

Geographical Information System For Planning And Management Of Rural Roads**B. Kanaga Durai** , A .Mohan Rao* , P.K.Jain** and P.K. Sikdar*******ABSTRACT**

Geographic Information System (GIS) is a computer based information system that enables storing, modeling, manipulation, retrieval, analysis and presentation of geographically referred data. The suitability of the GIS for rural road planning and management lies in the fact that all the data in this field is normally geographically referred. In this paper, a systematic approach has been evolved to generate GIS based database for preparation of rural road plan and core network plan, including detailed project report information through case studies. It also reviews various applications of GIS in plan implementation, monitoring and management aspects.

1. INTRODUCTION

Rural roads are the tertiary road system which provide access to villages on to the main roads and various centres of activities. In developing countries like India, rural roads are termed as the roads passing through rural and agricultural areas, connecting villages to main roads and/or a town/market centre. The traffic on these roads is relatively low, comprising of mixed modes of transport like bullock carts, bicycle and motorized modes. Nearly, 55 per cent of the about 6 lakh rural habitations are provided all-weather road connectivity. In addition to these roads in rural areas some villages also have cart tracts and footpaths connecting to the road system.

Recently, the Government of India launched the nation wide programme known as Pradhan Mantri Gram Sadak Yojana, in short PMGSY, to provide connectivity to all the villages in a phased manner, so as to connect all the habitations having population of more than 500. The National Rural Road Development Agency (NRRDA) under the Ministry of Rural Development (MORD) has been made responsible to monitor the program and oversee its implementation. The programme is being implemented through the state level agencies by preparing the detailed district level rural road plans (DRRP) and the core network plans (CNP), which provide prioritized links for connectivity of habitations carved out of DRRP with quantifying population. Under this process, a huge database spatial and non-spatial, related to rural roads, is being generated all over the country. Handling, managing and updating of the data by the

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traditional methods is not only tedious and time consuming, it is difficult to sort and retrieve. To obviate these difficulties it is, therefore, considered necessary to develop all the spatial and attribute data in digital format. Geographic Information System (GIS) is a

computer-based tool which can handle the entire database and help in the management of the entire rural development programme.

2. BACKGROUND ON GIS

GIS is an information system designed to work with data referenced by spatial/geographical coordinates. In other words 'GIS' is both a database system with specific capabilities for spatially referenced data as well as a set of operations for working with the data. It may also be considered as a higher order map data management system. GIS tools can be used effectively for planning, progress monitoring and as an effective tool for maintenance management of the road system. The database development under planning purposes can be easily used for maintaining and up keeping of the road system. It can also be used as an advanced online management system, which accommodates multi access data users. GIS has been widely used for various applications in transportation planning and management (Millar, 2001). Verma and Dhingra (2002) has reviewed development of GIS-Transportation and brought out the trends and future directions of research needs.

3. POTENTIAL USE OF GIS IN RURAL ROADS

The major components of rural roads are planning, project preparation, construction, monitoring and maintenance. Planning includes preparation of district rural road plans and core network plan (MORD 2001) which is helpful for identification of the links to be developed, and a broad estimation that is required for allocation of funds, since each selected link of rural roads is considered as a project. The detailed project report includes the survey information such as detailed design and drawings, cost estimates for various road works, etc., which are required for execution of the road works. The same information will be highly useful during construction monitoring, quality control and maintenance activities. Thus the district rural road plan with the core network prepared in GIS platform can be extended as a road information system for each project by incorporating the detailed project report data and drawings. This in turn then will be the basis for award of work, monitoring the progress of the work and quantity control in the field.

4. GIS APPLICATION IN PLANNING

GIS technology is useful in network as well as geographic analysis in the field of rural road planning (Sikdar, 2002) and measurement of rural accessibility (Durai et al, 2003). To avoid any duplication in planning of rural roads it is suggested that a master plan for rural roads at district level be prepared (NTPC, 1980; IRC, 1984; 2000). Similarly, guidelines for preparation of District Rural Road Plan for implementation under Pradhan Mantri Gram Sadak Yojana also suggest the master plan based prioritised rural road links for implementation. The master plan for rural roads prepared at Block level is convenient both from the point of map preparation & data collection and also for obtaining approval, under the Panchayati Raj System. All the block level information sets in a district can be combined easily to form a District Rural Road Plan.

