourse open to the traffic manager therefore is the option of optimising existing facilities to provide improved accessibility and mobility at a satisfactory level of safety and comfort to most of the road users. This can be achieved by studying and evaluating the problem in the light of sound and tested traffic management techniques, which are essentially low cost, easily implement and flexible. These are short-term solutions, primarily intended to reduce the intensity of inconvenience caused by congestion. They may

not offer a permanent solution, yet they lend themselves to some time earning relief up to a point where the administration may launch the long term and short term planning. Objective of short-term solutions should be within the perspective and is compatible with the goals set out in the long-term measures.

Though the identification of the problems and the correct diagnosis may automatically suggest the usefulness of a particular management technique, the application of the single technique, in isolation, is rarely sufficient in bringing about a significant improvement in the Level Of Service (LOS) and transportation mobility of an area. More often than not, the problems shifted to the adjacent locality or an entirely new problem is spawned as a consequence of the very technique used as a solution, if applied in isolation. It is therefore, essential to seek solutions in a combination of techniques, even in a relatively local situation, for effective management (Venkateswaralu, 1996). A solution must be observed as a part of the total scenario and the systems approach used to prepare a Transportation System Management (TSM) Plan for the entire network.

The traffic management techniques that have been tried all over the world have been listed below in seven main categories:

- Regulatory Techniques
- Traffic Control Devices
- Traffic Segregation Techniques
- Demand Management Techniques
- Bus Priority Techniques
- Self – Enforcing Techniques and
- Police – Public Interaction Techniques

2. Geographic Information System (GIS)

GIS is a computer-based tool for mapping and analysing things that exist and events that happen on earth. GIS technology integrates common database operations such as query and statistical analysis with the unique visualization and geographic analysis benefits offered by maps. These abilities distinguish GIS from other information systems and make it valuable to a wide range of public and private enterprises for explaining events, predicting outcomes, and planning strategies (Moses Santhakumar, 1998). GIS stores information about the world as a collection of thematic layers that can be linked together by geography. This simple but extremely powerful and versatile concept has proven invaluable for solving many real-world

problems from tracking delivery vehicles, to recording details of planning applications, to modeling global atmospheric circulation.

GIS allows us to bring all types of data together based on the geographic and locational component of the data. But unlike a static paper map, GIS can display many layers of information that is useful to us (www.esri.com). We will be able to integrate, visualize, manage, solve, and present the information in a new way. Relationships between the data will become more apparent and the data will become more valuable. GIS gives us the power to create maps, integrate information, visualize scenarios, solve complicated problems, present powerful ideas, and develop effective solutions like never before.

3. The Study Area

The Madurai Local Planning Area (LPA) has been taken for the study. Madurai is the second largest City in Tamilnadu State, having a very old history of about two thousand six hundred years and is often referred to as the *Athens of East*. It has three National Highways namely NH-7, NH-45B, NH-49 and state highways passing through it. The study area is limited to Madurai Local Planning Area (LPA). The land use details of the urban and rural settlement of the Local Planning Area are given in Table 1.

Table 1. Land use Details of Madurai LPA.

Sl.No	Land use zone	Area (ha)	Percentage of developed area
1	Residential	1817.60	74.89
2	Commercial	41.42	1.70
3	Industrial	76.76	3.16
4	Educational	99.50	4.10
5	Public and semi-public	181.79	7.48
6	Transportation	212.38	8.74

Source: CTTS Report for Madurai Local Planning Area, 1997

The heavy settlement has made Madurai as highly congested. The area for transportation infrastructure is less than ten percent of the developed area leading to transportation problems in the LPA. Different transportation system management measures

that can be applied feasibly during the present and the future conditions of Madurai LPA road network are discussed below. For that purpose forecasting of future traffic and capacity calculation for different road links are made.

