*Chapter 2*

# *CONTENTS OF THE PROJECT*

## Chapter 2 CONTENTS OF THE PROJECT

### 2-1 Basic Concept of the Project

#### (1) National Development Plan and Objectives of the Project

The TANZAM Highway (Dar es Salaam, Morogoro, Iringa, Mbeya, Zambia) is an international trunk road which starts from the Dar es Salaam, the capital and the largest sea port in Tanzania, and ends at Lusaka, the capital of Zambia. The total length of the Highway is 1,400km and it passes through Iringa and Mbeya Regions, the principal agricultural production area in Tanzania. The TANZAM Highway also serves as an outlet of sea transport for the neighbouring countries of Zambia, Malawi and Congo.

The Project is rehabilitation of a part of the TANZAM Highway in the Kitonga Gorge located 450km west of Dar es Salaam. The Project road will serves as an access road for one of the most prominent agricultural areas which produce 15% of the total agricultural products and 7.4% of the total cash crops in Tanzania.

Agriculture is the mainstay of the economy of Tanzania and the sector contributed approximately half of the GDP. The agricultural sector employed 90% of the working population and its export value amounted to over 70% of the total export value. Development of the agriculture sector is very important for both the national economic growth and improvement of the living level of the farmers that comprises majority of the poor population in Tanzania. In the Poverty Reduction Strategy Paper (PRSP), the agriculture sector is considered to be the key component for reduction of the poverty and improvement of the socio-economic indices and given the highest priority in the national policy and reforms. Establishment of the reliable transport systems between the high agricultural potential areas and the capital and seaports is fundamental necessity for national and regional economic development. The road is considered to be the basic infrastructure for vitalising the movement of agricultural outputs and production inputs such as fertiliser.

Under the above circumstances, the Government of Tanzania has established the Rolling Plan and Forward Budget for Tanzania (RPFB) as the national development plan and the priority was given in;

- rehabilitation of prioritized trunk and regional roads
- improvement of urban and regional traffic
- maintenance of rehabilitated trunk and regional roads

The Ministry of Works (MOW), which is responsible for the road sector, has established the Integrated Roads Project (IRP), which is a 10-year period road development plan, in 1990 and implemented IRP-I from year 1991 and IRP-II from 1997 under the co-operation of the Word Bank and other development partners. One of the major objectives of IRP is to rehabilitate the trunk road up to a level of 80% in good condition.

The objective of the Project is to reinstate the function of road and rehabilitate the road facilities in the Kitonga Gorge, which was given one of the highest priorities in the TANZAM Highway rehabilitation supported by various international agencies and countries under IRP-II.

**(2) Concept of the Project**

The Project is the rehabilitation of the road section of 10km including the Kitonga Gorge in accordance with the proposal of the Government of Tanzania. The slope of road is very steep, approximately 7-8%, and there are many repeating sharp curves since the Project is located in a mountainous terrain. After construction of the road with the asphalt concrete surface of 2 lanes in 1973, no substantial rehabilitation was conducted though serious deep rutting appeared due to overloaded vehicles. Serviceability of this road section is bad and well-known with high accident rates though the road is part of the TANZAM Highway because of that it has damaged and improper drainage facilities, erosion of shoulders at valley side and insufficient traffic safe facilities.

The Project will be implemented to solve the bottleneck of the TANZAM Highway at the Kitonga Gorge and contribute to achieving the national development objectives described in the above section 1-1. The Project will produce the direct benefit from reducing the risk of traffic accidents, improvement of the traffic safety and reduction of the road maintenance cost, and the indirect benefit from enhancement and vitalisation of the movement of people and agricultural products within Tanzania and between her neighbouring countries and vehicle operation cost savings.

The scope of the Project under cooperation of the Government of Japan will include not only the rehabilitation of the severely damaged pavement and drainage structures, but also repair and protection of shoulders from erosion and installation of traffic safety facilities.

## 2-2 Basic Design of the Requested Japanese Assistance

### 2-2-1 Design Policy

#### (1) Concept of the Project

The concept of the Project was confirmed, through the discussion with the Government of Tanzania and the field survey, that the Project is rehabilitation of the 10km-road as stated in the proposal submitted by the Government of Tanzania. It was also confirmed that there were no other road projects, which duplicate with the proposed Project, assisted by other donors in vicinity of the Project. The study team conducted 15km of the road survey including the section proposed by Tanzania and agreed with the Ministry of Works that the scope of the Project shall be:

- Rehabilitation of the road through the Kitonga Gorge on TANZAM Highway (L=10km)
- Installation of road traffic safety facilities

To achieve the objectives of the Project, the Project will include the following work:

- Rehabilitation of the road section of deep rutting on the road surface
- Improvement of geometric alignments required for maintaining smooth traffic flow
- Protection of shoulders from erosion
- Provision and repair of drainage structures

#### (2) Natural Conditions

The Project area is located in Iringa region, inland of East Africa, and belonged to the savannah climate zone. The annual rainfall at Iringa is 588mm as shown in the table below and this is not much compared with other regions in Tanzania. The annual rainfall at Dar es Salaam is 1,560mm since it is located in the climate zone influenced by sea. According to monthly rainfall records, the rainy season lasts from November to March while the dry season lasts from April to October. The most of rainfall concentrates in the rainy season..

Monthly Rainfall at Iringa and Dar es Salaam

Unit：mm

| Site | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Iringa | 148.5 | 132.0 | 120.2 | 49.0 | 21.7 | 0.2 | 0 | 0 | 1.2 | 6.3 | 24.1 | 84.8 | 587.9 |
| | 13 | 12 | 12 | 7 | 2 | 0 | 0 | 0 | 0 | 1 | 3 | 8 | 58 |
| Dar es Salaam | 56.5 | 99.7 | 187.1 | 285.7 | 237.0 | 47..7 | 32.5 | 24.3 | 160.3 | 92.8 | 166.8 | 166.9 | 1557.3 |

* : As per the data collected at the Iringa Meteorological Station, the upper row shows rainfall intensity and below row shows number of rain days.

The average monthly maximum temperature and minimum temperature at the Project area are 23°C in November and 18.8°C in July respectively within minor fluctuation of 4°C. However, since the Project area is located in the upland of 1,000m – 1,500m above sea level, it is cool in the morning and evening, temperatures ranging from 12 - 16°C, while it is hot in daytime, temperatures ranging from 25 - 29°C. The maximum temperature fluctuation reaches to 13°C. The following table shows monthly mean, maximum and minimum temperatures at the Iringa meteorological station for last 40 years.

Monthly Mean, Maximum and Minimum Temperatures at Iringa

Unit：°C

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mean | 21.02 | 21.48 | 21.51 | 21.39 | 20.61 | 19.45 | 18.76 | 19.24 | 20.61 | 22.07 | 22.99 | 22.53 | 20.97 |
| Max. | 26.09 | 25.83 | 26.32 | 26.07 | 25.68 | 25.10 | 24.32 | 25.12 | 26.94 | 28.42 | 28.83 | 27.31 | 26.34 |
| Min. | 15.96 | 15.67 | 15.32 | 15.27 | 14.15 | 12.42 | 11.94 | 12.15 | 13.00 | 14.39 | 15.69 | 16.26 | 14.35 |

The wind velocity in the Project area is in a range of 9 – 25km/hr. The dominant wind direction is from east to west with some variations from north to south in July – August and from south to north in January – February.

Though no hydrological data of the water level and run off exist for the Project area, a sign was observed during the field survey that the maximum flood level reached to the bottom of beam of the Mlowa bridge in 1997. There was no record that the run off from catchment areas overflowed the roadway due to insufficient discharge capacity of the culverts. However, it was observed that the rainwater, which overflowed to the roadway because of the decrease of discharge capacity by silting or hanging of debris in the roadside ditches and culverts, damaged or weakened pavement. Through the hearing survey at the field it was identified that a part of road sections at Kp 446+900 had been once submerged under the water overflowed from the Msavanga river along the Project road at the time its flow was obstructed by fallen large boulders.

### (3) Construction and Procurement Situation

The Project is located at the Kitonga Gorge approximately 450km west of Dar es Salaam and 60km east of Iringa. Though Iringa town is the largest town in this area, the construction equipment and materials required for the Project implementation are not available and, therefore, need to be procured from Dar es Salaam and other places.

The labours in the construction sector are currently more than demand in Tanzania. However, since the employment of skilled workers and operators other than unskilled workers near the Project area is difficult, and is required to be mobilised from Dar es Salaam. Aforesaid observation is supported by the Smallholder Irrigation Projects in the Central Wami River Basin at Malolo, located approximately 60km to east and further 40km to north through a feeder road, under the grant scheme of the Government of Japan, most of the skilled workers are mobilised from Dar es Salaam.

There are limited companies which can rent heavy equipment, large vehicles and plants in Tanzania. Therefore, it might be difficult to procure all equipment and plants for the Project implementation in Tanzania.

Initially, the crushed rock was expected to be obtained from the excavated materials at a hill in the Kitonga Gorge. However, this rock was weathered gneiss and it became clear from a result of the laboratory tests that its strength did not satisfy the requirements for base course, asphalt and concrete aggregates. The aggregates will be required to be purchased and transported from the existing quarry 300km away from the Project site or to produce them at site from the very hard rock available near the site though is not cost effective.

High voltage power lines of 220kv are running along the TANZAM Highway before the Project area but the Electricity Company (TANESCO) of Tanzania has no plan to extend theses power lines to Kitonga Gorge. The Contractor needs to bear all costs if he is extended the line to the Project site. However, this is not cost-effective, mobilisation of generators will be planed for power supply for the Project implementation.

The local residents obtain water from wells and rivers and use it without treatment though not healthy. A new well needs to be drilled at the camp yard and used for drinking water of the staff and workers after treatment and boiling. The water necessary for the construction works will be transported by a water tanker from the Lukosi river.

**(4) Use of the Contractors in Tanzania**

The number of the contractors registered at the highest class for the MOW is 29, in which 18 are foreign subsidised firms from South Africa, Norway, Japan and other countries and 11 are national firms. The national firms are mostly small except a few and taking the road maintenance works because of insufficient equipment and financial background to manage large contracts. While the foreign subsidized firms are awarded large contracts on the basis of a joint venture with national contractors or other foreign subsidised firms. Quotations on labour, materials and equipment depreciation costs offered by three of those firms have been used as the basis for unit price establishment and construction cost estimation.

**(5) Capability of the Executing Agency**

The executing agency, the Ministry of Works, has sufficient experience in implementation of the road projects including Southern Region Trunk Road Bridges, the Dar es Salaam City Road Rehabilitation Project and the Makuyuni-Ngorongoro Road Improvement Project implemented under the grant scheme of the Government of Japan. Since the educational level and technical knowledge of the MOW' staff is high and they are superior in planning, supervision and operation, the MOW has sufficient capability in organising and executing the Project.

Besides, the Iringa Office of the Tanzania National Roads Agency (TANROADS), which was separated from the MOW in July 2001 to carry out the road maintenance, is responsible for the maintenance of the Project road after rehabilitation. As the staff of TANROADS are those moved from the MOW, their organisation and capability is sufficient. TANRODAS is presently carrying out the road maintenance with the equipment partly granted by the Government of Japan. The maintenance work includes periodic repair of potholes and cracks and cleaning of roadside ditches and culverts. TANROADS is also conducting the design and maintenance works of large-scale by contracting out to the contractors. In light of the above, it was confirmed that the MOW has sufficient capability, systems and budget for maintenance of the Project road.

**(6) Policy on Standard of Facilities**

The scope of works, geometric design standards and relevant facilities for the Project will be established based on the following policies:

**－Geometric Design and Road Width**

The present horizontal alignments, vertical alignments and road width will be kept in principle since the widening and alignment improvement require large rock excavation, of which materials are impossible to utilise for the base because of insufficient strength, and cause very high costs. The large rock excavation is not cost effective when taking the present ADT of 500 vehicles into account. However, safety measures will be taken for the road sections where hazardous geometric alignments exist.

**－Measure against Utilities**

No other utilities, which may disturb the Project implementation, exist at the site other that the oil pile line connected between Dar es Salaam and Ndora in Zambia. Part of the pipeline is crossing the Project road at 3 points. The Project will adopt the design and construction methods which minimise protection, movement or reinforcement of the pipe line and related facilities based on detailed study of location and condition.

**－Pavement Structures**

Desirable pavement rehabilitation plan of overlay and reconstruction for the Project road will be established based on the assessment of exiting damages, pavement structures and PSI （Present Serviceability Index） survey.

The pavement structure for reconstruction of the Kitonga Gorge section will be designed based on the existing subgrade CBR and the design load estimated for the heavy vehicles passing for the design period. However, since slow movement of overloaded vehicles have caused the existing deep rutting on the uphill lane in the gorge section, the asphalt pavement would not be suitable to solve this problem. Appropriate pavement structure will be selected based on the comparison and assessment between asphalt concrete and concrete pavement.

**－Drainage Structures**

The existing V-shaped roadside ditches at hillside and cross culverts will be utilised as much as practical in drainage design since the road alignment improvement and widening were not scheduled for the Project. The runoff and discharge of the existing drainage structures will be assessed and additional drains will be provided if capacity is insufficient. Damaged drains will be repaired and silting in culverts will be removed. Measures will be taken to prevent seepage of water from the back of roadside ditches to the pavement. The surface drainage will be provided along the shoulders of gorge side to prevent erosion.

Retaining wall type drainage structures will be provided at the shoulders to protect from failures due to severe erosion. Concrete poles will be installed at the shoulders to prevent the heavy vehicles entering and causing failures.

**－Traffic Safety Facilities**

Concrete traffic barriers will be provided at the hazardous curves in the gorge section where vehicles may fall. Guideposts and lane marking will be provided at curves for guidance of drivers.

### (7) Policy on Construction Methods and Construction Period

**－Construction Methods**

As the Project road is an important road from Dar es Salaam to the west of Tanzania and Zambia and majority of the traffic are buses and cargo trucks, and therefore halting of the traffic during construction will cause serious socio-economic problems. However, since there are no detours in the steep Kitonga Gorge, the work will be progressed at closed lane to provide a workspace while the opposite lane opens to the public traffic for 24 hours in accordance with the traffic control plan. Sufficient traffic safety measures will be taken during the works at steep slopes, especially in the rainy season, as the road is slippery.

**－Construction Period**

Rainfall patterns will be taken into account for estimation of the required construction period. The critical work items for the overall construction period estimation are procurement of equipment and plants from Dar es Salaam, mobilisation and establishment, production of aggregates, demolishing of the existing pavement and construction of pavements. The crushing plant will be established at the Project site to produce aggregates for the base, asphalt and concrete pavement. Asphalt and concrete mixing plants will also be established on site for pavement works. Since the number of heavy equipment and plants in Dar es Salaam is limited, their availability during the construction period will be confirmed.

### 2-2-2 Basic Plan

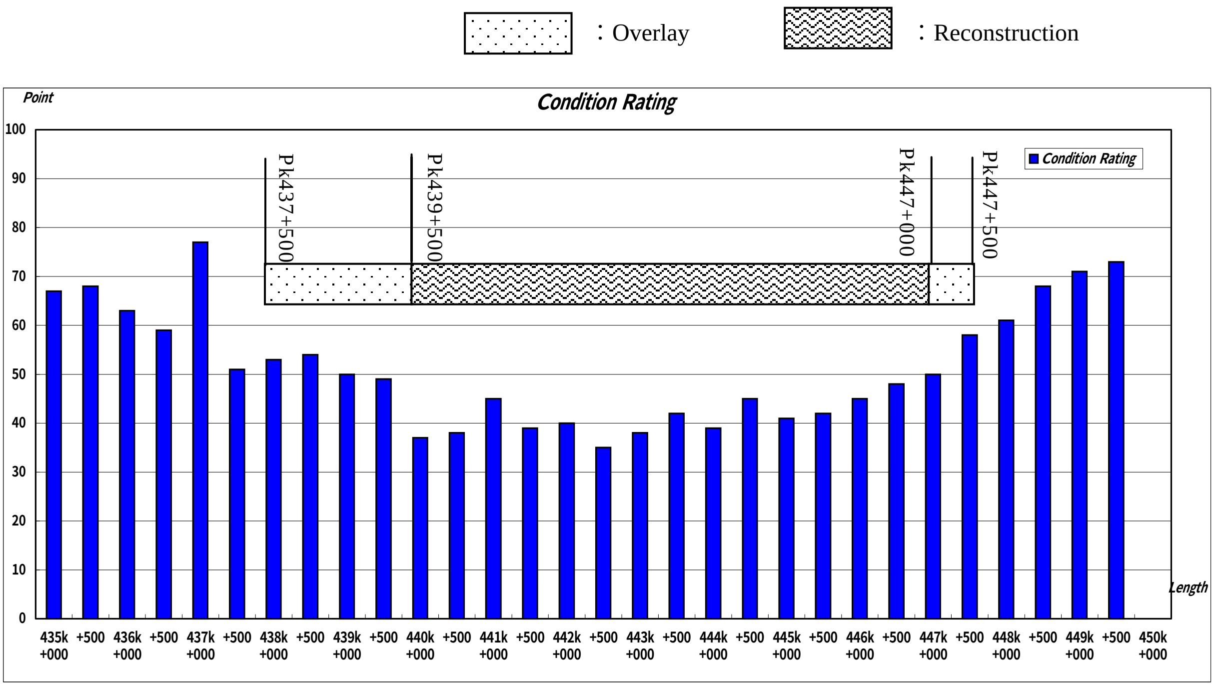
### 2-2-2-1 Overall Plan and Basic Design Policy

#### (1) Road Rehabilitation Options

Desirable road rehabilitation plan for the Project was established based on the road inventory and PSI (Present Serviceability Index) survey. The rehabilitation options for the Project were classified into the following:

- PSI≧ 55： Maintenance only since no substantial problems exist on geometric alignments and pavement .
- 55＞PSI≧50： Overlays to strengthen pavement structures since there are many potholes and alligator cracks though no substantial problems exist on geometric alignments.
- PSI＜50： Reconstruction of pavement due to serious rutting, alligator cracks and other defects on pavement surface. Rehabilitation of drainage structures since existing ones are over-aged and seriously damaged.

Based on the Fig. 2-1 below, the overlay set to cover 2.0km length are Dar es Salaam side and 0.5km at another side total of 2.5km and reconstruction of the pavement set to cover 7.5km.




Refer to PSI result at Appendices 6-2

Fig. 2-1 Selection of Pavement Rehabilitation Method based on PSI

### (2) Horizontal and Vertical Alignments

The present horizontal and vertical alignments will be kept in principle since the objective of the Project is to rehabilitate the existing road by taking the economic viability shall be taken into consideration. However, safety facilities will be provided for the road sections where hazardous geometric alignments exist.

### (3) Roadway Width

The Project road is located in a steep mountainous terrain, the existing roadway width is mostly 7m, except some sections of over 9m, as shown in the road inventory table. High cut and slope stability measures will become necessary if the standard 9.5m roadway width is provided in accordance with the standard design criteria for the trunk roads in Tanzania. Besides, the provision of standard width will not contribute much improving passing demands as shown in Table 2-1. Therefore, the existing road width will be maintained without widening though it does not meet the standard.

