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# Designing Pavement for a Typical Village Road in India – A Case Study

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***Abstract* - The Extension of rural road net work is of vital importance for bringing the social amenities, education and health within reasonable reach of villagers/tribals and for the expeditious transportation of agricultural produce from tribal villages to market yards and distribution centers. There are 72407 habitations in the state of Andhra Pradesh, of which only 41619 habitations are connected by all weather roads. The total length of road network in the state is about 146944 kms (91307 miles). Of the total road length of 146944 kms, the length of BT road is 8819 kms, WBM is 34226 kms and Gravel road is 60768 kms. There are 6824 unconnected habitations of which 6134 are having a population of 100 and above. The existing soils, climate and terrain conditions in Srikakulam district of Andhra Pradesh state in India are suitable for the development of Agricultural, Sea and Horticulture Products. This paper attempts to address the issues relating to design of such a village road through which the all round development of the District can be achieved.**

***Keywords*—Rigid Pavement, Flexible Pavement, Habitations, Village Roads, WBM Roads, Gravel Roads.**

## I. INTRODUCTION

Srikakulam District, situated within the geographic co-ordinates of 18°-20’ and 19°-10’ N and 83°-50’ and 84°-50’ E, is towards the extreme north east end of the state of Andhra Pradesh in India, with an area of 5837 sqm and a total population of 26.99 Lakhs (as per 2011 census). The district comprises three Revenue divisions - Srikakulam, Tekkali and Palakonda, with 38 Mandals. Typical soil present is Black Cotton, mean maximum and minimum temperatures are $42^0$C and $28^0$C and average annual rainfall is 1328.60 mm. The existing surface of the proposed road from CSP ROAD @ 37/8 KM TO PANSALOVA (ST) VILLAGE OF SARAVAKOTA MANDAL OF SRIKAKULAM DISTRICT is gravel surface with fair geometry. The proposed road is to have Black Top standards from Km 0/0 to 1/7 and Concrete Pavement from km 1/7 to 2/0.

## II. FIELD WORK

The details of surveys including inventory studies and investigations carried out during the feasibility study are:

- Traffic surveys, Pavement condition and road inventory surveys.
- Investigations on the existing pavement and sub grade and DCP tests.
- Collection of samples from pits adjacent to the existing road and their testing Identification of borrow areas for different types of pavement and bridge construction material, collection of samples and their analysis

The figure below shows the map of Srikakulam District in the state of Andhra Pradesh in India.


**FIGURE – 1**

### *2.1 Traffic Studies*

Traffic surveys were conducted on the project road and traffic volume counts were conducted for 3 days, and the number of vehicles plying on the road was recorded. From the classified traffic volume counts, the number of commercial vehicles (>3T) were considered in the pavement design. The following table gives the details about the number of commercial vehicles per day at present plying on the road and the estimated number of vehicles that will ply on the road at the end of design life.

*2.1.1 Traffic Details*

The following are the traffic details of the proposed road section i.e. from CSP ROAD @ 37/8 KM TO PANSALOVA (ST) VILLAGE OF SARAVAKOTA MANDAL OF SRIKAKULAM DISTRICT.

**TABLE – I**

| S.No | From | To | Length in Km | Present CVPD | Projected CVPD |
|---|---|---|---|---|---|
| 1 | C.P.Road @ 37/8 Km | Panasalova | 2.00 | 44 | 84 |

*2.2 Road Inventory Survey*

Detailed road inventory surveys were carried out to collect details of all existing road and pavement features along the existing road sections. The data collected included, but not limited to - Terrain (flat, rolling mountainous), Land-use (agricultural, commercial, forest, residential etc.), Carriageway width, surfacing type, Shoulder surfacing type and width, Su-grade/local soil type (textural classification), Horizontal curve: Vertical curve, Cross road type and details, Road intersection type and details, Location of water bodies (lakes and reservoirs), Height of embankment or depth of cutting, Land width - RoW (if available), Culverts, bridges and other structures (type, size, span arrangement and location), Roadside arboriculture, Existing utility services on either side within RoW, General drainage conditions, etc.

*2.3 Pavement Condition Survey*

Condition of the pavement was evaluated based on the field measurements. In case of Bituminous surface roads, primary pavement surface distress indicators like cracking (narrow and wide), patching, raveling, rutting and potholing were estimated visually coupled with physical measurements, and in case of gravel/ WBM roads apart from cracking and potholes, depressions, corrugations and material loss have been estimated. The extent of each distress has been visually estimated for every 200m length of the road in terms of percentage area affected and then averaged for a kilometer length. Edge breaking was also noted in terms of percentage length of road affected and shoulder drop off in terms of depth in millimeters.