4. GIS Based TSM

4.1.Forecasting the Traffic

The traffic volume for the year 2002 and future year 2007 are forecasted with respect to the 1997 traffic volume taken from the CTTS Report (CTTS Report, 1997), vehicle growth rate and the sample survey conducted at different locations. However, the capacity restraints are not taken into account. The traffic volume count made at different selected locations the percentage share of each type of vehicle is computed. As per IRC: 106-1990 (IRC: 106, 1990) the PCU values are assigned and the total PCU share of each vehicle is obtained on each link. Fig. 1 shows the traffic flow in the CBD.

Based on the registered vehicle data collected from the Regional Transport Office Madurai North and South the growth rate of each type of vehicle is calculated. For the unregistered vehicles like bicycle and cycles rickshaws the growth rate was obtained through the general enquiry made at different cycle marts and cycle rickshaw unions that is mentioned in the growth rate table. For forecasting traffic on NH, SH, MDR's overall growth rate of 12 percent is taken.

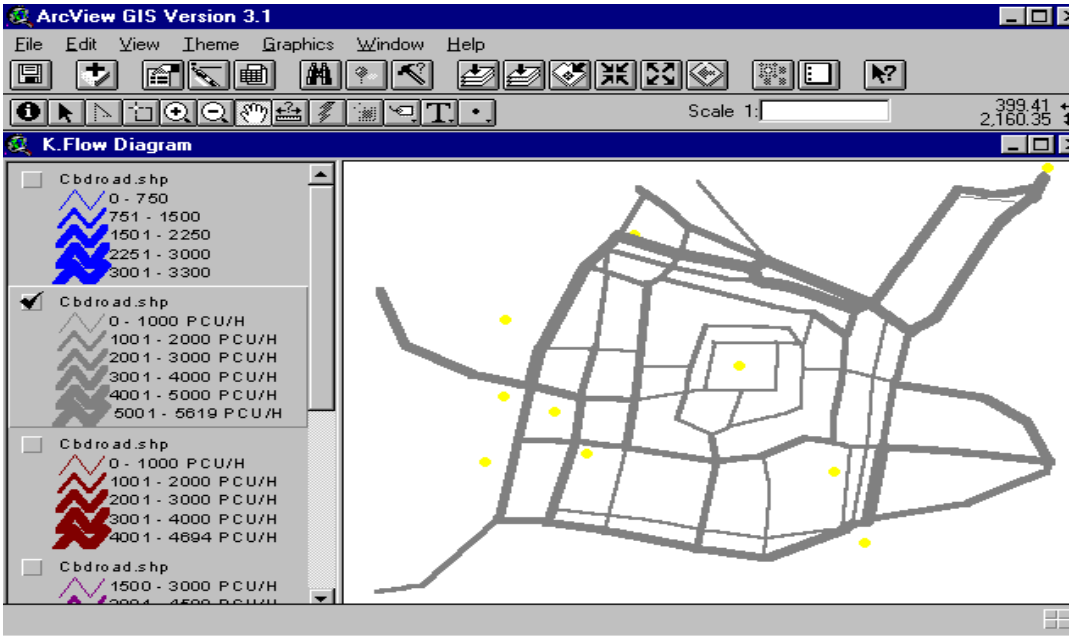

Fig. 1 Peak Hour Traffic Flow in CBD

4.2. Road Capacity Calculation

Capacity of all the links are made with three different categories:

- Capacity with parking
- Capacity with restricted parking
- Capacity without parking

The capacity of road links as per HCM 1985 is 1300-1500 PCU per lane per hour. Adopting the average value of 1400 and a lane width of 3.50 m, the capacity is computed as 400 PCU/hr per one metre effective width of carriage way.

The following formula is adopted for the calculation of capacity,

Capacity = Effective width of road way * 400 PCU/hr

To obtain the effective width of road, road inventory survey was conducted and total width (after encroachment) and parking width are measured. For the different cases the effective width is taken as,

Effective width *with parking* = Total width – parking width
Effective width *without parking* = Total width
Effective width *with restricted parking* = Total width – parking width allowed.