### (4) Design Standards

The following road design standards of Tanzania will be used, in principle, for the Project:

- Geometric Design :Draft Road Manual 1989 Edition, Ministry of Communication and Works
- Pavement Design :Pavement and Materials Manual 1999, Ministry of Works
- Drainage Design : “TRRL East African Flood Model” for runoff estimation

# Table 2-1 Verification of Present Road and Trunk Road Standard Width which can be passed

| IP No. | BC point (m) | EC point (m) | Curvilinear radius (m) | Direction | Curvilinear length (m) | Straight line length (m) | The section which can be overtaken: Present condition Ascent To Iringa (m) | Present condition Descend To DSM (m) | Standard width Ascent To Iringa (m) | Standard width Descend To DSM (m) |
|---|---|---|---|---|---|---|---|---|---|---|
| Start | 435000.00 | | | | | | | | | |
| | | | | | | 414.018 | 414 | 414 | 414 | 414 |
| IP1 | 435414.02 | 435647.74 | 2500 | Right | 233.722 | | 234 | 234 | 234 | 234 |
| | | | | | | 357.277 | 357 | 357 | 357 | 357 |
| IP2 | 436005.02 | 436331.84 | 3000 | Left | 326.818 | | 0 | 0 | 0 | 0 |
| | | | | | | 722.099 | 722 | 722 | 722 | 722 |
| IP3 | 437053.93 | 437249.71 | 600 | Left | 195.779 | | 0 | 0 | 0 | 0 |
| | KP435+000 | | | | | 469.145 | 469 | 469 | 469 | 469 |
| IP4 | 437718.86 | 438083.61 | 260 | Right | 364.755 | | 365 | 365 | 365 | 365 |
| | | | | | | 596.036 | 596 | 596 | 596 | 596 |
| IP5 | 438679.65 | 438931.58 | 1200 | Right | 251.926 | | 252 | 252 | 252 | 252 |
| | | | | | | 668.321 | 668 | 668 | 668 | 668 |
| IP6 | 439599.90 | 439884.18 | 185 | Left | 284.279 | | 0 | 0 | 0 | 0 |
| | | | | | | 15.449 | 15 | 15 | 15 | 15 |
| IP7 | 439899.62 | 439954.80 | 500 | Right | 55.179 | | 55 | 55 | 55 | 55 |
| | | | | | | 3.839 | 4 | 4 | 4 | 4 |
| IP8 | 439958.64 | 439992.94 | 250 | Right | 34.297 | | 34 | 34 | 34 | 34 |
| | | | | | | 0.279 | 0 | 0 | 0 | 0 |
| IP9 | 439993.22 | 440024.26 | 100 | Left | 31.039 | | 0 | 0 | 0 | 0 |
| | | | | | | 13.164 | 13 | 13 | 13 | 13 |
| IP10 | 440037.42 | 440071.98 | 50 | Right | 34.563 | | 35 | 35 | 35 | 35 |
| | | | | | | 23.899 | 24 | 24 | 24 | 24 |
| IP11 | 440095.88 | 440180.34 | 175 | Right | 84.461 | | 84 | 84 | 84 | 84 |
| | | | | | | 2.717 | 3 | 3 | 3 | 3 |
| IP12 | 440183.06 | 440285.33 | 180 | Right | 102.270 | | 102 | 102 | 102 | 102 |
| | | | | | | 49.212 | 49 | 49 | 49 | 49 |
| IP13 | 440334.54 | 440412.00 | 120 | Left | 77.452 | | 0 | 0 | 0 | 0 |
| | | | | | | 17.818 | 18 | 18 | 18 | 18 |
| IP14 | 440429.81 | 440542.45 | 110 | Left | 112.638 | | 0 | 0 | 0 | 0 |
| | | | | | | 7.533 | 8 | 8 | 8 | 8 |
| IP15 | 440549.98 | 440641.41 | 260 | Right | 91.424 | | 91 | 91 | 91 | 91 |
| | | | | | | 43.037 | 43 | 43 | 43 | 43 |
| IP16 | 440684.45 | 440782.85 | 385 | Left | 98.402 | | 0 | 0 | 0 | 0 |
| | | | | | | 46.324 | 46 | 46 | 46 | 46 |
| IP17 | 440829.17 | 440922.42 | 190 | Right | 93.252 | | 93 | 93 | 93 | 93 |
| | | | | | | 27.291 | 27 | 27 | 27 | 27 |
| IP18 | 440949.71 | 440999.75 | 200 | Left | 50.032 | | 0 | 0 | 0 | 0 |
| | | | | | | 42.591 | 43 | 43 | 43 | 43 |
| IP19 | 441042.34 | 441131.43 | 130 | Right | 89.097 | | 89 | 89 | 89 | 89 |
| | | | | | | 44.759 | 45 | 45 | 45 | 45 |
| IP20 | 441176.19 | 441295.79 | 80 | Left | 119.596 | | 0 | 0 | 0 | 0 |
| | | | | | | 33.822 | 34 | 34 | 34 | 34 |
| IP21 | 441329.61 | 441376.78 | 100 | Right | 47.166 | | 47 | 47 | 47 | 47 |
| | | | | | | 77.976 | 78 | 78 | 78 | 78 |
| IP22 | 441454.75 | 441520.07 | 175 | Right | 65.316 | | 65 | 65 | 65 | 65 |
| | | | | | | 51.036 | 51 | 51 | 51 | 51 |
| IP23 | 441571.11 | 441667.65 | 95 | Left | 96.544 | | 0 | 0 | 0 | 0 |
| | | | | | | 73.747 | 74 | 74 | 74 | 74 |
| IP24 | 441741.40 | 441768.94 | 100 | Left | 27.544 | | 0 | 0 | 0 | 0 |
| | | | | | | 44.598 | 45 | 45 | 45 | 45 |
| IP25 | 441813.54 | 441856.20 | 45 | Right | 42.664 | | 43 | 43 | 43 | 43 |
| | | | | | | 25.686 | 26 | 26 | 26 | 26 |
| IP26 | 441881.89 | 441923.93 | 75 | Left | 42.045 | | 0 | 0 | 0 | 0 |
| | | | | | | 43.543 | 44 | 44 | 44 | 44 |
| IP27 | 441967.48 | 442034.67 | 32 | Right | 67.191 | | 67 | 67 | 67 | 67 |
| | | | | | | 55.521 | 56 | 56 | 56 | 56 |
| IP28 | 442090.19 | 442192.73 | 80 | Left | 102.542 | | 0 | 0 | 0 | 0 |
| | | | | | | 21.827 | 22 | 22 | 22 | 22 |
| IP29 | 442214.56 | 442258.33 | 35 | Right | 43.769 | | 44 | 44 | 44 | 44 |
| | | | | | | 16.912 | 17 | 17 | 17 | 17 |
| IP30 | 442275.24 | 442309.24 | 38 | Left | 34.001 | | 0 | 0 | 0 | 0 |
| | | | | | | 23.488 | 23 | 23 | 23 | 23 |
| IP31 | 442332.73 | 442416.04 | 50 | Right | 83.309 | | 83 | 83 | 83 | 83 |
| | | | | | | 62.250 | 62 | 62 | 62 | 62 |
| IP32 | 442478.29 | 442554.98 | 125 | Left | 76.693 | | 0 | 0 | 0 | 0 |
| | | | | | | 17.791 | 18 | 18 | 18 | 18 |
| IP33 | 442572.77 | 442575.96 | 100 | Right | 3.190 | | 3 | 3 | 3 | 3 |
| | | | | | | 41.006 | 41 | 41 | 41 | 41 |
| IP34 | 442616.97 | 442666.86 | 200 | Left | 49.898 | | 0 | 0 | 0 | 0 |
| | | | | | | 25.464 | 25 | 25 | 25 | 25 |
| IP35 | 442692.33 | 442749.17 | 65 | Left | 56.842 | | 0 | 0 | 0 | 0 |
| | | | | | | 72.997 | 73 | 73 | 73 | 73 |
| IP36 | 442822.17 | 442872.58 | 25 | Right | 50.415 | | 50 | 50 | 50 | 50 |
| | | | | | | 11.794 | 12 | 12 | 12 | 12 |
| IP37 | 442884.38 | 442918.78 | 60 | Left | 34.400 | | 0 | 0 | 0 | 0 |
| | | | | | | 23.020 | 23 | 23 | 23 | 23 |
| IP38 | 442941.80 | 443006.48 | 55 | Left | 64.679 | | 0 | 0 | 0 | 0 |
| | | | | | | 30.125 | 30 | 30 | 30 | 30 |
| IP39 | 443036.60 | 443077.70 | 200 | Left | 41.096 | | 0 | 0 | 0 | 0 |
| | | | | | | 36.500 | 37 | 37 | 37 | 37 |
| IP40 | 443114.20 | 443176.42 | 140 | Right | 62.225 | | 62 | 62 | 62 | 62 |
| | | | | | | 24.183 | 24 | 24 | 24 | 24 |
| IP41 | 443200.60 | 443239.92 | 65 | Right | 39.319 | | 39 | 39 | 39 | 39 |
| | | | | | | 52.887 | 53 | 53 | 53 | 53 |
| IP42 | 443292.81 | 443338.73 | 450 | Right | 45.915 | | 46 | 46 | 46 | 46 |
| | | | | | | 32.688 | 33 | 33 | 33 | 33 |
| IP43 | 443371.41 | 443428.20 | 750 | Left | 56.785 | | 0 | 0 | 0 | 0 |
| | | | | | | 41.320 | 41 | 41 | 41 | 41 |
| IP44 | 443469.52 | 443491.38 | 75 | Left | 21.860 | | 0 | 0 | 0 | 0 |
| | | | | | | 41.091 | 41 | 41 | 41 | 41 |
| IP45 | 443532.47 | 443559.05 | 1000 | Right | 26.584 | | 27 | 27 | 27 | 27 |
| | | | | | | 16.340 | 16 | 16 | 16 | 16 |
| IP46 | 443575.39 | 443617.93 | 65 | Left | 42.536 | | 0 | 0 | 0 | 0 |
| | | | | | | 15.238 | 15 | 15 | 15 | 15 |
| IP47 | 443633.17 | 443676.36 | 40 | Right | 43.196 | | 43 | 43 | 43 | 43 |
| | | | | | | 4.470 | 4 | 4 | 4 | 4 |
| IP48 | 443680.83 | 443735.87 | 95 | Left | 55.035 | | 0 | 0 | 0 | 0 |
| | | | | | | 42.582 | 43 | 43 | 43 | 43 |
| IP49 | 443778.45 | 443810.43 | 120 | Right | 31.980 | | 32 | 32 | 32 | 32 |
| | | | | | | 40.115 | 40 | 40 | 40 | 40 |
| IP50 | 443850.55 | 443884.93 | 120 | Left | 34.384 | | 0 | 0 | 0 | 0 |
| | | | | | | 54.313 | 54 | 54 | 54 | 54 |
| IP51 | 443939.24 | 443969.82 | 75 | Right | 30.573 | | 31 | 31 | 31 | 31 |
| | | | | | | 29.737 | 30 | 30 | 30 | 30 |
| IP52 | 443999.55 | 444079.62 | 125 | Left | 80.065 | | 0 | 0 | 0 | 0 |
| | | | | | | 17.490 | 17 | 17 | 17 | 17 |
| IP53 | 444097.11 | 444166.26 | 105 | Left | 69.156 | | 0 | 0 | 0 | 0 |
| | | | | | | 13.627 | 14 | 14 | 14 | 14 |
| IP54 | 444179.89 | 444248.22 | 350 | Right | 68.326 | | 68 | 68 | 68 | 68 |
| | | | | | | 6.535 | 7 | 7 | 7 | 7 |
| IP55 | 444254.75 | 444290.11 | 70 | Right | 35.356 | | 35 | 35 | 35 | 35 |
| | | | | | | 13.155 | 13 | 13 | 13 | 13 |
| IP56 | 444303.26 | 444350.13 | 100 | Left | 46.867 | | 0 | 0 | 0 | 0 |
| | | | | | | 90.899 | 91 | 91 | 91 | 91 |
| IP57 | 444441.03 | 444469.05 | 75 | Left | 28.021 | | 0 | 0 | 0 | 0 |
| | | | | | | 44.987 | 45 | 45 | 45 | 45 |
| IP58 | 444514.04 | 444528.55 | 50 | Right | 14.511 | | 15 | 15 | 15 | 15 |
| | | | | | | 19.692 | 20 | 20 | 20 | 20 |
| IP59 | 444548.24 | 444591.51 | 125 | Left | 43.273 | | 0 | 0 | 0 | 0 |
| | | | | | | 14.412 | 14 | 14 | 14 | 14 |
| Sub-total | | | | | 4,636 | 4,970 | 5,126 | 5,167 | 5,126 | 5,167 |

| IP No. | BC point (m) | EC point (m) | Curvilinear radius (m) | Direction | Curvilinear length (m) | Straight line length (m) | The section which can be passed: Present condition Ascent To Iringa (m) | Present condition Descend To DSM (m) | Standard width Ascent To Iringa (m) | Standard width Descend To DSM (m) |
|---|---|---|---|---|---|---|---|---|---|---|
| IP60 | 444605.92 | 444631.26 | 100 | Right | 25.333 | | 25 | 25 | 25 | 25 |
| | | | | | | 40.783 | 41 | 41 | 41 | 41 |
| IP61 | 444672.04 | 444704.79 | 60 | Left | 32.746 | | 0 | 0 | 0 | 0 |
| | | | | | | 17.499 | 17 | 17 | 17 | 17 |
| IP62 | 444722.29 | 444777.57 | 65 | Right | 55.285 | | 55 | 55 | 55 | 55 |
| | | | | | | 60.136 | 60 | 60 | 60 | 60 |
| IP63 | 444837.71 | 444878.06 | 50 | Right | 40.349 | | 40 | 40 | 40 | 40 |
| | | | | | | 15.205 | 15 | 15 | 15 | 15 |
| IP64 | 444893.26 | 444951.03 | 175 | Left | 57.769 | | 0 | 0 | 0 | 0 |
| | | | | | | 46.190 | 46 | 46 | 46 | 46 |
| IP65 | 444997.22 | 445060.54 | 175 | Left | 63.325 | | 0 | 0 | 0 | 0 |
| | | | | | | 11.161 | 11 | 11 | 11 | 11 |
| IP66 | 445071.71 | 445121.13 | 135 | Right | 49.428 | | 49 | 49 | 49 | 49 |
| | | | | | | 89.548 | 90 | 90 | 90 | 90 |
| IP67 | 445210.68 | 445248.59 | 120 | Left | 37.904 | | 0 | 0 | 0 | 0 |
| | | | | | | 291.164 | 291 | 291 | 291 | 291 |
| IP68 | 445539.75 | 445651.19 | 185 | Left | 111.445 | | 0 | 0 | 0 | 0 |
| | | | | | | 34.518 | 35 | 35 | 35 | 35 |
| IP69 | 445685.71 | 445794.98 | 80 | Right | 109.268 | | 109 | 109 | 109 | 109 |
| | | | | | | 13.997 | 14 | 14 | 14 | 14 |
| IP70 | 445808.98 | 445907.54 | 75 | Left | 98.564 | | 0 | 0 | 0 | 0 |
| | | | | | | 42.887 | 43 | 43 | 43 | 43 |
| IP71 | 445950.43 | 446019.55 | 178 | Right | 69.117 | | 69 | 69 | 69 | 69 |
| | | | | | | 23.527 | 24 | 24 | 24 | 24 |
| IP72 | 446043.07 | 446145.16 | 95 | Left | 102.092 | | 0 | 0 | 0 | 0 |
| | | | | | | 15.583 | 16 | 16 | 16 | 16 |
| IP73 | 446160.75 | 446258.64 | 122 | Right | 97.895 | | 98 | 98 | 98 | 98 |
| | | | | | | 33.888 | 34 | 34 | 34 | 34 |
| IP74 | 446292.53 | 446380.37 | 157 | Left | 87.841 | | 0 | 0 | 0 | 0 |
| | | | | | | 24.568 | 25 | 25 | 25 | 25 |
| IP75 | 446404.94 | 446489.63 | 210 | Right | 84.687 | | 85 | 85 | 85 | 85 |
| | | | | | | 61.714 | 62 | 62 | 62 | 62 |
| IP76 | 446551.34 | 446608.98 | 200 | Left | 57.638 | | 0 | 0 | 0 | 0 |
| | | | | | | 37.072 | 37 | 37 | 37 | 37 |
| IP77 | 446646.05 | 446738.52 | 650 | Right | 92.471 | | 92 | 92 | 92 | 92 |
| | | | | | | 14.377 | 14 | 14 | 14 | 14 |
| IP78 | 446752.90 | 446771.75 | 200 | Right | 18.853 | | 19 | 19 | 19 | 19 |
| | | | | | | 80.248 | 80 | 80 | 80 | 80 |
| IP79 | 446852.00 | 446880.05 | 100 | Left | 28.050 | | 0 | 0 | 0 | 0 |
| | | | | | | 16.773 | 17 | 17 | 17 | 17 |
| IP80 | 446896.82 | 446935.93 | 150 | Left | 39.104 | | 0 | 0 | 0 | 0 |
| | | | | | | 17.664 | 18 | 18 | 18 | 18 |
| IP81 | 446953.59 | 446973.50 | 250 | Right | 19.908 | | 0 | 0 | 0 | 0 |
| | | | | | | 29.424 | 29 | 29 | 29 | 29 |
| IP82 | 447002.92 | 447022.47 | 100 | Right | 19.547 | | 20 | 20 | 20 | 20 |
| | | | | | | 30.456 | 30 | 30 | 30 | 30 |
| IP83 | 447052.93 | 447072.87 | 100 | Right | 19.944 | | 20 | 20 | 20 | 20 |
| | | | | | | 250.769 | 251 | 251 | 251 | 251 |
| IP84 | 447323.64 | 447435.23 | 4000 | Right | 111.594 | | 112 | 112 | 112 | 112 |
| | | | | | | 54.178 | 54 | 54 | 54 | 54 |
| IP85 | 447489.41 | 447541.59 | 2000 | Right | 52.177 | | 52 | 52 | 52 | 52 |
| | KP447+500 | | | | | 270.634 | 271 | 271 | 271 | 271 |
| IP86 | 447812.22 | 447816.76 | 2000 | Left | 4.534 | | 0 | 0 | 0 | 0 |
| | | | | | | 270.492 | 270 | 270 | 270 | 270 |
| IP87 | 448087.25 | 448098.95 | 500 | Right | 11.699 | | 12 | 12 | 12 | 12 |
| | | | | | | 74.978 | 75 | 75 | 75 | 75 |
| IP88 | 448173.92 | 448264.87 | 450 | Right | 90.941 | | 91 | 91 | 91 | 91 |
| | | | | | | 35.298 | 35 | 35 | 35 | 35 |
| IP89 | 448300.16 | 448330.65 | 250 | Right | 30.484 | | 30 | 30 | 30 | 30 |
| | | | | | | 519.582 | 520 | 520 | 520 | 520 |
| IP90 | 448850.23 | 448850.31 | 150 | Right | 0.082 | | 0 | 0 | 0 | 0 |
| | | | | | | 478.374 | 478 | 478 | 478 | 478 |
| IP91 | 449328.69 | 449337.26 | 100 | Left | 8.575 | | 0 | 0 | 0 | 0 |
| | | | | | | 48.063 | 48 | 48 | 48 | 48 |
| IP92 | 449385.32 | 449428.11 | 150 | Left | 42.790 | | 0 | 0 | 0 | 0 |
| | | | | | | 65.484 | 65 | 65 | 65 | 65 |
| IP93 | 449493.60 | 449523.82 | 100 | Left | 30.225 | | 0 | 0 | 0 | 0 |
| | | | | | | 58.342 | 58 | 58 | 58 | 58 |
| IP94 | 449582.16 | 449629.52 | 500 | Left | 47.351 | | 0 | 0 | 0 | 0 |
| | | | | | | 293.307 | 293 | 293 | 293 | 293 |
| IP95 | 449922.82 | 450018.16 | 750 | Right | 95.342 | | 95 | 95 | 95 | 95 |
| | | | | | | 17.840 | 18 | 18 | 18 | 18 |
| IP96 | 450036.00 | 450098.87 | 500 | Right | 62.866 | | 63 | 63 | 63 | 63 |
| | | | | | | 36.473 | 36 | 36 | 36 | 36 |
| IP97 | 450135.34 | 450183.24 | 500 | Right | 47.900 | | 48 | 48 | 48 | 48 |
| | | | | | | 23.442 | 23 | 23 | 23 | 23 |
| END | 450206.69 | | | | | | | | | |
| Total | | 15,000 | | | 6,691 | 8,515 | 8,776 | 8,817 | 8,776 | 8,817 |

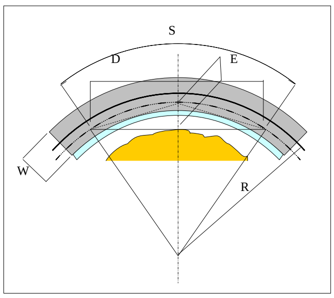
Present condition and the section which can be 1st proposal passed
Required sight distance = 180 m
R=D^2/8m
R: Curvilinear radius
D: Required sight-distance = (2+S [ S/]/2)
Passing required length = 180m

**Case-1 : Present Condition**
E: Distance from a traffic-lane center = 2.9m (ascent) = 6.65m (descend)

R=180*180/8*2.9=1400m (ascent)
R=180*180/8*6.7=600m (descend)

**Case-2 : Trunk Road Standard Width**
E: Distance from a traffic-lane center = 4.175m (ascent) = 7.425m (descend)

R=180*180/8*4.175=970m (ascent)
R=180*180/8*7.425=545m (descend)



### 2-2-2-2 Basic Design

#### (1) Geometric Design Criteria

**— Design Speed**

Not fixed speed (adopted designed speed for plan: V = 30km/h)

**— Geometric Design Criteria**

The geometric design criteria for the Project was established based on “Draft Road Manual 1989 Edition（Ministry of Communication and Works）” and taking the basic policy of the road Project, of which the objective is to rehabilitate the existing road. Following Geometric Design Criteria were taken into consideration..

Table 2-2 Geometric Design Standard of Tanzania and its Application for Project

| Design Speed | | | 30km/h | Application** |
|---|---|---|---|---|
| Minimum Radius of Curves (m) | Desirable | | 50 | × |
| | Absolute | $e_{max}$ = 0.08 | 30 | × |
| | | $e_{max}$ = 0.06 | 30 | × |
| Minimum Radius for no transition(m) | $e_0$ = 0.020 | | 150 | × |
| | e = 0.025 | | 120 | × |
| Maximum Grade (%) | Flat Terrain | | 6 (7:Limit Length 150m) | × |
| | Rolling Terrain | | 8 (9:Limit Length 150m) | × |
| | Mountainous Terrain | | 10 (11:Limit Length 150m) | ○ |
| Minimum Vertical Curve Length (m) | Stopping Sight Distance (m) | Crest | 4A* | ○ |
| | | Sag | 6A* | ○ |
| | Passing Sight Distance (m) | | 35A* | × |
| Sight Distance on Holizontal Curves (m) | Stopping Sight Distance (m) | | 30 | ○ |
| | Passing Sight Distance (m) | | 180 | × |

*A: Algebraic difference in grades (%)
**Application of Standard: ○Applied ×Not Applied

－ **Superelevation**

In the Project area, horizontal alignments are a combination of repeating smaller curves and short straight sections. Therefore, a maximum cross fall of 2.5% shall be used for the Project since application of the standard superelevations is difficult. The curve radius for which superelevation becomes negligible will be computed from the following equation specified in the Draft Road Manual 1989 of Tanzania.

$$E = V^2/(314*R)$$

If superlevation (e) = 2.5% is input in this formula, a radius (R) =114m is obtained. Therefore, a value of 114m is the minimum radius where superelevation is not required to provide.

