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Technical Review for One Oversea Road Project under Design and Built Contract

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Abstract: Manyoni to Singida road is one of the first design and built road project applied in Tanzania Eastern Africa, it had been recognized locally that it was one of the best road constructed in the country. Technical brief reviews regarding topographic survey, material investigation, alignment design, hydrological investigation, hydraulic study, pavement design, junction design, structural design and design for road signs are presented, some works and achievements for the project is introduced.

Key words: road project; technical review; design and built; Manyoni to Singida road

1. Introduction

Manyoni to Singida road is located at central corridor of Tanzania which is one of the key national roads. This was first one of the four design and built road projects applied in Tanzania, it was started in 2003 and completed in 2007, over 12 years passed, the road condition is still good and it had been recognized that this was one of the best road constructed in Tanzania. Technical reviews regarding material investigation, alignment design, hydrological investigation, hydraulic study, pavement design, junction design, and structural design are made.

2. Project Overview

The old road from Manyoni to Singida in Tanzania is 118.5km made of earth road. The general climatic condition is of arid and semi-arid area. The area experiences one rainy season from November to April. Maximum annual daily rainfall ranges from 35mm to 152 mm. Annual mean maximum temperatures is 29° C and annual mean minimum temperature is 15° C.

This is one of the important roads located in the middle of the country. The employer is the Ministry of Works Tanzania, SIETCO is the contractor undertaking the design and built works. The consultant is BLACK &VEATCH associated in association with MAKCONSULT.

3. Technical Reviews and Major Achievements

The brief technical reviews are made to the material investigation, hydrological investigation, hydraulic study, pavement design, and structural design.

3.1 Traffic survey

Traffic and axle load criteria were assessed by the employer during project preparation. The cumulative Equivalent

Standard Axles (ESA) for a design life of twenty years, with an annual growth of 5% and diverted traffic equal to 50% of current traffic after completion was estimated at approximately 11 million ESA. This figure places the traffic loading just inside Traffic Load Class TLC 20 as defined in the Pavement and Materials Design Manual of Tanzania.

3.2 Topographic survey

Topographic survey works had been done over the whole length of the proposed alignment. Survey control was effected by the provision of a series of inter-visible beacons not more than 1000m apart located over the whole length of the road within the final right of way and offset sufficiently from the road line to be unaffected by the works. Beacon locations are defined by the UTM co-ordinate system and the beacons are associated with national control points located at Singida airport, Puma trig point and Mkungwa (near Mkiwa) trig point.

3.3 Material investigation

Before submission the alignment design, material investigation have been done on the existing road since to be designed alignment would try to be reasonably as close to the existing road. After alignment is designed the existing alignment in some sections cannot be followed because of geometric standard specified in contract.

Material investigations have been done in two stages:

(I)Before the alignment is designed;

(II)After the alignment is designed and approved.

Field investigations and laboratory tests were conducted for the whole project area. Samples for indicator tests were collected at interval of 400m giving a frequency of 3 tests per kilometer visual assessment of the Trial Pit Soil Logs was made, soil sampling were taken at levels that fall within design depth of the road (0.8m), this requirement has been adhered to throughout to the road as far as practicable. DCP tests were carried out at intervals of 400m.

3.3.1 Borrow pit investigation

Borrow pit investigations had been made along the project road. Suitable borrow pit had been proposed and used.

3.3.2 Soil investigations in other sections

Material investigations had been done to the sections in cut, to the sections in existing roadbed, to the locations of the culverts, to the sections of side roads to determine it can be used nor not.

3.3.3 Treatment for wet/soft low-lying areas under the road formation

Following measures can be taken for treatment of wet/soft low-lying area:

(1)If the depth of unsuitable soil under formation of the road is less than 1m, it will be removed and replaced with subgrade material at least G3 and compacted layer by layer to the specified density.