The width of parking allowed is computed by adopting the following four conditions:

Total road width (m)	Parking width allowed (m)
Less than 5 m	0.0
>5 m and <= 10 m	2.0
>10 m and <=15 m	2.5
Greater than 15 m	3.0

4.3.Conversion of One-way Streets

South Veli and East Veli Streets of the CBD are identified as highly congested. They can be made as one-way streets, with the help of the parallel streets. Analysis was conducted on the peak hour volume count made during morning and evening at South Veli, East Veli, and their parallel streets South Marret and East Marret. From that the maximum peak hour composition in each direction is found out and assigned to the roads by comparing their capacities. As per the rules of Madurai Corporation buses are not permitted to operate on the inner roads within the Veli streets. It is taken into consideration and the movement of buses alone may be allowed through the Veli Street even after the conversion of those roads as one-way streets. IRC Special Publication 43 (IRC SP: 43, 1990) permits the above situation. The streets before and after the introduction of one-way streets are shown in Fig. 2 and Fig .3.

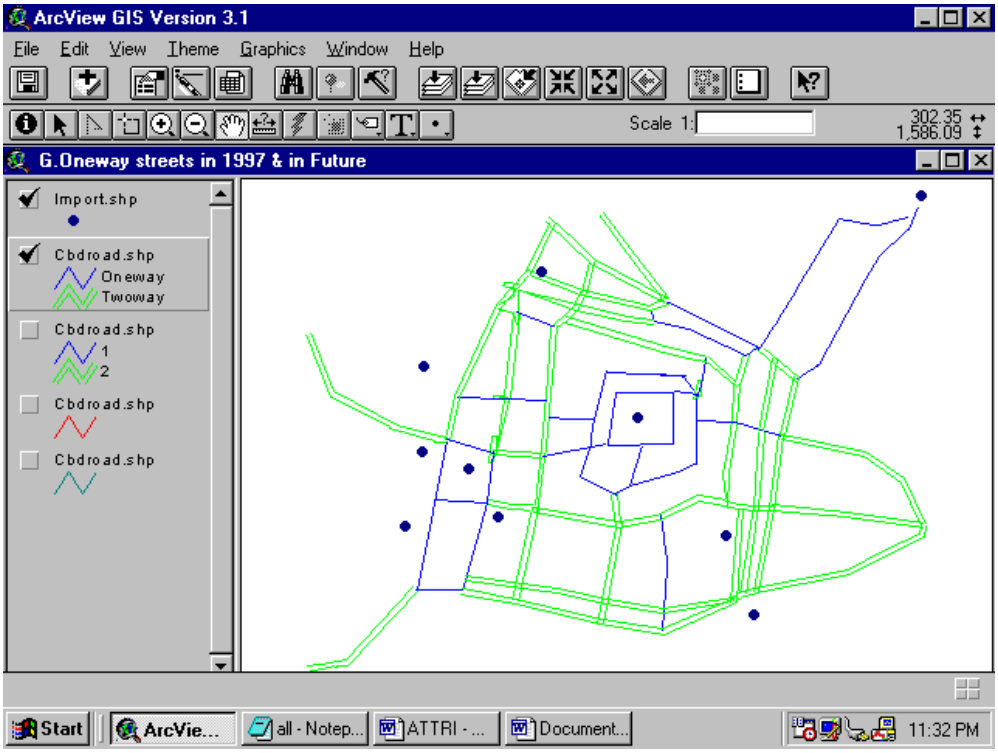

Fig. 2 Before Introduction of One-way Streets in Madurai CBD

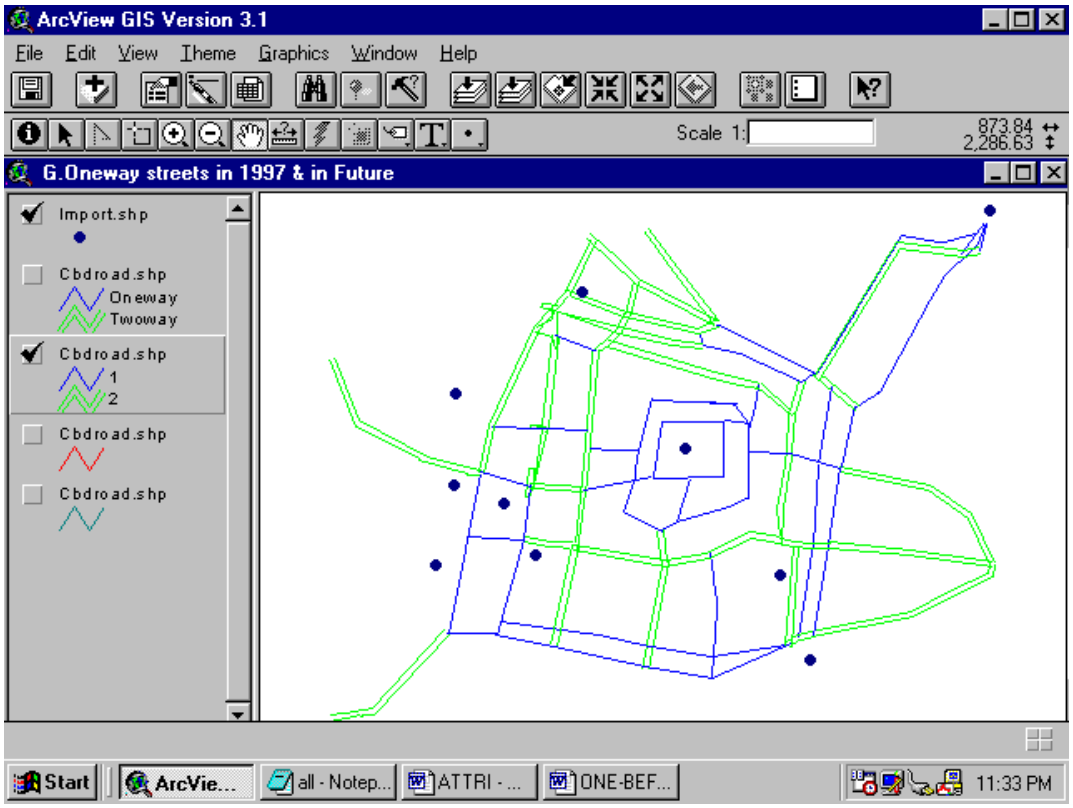

Fig. 3 After Introduction of One-way Streets in CBD

After the conversion of the existing two-way streets to one-way streets the reduction in the V/C Ratio and improvement in the whole network was studied. By running the Avenue script and selecting the required LOS from the list, the links falling under that category will be selected. This process (LOS = A) is shown in Fig. 4.