As the GTS benchmark levels were not available, the survey was carried out assuming the value of elevation. Open traversing was done on the project road to establish temporary benchmark pillars, and these pillars were established at every 500m interval approximately on existing culverts or other landmarks.

After establishing the TBM's and reference pillars, Cross section surveys were carried out. The data was collected at an interval of 50m. The entire width of available ROW was covered during the cross section surveys. The survey data obtained from Total station is plotted and the topographic plan is prepared for the Project Road. This forms the input for the Geometric Design.

*2.4 Alignment*

Utmost care has to be taken in deciding the proposed road alignment as it plays a pivotal role with regards to the total cost of construction. Due consideration has to be given to the following items which economize the cost of construction.

- As far as possible the alignment must pass along the ridges, for easy drain off.
- The alignment must pass through minimum cross drains, must be straight and plain to avoid the horizontal and vertical curves.
- The alignment must preferably pass through the out skirts of the habitation rather than passing through the midway of the habitation.

Generally in rural areas, the alignment is predetermined because there are earmarked tracks. The present road project is for up gradation of the existing Gravel road up to black top standards.

*2.5 Land Acquisition*

Generally in Rural Areas, the alignment of the proposed roads in predetermined, because of existing earmarked tracks. The existing tracks will generally have a minimum width equal to length of one Ganter's chain i.e., 33'-0" or one length of Engineer's chain i.e, 66'-0". In some rare occasions only, where there are no such pre-existing tracks, for their convenience in transportation of the agriculture products, the farmers on either side of the existing pavement, donate some of their land for a nominal width of the track i.e. up to a maximum width of 20'-0" only. Hence, in such cases only when the proposed road has to pass through the fields land acquisition problem arises. As the present road project is for up gradation only and having sufficient existing road width, land acquisition problem is not anticipated.

*2.6 Sub-grade Investigations*

Basic objective of sub grade investigations is to determine the suitability of existing sub grade to support the pavement in widening portion. The strength and the level of compaction of the existing sub grade were determined by conducting various tests in the field and laboratory.

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The figure below shows the existing gravel road being used by Villagers to transport their Produce.

**FIGURE – 2**

*2.7 Test Pits*

Sub grade soil samples were collected by digging test pits at the interface of the carriageway and shoulder so that both the pavement and the shoulder composition could be known. To determine the field density, core cutter was used. Following tests were conducted on the soil samples collected from the field.

- The pavement layers were measured and logged
- The field moisture content was determined by rapid moisture meter at site
- Grain size analysis and Atterberg's limits were determined in the laboratory for classification of soils
- The Maximum Dry Density and Optimum Moisture Content were' determined as per IS 2720 Part 7
- CBR testing was carried out on the specimens compacted at OMC at 3 different energy levels, on specimens both for un soaked and 4 day soaked
- CBR of samples remolded at field moisture density. The test results are produced.

*2.8 Soil Classification*

The soils were found to Black Cotton, which are suitable for embankment/sub grade and do not pose any problem in with regards to pavement construction.

*2.9 CBR*

CBR tests were carried out as per IS: 2720. The samples were compacted at OMC at three heights corresponding to 10, 30 and 65 blows. The samples were soaked for 4 days and the tests were carried out on the soaked samples.

## III. Design Standards

*3.1 Introduction*

The guidelines prescribed in IRC: SP; 20-2002 are adopted in general. These guidelines are applicable to other district roads and village roads. These roads provide accessibility to the villages in the rural area of the country, Geometric design standards of the rural roads need not be restricted to the minimum set out and milder values than the minimum should be preferred where conditions are favorable and the cost is not excessive. Higher standards in the initial stages may be warranted in cases where improvement of road geometry (like widening of foundation width) at a later date in anticipated due to increased traffic.

*3.2 Terrain Classification*

The general slope of the country classifies the terrain across the area. The terrain is an important parameter governing the geometric standards and the criteria given in the table below, are used in classifying terrain under these categories. While classifying a terrain, short isolated stretches of varying terrain should not be taken into consideration.