－ **Curve Widening**

Table 2-3 shows the standard carriageway width required at curves. If a standard carriageway width of 7.0m or 6.5m is applied for the Project, a maximum curve widening of 2.0 m or 2.2m will become necessary.

Horizontal alignments of the Project are a combination of repeating smaller curves and short straight sections. Application of these standard-widening criteria will cause a significant increase of rock excavation and associated cost. Hence, the widening criteria shall not be applied to the Project due to budgetary constants.

Table 2-3 Carriageway Width required at Curves

Carriageway Width : 7.00 m

| Curve Radius (m) | 30 | 40 | 50 | 60 | 80 | 100 | 150 | 200 | 250 | 300 | 400 | 500 | 600 | 800 | 1000 | 1200 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Width (m) | 9.0 | 8.5 | 8.2 | 8.0 | 7.8 | 7.6 | 7.4 | 7.3 | 7.2 | 7.2 | 7.1 | 7.1 | 7.1 | 7.0 | 7.0 | 7.0 |

Carriageway Width : 6.50 m

| Curve Radius (m) | 30 | 40 | 50 | 60 | 80 | 100 | 150 | 200 | 250 | 300 | 400 | 500 | 600 | 800 | 1000 | 1200 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Width (m) | 8.7 | 8.2 | 8.0 | 7.8 | 7.5 | 7.4 | 7.2 | 7.1 | 7.0 | 6.9 | 6.9 | 6.8 | 6.8 | 6.8 | 6.8 | 6.8 |

— **Stopping Sight Distance**

The Project road is used by pedestrians and vehicles. The broken vehicles due to overheating at steep slopes or insufficient maintenace often park on the carriageway. Stopping sight distances on horizontal curves should be ensured to minimize vehicle crashing and identify pedestrians in ealiest timing. However, passing site distance will not be inovated due to budgetary constants.

Table 2-4 shows an evaluation result of the stopping site distance for the Project road. Widening is only required for one section at IP30 but further widenig is not required since sufficent setback distance exsits on this curve as shown as Fig. 2-2.

Required setback distance to keep the stopping site distance of 30m at a design speed of 30km/h is computed from the following equation as below:

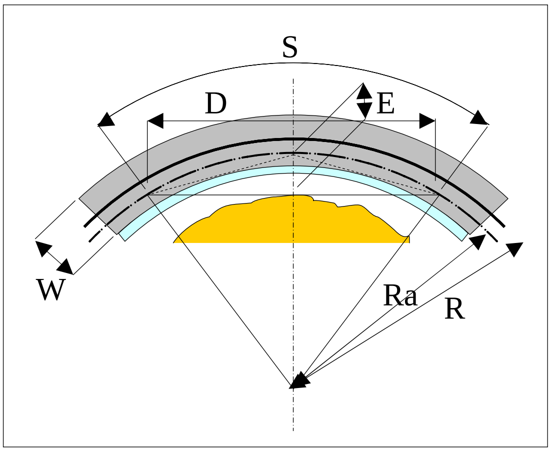
$E = D^2/8R$

where,

E: Setback distance

D: Sight distance S (m)

Ra: Curve radius (m)




Site Distance on Horizontal Curve

Table 2-4　Evaluation of Required Stopping Site Distance

Required Stopping Site Distance＝ 30.0 m

| IP No. | Curves | | | Road Width | R at Up lane | Required | Width | | | | Judge |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Starting Point | End Point | Radius R (m) | W (m) | Ra (m) | $E_{req}$ (m) | W/4 (m) | Ditch (m) | Space (m) | Total E (m) | $E>E_{req}$ |
| IP6 | 439 + 599.898 | 439 + 884.177 | 185.00 | 6.682 | 183.33 | 0.61 | 1.671 | 1.05 | - | 2.72 | OK |
| IP9 | 439 + 993.220 | 439 + 24.259 | 100.00 | 4.190 | 98.95 | 1.14 | 1.048 | 1.05 | - | 2.10 | OK |
| IP13 | 440 + 334.543 | 440 + 411.994 | 120.00 | 6.140 | 118.47 | 0.95 | 1.535 | 1.05 | - | 2.59 | OK |
| IP14 | 440 + 429.812 | 440 + 542.451 | 110.00 | 4.752 | 108.81 | 1.03 | 1.188 | 1.05 | - | 2.24 | OK |
| IP16 | 440 + 684.444 | 440 + 782.847 | 385.00 | 6.868 | 383.28 | 0.29 | 1.717 | 1.05 | - | 2.77 | OK |
| IP18 | 440 + 949.713 | 440 + 999.746 | 200.00 | 6.704 | 198.32 | 0.57 | 1.676 | 1.05 | - | 2.73 | OK |
| IP20 | 441 + 176.193 | 441 + 295.788 | 80.00 | 8.960 | 77.76 | 1.45 | 2.240 | 1.05 | - | 3.29 | OK |
| IP23 | 441 + 571.104 | 441 + 667.648 | 95.00 | 5.260 | 93.69 | 1.20 | 1.315 | 1.05 | - | 2.37 | OK |
| IP24 | 441 + 741.395 | 441 + 768.939 | 100.00 | 7.040 | 98.24 | 1.15 | 1.760 | 1.05 | - | 2.81 | OK |
| IP26 | 441 + 881.887 | 441 + 923.932 | 75.00 | 5.716 | 73.57 | 1.53 | 1.429 | 1.05 | - | 2.48 | OK |
| IP28 | 442 + 90.187 | 442 + 192.729 | 80.00 | 3.604 | 79.10 | 1.42 | 0.901 | 1.05 | - | 1.95 | OK |
| IP30 | 442 + 275.236 | 442 + 309.238 | 38.00 | 4.304 | 36.92 | 3.05 | 1.076 | 1.05 | 2.30 | 4.43 | OK |
| IP32 | 442 + 478.285 | 442 + 554.978 | 125.00 | 5.732 | 123.57 | 0.91 | 1.433 | 1.05 | - | 2.48 | OK |
| IP34 | 442 + 616.966 | 442 + 666.864 | 200.00 | 8.668 | 197.83 | 0.57 | 2.167 | 1.05 | - | 3.22 | OK |
| IP35 | 442 + 692.328 | 442 + 749.170 | 65.00 | 7.428 | 63.14 | 1.78 | 1.857 | 1.05 | - | 2.91 | OK |
| IP37 | 442 + 884.376 | 442 + 918.776 | 60.00 | 5.654 | 58.59 | 1.92 | 1.414 | 1.05 | - | 2.46 | OK |
| IP38 | 442 + 941.796 | 443 + 6.475 | 55.00 | 5.350 | 53.66 | 2.10 | 1.338 | 1.05 | - | 2.39 | OK |
| IP39 | 443 + 36.600 | 443 + 77.696 | 200.00 | 6.788 | 198.30 | 0.57 | 1.697 | 1.05 | - | 2.75 | OK |
| IP43 | 443 + 371.413 | 443 + 428.198 | 750.00 | 6.962 | 748.26 | 0.15 | 1.741 | 1.05 | - | 2.79 | OK |
| IP44 | 443 + 469.518 | 443 + 491.378 | 75.00 | 6.708 | 73.32 | 1.53 | 1.677 | 1.05 | - | 2.73 | OK |
| IP46 | 443 + 575.393 | 443 + 617.929 | 65.00 | 6.868 | 63.28 | 1.78 | 1.717 | 1.05 | - | 2.77 | OK |
| IP48 | 443 + 680.832 | 443 + 735.867 | 95.00 | 5.756 | 93.56 | 1.20 | 1.439 | 1.05 | - | 2.49 | OK |
| IP50 | 443 + 850.545 | 443 + 884.930 | 120.00 | 6.992 | 118.25 | 0.95 | 1.748 | 1.05 | - | 2.80 | OK |
| IP52 | 443 + 999.551 | 444 + 79.616 | 125.00 | 7.548 | 123.11 | 0.91 | 1.887 | 1.05 | - | 2.94 | OK |
| IP53 | 444 + 97.107 | 444 + 166.263 | 105.00 | 8.542 | 102.86 | 1.09 | 2.136 | 1.05 | - | 3.19 | OK |
| IP56 | 444 + 303.262 | 444 + 350.129 | 100.00 | 6.912 | 98.27 | 1.14 | 1.728 | 1.05 | - | 2.78 | OK |
| IP57 | 444 + 441.028 | 444 + 469.049 | 75.00 | 7.896 | 73.03 | 1.54 | 1.974 | 1.05 | - | 3.02 | OK |
| IP59 | 444 + 548.238 | 444 + 591.511 | 125.00 | 6.606 | 123.35 | 0.91 | 1.652 | 1.05 | - | 2.70 | OK |
| IP61 | 444 + 672.040 | 444 + 704.786 | 60.00 | 6.264 | 58.43 | 1.93 | 1.566 | 1.05 | - | 2.62 | OK |
| IP64 | 444 + 893.261 | 444 + 951.031 | 175.00 | 6.208 | 173.45 | 0.65 | 1.552 | 1.05 | - | 2.60 | OK |
| IP65 | 444 + 997.221 | 445 + 60.546 | 175.00 | 5.610 | 173.60 | 0.65 | 1.403 | 1.05 | - | 2.45 | OK |
| IP67 | 445 + 210.683 | 445 + 248.586 | 120.00 | 6.404 | 118.40 | 0.95 | 1.601 | 1.05 | - | 2.65 | OK |
| IP68 | 445 + 539.751 | 445 + 651.196 | 185.00 | 6.524 | 183.37 | 0.61 | 1.631 | 1.05 | - | 2.68 | OK |
| IP70 | 445 + 808.979 | 445 + 907.542 | 75.00 | 5.768 | 73.56 | 1.53 | 1.442 | 1.05 | - | 2.49 | OK |
| IP72 | 446 + 43.073 | 446 + 145.165 | 95.00 | 4.660 | 93.84 | 1.20 | 1.165 | 1.05 | - | 2.22 | OK |
| IP74 | 446 + 292.531 | 446 + 380.372 | 157.00 | 6.986 | 155.25 | 0.72 | 1.747 | 1.05 | - | 2.80 | OK |
| IP76 | 446 + 551.341 | 446 + 608.979 | 200.00 | 6.774 | 198.31 | 0.57 | 1.694 | 1.05 | - | 2.74 | OK |
| IP79 | 446 + 852.000 | 446 + 880.050 | 100.00 | 5.882 | 98.53 | 1.14 | 1.471 | 1.05 | - | 2.52 | OK |
| IP80 | 446 + 896.823 | 446 + 935.928 | 150.00 | 4.194 | 148.95 | 0.76 | 1.049 | 1.05 | - | 2.10 | OK |
| IP81 | 446 + 953.591 | 446 + 973.499 | 250.00 | 5.880 | 248.53 | 0.45 | 1.470 | 1.05 | - | 2.52 | OK |

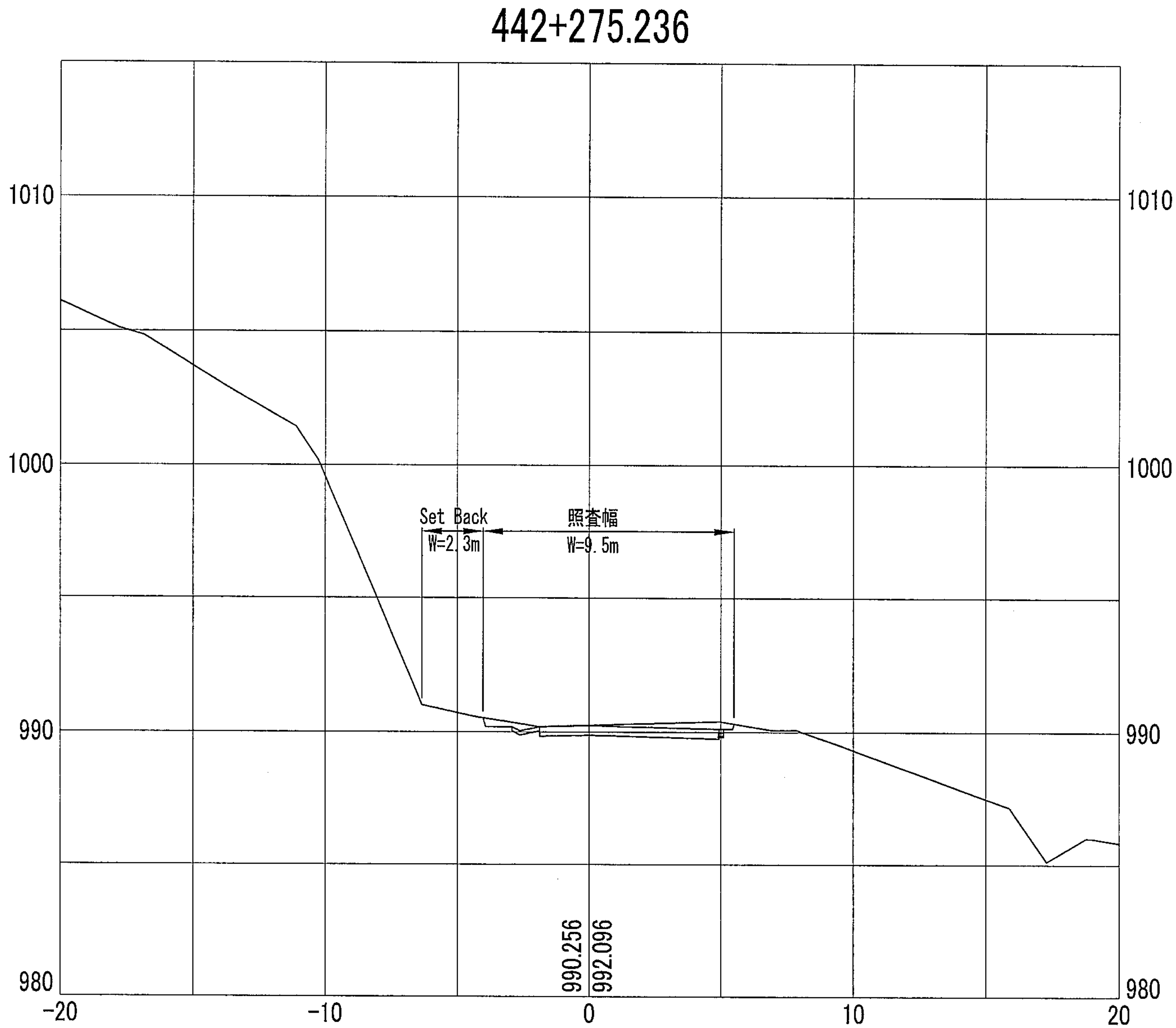



Fig. 2-2 Cross Section for review of Site Distance at No.442+275-309 (IP30)

## (2) Design Traffic Volume

### － Design Base Year and Baseline Traffic Volume

The baseline design traffic volume will be used as the basis of design traffic estimation for the pavement design. The design analysis period in Japan is 10 years, in general, after the date of opening. While, the specified deign period is 20 years in Tanzania for new or rehabilitated bitumen surfaced pavements according to the “Pavement and Materials Design Manual（1999）”, considering difficulty of stable budget allocation for the road maintenance after construction or rehabilitation. Therefore, both 10-year and 20-year design periods were used for economic viability analysis for the pavement design of the Project.

The baseline traffic for the Project was established based on the traffic survey conducted by this basic design study team of the Project as shown in Table 2-5.

Table 2-5 Summary of Traffic Survey

| Year | Month | Location | Passenger Cars | | Trucks | | | Buses | | | Total | 24 Hour Factor | Seasonal Factor | Adjusted ADT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Passenger Car | Pick-up Truck + 4WD | 2axles | 3axles | 4 or more axles | Mini Bus | Medium Bus over 25 pass | Large Bus over 40 pass | | | | |
| 1996 | - | Kitonga | - | - | - | - | - | - | - | - | 382 | - | | |
| 1998 | July | Mikumi | 11 | 94 | 55 | 12 | 27 | | 16 | 64 | 280 | 1.570 | 0.985 | 433 |
| | | Iringa | 15 | 74 | 55 | 12 | 18 | | 13 | 49 | 237 | 1.570 | 0.985 | 367 |
| 1999 | May | Iringa | 21 | 126 | 39 | 35 | 26 | | 98 | 55 | 400 | 1.332 | 0.919 | 490 |
| 2001 | March | Mikumi | 22 | 108 | 39 | 56 | 51 | 55 | 51 | | 382 | - | - | - |
| | | Mikumi | 21 | 104 | 41 | 75 | 63 | 46 | 56 | | 406 | - | - | - |
| | | Mikumi | 34 | 96 | 39 | 77 | 50 | 45 | 47 | | 388 | - | - | - |
| | | Mikumi | 23 | 99 | 38 | 86 | 40 | 42 | 58 | | 386 | - | - | - |
| | | Mikumi | 35 | 131 | 27 | 89 | 45 | 37 | 58 | | 422 | - | - | - |
| | April | Mikumi | 49 | 136 | 41 | 68 | 45 | 45 | 53 | | 437 | - | - | - |
| | | Mikumi | 18 | 85 | 24 | 31 | 27 | 30 | 53 | | 268 | - | - | - |
| | June | Kitonga | 10 | 107 | 223 | 33 | 17 | 27 | 7 | 53 | 477 | - | - | - |
| | | Kitonga | 27 | 149 | 184 | 36 | 16 | 24 | 3 | 61 | 500 | - | - | - |

### － Traffic Growth Rate

The traffic growth rates specified in the “TANZAM HIGHWAY REHABILITATION PROJECT SECTIONS 1.1A, 1.1B and 3B Report” in 1994 were used for the design traffic loading estimation up to year 2015. The same traffic growth rates of the 2003-2015 periods were applied after year 2015 up to year 2023. Since this report only indicated the growth rate of heavy vehicles necessary for the pavement design, the growth rate of large bus was used as that for passenger cars, pick-ups and small/medium buses as shown in Table 2-6.

Table 2-6 Traffic Growth Rate

| Vehicle Category / Period | 1993-2003 | | 2003-2015 | |
|---|---|---|---|---|
| Large Bus | 5.50 | % | 4.80 | % |
| Small/Medium Bus | 5.50 | % | 4.80 | % |
| Good Vehicles (over 5t) | 4.00 | % | 3.00 | % |
| Trailer | 4.00 | % | 3.00 | % |
| Passenger car/4WD, etc. | 5.50 | % | 4.80 | % |

Source of Informetion and Date

TANZAM HIGHWAY REHABILITATION PROJECT SECTIONS 1.1A, 1.1B and 3B (1994)

– **Estimation of Traffic Volume**

Construction period of the Project is estimated at 15 months. If the commencement of the works is scheduled in year 2002, the opening of rehabilitated road will be in year 2003. Design traffic was estimated for the period of 10 years and 20 years as generally used in Japan and Tanzania respectively.

Table 2-7 shows the estimated future traffic on the Project road. The future traffic estimation for passenger car/4WD and small/medium bus is for a reference of geometric design but not for the traffic loading estimation of pavement design.