Normally, 1:50,000 scale is convenient and easy to handle at the Block level. Therefore, the base map for a Block is prepared at the 1:50,000 scale by referring to the Survey of India toposheets which have proper geo-referencing system. In the first instance, if the base map for road network is being prepared in GIS environment, it will be easy for preparation of District Rural Road Plan (DRRP) and Core Network Plan (CNP). The relevant attribute data collected for preparation of the DRRP can also be incorporated easily in the GIS base map to generate the core network on population size criteria of habitations for connectivity as well as to do prioritization of the links for implementation. The network and the route analysis modules available in the various GIS software (Caliper Corp. 2001, ESRI 2003) can be used to optimize the network by adopting the connectivity principles.

4.1 Case study – Preparation of DRRP

Simdega Block in Jharkhand State has been taken as the case study to demonstrate the steps involved in the preparation of GIS base map preparation and core network plan making. As a first step, the map of 1:50,000 scale was prepared by taking Survey of India toposheets as the base on paper and incorporating the features of road network, habitation locations, water bodies and block/district/state boundaries. This map was further updated by referring to Census of India - Community Block map and road maps available with the field engineers. The updated map was taken as the base map for generating spatial information for the Block.

The paper base map was scanned and registered with pre-marked control points showing longitude and latitude to convert it into GIS environment. From the scanned image, six different layers viz. boundary as area layer, road, water bodies and railway lines as line layers and location of habitations and cross drainage structures as point layers were extracted. While digitizing the different layers a unique identification number has been provided to the habitations in the point layer as well as to the roads in the line layer, as given in the attribute data tables to make the spatial information database compatible to the map data within the GIS software. This labeling is essential for further analysis and referencing. The digital base map thus prepared with all the features and important labeling of the spatial information for a typical block is shown in Figure 1.