(2)If the depth of unsuitable soil under formation of the road is more than 1m, the unsuitable soils will be removed to 0.5 meter depth and put 0.5m depth of rip-rap stone used as platform to carry the load above and also to enable water pass through the embankment. On top of the platform will be backfilled with subgrade material of at least G3 compacted layer by layer to the required density.

3.3.4 Expansive soil

The expansive soils with PI over 20 were found in many locations and they were excavated and replaced with good Subgrade material.

3.3.5 Erodible soil

Some easily erodible soils have been found in four sections for Km 80-117 and they are replaced with the approved fill material.

3.4 Material sources

3.4.1 Water sources

Since the project is located at semi-dry area, some simple earth dams were constructed at Km 24+085L, 32+333L, 42+200L, Km 59+900L, 62+716L and 65+655R before rain come; the rainwater can be stored both for the use of local residents and the construction purpose.

3.4.2 Rock sources

There are two larger rock sources in the project, one is located at Puma and one is at Mkiwa. The tests results show that the quality at the two rock sources meet technical requirement.

3.4.3 Sand resources

Sand source in section 0-63 are located at Km Utaho Quarry, 8km away from Singida Urban Area. Beyond Km 63 there is one sand source located at Km 98+150RHS.

4. Alignment design

4.1 Design standard

The Alignment design standards used is the Ministry of Works Draft Road Manual and the SATCC Draft Code of Practice for the Geometric Design of Trunk Roads.

Flat area is defined as gradient under 0.5%.

4.2 Design speed

Design speed is 100km/hr unless otherwise dictated by the terrain; operational speed reduced to 50km/hr in urban area and village settlements.

4.3 Bus bay

Bus bays are provided at each village and at Singida urban area.

4.4 Truck parking bay

Truck paring bays are provided at Singida urban area, Puma and Ikungi.

4.5 Railway crossing

Three railway crossing are designed and provided for the project.

4.6 Junction design

Total 77 Junctions are provided for the project.

4.7 Traffic signs and road marking

The standard used for traffic sign, furniture and road markings are SATTC Road Traffic Signs Manuals. 308 No of traffic signs are provided for the project.

4.8 Other road facilities

Other road facilities such as kilometer post, Kerb and chute on the high embankment are provided.

5. Pavement design

The pavement structure from top to down is 150mm thick CRR base、Cement stabilized subbase of C2 and C1 with total thickness of 300mm, Subgrade with standard of G15 and G7 with total thickness of 350mm.

Total pavement thickness is 800mm. The G15 is mean that CBR is over 15% under heavy compaction; C2 is mean that unconfined compressive strength of the material is over 2MPa. The cross fall of the road is 3%. The total with of the road is 10.5m including 1.5m shoulders on each side of the road. Computer program for pavement design is developed by the Author as per the local standard.

On top of the base course is the Double Bitumen Surface Dressing.

Pavement design for railway crossing, for road section in rock cut, for Itigi gravel access road and for Truck Parking Bay with gravel hard standing were provided.

6. Hydrological Investigation

Hydrological investigation was to determine peak flow values for the hydraulic design of drainage structures. The TRRL east African flood model was used to estimate peak flows at various drainage points where bridges and culverts are required to be put in place.

The TRRL Model was developed by the UK Transport and Road Research laboratory. The method was developed based on physical reasoning of the hydrological interactions between rainfall and runoff. The application of the model requires information on area, land slope, channels slope, soil type, antecedent moistures conditions and climate zone to generate runoff from rainfall.

From Km 0+000-Km 80+000, estimated peak flow of the site was divided into 26 sections, while from Km 80+000-117+000 it was divided into 22 sections.

Based on the assumption that the frequency of peak discharged at a given site is the same as that of the rainfall depth, frequency analysis was carried out on the annual maximum daily rainfall data to determine rainfall depth values with the frequency of occurrence of 5, 10, 20, 25, 50 and 100 year return periods.