## Table 2-7 Calculation of Design Traffic Counts

| Type of veheicle | | 2001/6 | Traffic growth rate (%) | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | ADT | 2001-2003 | 2004- | - | - | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| Medium Goods Vehicle | - 2 axles, incl, steeling axle and<br>- 3 tonnes empty weigt, or more | 223 | 4.0 | 3.0 | 232 | 241 | 248 | 256 | 264 | 271 | 280 | 288 | 297 | 306 | 315 | 324 | 334 | 344 | 354 | 365 | 376 | 387 | 399 | 411 | 423 | 436 |
| Heavy Goods Vehicle | - 3 axles, incl, steeling axle and<br>- 3 tonnes empty weigt, or more | 33 | 4.0 | 3.0 | 34 | 36 | 37 | 38 | 39 | 40 | 41 | 43 | 44 | 45 | 47 | 48 | 49 | 51 | 52 | 54 | 56 | 57 | 59 | 61 | 63 | 64 |
| Very Heavy Goods Vehicle | - 4 or more axles, incl, steeling axle and<br>- 3 tonnes empty weigt, or more | 17 | 4.0 | 3.0 | 18 | 18 | 19 | 20 | 20 | 21 | 21 | 22 | 23 | 23 | 24 | 25 | 25 | 26 | 27 | 28 | 29 | 30 | 30 | 31 | 32 | 33 |
| Large-sized bus | - Seating capacity of 40, or more | 53 | 5.5 | 4.8 | 56 | 59 | 62 | 65 | 68 | 71 | 75 | 78 | 82 | 86 | 90 | 94 | 99 | 104 | 109 | 114 | 119 | 125 | 131 | 137 | 144 | 151 |
| Small / Medium size bus | - Seating capacity of less than 40 | 34 | 5.5 | 4.8 | 36 | 38 | 40 | 42 | 44 | 46 | 48 | 50 | 53 | 55 | 58 | 60 | 63 | 66 | 70 | 73 | 76 | 80 | 84 | 88 | 92 | 97 |
| Vehicles | | 10 | 5.5 | 4.8 | 11 | 11 | 12 | 12 | 13 | 13 | 14 | 15 | 15 | 16 | 17 | 18 | 19 | 20 | 20 | 21 | 22 | 24 | 25 | 26 | 27 | 28 |
| 4WD(s) / pickup | | 107 | 5.5 | 4.8 | 113 | 119 | 125 | 131 | 137 | 144 | 151 | 158 | 165 | 173 | 182 | 190 | 199 | 209 | 219 | 230 | 241 | 252 | 264 | 277 | 290 | 304 |
| Total amount | | 477 | | | 499 | 522 | 547 | 574 | 601 | 630 | 660 | 692 | 725 | 760 | 797 | 835 | 875 | 917 | 961 | 1007 | 1055 | 1106 | 1159 | 1215 | 1273 | 1334 |
| Note | | | | | | ▲ | Completion of the Project | | | | | | | | | ▲ | Ten years after Completion | | | | | 20 years after Completion | | | | ▲ |

### 2-2-2-3 Pavement Design

－ **Deformation of Existing Pavement**

The following deformation was identified in the existing pavement by visual inspection and test pits excavation in the gorge section of the Project.

a) Rutting in the uphill lane pavement was approximately 10cm deep. The depth of rutting in the downhill lane was approximately a half of the uphill lane, but intensive corrugations were observed instead.

b) The rutting in the existing asphalt concrete surface of 15cm thickness seemed to be the lateral material displacement caused by overloaded vehicle axle loads of slow movement.

c) In the gorge section, no crushed rock base was seen. Instead, a mixture of sand, natural gravel, soil and crushed rocks was used as the road base.

d) If the existing layer of 50cm thickness beneath the asphalt concrete is assumed to work as subbase (equivalent CBR = 25%), the Structure Number (TA') computed in accordance with the Manual for Asphalt Pavement, Japan Road Association, will be as follows:

Structure Number of the exiting pavement at the Kitonga Gorge section

$$TA' = 1.00 \times 15 + 0.20 \times 50 = 25.0 \text{ cm}$$

where,

Structure of the existing pavement: Asphalt concrete surface t=15cm
Subbase (CBR=25%) t=50cm
Subgrade CBR = 16%

－ **Quality of the Existing Asphalt Concrete Material**

The existing asphalt concrete materials were sampled at the gorge section and bitumen content and grading were tested at a laboratory. The asphalt content was 5.3% and this was more than that specified in the manual of Tanzania. Grading of aggregates is within a specified envelope as shown in Fig. 2-3. No substantial defects were found.

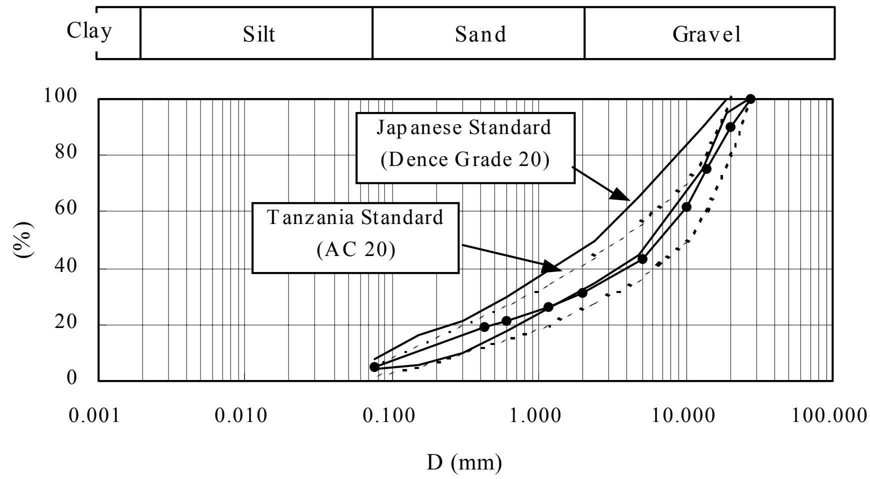



Fig. 2-3 Grading of Asphalt Concrete Aggregates sampled from Kitonga Gorge

## — Traffic

According to the traffic survey, there were approximately 50 number of 3-group axle and 4-group axle trailers passing the Project road per day. Only group axle loads of the 3-group axle trailers were measured at the weigh-bridge station of Makanbako, MOW and their results were as follows:

Gross weight of 3-group axle vehicles with full-loading =

7.0 t (1$^{st}$ Group axle)＋18.0 t (2$^{nd}$ Group axle)＋25.0 t (3$^{rd}$ Group axle) ＝50 t

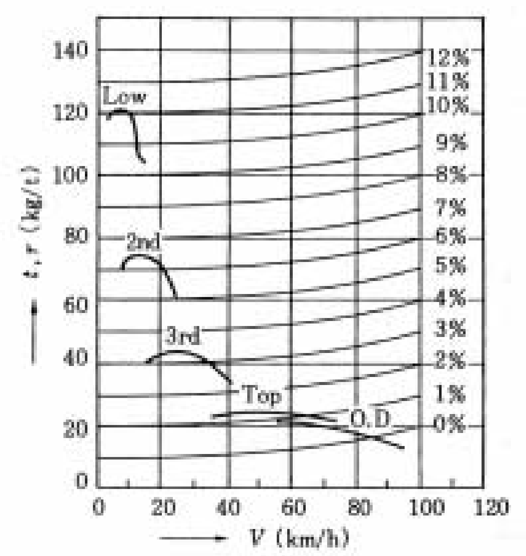
In addition to the above group axle loads, the following loads were considered working on the pavement:

a) Vibration load of vehicles: 50 t × 0.20 = 10 t

b) Vehicle driving forces acting on vehicle during climbing up slopes

Fig.2-4 shows a graph showing the driving force of 32-ton trailer with full-loading taken from the Geometric Design Code and its Guidance, Japan Road Association. An average vertical grade of the Kitonga Gorge section is approximately 8% and heavy vehicles runs with a low speed of approximately 8km/hr on the uphill direction and its driving force is estimated at:

Driving force at uphill: 50 t×0.12＝6t



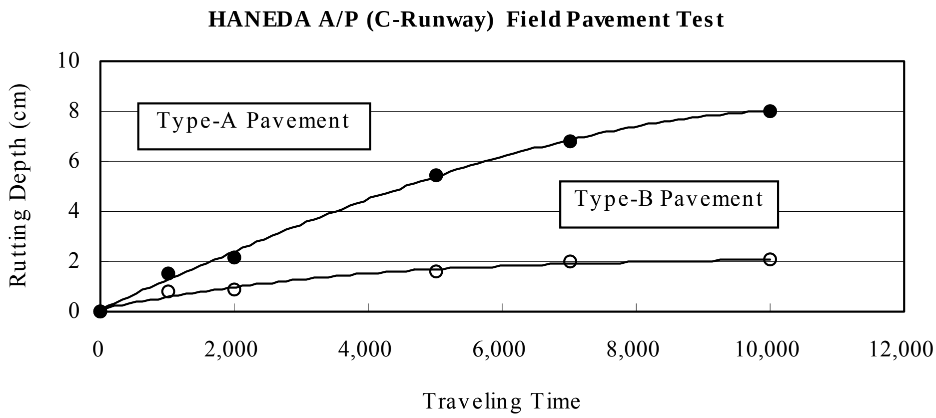

t: Driving Force、r: Resistance per Unit Weight、V: Vehicle Speed

Fig. 2-4 Driving Characteristic Curve for Trailer of 32ton at Full-loading

(Source：" Geometric Design Code and its Guidance", Japan Road Association)

— **Causes of Deformation of Existing Road** (A Case Study of Pavement Deformation on Field Test Pavement at C-Runway of Haneda Airport)

A field test pavement was constructed and experimental loading was carried out at the C-runway of the Haneda Airport in Tokyo, during the design stage. A few alternative pavement structures were constructed for experiment. An equivalent load (90ton) of an aeroplane was applied 10,000 times and deformation such as rutting and stress in the test pavement were measured. Fig.2-5 shows a relationship between depth of rutting and loads. Type-A and B in the figure indicate the pavement structures shown in Fig.2-6.




＊Gross Weight of Loading Vehicle＝90 t、Running Speed=15 km/hr

Fig. 2-5 Relationship of Rutting and Loading at C-Runway of Haneda Airport

| Type-A Pavement | |
|---|---|
| AsphaltConcrete | t=15cm |
| Base<br>（Screed Crushed Rock） | t=30cm |
| Subbase<br>（Crusher-run） | t=65cm |
| Subgrade<br>t=200cm<br>（Sand　CBR＝10%） | |

| Type-B Pavement | |
|---|---|
| Asphalt Concrete | t=15cm |
| Base(Asphalt Treated Base) | t=15cm |
| Subbase<br>（Crusher-run） | t=65cm |
| Subgrade<br>t=200cm<br>（Sand　CBR＝10%） | |

Fig. 2-6 Pavement Structure for Field Test at C-Runway of Haneda

The Structure Number (TA') for Type-A and B pavement computed based on the "Manual for Asphalt Pavement", Japan Road Association is as follows:

$TA' = a1\ T1 + a2\ T2 + \cdots + an\ Tn$

Where,

a1 , a2 ,･･･,an：Coefficient to convert to equivalent thickness of asphalt concrete

| | |
|---|---|
| Hot Asphalt Mix for surface and binder course： | a＝1.00 |
| Bituminous stabilisation for base course：<br>（Stability more than 350kgf） | a＝0.80 |
| Screened crushed rock base course（CBR>=80）： | a＝0.35 |
| Crusher-run subbase course（CBR>=20）： | a＝0.20 |

T1 , T2 ,･･･,Tn：Thickness of each layer (cm)

Type-A Pavement：　$TA' = 1.00 \times 15 + 0.35 \times 30 + 0.20 \times 65 = 38.5$ cm

Type-B Pavement：　$TA' = 1.00 \times 15 + 0.80 \times 15 + 0.20 \times 65 = 40.0$ cm

－ **Assessment of Pavement Surface Deformation**

Table 2-8 shows a comparison of depth of rutting between the pavement in the Kitonga Gorge section and the Type-A pavement at the C-Runway of Haneda. It is difficult to define the theoretical relationship between both pavements since vehicle weight, running condition, pavement structures and other conditions are not same. However, the comparison results suggest that the deformation in the Kitonga Gorge section was caused by the slow overloaded vehicles which are almost equivalent to aeroplane loading.

Hence, rigid pavement should be used for the reconstruction of pavement for the steep slope sections of the Project road to avoid excessive deformation and rutting.

Table 2-8 Estimated Depth of Rutting at 10,000 time of Passage

| | Gross Weight | Running Condition | | Pavement Condition | | Depth of Rutting |
|---|---|---|---|---|---|---|
| | | Slope | Driving Force | Subgrade CBR | Structure Number TA' | |
| Kitonga Gorge Section | 60t | i=8% | 6.0t | 16% | 25.0cm | 10cm |
| Haneda C-Runway | 90t | i=6% | 4.5t | 10% | 38.5cm | 8cm |

## — Design Standard and Design Method

The design standards used for the Project are as follows:

- Reconstruction Sections: Mutilayered Elastic Theory specified in the Manual for Pavement Design, Japan Road Association. ”
- Overlay Sections: “Pavement and Materials Design Manual”, 1999, MOW, Tanzania

## — Rigid Pavement Design based on “Multilayered Elastic Analysis”

a) Physical Characteristics of Materials

The rigid pavement was designed using the multilayered elastic theory taking wheel loads of heavy vehicles into account. The materials characteristics (elasticity module and Poisson ratio) used for this analysis is as shown in Table 2-9.

Table 2-9 Material Characteristics for Multilayered Elastic Theory Design

| Material | Elasticity Module E ($kgf/cm^2$) | Poisson Ratio ν |
|---|---|---|
| Asphalt Concrete | 10,000 | 0.35 |
| Modified Asphalt Concrete | 40,000 | 0.35 |
| Concrete Pavement | 350,000 | 0.15 |
| Screened Crushed Stone (Base Course) | 2,000 | 0.30 |
| Asphalt Treated Base (Base Course) | 8,000 | 0.30 |
| Crusher-run (Subbase) | 1,500 | 0.30 |
| Subgrade (Kitonga) CBR=16 | 1,200 | 0.30 |
| Subgrade (Haneda A/P), CBR=10 | 750 | 0.30 |
| Natural Ground (Kitonga), Weathered Rock | 5,000 | 0.35 |
| Natural Ground (Haneda A/P） N=10 | 150 | 0.35 |

b) Pavement Structure Models for Analysis

The below pavement structure model will represent application of the following cases:

Case-1：Existing pavement

Case-2：Pavement structure designed based on the Tanzanian Standard

Case-3：Asphalt treated base (Asphalt treated base will be used for the base course in stead of the screed crushed rock in Case-2)

Case-4：Modified asphalt concrete pavement （Modified asphalt will be used instead of straight asphalt in Case-3）

Case-5：Concrete pavement

| **Case-1** |
|---|
| Asphalt Concrete t=15cm |
| Subgrade (Natural Gravel)<br>CBR＝16% t=50cm |
| Natural Ground (Weathered Rock) |

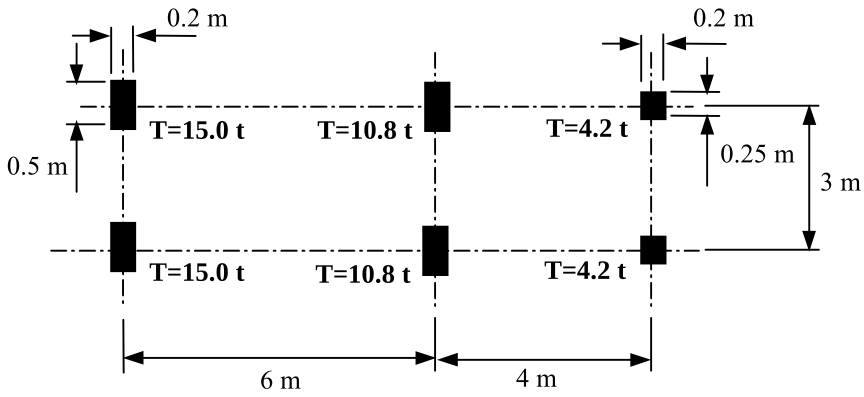
| **Case-2** |
|---|
| Asphalt Concrete t=10cm |
| Base (Screened Crushed Rock) t=10cm |
| Base (Crusher-run) t=15cm |
| Subgrade (Natural Gravel)<br>CBR＝16% t=50cm |
| Natural Ground (Weathered Rock) |

| **Case-3, Case-4** |
|---|
| Asphalt Concrete (case-3)<br>Modified Asphalt Concrete (case-4) |
| Base (Asphalt Treated Base) t=10cm |
| Base (Crusher-run) t=15cm |
| Subgrade (Natural Gravel)<br>CBR＝16% t=50cm |
| Natural Ground (Weathered Rock) |

| **Case-5** |
|---|
| Concrete Pavement t=25cm<br>$\sigma ca$=45 kgf/cm$^2$ |
| Base (Screened Gravel) t=15cm |
| Subgrade (Natural Gravel)<br>CBR＝16% t=50cm |
| Natural Ground (Weathered Rock) |

Fig. 2-7 Pavement Model for Multilayered Elastic System Analysis
(Kitonga Gorge Section)

— **Wheel Load Condition for the Kitonga Gorge section** (3-group axle trailer)




— **Result of Rigid Pavement Analysis**

Table 2-10 shows results of the multilayered elastic analysis by case (model). Horizontal tensile strains ( εx) in the case at the bottom of the asphalt layer or the concrete slab will relate to fracture or cracking and vertical compressive strains ( εz)at the top of the subgrade will relate to distortion or rutting of the pavement. Allowable strains are the values at the vehicle passage of 100,000 times, which is equivalent to daily passage of 20 heavy vehicles for a period of 10 years. Only group axle loads were considered for analysis and vehicle-driving force was neglected.

According to the analysis for the Kitonga Gorge section, vertical compressive strains ( εz) causing rutting will not be reduced much even though the asphalt treated base (Case-3 and 4) or modified asphalt (Case-4) which has high resistance in high temperate are provided. Only concrete pavement (Case-5) will satisfy against both horizontal and vertical strains for passage of the designed heavy vehicles in the gorge section.

Table 2-10 Result of Multilayered Elastic Analysis by Model

| | Allowable Value | Case-1 | Case-2 | Case-3 | Case-4 | Case-5 |
|---|---|---|---|---|---|---|
| | | Existing Pavement | Tanzanian Standard | Asphalt treated base | Modified A + Treated | Concrete |
| Horizontal Strain at Bottom of Asphalt Concrete εx | $4.0\times10^{-4}$ | $11.9\times10^{-4}$ | $12.0\times10^{-4}$ | **$2.94\times10^{-4}$** | **$3.39\times10^{-4}$** | **$0.06\times10^{-4}$** |
| Vertical Strain on Top of Subgrade εz | $8.0\times10^{-4}$ | $18.8\times10^{-4}$ | $27.0\times10^{-4}$ | $22.4\times10^{-4}$ | $17.3\times10^{-4}$ | **$3.13\times10^{-4}$** |
| Result | | | | | | **Adopted** |

Based on the above result, the concrete pavement (Case-5) will be adopted for the pavement at Kitonga Gorge section due to avoid the rutting on the new asphalt concrete pavement.

— **Design Method for the Overlay Section**

“The Pavement and Materials Design Manual”（1999）of Tanzania was applied to the overlay section of the Project. The pavement design methods of Tanzania are classified into 2 methods, new roads and pavement rehabilitation and the latter was applied for the Project.

The basic theory of the pavement design in Tanzania is similar to that in “Manual for Asphalt Pavement Manual” in Japan. Required pavement strength should be equal or more than the Structure Number (SN) which is defined as the products between thickness (t) of each pavement layer (n) and its corresponding material coefficient (a).

$$SN = (a1 \times t1 + a2 \times t2 + a3 \times t3 + \cdot\cdot + an \times tn) / 25.4$$

SN：Structure Number
a：Equivalent material coefficient
t：Layer thickness (mm)

Table 2-11 Required Structure Number from Subgrade CBR and Design Load

| Subgrade CBR | Required Structure Number $SN_{Required}$ | | | | | | |
|---|---|---|---|---|---|---|---|
| | Traffic Load Classes | | | | | | |
| | TLC02 | TLC05 | TLC1 | TLC3 | TLC10 | TLC20 | TLC50 |
| >=30 | 1.10 | 1.25 | 1.60 | 1.90 | 2.35 | 3.00 | 3.50 |
| 15－20 | 1.35 | 1.50 | 1.80 | 2.20 | 2.75 | 3.80 | 4.20 |
| 10－14 | 1.60 | 1.80 | 2.10 | 2.50 | 3.00 | 4.10 | 4.50 |
| 7－9 | 1.90 | 2.00 | 2.30 | 2.75 | 3.30 | 4.30 | 4.70 |
| 5－6 | 2.10 | 2.20 | 2.50 | 2.90 | 3.50 | 4.50 | 5.00 |
| 3－4 | 2.40 | 2.80 | 3.10 | 3.40 | 4.00 | 5.00 | 5.50 |

Source: Pavement and Material Design Manual 1999, MOW, Tanzania

— **Traffic Load Class (TLC)**

The design traffic loading for the Project estimated for both 10-year and 20-year periods was classified into TLC10. Therefore, there will be no difference in pavement structure between Japanese and Tanzanian Methods. Table 2-12 shows detailed computation of the design traffic load and Table 2-13 shows the Traffic Load Class to be used for the pavement design. The equivalent factors used for the Project are as shown in the following Table 2-14.