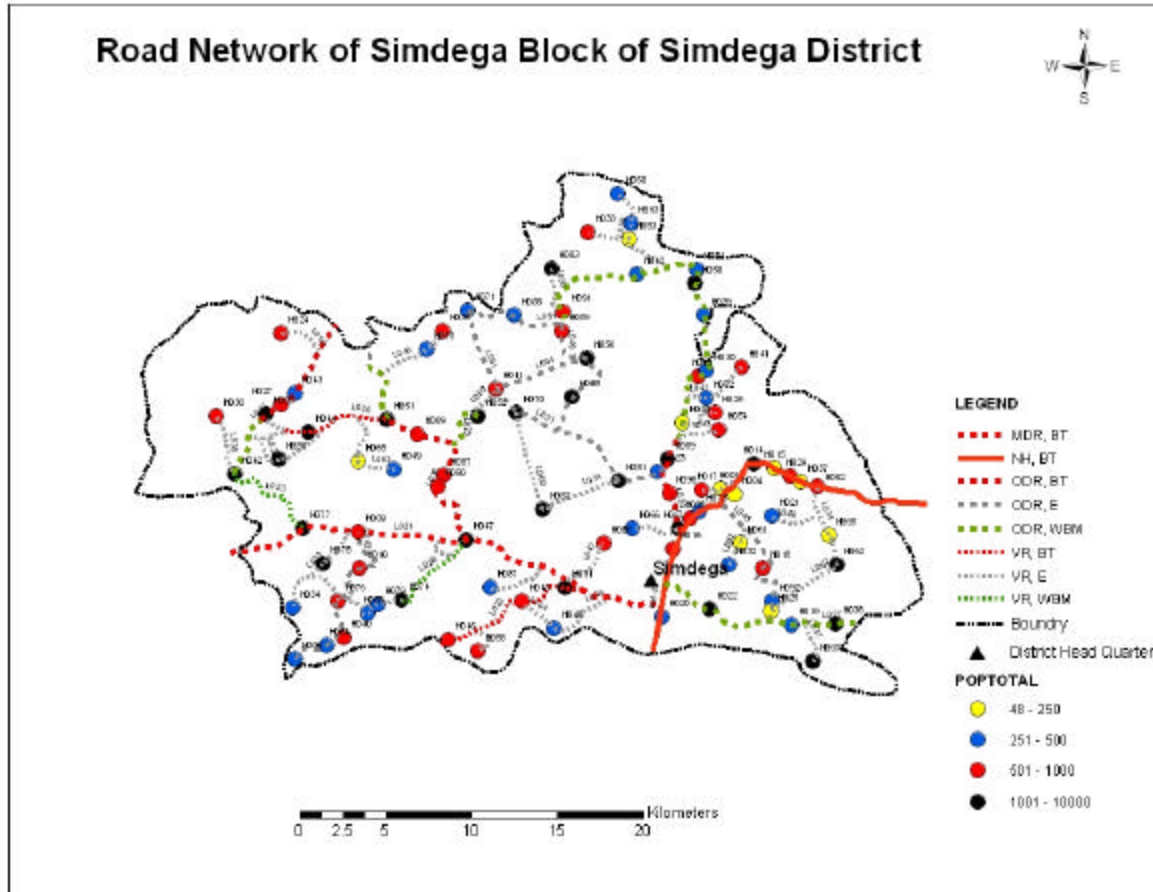


Figure 1 Typical GIS Base Map for DRRP

4.2 Core Network Preparation

Core network is essentially a network that provides basic access to all habitations of qualifying population with all-weather road connectivity (MORD, 2002). The core network consists of through routes and link routes. Through routes are the ones which collect traffic from several link roads serving a long chain of villages and lead to market centres either directly or through the higher category road such as a National Highway, State Highway or a Major District Road (MDR). Link routes are the roads connecting a single habitation or a group of habitations to through routes or a major link road leading to the market centre directly. Using the network and routing modules in GIS environment, the task of preparation of the core network can be simplified. The core network thus identified can be prioritized by calculating i.e. identifying and collating the population served by each link, and also the type of construction needed for upgradation, etc. and can be determined in GIS.

Using the network and routing tools of the GIS software the core network prepared as per the guidelines is presented in Figure 2. The core network map shows the complete thematic features for the existing and the proposed road network as well

as the through roads and link roads. Also indicated in the map are the detailed core network attribute information such as (i) link numbers, length and the habitation numbers served directly and/or indirectly by the link, (ii) total population served by the links, (iii) connected and unconnected habitations and the links connecting them, (iv) details of existing road and core network link with surface type and length, (v) summary of all the existing roads in the Block, and (vi) details of the unconnected habitations and links proposed for connecting them.