The return periods for pipe culverts and side drain is 10-years, it is 25-years and 50-years for the box culvert and the bridges respectively. All four rivers are ephemeral ones with 50 year design storms of 41m3/s to 150m3/s.

The Author has made computer program making hydrological study easy base on the TRRL model.

7. Hydraulic Design

Base on the hydrological investigation, hydraulic study is made to each location of the cross drains. Hydraulic program of HY-8 made by FHWA is used to determine the discharge flow, headwater elevation, inlet control depth, outlet control depth, and tail water depth and tail water velocity.

600mm pipe culverts are provided for the minor junction, and 900mm pipe culverts are provided for the major junction.

Erosion check dams are provided at three sections along the road, miter drains are provided as per the site condition. Cut of drains are provided at where surface water may flow into the road. Concrete chute are provided at the location where there is high embankment.

Subsoil drains are provided at five locations of the road where the water level is higher.

Risk analysis of two earth dams break located at upper stream to the newly designed road was carried out at km

65+655.

Four bridges are provided at km 7+769 (Kirikungu River), km 32+333 (Kipumbwiko River), km 42 + 210 (Nanahati River) and km 62 + 708 (Mkuhi River). The first three bridges are 2 spans of 12m bridges and the last one is the 3 span of 12m bridges.

8. Structural Design

8.1 Design standard

The code for design is the Draft Code of Practice for the Design of Road Bridges and Culverts September 1998 (Reprinted July 2001).

The design loads used are:

(i)Normal loading, NA

(ii)Abnormal loading, NB36

(iii)Super loading, NC-30 x 5 x 40

8.2 Pipe culvert design

D-Loading design is provided as per the Code of Practice for Selection of pipes for buried pipelines, Part II: Rigid pipes, SABS 0102, proof loading tests are carried out for the pipe culvert with dimension of 600mm and 900mm at Dar est University.

Totally, 165 No. of pipe culverts with total length of 2805m are provided, and totally 77 No. of pipe culverts with total length of 739m are provided for longitudinal drain.

8.3 Box culvert design

Loading as per SATTC of South Africa standard is followed, structural calculations by FEA are carried out. Totally 46 number of box culverts with length of 792 are provided.

8.4 Lined side drains

Based in hydrological and hydraulic study, totally 7.2km lined side drains are provided at Singida town. Side drains are provided for all those sections in cut.

8.5 Bridge design

Bridge design has been carried out for four bridges. The bridge deck consists of precast concrete beams. The beams are supporting an in-situ deck. The precast beams are 900mm deep and 500mm wide with a tapered web. In-situ reinforced concrete transverse beams 660mm by 400mm at ends and mid-span, enhance the torsion stiffness of the deck.

Soil bearing capacity is from 210 kN/sq.m to 690 kN/sq.m at depths ranging from 3.0m to 4.0m for each bridge site. Spread foundations are thus the most economical solution for all the four sites.

The design was done by the use of computerized calculations of the section properties of the bridge deck, abutments and piers. Grillage geometry was chosen and loads calculated at nodal points for all relevant types of loads.

The bearings are elastomeric which can accommodate longitudinal and transverse translational movement. Rotational movements are accommodated by elastic deformation. The elastomeric bearings will be type GJZ 300x400x47 made by Shanghai Pengpu General Factory of Rubber Products, in China.

9. Others

Pipe making machine in introduced in the project, this special workmanship guarantee that pipe culvert provided as per the design having very high quality and the minimum earth cover for the pipe culvert can be reduced to 0.25m. Based on our successful experience, it is widely used in Tanzania.

10. Conclusion

Before tendering the total length from start point to the end point following the existing road is 118.5km, after design the total length of the road is shortened and it is 116.7km long, that is 1.8km is shortened.

Manyoni to Singida road had been completed successfully under the design and built contract. It had been recognized by public that is one of the best roads constructed by the Chinese contractor. Many of the successful experiences and construction workmanship have been shared by other projects in the same country.

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