## Table 2-12 Calculation of Design Traffic Loading

| Type of vehicle | Basic design study 2001 (ADT) | Annual number of vehicle (nos.) | Vehicle equivalency factors 8.2t | Annual traffic loading 8.2t | Traffic growth rates (%) 2001-2003 | Traffic growth rates (%) 2003- | Project Construction 2002 | Project Construction 2003 | 1<br>2004 | 2<br>2005 | 3<br>2006 | 4<br>2007 | 5<br>2008 | 6<br>2009 | 7<br>2010 | 8<br>2011 | 9<br>2012 | 10<br>2013 | Total 10 yeas |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Medium Goods Vehicle | 223 | 43,953 | 2.920 | 128343.6 | 4.0 | 3.0 | 133,477 | 138,816 | 142,981 | 147,270 | 151,689 | 156,239 | 160,926 | 165,754 | 170,727 | 175,849 | 181,124 | 186,558 | 1,348,865 |
| Heavy Goods Vehicle | 33 | 6,504 | 5.869 | 38173.7 | 4.0 | 3.0 | 39,701 | 41,289 | 42,527 | 43,803 | 45,117 | 46,471 | 47,865 | 49,301 | 50,780 | 52,303 | 53,872 | 55,489 | 401,198 |
| Very Heavy Goods Vehicle | 17 | 3,351 | 21.693 | 72686.7 | 4.0 | 3.0 | 75,594 | 78,618 | 80,977 | 83,406 | 85,908 | 88,485 | 91,140 | 93,874 | 96,690 | 99,591 | 102,579 | 105,656 | 763,923 |
| Buses<br>seating capacity of 40, or more | 53 | 10,446 | 3.456 | 36102.4 | 5.5 | 4.8 | 38,088 | 40,183 | 42,112 | 44,133 | 46,251 | 48,471 | 50,798 | 53,236 | 55,792 | 58,470 | 61,276 | 64,218 | 524,758 |
| Cumulative EAL | | 90% of one traffic lane | | | | | | | 266,485 | 274,479 | 282,714 | 291,195 | 299,931 | 308,929 | 318,197 | 327,743 | 337,575 | 347,702 | 3,054,950 |
| | | | | | | | | | | | | | | | | | | Design traffic loading at 10 years | 3.05 *10^6 |

| Type of vehicle | 11<br>2014 | 12<br>2015 | 13<br>2016 | 14<br>2017 | 15<br>2018 | 16<br>2019 | 17<br>2020 | 18<br>2021 | 19<br>2022 | 20<br>2023 | Total 20 years |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Medium Goods Vehicle | 192,154 | 197,919 | 203,857 | 209,972 | 216,272 | 222,760 | 229,442 | 236,326 | 243,416 | 250,718 | 3,551,701 |
| Heavy Goods Vehicle | 57,153 | 58,868 | 60,634 | 62,453 | 64,326 | 66,256 | 68,244 | 70,291 | 72,400 | 74,572 | 1,056,396 |
| Very Heavy Goods Vehicle | 108,826 | 112,090 | 115,453 | 118,917 | 122,484 | 126,159 | 129,944 | 133,842 | 137,857 | 141,993 | 2,011,487 |
| Buses<br>seating capacity of 40, or more | 67,300 | 70,530 | 73,916 | 77,464 | 81,182 | 85,079 | 89,163 | 93,442 | 97,928 | 102,628 | 1,363,390 |
| Cumulative EAL | 425,433 | 439,408 | 453,860 | 468,806 | 484,264 | 500,254 | 516,793 | 533,901 | 551,600 | 569,911 | 7,999,180 |
| | | | | | | | | | | Design traffic loading at 20 years | 8.00 *10^6 |



## Table 2-13 Traffic Load Class - TLC

| Design traffic loading [E80*10^6] | Traffic load class (TLC) | Kitonga Gorge |
|---|---|---|
| <0.2 | TLC02 | |
| 0.2 to 0.5 | TLC05 | |
| 0.5 to 1.0 | TLC1 | |
| 1.0 to 3.0 | TLC3 | |
| 3.0 to 10.0 | TLC10 | ● |
| 10.0 to 20.0 | TLC20 | |
| 20.0 to 50.0 | TLC50 | |

Reference : P8.4 Pavement and Materials Design Manual 1999

TLC : Traffic Load Class

Table 2-14 Equivalent Factor (E80) by Vehicle Category

| Heavy Vehicle Category | | Average Gross Weight (tons) | Average Equivalent Factor (80kN) | ADT (Vehicle/Day) |
|---|---|---|---|---|
| Medium Goods Vehicle (MGV) | - 2 group axles, incl.steering axle<br>- 3 tonnes empty weight, or more | 13.107 | 2.920 | 387 |
| Heavy Goods Vehicle (HGV) | - 3 group axles, incl.steering axle<br>- 3 tonnes empty weight, or more | 24.130 | 5.869 | 221 |
| Very Heavy Goods Vehicle (VHGV) | - 4 or more group axles, incl.steering axle<br>- 3 tonnes empty weight, or more | 47.867 | 21.693 | 233 |
| Buses | - Seating capacity of 40, or more | 15.584 | 3.456 | 218 |

Source: SUMMARY AXLE LOAD SURVEY 2000 FOR PAVEMENT MONITORING PROGRAMME
Survey Point: MIKUMI
Survey Period: 17th-24th November, 2000

## ― Design Subgrade CBR

The relation between the amount of penetration by DCP and CBR is defined in the following equation (refer to the "Overseas Road Note 31, A Guide to the Structural Design of Bitumen-surfaced Roads in Tropical and Sub-tropical Countries", Overseas Centre Transport Research Laboratory, Crownthorne, Cerkshire, United Kingdom):

$$\log10(CBR_{DCP}) = 2.632 - 1.28 \log10(\Delta S)$$

where, $CBR_{DCP}$ : CBR estimated by DCP

$\Delta S$ : Amount of penetration by DCP (mm/blow)

The Project road was divided into 3 sections based on topography. Table 2-15 shows integrated CBR values of exiting subbase and subgrade in 1m depth under crushed stone materials which were considered as the base course of the exiting pavement. The subgrade CBR was determined from the following equation:

$$CBRm=\{ (h_1 CBR_{1}{}^{1/3} + h_2 CBR_{2}{}^{1/3} + \cdots + h_n CBR_{n}{}^{1/3} ) / 100 \}^3$$

Where, CBRm : CBR at reflective point "m"

$CBR_1, CBR_2, \cdots, CBRn$ : CBR of each layer of subgrade at reflective point "m"

$h_1, h_2, \cdots, hn$ : depth of each layer at reflective point "m" (cm)

$h_1 + h_2 + \cdots + hn = 100$ cm

Table 2-15 Subgrade CBR obtained by DCP

a) Flat Section-1 (435k+000~439k+300)

| Pit No. | TP- 1 | TP- 2 | TP- 3 | TP- 4 | TP- 5 | TP- 6 | TP- 7 | TP- 8 | TP- 9 |
|---|---|---|---|---|---|---|---|---|---|
| Sta. No | 435k+000 | 435k+520 | 436k+053 | 436k+559 | 436k+800 | 437k+500 | 438k+100 | 438k+500 | 439k+000 |
| $CBR_{DCP}$ | 16 | 24 | 32 | 107 | 19 | 25 | 36 | 79 | 60 |

b) Gorge Section (439k+300~440k+800)

| Pit No. | TP-10 | TP- 11 | TP-12 | TP-13 | TP-14 | TP-15 | TP-16 |
|---|---|---|---|---|---|---|---|
| Sta. No | 439k+500 | 440k+000 | 440k+500 | 441k+000 | 441k+500 | 442k+000 | 442k+500 |
| $CBR_{DCP}$ | 165 | 93 | 93 | 107 | 99 | 64 | 72 |

| Pit No. | TP-17 | TP-18 | TP-19 | TP-20 | TP-21 | TP-22 | TP-23 | TP-24 |
|---|---|---|---|---|---|---|---|---|
| Sta. No | 443k+000 | 443k+500 | 444k+000 | 444k+500 | 445k+000 | 445k+500 | 446k+000 | 446k+500 |
| $CBR_{DCP}$ | 232 | 320 | 66 | 18 | 101 | 45 | 89 | 57 |

c) Flat Section-2 (440k+800~445k+000)

| Pit No. | TP-25 | TP-26 | TP-27 | TP-28 | TP-29 | TP-30 | TP-31 |
|---|---|---|---|---|---|---|---|
| Sta. No | 447k+000 | 447k+500 | 448k+000 | 448k+500 | 449k+000 | 449k+500 | 450k+000 |
| $CBR_{DCP}$ | 80 | 67 | 177 | 70 | 69 | 54 | 71 |

The design CBR for each homogenous section has been determined in accordance with statistical method specified in the "Pavement and Material Design Manual, 1999", MOW, Tanzania. The CBR for a section is the 90% value of the CBR test results for a section with homogenous strength. The design CBR will be "d-th" value plotted in a graph in ascending order, except values in cut sections, as indicated in the following equation:

$d = 0.1 \times ( n - 1 )$

where, d : value on X-axis stating from "1"

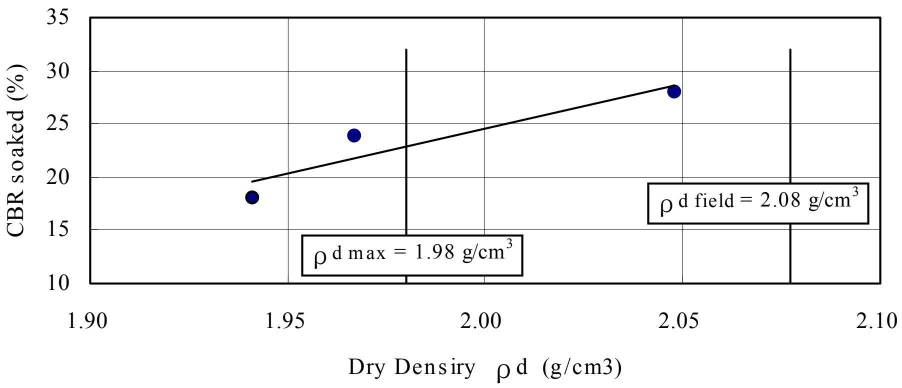
n : number of samples

Table 2-16 Design CBR obtained by DCP

| Section | | n | d | Design $CBR_{DCP}$ |
|---|---|---|---|---|
| Flat Section-1: | 435k+000~439k+300 | 9 | 0.8 | 22 |
| Gorge Section: | 439k+300~440k+800 | 14 | 1.3 | 59 |
| Flat Section-2: | 440k+800~445k+000 | 7 | 0.6 | 62 |

* CBR data at T/P-20(CBR=18) in Kitonga Gorge section was omitted.

T/P-13 (441k+000)




T/P-23 (446k+000)

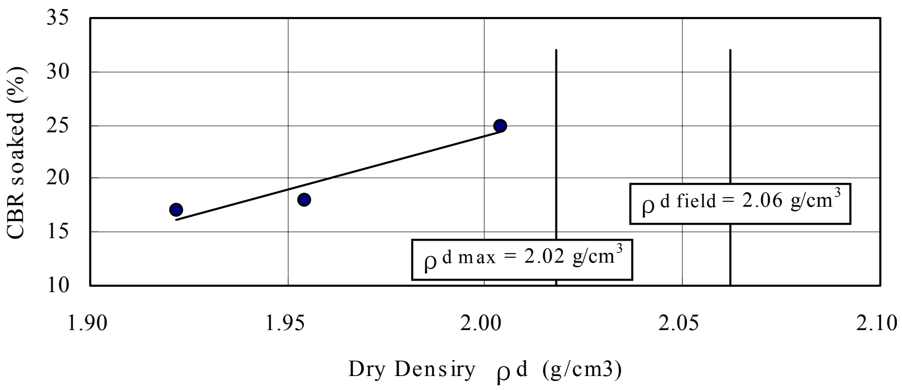



Fig. 2-8 4-day Soaked CBR of Subgrade Materials from Test Pits

Test pits were excavated and subgrade materials were sampled at T/P-13 (441k+000) and T/P-23 (446k+000) in the gorge section. Four-day soaked CBR tests in the laboratory were carried out at three dry density values. Fig. 2-8 shows a test result, relation of dry density ρd and CBR values. The field density ( ρd field) test results are also shown in the figure. Since the dry density of CBR tests at both locations were lower than the field density, the CBR value at the equivalent field density has been established as follows:

T/P-13: 4-day soaked CBR at the equivalent field density CBR>=28

T/P-23: 4-day soaked CBR at the equivalent field density CBR>=25

Fig.2-9 shows sieve analysis test results of the subgrade materials sampled from the gorge section.

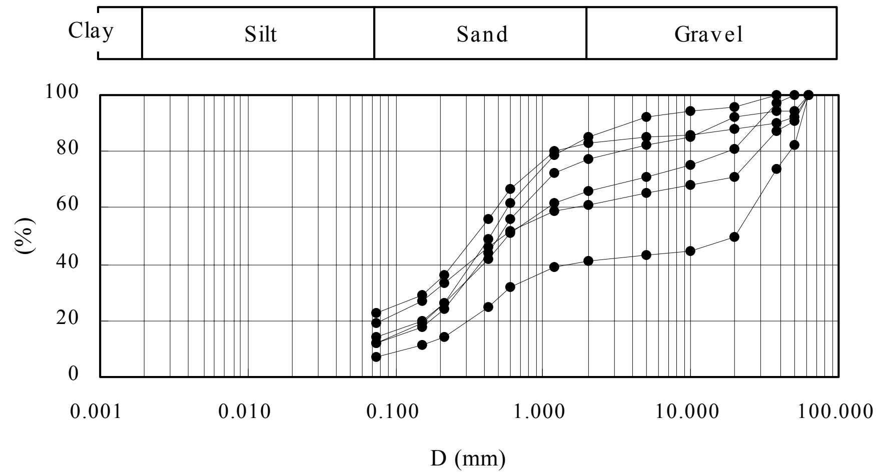



Fig. 2-9 Grading of Subgrade Materials in Gorge Section

### — Design CBR by Section

The CBR values estimated form the DCP tests at field were considerably higher than those of soaked CBR in laboratory. However, since it is assumed that the penetration amount of DCP has good correlation with CBR value in general, the DCP-based CBR can be converted to the design CBR. A conversion factor from the DCP-based CBR to the soaked CBR can be obtained comparing both test results on the same point, as follows:

T/P-13：28 / 107 = 0.26
T/P-23：25 / 89 = 0.28

An average of these 2 points is 0.27.

The design CBR for each section can be established using this average conversion factor of 0.27, as shown below:

Flat Section -1 (435k+000~439k+500)： Design CBR＝22×0.27 = 5.9 = 6%
Gorge Section (439k+300~440k+800)： Design CBR＝59×0.27 = 15.9 = 16%
Flat Section-2 (440k+800~447k+500)： Design CBR＝62×0.27 = 16.7 = 17%

### — Computation of Overlay Thickness

Material coefficients for pavement rehabilitation in the Pavement and Materials Design Manual, 1999 are as shown in Table 2-17. The material coefficients for the road base shown in Appendix A-6 were determined based on the DCP test results.

In the overlay section of the Project, the CBR value at Kp437+500 in the starting section is only 35% and this is substantially lower than other sections. Therefore, the overlay section was divided into the following 3 types based on assessment of the base CBR and subgrade CBR strength.

Ov-1：Base Material Coefficient 0.10,  Subgrade CBR 6.0%  （Kp437+500～Kp438+000）
Ov-2：Base Material Coefficient 0.12,  Subgrade CBR 6.0%  （Kp438+000～Kp439+500）
Ov-3：Base Material Coefficient 0.12,  Subgrade CBR 17.0%  （Kp447+000～Kp447+500）

Table 2-17  Material Coefficient for Assessment of Existing Base

| Location (Kp) | Base 1 | | Base 2 | | Base 3 | | Base CBR | Coefficients |
|---|---|---|---|---|---|---|---|---|
| | Thick (cm) | CBR | Thick (cm) | CBR | Thick (cm) | CBR | | |
| KP437+500 | 15.0 | 35.0 | 10.0 | 67.2 | 20.0 | 33.4 | 40 | 0.10 |
| KP438+100 | 15.0 | 85.2 | 10.0 | 49.7 | 15.0 | 83.2 | 74 | 0.12 |
| KP438+500 | 15.0 | 162.0 | 35.0 | 95.7 | 0.0 | 0.0 | 113 | |
| KP439+000 | 15.0 | 140.0 | 5.0 | 311.0 | 0.0 | 0.0 | 175 | |
| KP439+500 | 10.0 | 759.0 | 10.0 | 418.0 | 15.0 | 69.1 | 275 | |
| KP447+000 | - | 79.9 | - | - | - | - | 80 | |
| KP447+500 | 15.0 | 96.7 | 15.0 | 39.8 | 10.0 | 153.0 | 82 | |

Table 2-18  Material Coefficient for Assessment of Existing Pavement

| Type of Material and Condition of the Layer | Existing Material coefficients (a) |
|---|---|
| Surfacing : | |
| Asphalt Concrete (AC) that exhibit some cracking but with little deformation in the wheel paths | 0.30 |
| Low grade base course : | |
| Fully cracked cemented subbase or granular layers of natural gravel or with small proportions of crushed particles, CBR min 60 | 0.12 |
| Natural gravel of nominally subbase quality, CBR min 25 | 0.10 |

Table 2-19 shows a result of pavement thickness calculation.

Table 2-19 Thickness Calculation of Pavement

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Type | Start | End | Length | Design | SN | Existing Base | | Exsiting Pavement | | New Overlay Pavement | | Total |
| of Pavement | Point | Point | (m) | CBR | | Thickness (mm) | Co-efficient | Thickness (mm) | Co-efficient | Thickness (mm) | Co-efficient | |
| Ov-1 | Kp437+500 | Kp438+000 | 500.0 | 6 | 3.50 | 450 | 0.10 | 70 | 0.30 | 60 | 0.40 | 3.54 |
| Ov-2 | Kp438+000 | Kp439+500 | 1500.0 | 6 | 3.50 | 400 | 0.12 | 70 | 0.30 | 60 | 0.40 | 3.66 |
| Ov-3 | Kp447+000 | Kp447+500 | 500.0 | 17 | 2.75 | 400 | 0.12 | 70 | 0.30 | 10 | 0.40 | 2.87 |

Minimum overlay thickness was designed to be 50mm taking the construction easiness into account. Hence, 2 types of overlay thickness, 50mm and 60mm have been planned for the Project.

### 2-2-2-4 Drainage and Drainage Structure Design

― **Design Flood（Return Period）**

Design flood (return period) for the drainage structure design of the Project was established for:

Pipe culvert with large catchment area : 25 years
Pipe culvert with small catchment area : 10 years
Roadside ditches: 5 years

― **Estimation of Runoff**

The peak runoff which causes flooding was estimated by the TRRL (Transport and Road Research Laboratory) method popularly used in East Africa. However, the rational method was used for runoff calculation of surface drainage systems since it uses rainfall intensity and provides better rainfall characteristics than the TRRL method.

The probable daily rainfall, which are a basic input factor for both the TRRL and the rational methods, was established based on the rainfall data of past 40 years at Iringa by applying GUMBLE、PEASON、HAZEN formulas. Since there was no substantial difference on results among 3 formulas, GUMBLE"s formula, which gave the most conservative value, was used for the Project.

Table 2-21 Comparison of Probable Daily Rainfall by Formula

unit：mm/day

| Return Period | 3 | 5 | 10 | 20 | 25 | 50 |
|---|---|---|---|---|---|---|
| GUMBLE | 56.43 | 65.64 | 77.22 | 88.32 | 91.85 | 102.74 |
| PEASON | 53.42 | 62.17 | 72.35 | 82.24 | 85.71 | 96.27 |
| HAZEN | 54.28 | 62.46 | 71.98 | 81.49 | 84.59 | 94.20 |

― **Runoff Estimation by the TRRL Method**

Since the runoff calculated by the TRRL method was for a 10-year flood period (return period), the following equation was used for converting the 10-year runoff to the respective flood runoff of drainage structure.

$$Qx = Ix / I_{10} \times Q_{10}$$

where,

$Qx$ ： Runoff for a return period of “x” years (m3/sec)

$Ix$ ： Probable daily rainfall or a return period of “x” years (mm/day)

$I_{10}$ ： Probable daily rainfall or a return period of 10 years (mm/day)

$Q_{10}$ ： Runoff for a return period of “x” years (m3/sec)

－ **Drainage System and Estimated Runoff by the TRRL Method**

The major water systems in the Project area are the Msavanga river which flows from the west to the east along the right-hand side of the Project road and the Mlowa river which meets the Msavanga river near KP445＋800. The Mlowa river turns from the right-hand to the left-hand side at the Mlowa bridge and meet the Lukosi river. This Lukosi river also partly influences to the drainage systems of the Project. Therefore, surface runoff from the Project road flows from the right to the left and descend to the Lukosi river before the Mlowa bridge. After the bridge, the surface water runs to opposite, from the left to the right, and flows to the Mlowa river or the Musavaran river. The catchment area of the Project road was divided into 44 sub-streams in respects of topography.

Fig. 2-10 shows these drainage systems and Table 2-21 shows catchment area and results of peak runoff estimation. Table 2-22 shows input data and calculation procedures for applying the TRRL method.

V-shaped ditches have been provided along the hillside through the most of road sections and guided to outlets. While, L-shape ditches have been provided along the curve sections to collect the surface water for protection of shoulders and slopes on the valley side.