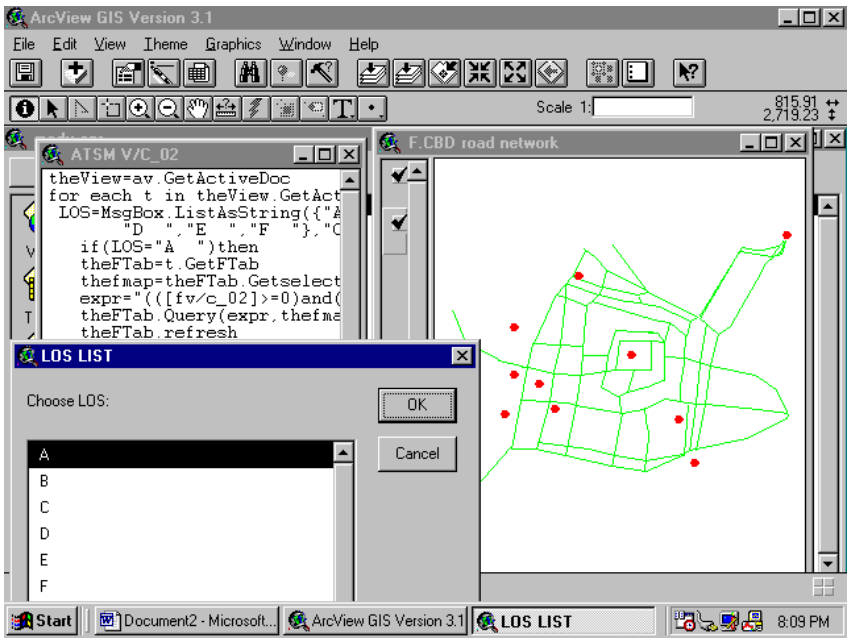

Fig. 4 Level of Service A

4.4. Diversion of Traffic

Madurai LPA is divided in to two parts viz Madurai North and South by river Vaigai. There are a number of bridges and causeways constructed across the river to establish good connectivity. But the old Albert Victor Bridge (A.V.Bridge) and the newly constructed bridge over the old Kalpalam causeway play a major role in handling the traffic. The old Kalpalam causeway was closed after the construction of the new bridge and it is presently used as a parking place for the tempos and other goods vehicles.

During the peak hours, the volume of traffic handled by both the bridges are exceeding the capacities. As a TSM measure, it is decided to divert some of the traffic movement through the old causeway. By considering the capacity of the causeway only cycles and two-wheelers are taken for the diversion. The traffic from North to South Madurai is assigned to the right link of the Kalpalam; similarly, the traffic from the South to North Madurai is assigned to left link.

4.5. Parking Management

Parking management was selected as the next measure. As far as Madurai CBD is concerned it is not an easy measure to ban parking, as it will lead to major local problems. So parking may be permitted if the V/C ratios of the links are less then 0.8. It is specified as the design capacity for urban roads as per IRC: 106-1990. Recommendations are made for restricting parking only when the links are identified as highly congested.

After the application of parking management, the LOS improved rapidly. Analysis shows that reduction in parking width will reduce the traffic congestion. The effect on V/C ratio for the important roads due to this measure is presented in Table 2.

Table 2 Effect on V/C Ratio due to Parking Restriction

Road	Before Parking Restriction	After Parking Restriction
West Chithirai Street	0.57	0.52
Kamarajar Road	1.21	0.79
Amman Sannathi Street	0.68	0.63
East Veli Street	0.98	0.51

4.6. Effect of New Links

To control future traffic problems inside the Madurai LPA, the Corporation of Madurai had decided to construct three ring roads in and around Madurai, namely outer, intermediate and inner ring roads. The outer ring road running through the outer edge of the LPA is under construction and is expected to be finished by the year 2003. The intermediate and inner ring roads planned to be constructed inside the LPA are yet to commence. So only the effect of outer ring road is taken for the study. It is connecting six major arterial roads running out from Madurai. The diversion of traffic during the peak hour in different years from these roads is predicted from the overall diversion given per day in CTTS report (CTTS Report, 1997) with the assumption of 12 percent peak hour flow.

New traffic volume on each link is the difference between the projected traffic and the diverted traffic. Two wheelers are not considered for the diversion of traffic during peak hours. Due to this measure, the V/C ratio on NH-7 (Thirunelveli Road) is greater than one. This is due to heavy truck movement and higher population density along this road.

4.7. Overall Improvement

The effect on V/C ratio and LOS for the entire city road network due to application of each TSM measures is studied using the avenue program. Suitable coding is written in the avenue to take care of entire road network. Overall V/C ratio of the CBD road network is calculated using the formula:

$$\text{Overall V/C Ratio} = \frac{\sum_{i=1}^{n} V_i * L_i}{\sum_{i=1}^{n} C_i * L_i}$$

where V_i = Volume of traffic in link *i* in PCU/hr

L_i = Length of the link *i* in km

C_i = Capacity of the link *i* in PCU/hr

The effect on overall V/C ratio for the entire city road network due to One-way streets, Parking Management System and Diversion of Traffic is presented in Table 3. Analysis shows that the overall V/C ratio is less than 0.81 for the present condition. But for

the year 2007 the overall V/C ratio is greater than 1.15. Hence the long-term TSM measures such as widening of roads and construction new roads may be implemented to reduce the congestion in the future.