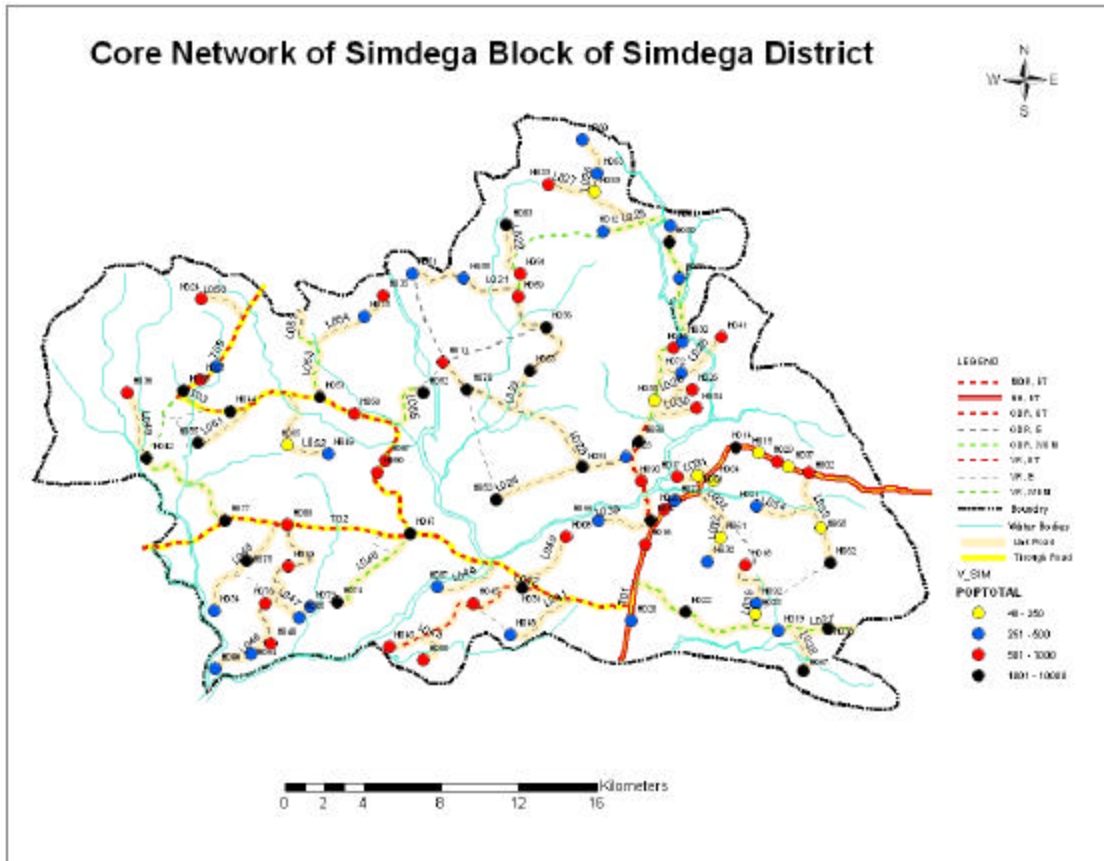


Figure 2 Core Network Prepared from GIS Base map

5. DETAILED PROJECT PREPARATION

Once the alignment is selected for providing connectivity to the habitations, the usual procedure then is to prepare a detailed project report (DPR) for the route. Normally the route selected should be considered as an individual project. The DPR contains detailed drawings of plan, L-section, C-section, detailed survey information on subgrade soil, materials, existing pavement condition, traffic, adjacent land use details, etc (IRC, 2002) along with proposed geometrics, pavement design, etc. All this information is linearly referenced for each link attached to the digital GIS base map.

This information once built into the GIS map can be utilized for effective on-line project monitoring activities. The GIS system will also allow the various users/stake holders to monitor the progress and also takes care of all monitoring information in to the system, which will be helpful for further pavement management aspects.

5.1 Case Study

Though DRRP and CNP for Sirmedaga district have been prepared, DPR for any road in the area has not yet been prepared. In order to explain the development of GIS based road information system (Rao et al, 2002), the DPR data available for a section of NH-2 (Varanasi to Aurangabad) is being used here as a case study. The detailed drawings prepared in digital format as part of DPR and geo-referenced with the help of Survey of India Toposheets (1:50,000) are being used. The base map in the scale of 1:50,000 prepared for the study area is taken up and a portion of the section of NH-2 captured in the base map as shown in Figure 3. All related attribute information available on the toposheets and population census record of the neighboring habitations are also attached to this map. Figure 4 shows the typical plan drawing prepared in AutoCAD environment as part of DPR. This drawing is directly geo-referenced with the base map prepared in the 1:50,000 scale and is attached to the base map as spatial information. All the other attribute data related to the road section are also attached to create a full-fledged GIS for Road Information System. Figure 5 shows the GIS map of the road section with detailed data. Figure 6 shows the typical detailed alignment plan of a portion of the section of the road.