**TABLE – II**
**Terrain Classification Recommended by IRC**

| Terrain Classifieds | Cross slope of the country | |
|---|---|---|
| Plain | 0-10 | More than 1 in 10 |
| Rolling | 10-25 | 1 in 10 to 1 in 4 |

The present road project falls under plain terrain and hence all the design parameters have taken pertaining to plain terrain.

**TABLE – III**
**Design Speeds to be adopted**

| Road Classification | Design Speed (Km/h) | |
|---|---|---|
| | Plain Terrain | |
| | Ruling | Min. |
| Rural Roads (VR) | 50 | 40 |

Normally, ruling design speed should be the guiding criterion for the purpose of the geometric design. Minimum design speed may, however, be adopted where site condition and cost does not permit a design based on "Ruling Design Speed". Hence for the present project a design speed of 50 Kmph is taken.

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### *3.3 Road Land Width*

Road land width or right-of-way is the width of land acquired for road purposes. The desirable land width for rural roads in different terrain conditions are given in the following Table.

**TABLE – IV**
**Terrain Classification Recommended by IRC**

| Road Classification | Plain & Rolling Terrain | | | |
|---|---|---|---|---|
| | Open Area | | Built-up area | |
| | Normal | Range | Normal | Range |
| Rural Roads (VR) | 15 | 15-25 | 15 | 15-20 |

For the present road project the existing road land width of 4 - 4.5 meters has been considered.

### *3.4 Roadway Width*

Roadway width, which includes parapet, side drains for rural roads for different terrain conditions shall be as per the guidelines given below.

**TABLE – IV**
**Recommended Roadway width**

| Terrain Classification | Roadway width(m) |
|---|---|
| Plain & Rolling | 7.5 |

### *3.5 Carriageway Width*

The standard width of carriageway for both plain and rolling as well as in mountainous and steep terrain shall be as per the Table given below.

**TABLE – VI**
**Recommended Carriageway width**

| Road Classification | Carriageway width(m) |
|---|---|
| Rural Roads (VR) | 3.75 |

The existing carriage way width for the present road project is 3. 75 m.

### *3.6 Shoulder Width*

The width of the shoulders for the rural roads in different terrain should be equal to one half of the difference between roadway width and carriageway width.

For the present road project the shoulder width is as per the requirement.

### *3.7 Side Slopes*

Side slopes for the rural roads where embankment height is less than 3m is given in the Table below.

**TABLE – VII**
**Recommended Side slopes**

| Condition | Slope (H:V) |
|---|---|
| Embankment - silty/sand/gravelly soil | 2:1 |
| Embankment - clay/clayey silt/inundated condition | 2½:1 to ½:1 |
| Cutting - silty/sand/gravelly soil | 1:1 to ½:1 |
| Cutting - disintegrated rock / conglomerate | ½:1to ¼:1 |
| Cutting - soft rock like shale | ¼:1 to 1/8:1 |
| Cutting - medium like sand stone, phyllite | 1/12:1 to 1/16:1 |
| Cutting - hard rock like quartzite, granite | Near Vertical |

The present proposed road falls under Black Cotton soils and the embankment slopes were taken as 2:1

### *3.8 Sight Distance*

Visibility is an important requirement for the safety of travel on roads. It is necessary that sight distance of adequate length be available in different situations to provide drivers enough time and distance to control their vehicles so that chances of accidents are minimized. Three types of sight distance are relevant in the design of road geometry; Stopping Sight Distance (SSD), Intermediate Sight Distance (ISO) and Overtaking Sight Distance (OSD).

### *3.9 Stopping Sight Distance*

The stopping sight distance is the clear distance ahead needed by a driver to bring his vehicle to a stop before collision with a stationary object in his path, and is calculated as the sum of braking distance required at the particular speed and the distance traveled by the vehicle during perception and brake reaction time. Based on the design speed of 50 Kmph the stopping sight distance is calculated to be 60 m.

### *3.10 Intermediate Sight Distance*

Intermediate sight distance is defined as twice the stopping sight distance. For the present road project the ISD is 120 m as the SSD is 60 m.

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*3.11 Overtaking Sight Distance*

Overtaking sight distance is the minimum sight distance that should be available to a driver on a two-way road to enable him to overtake another vehicle. The provision of overtaking sight distance is by and large not feasible on hill roads and also not considered for single lane roads. The design values are given in the Table below.