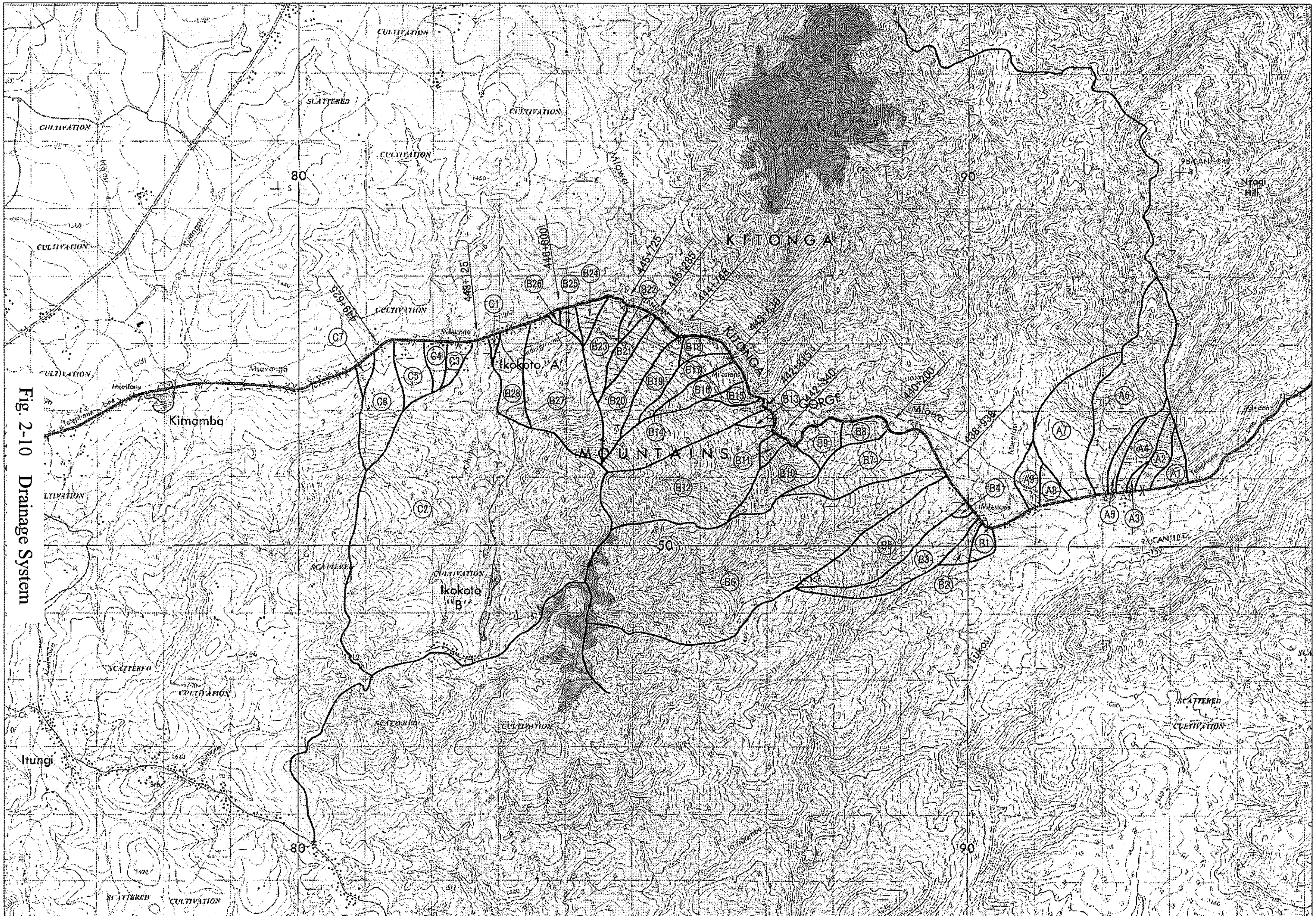



Fig. 2-10 Drainage System

## Table 2-21 Calculation of Catchemnt Area by the TRRL Method

| Cachment Area No. | A km2 | L km | Sc m/m | K hrs | CS | CW | CL | CA | Tp hrs | TB hrs | R10 mm | RTB mm | ARF | P mm | RO m3 | Q m3/s | TA hrs | TB' hrs | RTB' mm | ARF' | P' mm | RO' m3 | Q' m3/s | TA' hrs | TB" hrs | RTB" mm | ARF" | P" mm | RO" m3 | Q" m3/s | Qd m3/s | 5yr m3/s | 10yr m3/s | 25yr m3/s | 50yr m3/s |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A1 | 0.217 | 0.30 | 0.283 | 3.00 | 0.45 | 0.50 | 1.00 | 0.225 | 0.75 | 7.65 | 77.2 | 71.75 | 0.963 | 69.1 | 3374.7 | 0.114 | 0.02718 | 7.68 | 71.77 | 0.963 | 69.135 | 3375.5 | 0.114 | 0.027 | 7.68 | 71.8 | 0.963 | 69.1 | 3375.61 | 0.114 | 0.261 | 0.222 | 0.261 | 0.311 | 0.348 |
| A2 | 0.242 | 0.50 | 0.200 | 3.00 | 0.45 | 0.50 | 1.00 | 0.225 | 0.75 | 7.65 | 77.2 | 71.75 | 0.961 | 69.0 | 3755.5 | 0.127 | 0.05246 | 7.70 | 71.79 | 0.961 | 69.002 | 3757.2 | 0.126 | 0.053 | 7.70 | 71.8 | 0.961 | 69.0 | 3757.28 | 0.126 | 0.290 | 0.246 | 0.290 | 0.345 | 0.386 |
| A3 | 0.028 | 0.30 | 0.100 | 3.00 | 0.45 | 0.50 | 1.00 | 0.225 | 0.75 | 7.65 | 77.2 | 71.75 | 0.987 | 70.8 | 446.1 | 0.015 | 0.07582 | 7.73 | 71.81 | 0.987 | 70.859 | 446.4 | 0.015 | 0.076 | 7.73 | 71.8 | 0.987 | 70.9 | 446.42 | 0.015 | 0.034 | 0.029 | 0.034 | 0.041 | 0.046 |
| A4 | 0.376 | 0.50 | 0.200 | 3.00 | 0.45 | 0.50 | 1.00 | 0.225 | 0.75 | 7.65 | 77.2 | 71.75 | 0.952 | 68.3 | 5776.9 | 0.195 | 0.0471 | 7.70 | 71.79 | 0.952 | 68.312 | 5779.2 | 0.194 | 0.047 | 7.70 | 71.8 | 0.952 | 68.3 | 5779.37 | 0.194 | 0.446 | 0.379 | 0.446 | 0.531 | 0.594 |
| A5 | 0.165 | 0.40 | 0.100 | 3.00 | 0.45 | 0.50 | 1.00 | 0.225 | 0.75 | 7.65 | 77.2 | 71.75 | 0.968 | 69.5 | 2578.6 | 0.087 | 0.0652 | 7.72 | 71.80 | 0.968 | 69.496 | 2580.1 | 0.086 | 0.065 | 7.72 | 71.8 | 0.968 | 69.5 | 2580.11 | 0.086 | 0.199 | 0.169 | 0.199 | 0.236 | 0.264 |
| A6 | 1.665 | 3.00 | 0.200 | 3.00 | 0.45 | 0.50 | 1.00 | 0.225 | 0.75 | 7.65 | 77.2 | 71.75 | 0.898 | 64.5 | 24146.8 | 0.815 | 0.19766 | 7.85 | 71.90 | 0.897 | 64.524 | 24172.2 | 0.796 | 0.199 | 7.85 | 71.9 | 0.897 | 64.5 | 24174.29 | 0.796 | 1.830 | 1.555 | 1.830 | 2.177 | 2.435 |
| A7 | 1.247 | 1.50 | 0.053 | 2.50 | 0.45 | 0.50 | 1.00 | 0.225 | 0.75 | 6.50 | 77.2 | 70.79 | 0.917 | 64.9 | 18206.2 | 0.724 | 0.19725 | 6.70 | 70.97 | 0.916 | 64.996 | 18236.3 | 0.703 | 0.199 | 6.70 | 71.0 | 0.916 | 65.0 | 18237.56 | 0.703 | 1.618 | 1.374 | 1.618 | 1.924 | 2.152 |
| A8 | 0.150 | 0.30 | 0.086 | 2.50 | 0.45 | 0.50 | 1.00 | 0.225 | 0.75 | 6.50 | 77.2 | 70.79 | 0.971 | 68.7 | 2320.1 | 0.092 | 0.05198 | 6.55 | 70.84 | 0.971 | 68.785 | 2321.5 | 0.092 | 0.052 | 6.55 | 70.8 | 0.971 | 68.8 | 2321.54 | 0.092 | 0.211 | 0.179 | 0.211 | 0.250 | 0.280 |
| A9 | 0.260 | 0.65 | 0.086 | 2.50 | 0.45 | 0.50 | 1.00 | 0.225 | 0.75 | 6.50 | 77.2 | 70.79 | 0.962 | 68.1 | 3983.6 | 0.158 | 0.09839 | 6.60 | 70.88 | 0.962 | 68.17 | 3987.9 | 0.156 | 0.099 | 6.60 | 70.9 | 0.962 | 68.2 | 3988.06 | 0.156 | 0.359 | 0.305 | 0.359 | 0.427 | 0.478 |
| B1 | 0.088 | 0.30 | 0.100 | 2.30 | 0.45 | 0.50 | 1.00 | 0.225 | 0.75 | 6.04 | 77.2 | 70.33 | 0.978 | 68.8 | 1362.5 | 0.058 | 0.05406 | 6.09 | 70.39 | 0.978 | 68.865 | 1363.5 | 0.058 | 0.054 | 6.09 | 70.4 | 0.978 | 68.9 | 1363.54 | 0.058 | 0.133 | 0.113 | 0.133 | 0.158 | 0.177 |
| B2 | 0.172 | 0.70 | 0.100 | 2.50 | 0.45 | 0.50 | 1.00 | 0.225 | 0.75 | 6.50 | 77.2 | 70.79 | 0.969 | 68.6 | 2654.8 | 0.106 | 0.10875 | 6.61 | 70.89 | 0.969 | 68.684 | 2658.1 | 0.104 | 0.109 | 6.61 | 70.9 | 0.969 | 68.7 | 2658.14 | 0.104 | 0.239 | 0.203 | 0.239 | 0.284 | 0.318 |
| B3 | 0.818 | 2.00 | 0.127 | 3.00 | 0.45 | 0.50 | 1.00 | 0.225 | 0.75 | 7.65 | 77.2 | 71.75 | 0.929 | 66.6 | 12264.8 | 0.414 | 0.19611 | 7.85 | 71.90 | 0.928 | 66.729 | 12281.4 | 0.404 | 0.197 | 7.85 | 71.9 | 0.928 | 66.7 | 12282.16 | 0.404 | 0.930 | 0.790 | 0.930 | 1.106 | 1.237 |
| B4 | 0.030 | 0.15 | 0.100 | 3.00 | 0.45 | 0.50 | 1.00 | 0.225 | 0.75 | 7.65 | 77.2 | 71.75 | 0.986 | 70.8 | 477.7 | 0.016 | 0.03727 | 7.69 | 71.78 | 0.986 | 70.799 | 477.9 | 0.016 | 0.037 | 7.69 | 71.8 | 0.986 | 70.8 | 477.90 | 0.016 | 0.037 | 0.031 | 0.037 | 0.044 | 0.049 |
| B5 | 1.379 | 2.00 | 0.241 | 3.00 | 0.45 | 0.50 | 1.00 | 0.225 | 0.75 | 7.65 | 77.2 | 71.75 | 0.907 | 65.1 | 20202.7 | 0.682 | 0.12552 | 7.78 | 71.85 | 0.907 | 65.16 | 20217.6 | 0.672 | 0.126 | 7.78 | 71.8 | 0.907 | 65.2 | 20219.04 | 0.672 | 1.545 | 1.312 | 1.545 | 1.838 | 2.056 |
| B6 | 6.342 | 5.80 | 0.166 | 3.50 | 0.45 | 0.75 | 1.00 | 0.3375 | 0.75 | 8.80 | 77.2 | 72.53 | 0.792 | 57.4 | 122963.1 | 3.610 | 0.28918 | 9.09 | 72.71 | 0.790 | 57.422 | 122907.6 | 3.493 | 0.292 | 9.09 | 72.7 | 0.790 | 57.4 | 122931.202 | 3.493 | 8.034 | 6.825 | 8.034 | 9.556 | 10.689 |
| B7 | 0.571 | 1.90 | 0.179 | 3.00 | 0.45 | 0.50 | 1.00 | 0.225 | 0.75 | 7.65 | 77.2 | 71.75 | 0.940 | 67.5 | 8669.5 | 0.293 | 0.17095 | 7.82 | 71.88 | 0.940 | 67.566 | 8680.6 | 0.287 | 0.172 | 7.82 | 71.9 | 0.940 | 67.6 | 8681.04 | 0.287 | 0.659 | 0.560 | 0.659 | 0.784 | 0.877 |
| B8 | 0.213 | 0.20 | 0.320 | 0.50 | 0.45 | 0.50 | 0.70 | 0.1575 | 0.75 | 1.90 | 77.2 | 60.60 | 0.977 | 59.2 | 1986.5 | 0.270 | 0.01373 | 1.91 | 60.68 | 0.977 | 59.29 | 1989.0 | 0.268 | 0.014 | 1.91 | 60.7 | 0.977 | 59.3 | 1989.05 | 0.268 | 0.752 | 0.639 | 0.752 | 0.894 | 1.000 |
| B9 | 0.315 | 0.20 | 0.320 | 0.30 | 0.45 | 0.50 | 0.70 | 0.1575 | 0.75 | 1.44 | 77.2 | 57.33 | 0.975 | 55.9 | 2772.4 | 0.497 | 0.01179 | 1.45 | 57.44 | 0.975 | 55.976 | 2777.1 | 0.494 | 0.012 | 1.45 | 57.4 | 0.975 | 56.0 | 2777.12 | 0.494 | 1.384 | 1.175 | 1.384 | 1.646 | 1.841 |
| B10 | 0.656 | 1.10 | 0.282 | 2.00 | 0.45 | 0.50 | 0.50 | 0.1125 | 0.75 | 5.35 | 77.2 | 69.55 | 0.943 | 65.6 | 4841.8 | 0.234 | 0.08341 | 5.43 | 69.65 | 0.943 | 65.683 | 4847.4 | 0.230 | 0.084 | 5.43 | 69.7 | 0.943 | 65.7 | 4847.61 | 0.230 | 0.530 | 0.450 | 0.530 | 0.631 | 0.705 |
| B11 | 0.106 | 0.20 | 0.320 | 0.30 | 0.50 | 0.50 | 0.50 | 0.125 | 0.75 | 1.44 | 77.2 | 57.33 | 0.985 | 56.5 | 748.5 | 0.134 | 0.01635 | 1.46 | 57.48 | 0.985 | 56.627 | 750.3 | 0.133 | 0.016 | 1.46 | 57.5 | 0.985 | 56.6 | 750.31 | 0.133 | 0.373 | 0.317 | 0.373 | 0.443 | 0.496 |
| B12 | 2.437 | 2.55 | 0.266 | 4.30 | 0.50 | 0.75 | 0.50 | 0.1875 | 0.75 | 10.64 | 77.2 | 73.53 | 0.863 | 63.4 | 28982.9 | 0.704 | 0.15115 | 10.79 | 73.60 | 0.862 | 63.442 | 28989.2 | 0.694 | 0.152 | 10.79 | 73.6 | 0.862 | 63.5 | 28992.90 | 0.694 | 1.596 | 1.356 | 1.596 | 1.899 | 2.124 |
| B13 | 0.090 | 0.20 | 0.320 | 0.30 | 0.50 | 0.50 | 0.50 | 0.125 | 0.75 | 1.44 | 77.2 | 57.33 | 0.986 | 56.6 | 636.3 | 0.114 | 0.01703 | 1.46 | 57.48 | 0.986 | 56.699 | 637.9 | 0.113 | 0.017 | 1.46 | 57.5 | 0.986 | 56.7 | 637.87 | 0.113 | 0.260 | 0.221 | 0.260 | 0.309 | 0.346 |
| B14 | 1.130 | 1.40 | 0.270 | 2.00 | 0.50 | 0.75 | 0.50 | 0.1875 | 0.75 | 5.35 | 77.2 | 69.55 | 0.926 | 64.4 | 13639.6 | 0.659 | 0.08374 | 5.43 | 69.65 | 0.925 | 64.444 | 13654.1 | 0.649 | 0.084 | 5.43 | 69.7 | 0.925 | 64.4 | 13654.75 | 0.649 | 1.493 | 1.268 | 1.493 | 1.776 | 1.986 |
| B15 | 0.150 | 0.20 | 0.320 | 0.30 | 0.50 | 0.50 | 0.50 | 0.125 | 0.75 | 1.44 | 77.2 | 57.33 | 0.983 | 56.3 | 1056.2 | 0.189 | 0.015 | 1.46 | 57.46 | 0.982 | 56.455 | 1058.5 | 0.188 | 0.015 | 1.46 | 57.5 | 0.982 | 56.5 | 1058.54 | 0.188 | 0.526 | 0.447 | 0.526 | 0.626 | 0.700 |
| B16 | 0.349 | 0.90 | 0.267 | 2.00 | 0.50 | 0.50 | 0.50 | 0.125 | 0.75 | 5.35 | 77.2 | 69.55 | 0.959 | 66.7 | 2908.6 | 0.140 | 0.07966 | 5.43 | 69.65 | 0.958 | 66.753 | 2912.1 | 0.139 | 0.080 | 5.43 | 69.6 | 0.958 | 66.8 | 2912.19 | 0.139 | 0.319 | 0.271 | 0.319 | 0.379 | 0.424 |
| B17 | 0.296 | 1.00 | 0.276 | 2.00 | 0.50 | 0.50 | 0.50 | 0.125 | 0.75 | 5.35 | 77.2 | 69.55 | 0.962 | 66.9 | 2475.3 | 0.120 | 0.09064 | 5.44 | 69.66 | 0.962 | 66.993 | 2478.7 | 0.118 | 0.091 | 5.44 | 69.7 | 0.962 | 67.0 | 2478.80 | 0.118 | 0.271 | 0.230 | 0.271 | 0.322 | 0.360 |
| B18 | 0.256 | 0.20 | 0.320 | 0.30 | 0.50 | 0.50 | 0.50 | 0.125 | 0.75 | 1.44 | 77.2 | 57.33 | 0.977 | 56.0 | 1792.8 | 0.322 | 0.01315 | 1.45 | 57.45 | 0.977 | 56.131 | 1796.2 | 0.319 | 0.013 | 1.45 | 57.4 | 0.977 | 56.1 | 1796.20 | 0.319 | 0.894 | 0.760 | 0.894 | 1.063 | 1.190 |
| B19 | 0.399 | 1.20 | 0.274 | 2.00 | 0.50 | 0.50 | 0.50 | 0.125 | 0.75 | 5.35 | 77.2 | 69.55 | 0.956 | 66.5 | 3315.4 | 0.160 | 0.10148 | 5.45 | 69.67 | 0.956 | 66.574 | 3320.4 | 0.157 | 0.102 | 5.45 | 69.7 | 0.956 | 66.6 | 3320.49 | 0.157 | 0.362 | 0.307 | 0.362 | 0.430 | 0.481 |
| B20 | 0.551 | 1.50 | 0.239 | 2.00 | 0.50 | 0.50 | 0.50 | 0.125 | 0.75 | 5.35 | 77.2 | 69.55 | 0.948 | 65.9 | 4541.3 | 0.219 | 0.12554 | 5.48 | 69.70 | 0.948 | 66.054 | 4549.4 | 0.215 | 0.126 | 5.48 | 69.7 | 0.948 | 66.1 | 4549.62 | 0.215 | 0.494 | 0.419 | 0.494 | 0.587 | 0.657 |
| B21 | 0.291 | 1.00 | 0.236 | 2.00 | 0.50 | 0.50 | 0.50 | 0.125 | 0.75 | 5.35 | 77.2 | 69.55 | 0.962 | 66.9 | 2434.3 | 0.118 | 0.09844 | 5.45 | 69.67 | 0.962 | 67.023 | 2438.0 | 0.116 | 0.099 | 5.45 | 69.7 | 0.962 | 67.0 | 2438.04 | 0.116 | 0.266 | 0.226 | 0.266 | 0.316 | 0.354 |
| B22 | 0.060 | 0.30 | 0.160 | 0.50 | 0.50 | 0.50 | 0.50 | 0.125 | 0.75 | 1.90 | 77.2 | 60.60 | 0.988 | 59.9 | 449.0 | 0.061 | 0.04225 | 1.94 | 60.84 | 0.988 | 60.099 | 450.7 | 0.060 | 0.042 | 1.94 | 60.8 | 0.988 | 60.1 | 450.75 | 0.060 | 0.168 | 0.143 | 0.168 | 0.200 | 0.223 |
| B23 | 0.435 | 1.05 | 0.232 | 2.00 | 0.50 | 0.50 | 0.50 | 0.125 | 0.75 | 5.35 | 77.2 | 69.55 | 0.954 | 66.3 | 3607.2 | 0.174 | 0.09448 | 5.44 | 69.66 | 0.954 | 66.431 | 3612.2 | 0.171 | 0.095 | 5.44 | 69.7 | 0.954 | 66.4 | 3612.28 | 0.171 | 0.394 | 0.335 | 0.394 | 0.469 | 0.524 |
| B24 | 0.168 | 0.40 | 0.100 | 0.50 | 0.50 | 0.50 | 0.50 | 0.125 | 0.75 | 1.90 | 77.2 | 60.60 | 0.980 | 59.4 | 1246.8 | 0.170 | 0.0552 | 1.96 | 60.92 | 0.979 | 59.666 | 1253.0 | 0.166 | 0.056 | 1.96 | 60.9 | 0.980 | 59.7 | 1253.04 | 0.166 | 0.463 | 0.394 | 0.463 | 0.551 | 0.617 |
| B25 | 0.090 | 0.40 | 0.150 | 0.50 | 0.50 | 0.50 | 0.50 | 0.125 | 0.75 | 1.90 | 77.2 | 60.60 | 0.985 | 59.7 | 671.6 | 0.091 | 0.05261 | 1.95 | 60.90 | 0.985 | 59.987 | 674.9 | 0.089 | 0.053 | 1.95 | 60.9 | 0.985 | 60.0 | 674.88 | 0.089 | 0.250 | 0.212 | 0.250 | 0.297 | 0.333 |
| B26 | 0.020 | 0.20 | 0.100 | 0.50 | 0.45 | 0.50 | 0.50 | 0.1125 | 0.75 | 1.90 | 77.2 | 60.60 | 0.993 | 60.2 | 135.4 | 0.018 | 0.04808 | 1.95 | 60.88 | 0.993 | 60.445 | 136.0 | 0.018 | 0.048 | 1.95 | 60.9 | 0.993 | 60.4 | 136.01 | 0.018 | 0.050 | 0.043 | 0.050 | 0.060 | 0.067 |
| B27 | 1.671 | 1.80 | 0.121 | 2.30 | 0.45 | 0.50 | 0.70 | 0.1575 | 0.75 | 6.04 | 77.2 | 70.33 | 0.906 | 63.7 | 16767.6 | 0.717 | 0.15745 | 6.20 | 70.50 | 0.905 | 63.8 | 16791.1 | 0.700 | 0.158 | 6.20 | 70.5 | 0.905 | 63.8 | 16792.28 | 0.700 | 1.610 | 1.367 | 1.610 | 1.915 | 2.142 |
| B28 | 0.574 | 0.90 | 0.107 | 2.30 | 0.45 | 0.50 | 1.00 | 0.225 | 0.75 | 6.04 | 77.2 | 70.33 | 0.945 | 66.5 | 8582.3 | 0.367 | 0.09897 | 6.14 | 70.44 | 0.945 | 66.528 | 8592.1 | 0.362 | 0.099 | 6.14 | 70.4 | 0.945 | 66.5 | 8592.40 | 0.362 | 0.832 | 0.706 | 0.832 | 0.989 | 1.106 |
| C1 | 0.036 | 0.20 | 0.100 | 2.30 | 0.45 | 0.50 | 1.00 | 0.225 | 0.75 | 6.04 | 77.2 | 70.33 | 0.986 | 69.4 | 561.8 | 0.024 | 0.04498 | 6.08 | 70.38 | 0.986 | 69.406 | 562.2 | 0.024 | 0.045 | 6.09 | 70.4 | 0.986 | 69.4 | 562.19 | 0.024 | 0.055 | 0.047 | 0.055 | 0.065 | 0.073 |
| C2 | 12.250 | 6.00 | 0.094 | 2.80 | 0.45 | 0.75 | 1.00 | 0.3375 | 0.75 | 7.19 | 77.2 | 71.39 | 0.730 | 52.1 | 215411.5 | 7.740 | 0.32852 | 7.52 | 71.65 | 0.726 | 52.002 | 214993.8 | 7.387 | 0.332 | 7.52 | 71.7 | 0.726 | 52.0 | 215043.37 | 7.385 | 16.986 | 14.430 | 16.986 | 20.204 | 22.599 |
| C3 | 0.137 | 0.30 | 0.097 | 2.30 | 0.45 | 0.50 | 1.00 | 0.225 | 0.75 | 6.04 | 77.2 | 70.33 | 0.973 | 68.4 | 2109.6 | 0.090 | 0.04921 | 6.09 | 70.39 | 0.973 | 68.482 | 2111.0 | 0.090 | 0.049 | 6.09 | 70.4 | 0.973 | 68.5 | 2111.00 | 0.090 | 0.206 | 0.175 | 0.206 | 0.245 | 0.274 |
| C4 | 0.137 | 0.30 | 0.097 | 2.30 | 0.45 | 0.50 | 1.00 | 0.225 | 0.75 | 6.04 | 77.2 | 70.33 | 0.973 | 68.4 | 2109.6 | 0.090 | 0.04921 | 6.09 | 70.39 | 0.973 | 68.482 | 2111.0 | 0.090 | 0.049 | 6.09 | 70.4 | 0.973 | 68.5 | 2111.00 | 0.090 | 0.206 | 0.175 | 0.206 | 0.245 | 0.274 |
| C5 | 0.203 | 0.50 | 0.067 | 2.30 | 0.45 | 0.50 | 1.00 | 0.225 | 0.75 | 6.04 | 77.2 | 70.33 | 0.967 | 68.0 | 3107.1 | 0.133 | 0.08958 | 6.13 | 70.43 | 0.967 | 68.104 | 3110.6 | 0.131 | 0.090 | 6.13 | 70.4 | 0.967 | 68.1 | 3110.72 | 0.131 | 0.302 | 0.256 | 0.302 | 0.359 | 0.401 |
| C6 | 0.665 | 1.10 | 0.097 | 2.30 | 0.45 | 0.50 | 1.00 | 0.225 | 0.75 | 6.04 | 77.2 | 70.33 | 0.941 | 66.2 | 9898.6 | 0.423 | 0.1226 | 6.16 | 70.46 | 0.940 | 66.247 | 9912.1 | 0.416 | 0.123 | 6.16 | 70.5 | 0.940 | 66.2 | 9912.58 | 0.415 | 0.956 | 0.812 | 0.956 | 1.137 | 1.271 |
| C7 | 0.090 | 0.20 | 0.100 | 2.30 | 0.45 | 0.50 | 1.00 | 0.225 | 0.75 | 6.04 | 77.2 | 70.33 | 0.978 | 68.8 | 1393.1 | 0.060 | 0.03584 | 6.08 | 70.37 | 0.978 | 68.83 | 1393.8 | 0.059 | 0.036 | 6.08 | 70.4 | 0.978 | 68.8 | 1393.84 | 0.059 | 0.136 | 0.116 | 0.136 | 0.162 | 0.181 |