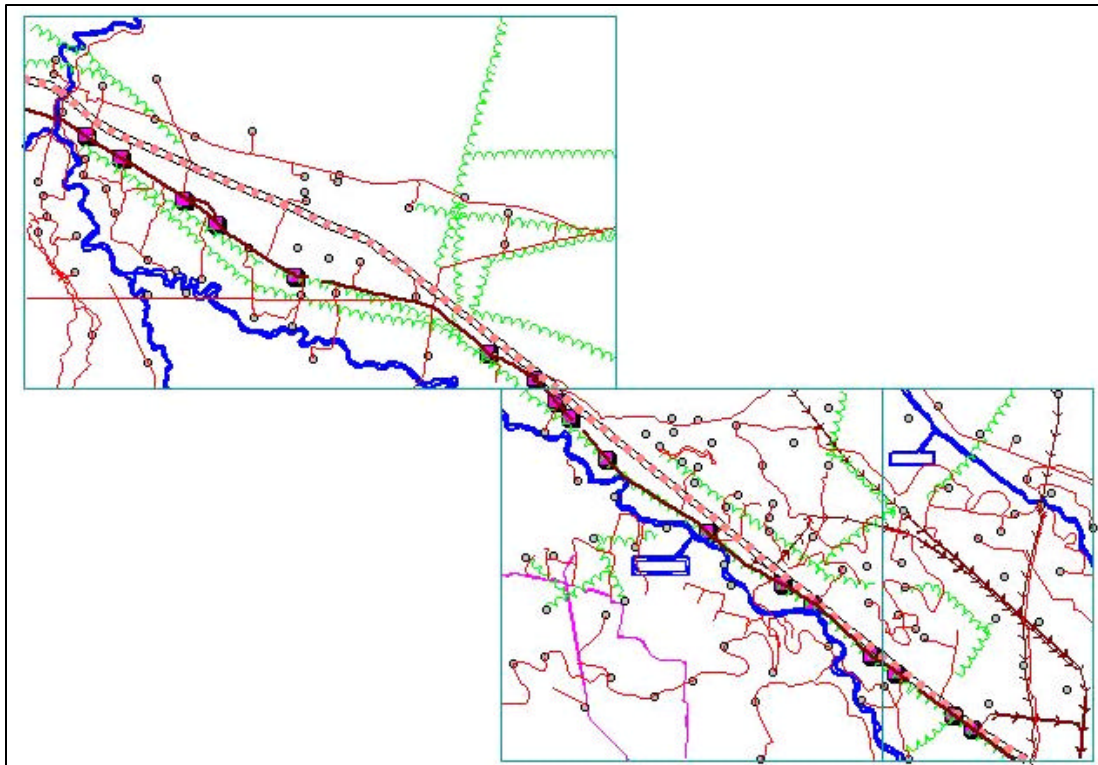


Figure 3 Base Map (1:50,000) of the Study Area

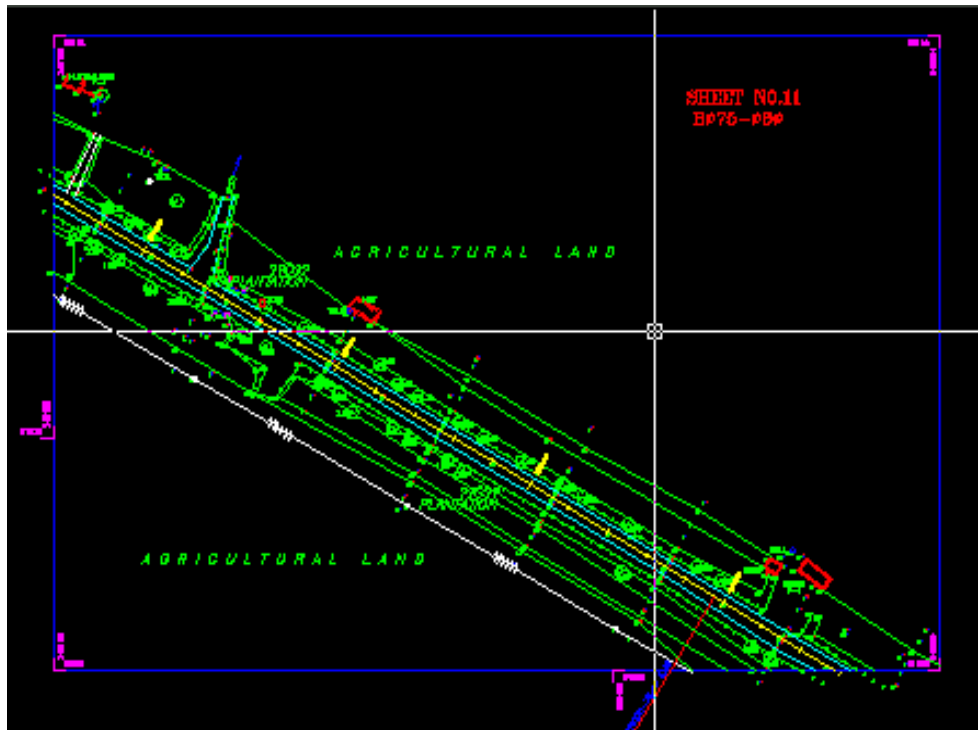


Figure 4 Typical Plan Drawing (Auto Cad environment)