**TABLE – VIII**
**Design values of Stopping, Intermediate and Overtaking Sight Distances**

| Speed (Mm/h) | Design Values (m) | | |
|---|---|---|---|
| | Ssd | Isd | Osd |
| 20 | 20 | 40 | - |
| 25 | 25 | 50 | - |
| 30 | 30 | 60 | - |
| 35 | 40 | 80 | - |
| 40 | 45 | 90 | 165 |
| 50 | 60 | 120 | 235 |

*3.12 Camber*

The camber on straight section of road shall be as recommended in the table below. As the present project falls under plain terrain with average annual rainfall of 1015.80 mm > 1000 mm and the surface is of thin bituminous pavement, the proposed camber is 3.50% for the BT stretch and that of 2.5% for the rigid pavement.

At super-elevated road sections, the shoulder should normally have the slope of same magnitude and direction as the pavement slopes subject to the minimum cross-fall allowable for shoulder. The camber for earth shoulder should be at least 0.5% more than that for the pavement subject to the minimum of 4%. However, 1.0% more slope than the camber for the pavement is desirable.

*3.13 Horizontal Curve*

Horizontal curve consists of circular portion flanked by spiral transition at both ends. Design speed, super elevation and coefficient of side friction affect the design of circular curves. Length of transition curve is determined on the basis of rate of change of centrifugal acceleration or the rate of change of super elevation.

*3.14 Super Elevation*

Super elevation is generally considered to counteract only a fixed percentage of the centrifugal force developed, so that the slow moving traffic will be aided.

The value of super elevation, which should not be less than the camber, is restricted to 7%. It is calculated by the following formula.

$$E = V^2/225R$$

Where ‘E’ is Super elevation

‘V’ is the design speed in Km/h

‘R’ is the radius in meters

**TABLE – IX**
**Radii beyond which Super elevation not required**

| Design Speed | | Radius (nl) camber of | | |
|---|---|---|---|---|
| (Km/h) | 4% | 3% | 2.5% | 2.0% |
| 20 | 50 | 60 | 70 | 90 |
| 25 | 70 | 90 | 110 | 140 |
| 30 | 100 | 130 | 160 | 200 |
| 35 | 140 | 180 | 220 | 270 |
| 40 | 180 | 240 | 280 | 350 |
| 50 | 280 | 370 | 450 | 550 |

*3.15 Rate Analysis and Quantity Estimates*

The Unit rates of all items of construction work have been analyzed as per the guidelines given in Standard Data Book of MORD which were obtained from office of the Superintending Engineer P.R Srikakulam. Market rates were taken for items the rates for which are not available in SSR. The location of material quarries like gravel, sand, crushed aggregates were provided by the office of the Executive Engineer. The quantities of earthwork in cut and fill are calculated based on the cross sections taken at 100m intervals. The pavement quantities are computed using the Pavement design and the typical cross section adopted.

## IV. Discussions And Conclusions

*Pavement Design*

Based on the field work, the traffic studies, reviewing various IRC codes for Rigid and Flexible pavement design, sub grade CBR and keeping the economics in consideration, the following composition has been suggested for the project under study.

**TABLE – X**
**Flexible Pavement Composition**

| S.No | Road Reach | Present | GSB (mm) | WBM (mm) | Surface (mm) OGPC |
|---|---|---|---|---|---|
| 1 | KM 0/0 to 2/0 | 84 | 250 | 150 | 20 |

**TABLE – XI**
**Rigid Pavement Composition**

| S.No | Road Reach | Present | WBM (mm) | CC (mm) |
|---|---|---|---|---|
| 1 | KM 1/7 to 2/0 | 84 | 0 | 200 |

## V. CONCLUSIONS

Rigid pavements have a high compressive strength, which tends to distribute the load over a relatively wide area of soil. Other advantages include - Low maintenance costs, Long life with extreme durability, High value as a base for future resurfacing with asphalt, decreasing base and sub grade requirements, Ability to be placed directly on poor soils, No damage from oils and greases and Strong edges.

On the other side, Flexible pavements consist of a series of layers, with the highest quality materials at or near the surface. The strength of a flexible pavement is a result of building up thick layers and thereby distributing the load over the sub grade; the surface material does not assume the structural strengths as with rigid pavements. Some of the other advantages include – adaptability to stage construction, Availability of low-cost type that can be easily built, Easy to repair frost heave and settlement and resistance to the formation of ice glaze.

The choice of pavement type has always been considered a tricky and complicated decision as it not only involves tedious field work, laborious calculations, etc., but also on the various economic and geopolitical influences on the project at the time of Designing-Constructing the road.

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