Table 2-22 Calculation Procedure of Peak Flow by the TRRL Method

- A calculation is performed according to the following procedure by step-by-step by using a run-off A1 as a model
- The formula is created considering the return-period flood as a base for ten years.

| Sr.N. | Items | Descreption | Value | Unit |
|---|---|---|---|---|
| **1st trial** | | | | |
| 1 | Cachment Area:A1 | Geographical map with 1/50000 scale | 0.217 | km2 |
| 2 | Altitude difference | Geographical map with 1/50000 scale | 0.085 | km |
| 3 | Channel Length:L | | 0.30 | km |
| 4 | Channel Slope:S | | 0.283 | m/m |
| 5 | Catcment Type | Caltivated land, Partry Forest | | |
| 6 | Lag Time:K | TRRL Method document Table 7 | 3.0 | hrs |
| 7 | Soil Type | | Well Drained | |
| 8 | Standard Contributing Area Coefficient:CS | | 0.45 | |
| 9 | Catcment Wetness Factor , CW | TRRL Method document Table 5 | 0.50 | |
| 10 | Land Use Factor, CL | TRRL Method document Table 6 | 1.00 | |
| 11 | Contributing Area Coefficient:CA | CA=Cs*CW*CL | 0.225 | |
| 12 | Rainfall Time (Inland Zone ):Tp | TRRL Method document Table 8 | 0.75 | hrs |
| 13 | Index:n | TRRL Method document Table 8 | 0.96 | |
| 14 | Base Time | TB=Tp+2.3K+TA 1st:TA=0 | 7.65 | hrs |
| 15 | 10year daily point rainfall:$R^{10/24}$ | | 77.2 | mm |
| 16 | Rainfall duaring Base Time:RTB | $TB/24*(24.33/(TB+0.33))^n*R10/24$ | 71.75 | mm |
| 17 | Area Redaction Factor:ARF | $1-0.04*TB^{1/3}*A1^{0.5}$ | 0.963 | |
| 18 | Average Rainfall:P | RTB*ARF | 69.12 | mm |
| 19 | Volume of Runoff:RO | $CA*(P-Y)*A1*10^3$ Y=0(Fix) | 3374.7 | m3 |
| 20 | Average Flow:Q | 0.93*RO/(3600*TB) | 0.114 | m3/sec |
| 21 | Attenuation Time:TA | $0.028*L/(Q^{1/4}*S^{1/2})$ | 0.027 | |
| 22 | Recalculatied base time:TB' | TB=Tp+2.3K+TA | 7.677 | hrs |
| **2nd trial** | | | | |
| 23 | RTB' | | 71.77 | mm |
| 24 | ARF' | | 0.963 | |
| 25 | P' | | 69.14 | mm |
| 26 | RQ' | | 3375.61 | m3 |
| 27 | Q' | | 0.114 | m3/s |
| 28 | TA' | | 0.027 | hr |
| 29 | TB" | | 7.677 | hr |
| **3rd trial** | | | | |
| 32 | ARF" | | 0.963 | |
| 33 | RTB" | | 72.04 | mm |
| 34 | P" | | 69.39 | mm |
| 35 | RO" | | 3387.88 | m3 |
| 36 | Q" | | 0.114 | m3/s |
| 37 | | | | |
| 38 | Design Peak Flow:Qd | F*Q" F=2.3(Fix) | 0.262 | m3/s |
| 39 | 5yr | $Qd*R_{5/24}/R_{10/24}$ | 0.223 | m3/s |
| 40 | 10yr | $Qd*_{R10/24}/R_{10/24}$ | 0.262 | m3/s |
| 41 | 25yr | $Qd*R_{25/24}/R_{10/24}$ | 0.312 | m3/s |
| 42 | 50yr | $Qd*R_{50/24}/R_{10/24}$ | 0.349 | m3/s |

source:TRRL Laboratory Report 706

## — Rainfall Intensity

The rainfall intensity necessary for runoff calculation was estimated by correcting the formula established for Dar es Salaam with the probable daily rainfall factor since there were no data and analysis near the Project site. The rainfall intensity to be used for the drainage design of the Project was established as follows:

Table 2-23 Probable Daily Rainfall at Iringa and Dar es Salaam

unit : mm/day

| Return Period | 3 | 5 | 10 | 20 | 25 | 50 |
|---|---|---|---|---|---|---|
| Iringa | 56.4 | 65.6 | 77.2 | 88.3 | 91.8 | 102.7 |
| Dar es Salaam | 79.6 | 96.6 | 111.0 | 123.6 | 128.5 | 141.2 |

Table 2-24 Rainfall Intensity

unit : mm

| Region | Return Period | Rianfall Intensity | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 15 | min | 30 | min | 1 | hr | 3 | hr | 5 | hr | 7 | hr | 24 | hr |
| Dar es Salaam | 5year | 213.2 | mm | 123.2 | mm | 71.2 | mm | 29.8 | mm | 19.9 | mm | 15.3 | mm | 5.8 | mm |
| | 25year | 189.7 | mm | 109.6 | mm | 63.3 | mm | 26.5 | mm | 17.7 | mm | 13.6 | mm | 5.1 | mm |
| | 50year | 140.4 | mm | 81.0 | mm | 46.8 | mm | 19.6 | mm | 13.1 | mm | 10.0 | mm | 3.8 | mm |
| Iringa | 5year | 144.8 | mm | 83.7 | mm | 48.3 | mm | 20.3 | mm | 13.5 | mm | 10.4 | mm | 3.9 | mm |
| | 25year | 135.6 | mm | 78.3 | mm | 45.2 | mm | 19.0 | mm | 12.7 | mm | 9.7 | mm | 3.7 | mm |
| | 50year | 102.1 | mm | 58.9 | mm | 34.0 | mm | 14.2 | mm | 9.5 | mm | 7.3 | mm | 2.7 | mm |

Fig.2-11 shows the rainfall intensity at Dar es Salaam.

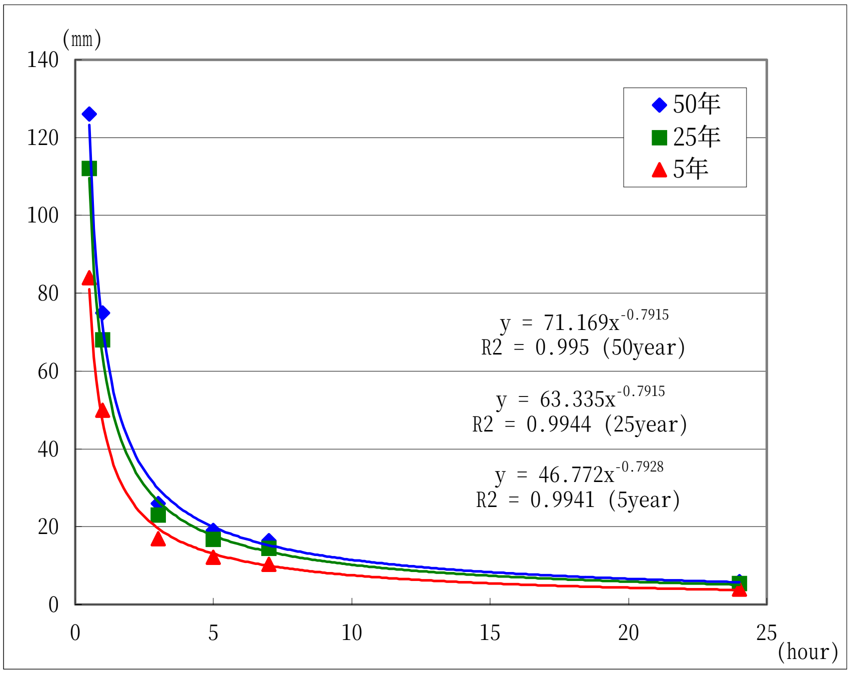



Fig. 2-11 Rainfall Intensity at Dar es Salaam（mm/h）

The rainfall intensity for the Project area has been obtained from the following equation:

$$Ix = Dx / Dd \times Id$$

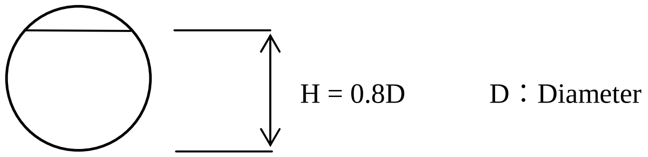
where,

| | | |
|---|---|---|
| Ix | : | Rainfall intensity at the Project area (mm/hr) |
| Dx | : | Probable daily rainfall at Iringa (mm/day) |
| Dd | : | Probable daily rainfall at Dar es Salaam (mm/day) |
| Id | : | Rainfall intensity at Dar es Salaam (mm/hr) |

## — Discharge Capacity of Existing Drainage Structures

a) Culvert

Discharge capacity of a pipe culvert was calculated at 80% of water depth as shown in the following sketch:




Since the sectional area at the 80% water depth is A = 0.512 x $D^2$ and a mean velocity of flow is assumed to be 2.50m/s, the discharge capacity of culvert by diameter will be as follows:

| Diameter（mm） | Velocity of Flow(m/s) | Discharge Capacity(m3/s) |
|---|---|---|
| 600 | 2.50 | 0.44 |
| 900 | 2.50 | 1.00 |
| 1200 | 2.50 | 1.80 |
| 1800 | 2.50 | 4.10 |
| 2200 | 2.50 | 6.10 |
| 3000 | 2.50 | 11.20 |

The runoff, estimated by the TRRL method, for the largest catchment area of C2（12.25ha）is 20.21m3/s. While, the discharge capacity of the existing drainage facility, 2 numbers of ϕ3.0m corrugate metal pipes, is 11.20x2 = 22.40m3/s. Therefore, it has sufficient discharge capacity.

As shown in Table 2-25, since the exiting culverts for other catchment areas have sufficient capacity, no additional culverts will be constructed under the Project.

b) V-shaped Roadside Ditches

The dimensions of the existing roadside ditches are as shown in the following sketch:

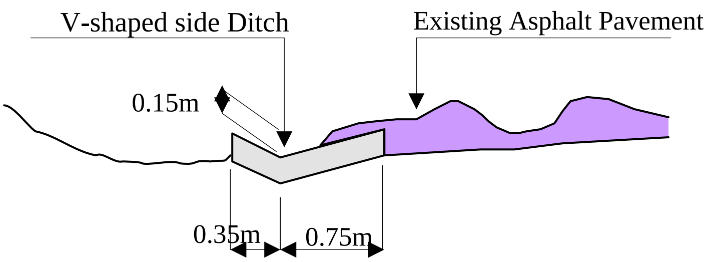


Table 2-25 Flow Capacity of Existing Culverts

| No. of Catch-ment | Area of Cachment km$^2$ | TRRL Method | | Size of Existing Structure | Flow Capacity of Existing Culverts | | Q/Qc | Judge |
|---|---|---|---|---|---|---|---|---|
| | | Q10yr m$^3$/s | Q25yr m$^3$/s | | Qc10yr m$^3$/s | Qc25yr m$^3$/s | | |
| | | | | | | | | |
| A1 | 0.217 | 0.261 | - | 2culverts with 0.90m & 1.20m dia | 2.80 | - | 0.09 | OK |
| A2 | 0.242 | 0.290 | - | Culvert with 0.90m dia | 1.00 | - | 0.29 | OK |
| A3 | 0.028 | 0.034 | - | Culvert with 0.90m dia | 1.00 | - | 0.03 | OK |
| A4 | 0.376 | 0.446 | - | 2culvert with 1.20m & 2.20 dia | 7.90 | - | 0.06 | OK |
| A5 | 0.165 | 0.199 | - | Culvert with 9.00m dia | 1.00 | - | 0.20 | OK |
| A6 | 1.665 | 1.830 | - | 2culverts with 2-1.20m dia | 3.60 | - | 0.51 | OK |
| A7 | 1.247 | 1.618 | - | Culvert with 3.00m dia | 11.20 | - | 0.14 | OK |
| A8 | 0.150 | 0.211 | - | 2culverts with 0.90m dia. | 2.00 | - | 0.11 | OK |
| A9 | 0.260 | 0.359 | - | 3culverts with 0.90m dia | 3.00 | - | 0.12 | OK |
| | | | | | | | | |
| B1 | 0.088 | 0.133 | - | Culvert with 0.90 dia | 1.00 | - | 0.13 | OK |
| B2 | 0.172 | 0.239 | - | Culvert With 2-1.20m dia | 3.60 | - | 0.07 | OK |
| B3 | 0.818 | 0.930 | - | Culvert with 1.80m dia | 4.10 | - | 0.23 | OK |
| B4 | 0.030 | 0.037 | - | Culvert with 0.90m dia | 1.00 | - | 0.04 | OK |
| B5 | 1.379 | 1.545 | - | Culvert with 1.80m dia | 4.10 | - | 0.38 | OK |
| B6 | 6.342 | - | 9.556 | Box culvert with 3.00 x3.00 | - | 11.2 | 0.85 | OK |
| B7 | 0.571 | 0.659 | - | 2culvert with 1.20m dia | 3.60 | - | 0.18 | OK |
| B8 | 0.213 | 0.752 | - | 7culverts with 1.20m and 0.6 dia | 4.44 | - | 0.17 | OK |
| B9 | 0.315 | 1.384 | - | 11culverts with 0.60m and 1.20m dia | 6.20 | - | 0.22 | OK |
| B10 | 0.656 | 0.530 | - | Culvert with 1.80m dia | 4.10 | - | 0.13 | OK |
| B11 | 0.106 | 0.373 | - | 3pit type culvert with 0.60m dia | 1.32 | - | 0.28 | OK |
| B12 | 2.437 | 1.596 | - | Culvert with 3.0m dia class | 11.20 | - | 0.14 | OK |
| B13 | 0.090 | 0.260 | - | 2culverts with 0.90m dia | 2.00 | - | 0.13 | OK |
| B14 | 1.130 | 1.493 | - | Culvert with 1.80m dia | 4.10 | - | 0.36 | OK |
| B15 | 0.150 | 0.526 | - | 5pit type culverts with 0.60m | 2.20 | - | 0.24 | OK |
| B16 | 0.349 | 0.319 | - | 3pit type culverts with 0.60 | 1.32 | - | 0.24 | OK |
| B17 | 0.296 | 0.271 | - | Pit type culvert with 2-1.20m dia | 3.60 | - | 0.08 | OK |
| B18 | 0.256 | 0.894 | - | 12pit type culverts with 0.60m & 0.90m | 4.20 | - | 0.21 | OK |
| B19 | 0.399 | 0.362 | - | 3pit type culverts with 0.90x1.20m box & 0.60m dia | 1.32 | - | 0.27 | OK |
| B20 | 0.551 | 0.494 | - | 5pit type culverts with 1.20m arched box & 0.60m dia | 2.20 | - | 0.22 | OK |
| B21 | 0.291 | 0.266 | - | Culvert with 120m dia | 1.80 | - | 0.15 | OK |
| B22 | 0.060 | 0.168 | - | 2pit type culverts with 0.90m & 0.60m | 1.44 | - | 0.12 | OK |
| B23 | 0.435 | 0.394 | - | Culvert with 1.80m dia | 4.10 | - | 0.10 | OK |
| B24 | 0.168 | 0.463 | - | 6pit type culverts with 0.60m & 0.90m | 3.76 | - | 0.12 | OK |
| B25 | 0.090 | 0.250 | - | 3pit type culvert with 0.60m & 0.90m | 2.44 | - | 0.10 | OK |
| B26 | 0.020 | 0.050 | - | Culvert with 0.90m dia | 1.00 | - | 0.05 | OK |
| B27 | 1.671 | 1.610 | - | Culvert with 3.00m dia | 11.20 | - | 0.14 | OK |
| B28 | 0.574 | 0.832 | - | 2 culverts with 0.90m & 2.20m dia | 7.10 | - | 0.12 | OK |
| | | | | | | | | OK |
| C1 | 0.036 | 0.055 | - | Culvert with 0.90m dia | 1.00 | - | 0.05 | OK |
| C2 | 12.250 | - | 20.204 | Culvert with 2-3.00m dia | - | 22.4 | 0.90 | OK |
| C3 | 0.137 | 0.206 | - | 2culverts with 0.90m & 2-1.20m dia | 4.60 | - | 0.04 | OK |
| C4 | 0.137 | 0.206 | - | 2culverts with 0.90m & 2-1.20m dia | 4.60 | - | 0.04 | OK |
| C5 | 0.203 | 0.302 | - | 2culverts with 0.90m & 2-1.20m dia | 4.60 | - | 0.07 | OK |
| C6 | 0.665 | 0.956 | - | 2culverts with 0.90m & 1.80m dia | 5.10 | - | 0.19 | OK |
| C7 | 0.090 | 0.136 | - | Culverts with 0.90m dia | 1.00 | - | 0.14 | OK |

Since maintenance of V-shaped open ditch is easy, the discharge capacity was calculated on an assumption that silting will not reduce the capacity.