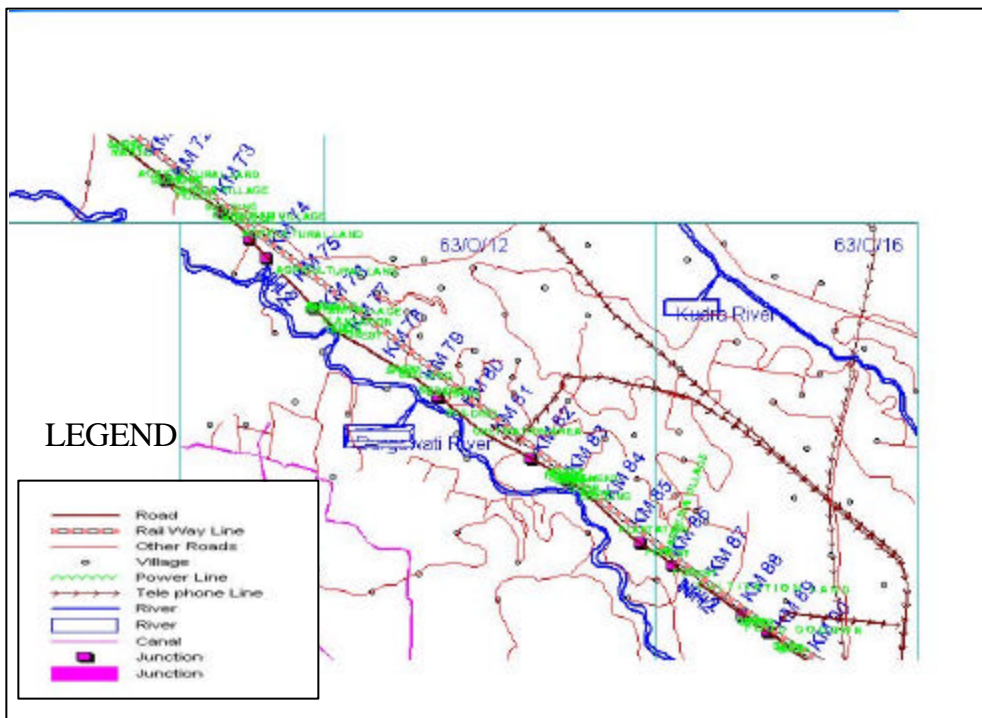


Figure 5 GIS Base map having features of base map(1:50,000) & DPR

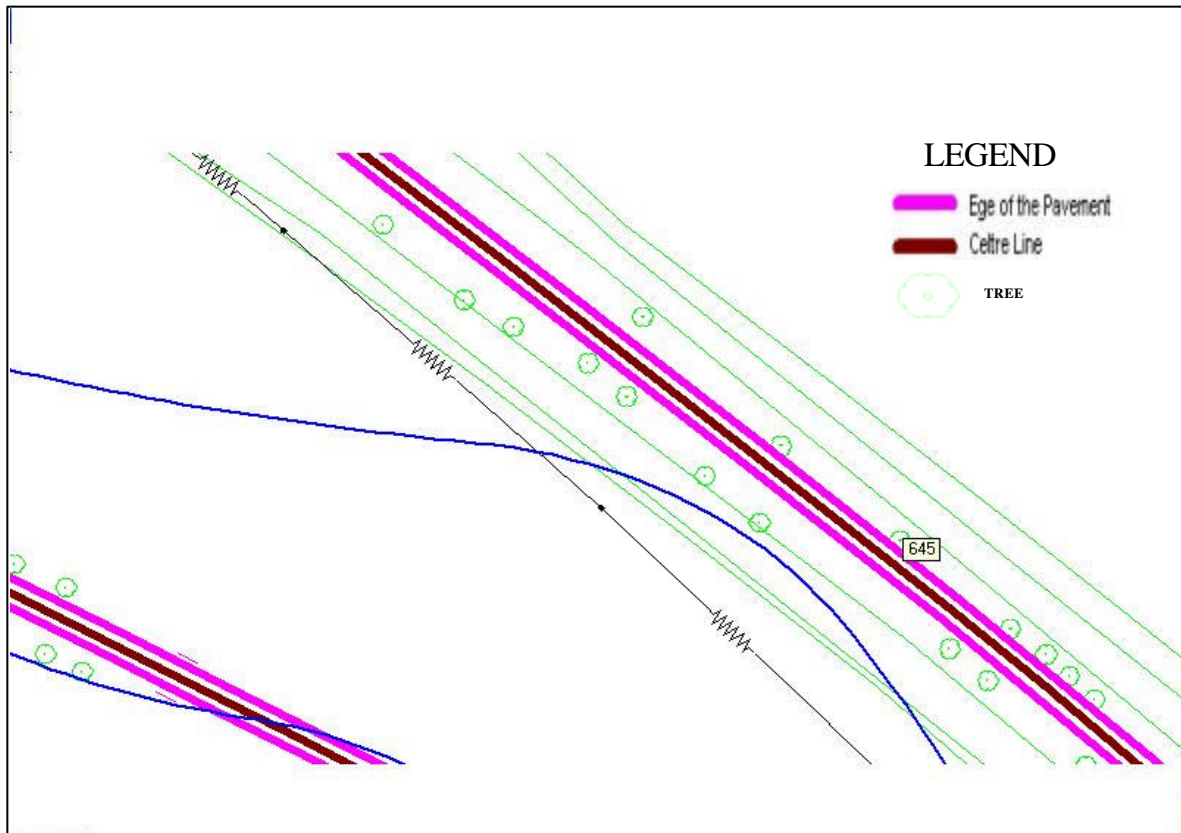


Figure 6 A Typical alignment of the section of the road

6. CONSTRUCTION AND EXECUTION

Some GIS software have modules that provide the facility to estimate quantity of cutting and filling, crust thickness design for various locations and estimation of cost for individual items. Thereafter, this information can be utilized, firstly, for award of the contract to the construction agency and then for monitoring the construction activities in terms of progress of the work in the particular link as a project of the core network.

Road information system can be developed using dynamic segmentation module of the GIS tool. Dynamic segmentation involves the division or segregation of network links into segments that are homogeneous for the specified set of link attributes. The segmentation is dynamic because it is created in response to the current attributes of the network. If the attributes are changed, then “dynamic segmentation” will create a new set of segments (ESRI, 2002). It allows multiple sets of attributes to be associated with any portion of a linear feature such as roads to analyze the current condition and predict the future state and performance of the assets of the identified sections of a road. The dynamic segmentation process of typical highway section for monitoring/

management aspects is shown in the Figure 7. This information system will be highly useful for monitoring the various work awarded along the road section.