Table 3. Effect on V/C Ratio Before and After Application of TSM Measures

TSM Measures	Effect for the year 2002		Effect for the year 2007	
	Before	After	Before	After
One-way Street	0.94	0.74	1.89	1.15
Parking Restriction	1.02	0.81	2.14	1.45
Diversion of Traffic	1.24	0.80	2.74	1.79

The overall improvement made in the LOS after the applications of all the measures is studied, by giving weightage to the length of the links. The LOS offered on each link before and after the application of TSM measures are represented in the form of colour-coded maps. These colour coded maps help the planner in choosing the roads has to be considered for the upgradation in the present and for the future traffic conditions. The effect on LOS for the year 2002 before and after application of all TSM measures is shown in Fig. 5 and Fig. 6.

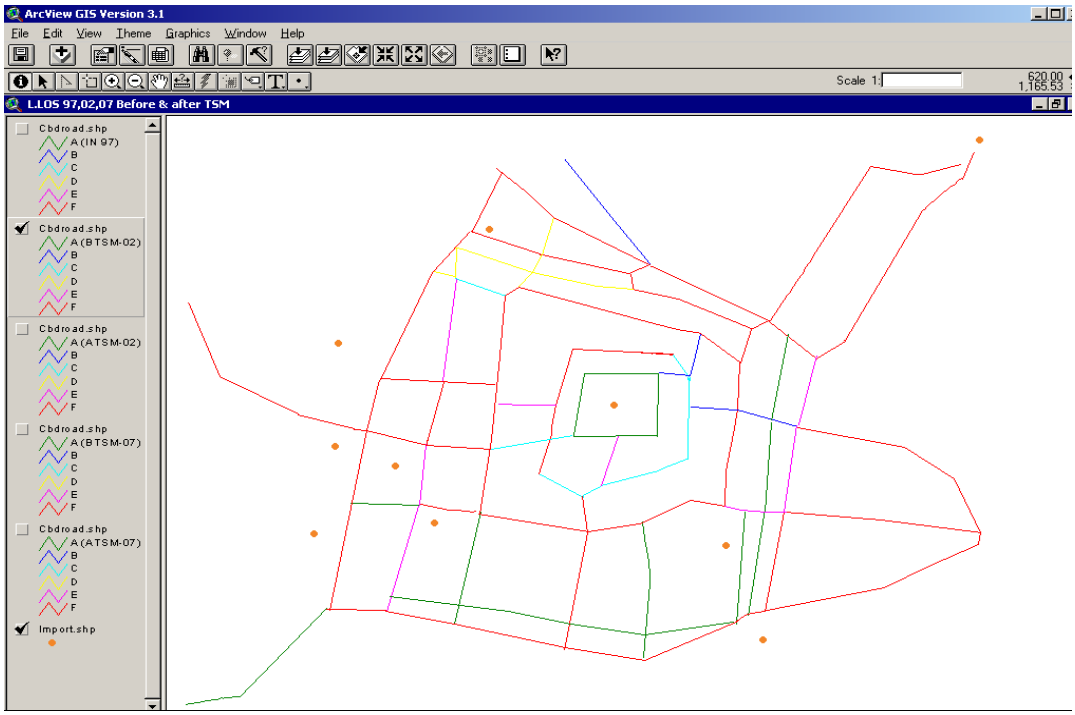

Fig. 5 Level of Service in CBD before Application of TSM Measures

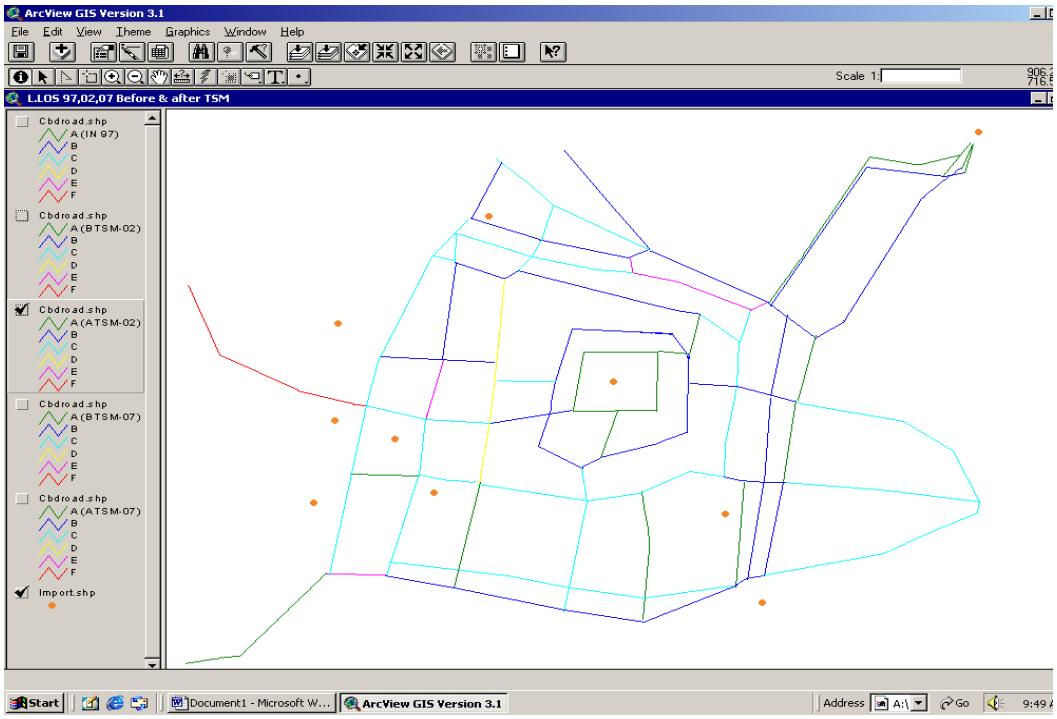

Fig. 6 Level of Service in CBD after Application of TSM Measures (2002)

5. Conclusions

Various feasible TSM measures are applied for the improvement of each link to facilitate efficient traffic movement. TSM studies for the Madurai Local Planning Area are effectively carried out using Arc/VIEW. The overall improvement of the network is studied after the application of various TSM measures. The following are the major conclusions:

1. The parallel streets South Veli and South Marrat, East Veli and East Marrat are made as one-way streets to study the effect. Due to introduction of one-way streets, the V/C ratio decreases from 0.94 to 0.74 for the present condition and 1.89 to 1.15 for the year 2007
2. The bi-cycle and two wheeler operations through the A.V. Bridge and the New bridge have to be diverted through the Old Kalpalam, to reduce the congestion on the bridges and to segregate the traffic flow
3. By considering the heavy congestion, parking management measures are applied to all the links. Due to parking management measures, the V/C ratio decreases for the whole network from 1.02 to 0.81 during the year 2002 and 2.14 to 1.45 for the year 2007

4. Due to restriction of fast moving vehicles such as car, jeep and vans during peak hours, the V/C ratio decreases from 1.02 to 0.71 for the present condition and 2.14 to 1.26 for the year 2007

5. The measures applied to the CBD road network hold good for the present traffic condition. But for the future conditions an urgent need for long-term measures is indicated. Congestion alleviation can be achieved through speeding up of projects such as ring roads, shifting of market place, etc.

6.0 References

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