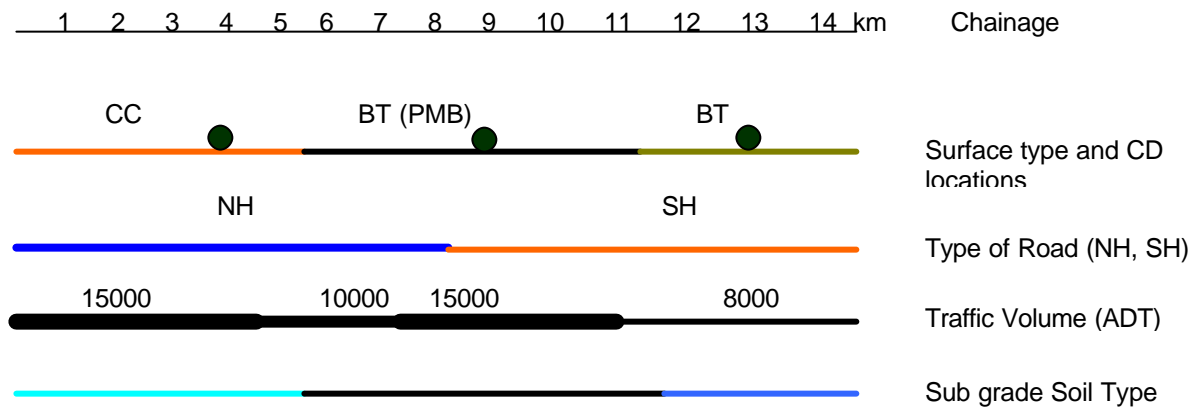


Figure 7 Linear Referencing of Various Segments of a Highway

7. MONITORING OF DELIVERY SYSTEM

Project level monitoring involves both the physical and financial progress of the project undertaken at block/district level against the allocated funds and defined time schedule for various work activities. The GIS map with the DPR information which is linearly referenced and dynamically segmented can be used for monitoring the sequential activities in the road construction at various points of time. The information can be used for different levels of monitoring by agencies spread all over the country. For example, under PMGSY, the information can be monitored by the district administration as well as State Level Standing Committee and also at the Center by the National Rural Road Development Agency or the Empowered Committee using on-line GIS enabled monitoring system. GIS maps can be web published using internet-GIS modules which can be enabled by various users and also stakeholders viz., administrative, business and public to view the information. The whole system of execution and monitoring of rural road projects will be transparent and will take less time for execution and will be useful in construction management of the project.

8. MAINTENANCE PLANNING AND MANAGEMENT

Most of the information required for maintenance planning aspects are already available in GIS environment in various formats such as base planning data from DRRP and Core Network Plans, DPR data including the design details of the road, traffic, materials used etc., which can be used for maintenance planning activities. Further, by carrying out additional inventory surveys such as condition surveys at regular intervals, which can also be incorporated in the existing GIS database, the data can be used to assess the pavement improvement measures required for various sections. Based on the pavement damage data, it is possible to separate the medium and long-term

maintenance measures required within the next 2-3 years for various periodic maintenance or rehabilitation measures.

9. CONCLUSIONS

With the introduction of GIS technology the basic philosophy of the planning and implementation of rural road network has changed. The DRRP and Core Network Plans prepared for each district has changed the total concept of execution of the rural road programme. These plans will also provide a vision for rural India in terms of assessing the needs and potential in general and rural transportation in particular. The outcome of developing a GIS based Master Plan i.e. DRRP along with other information will provide the following benefits:

- ?? Authentic database for rural road network which is easy to maintain, easy in updating and dynamic in decision making.
- ?? Enables systematic preparation of master plan and detailed project reports.
- ?? Provides true picture of accessibility of the rural masses based on a scientific method.
- ?? Helps in scientific planning, programming, budgeting and monitoring all the implementation aspects of rural roads.
- ?? Enables most convenient mechanism for data exchange between organisations.
- ?? Provides timely and effective management for implementing the development programmes at block/district level.
- ?? Unified tool for district level planning of location and allocation of various facilities based on rural accessibility.

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