The following Manning's formula has been used for a mean velocity and discharge capacity calculation:

$$V = 1/n \times R^{2/3} \times I^{1/2}$$

$$Q = A \times V$$

where, V = Mean velocity （m/s）
Q = Discharge （m3/s）
A = Area of the flow cross section （m2）
P = Wetted perimeter （m）
n = Manning's roughness coefficient
R = Hydraulic radius = A/P（m）
I = Slope of ditch

Table 2-26 Discharge Capacity of V-shaped Roadside Ditch

| A(m2) | P(m) | R(m) | n | I | V(m/s) | Q(m3/s) |
|---|---|---|---|---|---|---|
| 0.079 | 1.079 | 0.073 | 0.015 | 0.005 | 0.825 | 0.065 |
| | | | | 0.010 | 1.167 | 0.092 |
| | | | | 0.013 | 1.347 | 0.106 |
| | | | | 0.020 | 1.650 | 0.130 |
| | | | | 0.040 | 2.334 | 0.184 |
| | | | | 0.100 | 3.690 | 0.291 |

The largest runoff on V-shaped roadside ditch for the Project occurs at the catchment area of B13.

The runoff from hill slopes and road surface per liner meter of the roadside ditch is as follows:

Qr = 0.212 / 360 = 0.000589m3/m

where, the runoff of B13 = 0.212m3/s and
the length of roadside ditch = 360m

The maximum runoff (or max) on the roadside ditch between the longest catch pit distance of 200m is:

$Q_{r max}$ = 0.000589 x 200 = 0.117m3/s < 0.130m3/s

Since the grade of the roadside ditch in this section is more than 2%, the discharge capacity of 0.130m3/s can be secured.

While, the runoff of the catchment B25, of which road slope is less than 2%, is as follows:

Runoff Q = 0.212m3/s
Section distance L = 355m

Maximum distance between catchpits "l "max = 160m

qr = 0.212 / 355 = 0.000479 m3/s/m

Q max = 0.000597 x 160 = 0.096 < 0.106m3/s （equivalent to 1.5% slope）

Since other road sections are equivalent to the catchment area of B25 or distance between catchpits/culverts is less, all existing roadside ditches have sufficient discharge capacity.

However, care should be taken for a problem that the runoff water overflows the drainage structures because of silting of weathered materials from hillside slopes on the drainage systems. Another problem is that rainfall water flows longitudinally on road surface of steep grades.

### ― Basic Policy on Drainage Structure Design

The drainage structures should be rehabilitated on the following basic policies:

- The existing damaged V-shaped roadside ditches will be replaced with new V-shaped ditches of the same type.
- Gaps behind the V-shaped ditches will be filled with suitable materials to prevent seepage of surface water and protect the pavement from damage.
- Silting, debris and other obstacles in catchpits and culverts will be removed from drainage structures to maintain the required discharge capacity.
- Damaged or lost grating covers for the catchpits will be replaced.
- Where the surface runoff flows to valley side slopes, L-shaped ditches and water chutes will be provided at the shoulder edges or on slopes, guiding the runoff water to appropriate outlets, to protect shoulders and slopes from erosion.

The Manning's formula has been used for a mean velocity and discharge capacity calculation for the L-shaped roadside drains. The 0.5m edge of the pavement will be shaped to provide a function of drainage when heavy rainfall occurs.

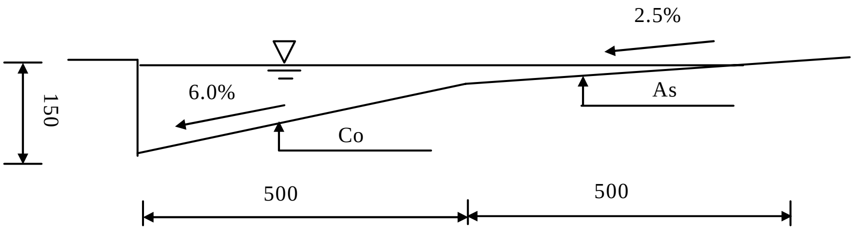



Table 2-27 Discharge Capacity of L-shaped Roadside Ditch

| A(m2) | P(m) | R(m) | n | I | V(m/s) | Q(m3/s) |
|---|---|---|---|---|---|---|
| 0.015 | 1.04 | 0.014 | 0.013 | 0.005 | 0.322 | 0.005 |
| | | | | 0.010 | 0.456 | 0.007 |
| | | | | 0.013 | 0.526 | 0.008 |
| | | | | 0.020 | 0.645 | 0.010 |
| | | | | 0.040 | 0.912 | 0.014 |
| | | | | 0.100 | 1.441 | 0.022 |

The following rational method was used for estimation of the road surface runoff:

$$Q = 1/(3.6 \times 10^6) \times C \times I \times A$$

where, Q = Runoff（m3/s）

C = Coefficient representing the ration of runoff to rainfall (paved road surface 0.70~0.95)

I = Rainfall intensity. 144.8mm / 15minuts from Table 2-24

A = Drainage area (m2) (7.0m2/m since an average road with of the Project is 7.0m)

Hence, the road surface runoff for the Project is:

$$Q = 1/ (3.6 \times 10^6) \times 0.8 \times 144.8 \times 7.0 = 0.00023 \text{ m3/s}$$

A water chute will be provided per 40m length of the L-shaped roadside ditches since an average grade of the road sections, where L-shaped ditches are installed, is approximately 2~4%.

### 2-2-2-5　Traffic Safety Facility Design

#### ー Emergency Parking Bay

According to the field survey, there is passing demand of vehicles for both directions of the up and down vehicle lanes. However, since it is possible to pass vehicles in the approximately 9km of the 15km road sections at present, as shown in Table 2-1, the Project will not provide passing lanes or climbing lanes due to the rehabilitation of existing road.

It was observed that many vehicles, which were broken because of overheating at steep slopes or insufficent maintenace, often park on the carriageway. As a measure to solve this problem, emegency parking bays will be introduced to provide safe spaces for those broken vehicles, taking existing alignment and exsisting topography into account. Dimensions of the parking bay are as shown in the following Fig. 2-12 and locations are shown in Table 2-28 and Fig. 2-13.

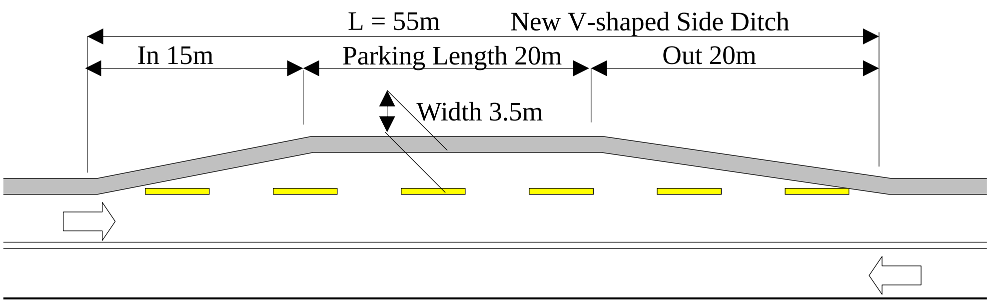



Fig. 2-12　Dimensions of Emergency Parking Bay

Table 2-28　Location of Emergency Parking Bays

| Point （KP） | Up-lane （To IRINGA） | Down-lane （To DSM） |
|---|---|---|
| KP440+100 | | ○ |
| KP440+632 | ○ | |
| KP441+400 | ○ | |
| KP442+ 177 | | ○ |
| KP442+608 | ○ | |
| KP442+780 | | ○ |
| KP444+797 | ○ | |
| KP445+628 | ○ | |
| KP446+327 | ○ | |

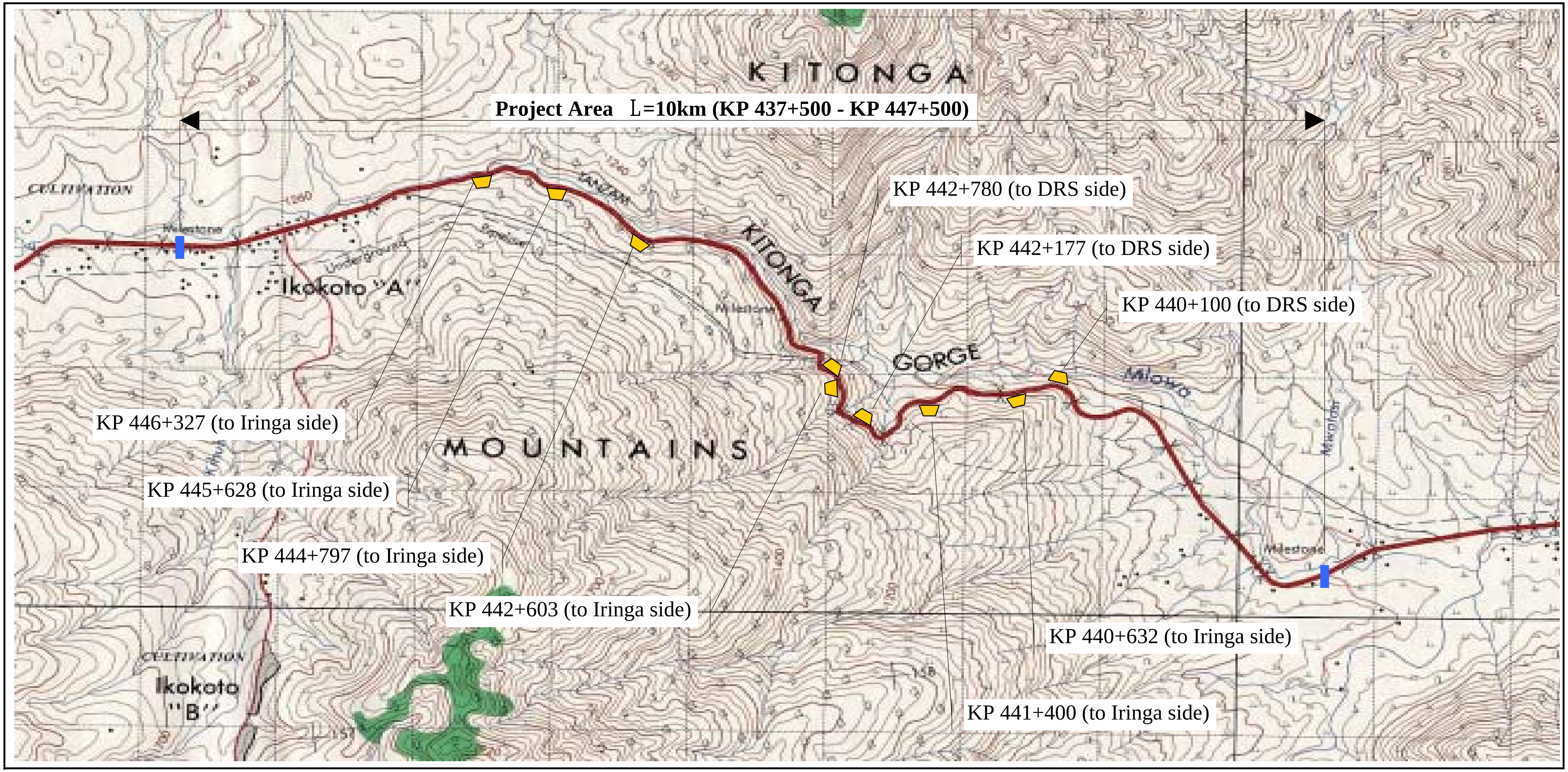



**Fig. 2-13 Layout of Emargency Parking Bays**

– **Vehicle Falling Hazard Prevention Facilities**

The Project will provide concrete barriers and concrete guideposts to minimise accidents of vehicles falling down to valleys from the roadway. These traffic safety facilities will be installed along the road sections on small curves and other hazardous spots where there will be high possibility of vehicles falling down from the roadway.

The minimum radius where superelevation is not required is 120m at the design speed of 30km/h. Safety facilities will be provided at the road sections on all right-bending curves of less than the 120m radius. The concrete barriers will be provided on the right-bending curves of which the radius is smaller than that calculated from the maximum superelevation of 2.5% at the design speed of 30km/h.

In addition, the concrete barriers will be provided at hazardous spots of vehicle falling identified in the field survey.

Equation to calculate the radius of curves where concrete barriers should become necessary is as follows:

$$R=V^2/127(i+f)$$

where,

| | |
|---|---|
| R: | Radius of curve (m) |
| V: | Design speed (km/h) |
| i: | Superelevation of carriageway |
| f: | Side-friction factor between road surface and tire (0.15) |

The product of R=40m is obtained from inputs of V=30km/h and i=0.025 on the above equation. Therefore, the concrete barriers need to be provided on the right-bending curves of which radius is less than 40m (R<40m).

– **Concrete Poles to prevent entering of overloaded vehicles on shoulders**

In the Project road, the distresses of shoulders such as erosion, cracks and deformation caused by surface water flow during heavy rain or heavy axle loads were seen. The Project will install concrete poles on shoulders to prevent the overloaded vehicles entering into shoulders and causing slope failures.

The road sections to provide this facility were determined in the field survey.

### — Traffic Signs

Based on the request from the MOW as a road administrator, type and number of the traffic sign plates as a necessary minimum are determined as shown in Table 2-29. The breakdown is three kinds (overtaking prohibition, overtaking prohibition release, speed limit of 25km/h at gorge section) of propitiatory signs, two kinds (small radius curve, steep hill) of warning signs, and the guidance sign of emergency parking bay.

Warning signs for small radius curve will be installed on the curves of R<=60m where large vehicles of opposite direction is difficult to cross. As shown in the following Table 2-30, those are on the curves where 1.0m widening becomes necessary.

Table 2-29 Type of Traffic Sign Plates

| Type of Road Sign Plate | No. of Plate | Remarks |
|---|---|---|
| Speed Limited (25km/h) | 2 | |
| Overtaking Prohibited | 2 | Attach at "Speed Limited" pole |
| Speed Limited (30km/h) | 2 | |
| End of Prohibited of Overtaking | 2 | Attach at "Speed Limited" pole |
| Dangerous Bend Sign | 26 | including "Double Bend" mark |
| Steep Hill Ascent | 1 | |
| Steep Hill Descent | 1 | |
| Parking | 9 | |
| Total | 45 | |

Table 2-30 Carriageway Widening Requirements

Carriageway Width : 7.0 m

| Radius of Curve (m) | 30 | 40 | 50 | 60 | 80 | 100 | 150 | 200 | 250 | 300 | 400 | 500 | 600 | 800 | 1000 | 1200 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Widening (m) | 9.0 | 8.5 | 8.2 | 8.0 | 7.8 | 7.6 | 7.4 | 7.3 | 7.2 | 7.2 | 7.1 | 7.1 | 7.1 | 7.0 | 7.0 | 7.0 |

An information board will be installed 20m ahead of each emergency parking bay.

Total 45 panels of road sign will be installed as following table according to the instruction by MOW on October 1st, 2001 for the purpose of the safety control of traffic.

－ Lane Marking

With the same reason explained in the preceding sub-section of traffic sign, based on the request from MOW as a road administrator and discussions with Study Team, carriageway lane marking at the center of the road will be provided. Because of the center line is effective and indispensable for the traffic safety as delineator, and moreover the police will take the administrator task about the responsibility when the traffic accident occurred without a division line. Color of the center line is white as following the Tanzanian standard. And others, yellow colored broken lines will be marked between the carriageway and the emergency parking bay to separate moving and parking vehicles.

#### 2-2-2-6 Confirmation of Environmental Consideration Matter

There was a comment considering about the following items with "Comment to environmental consideration" on June 18, 2001 based on the initial field survey of the project area, from NEMC (National Environment Management Council, Ministry of Natural Resource).

1) Technical inputs from geologists are required regarding geological formation of the area and future impacts with respect to disturbance of (rocky escarpment)

2) During the survey it was noted that the TANESCO transmission line crosses in some parts in the escarpment (Thus TANESCO regulations have to be consulted).

3) Environmentally sound disposal of the subbase (pavement) material to be removed should be planned.

4) TAZAMA pipeline intersects the road in three places. This issue needs collaboration with TAZAMA Management and relevant technical expertise needed in view of the undertaking in question.

5) Socio-economic concerns including compensation matters should be taken into account while identifying the borrow-pit area and location of the campsite.

6) Hearth aspects should be given consideration.

7) The undertaking will possibly involve blasting operations, thus mitigations measures for pollution to be caused should be designed (noise, air, and at times water).

8) Erosion control measures should be designed from the early stages of the basic design given the uniqueness of the undertaking.

9) Conservation of the vegetation should be taken into account, as it is significant with respect to erosion control measures.

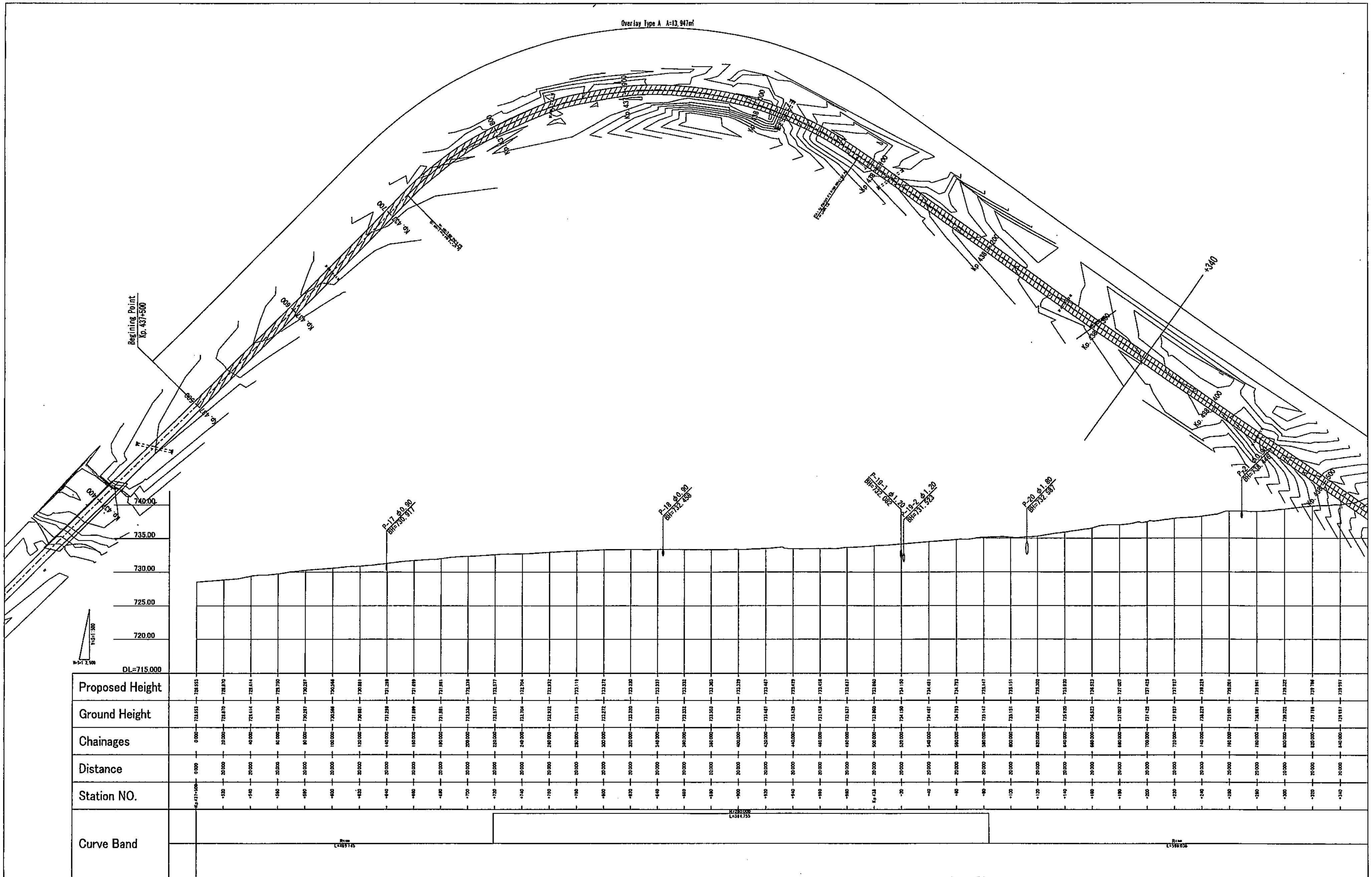
10) Consult relevant documents for Tanzania e.g. Environmental Policy; Tanzania EIA Procedure and Guidelines; Mining Act; Village Land Act 1999; TANESCO Operation Regulations; Ministry of Works Regulations while preparing the basic design.

On the other hand, at the time of "Draft Basic Design Report" explanation, the Study Team explained that this Project is a rehabilitation of pavement at existing road, so it to not including the alteration of a face of mountain slope by cutting, electric line of TANESCO, and TAZAMA pipeline, and not needing the new land acquisition by improvement of the road.

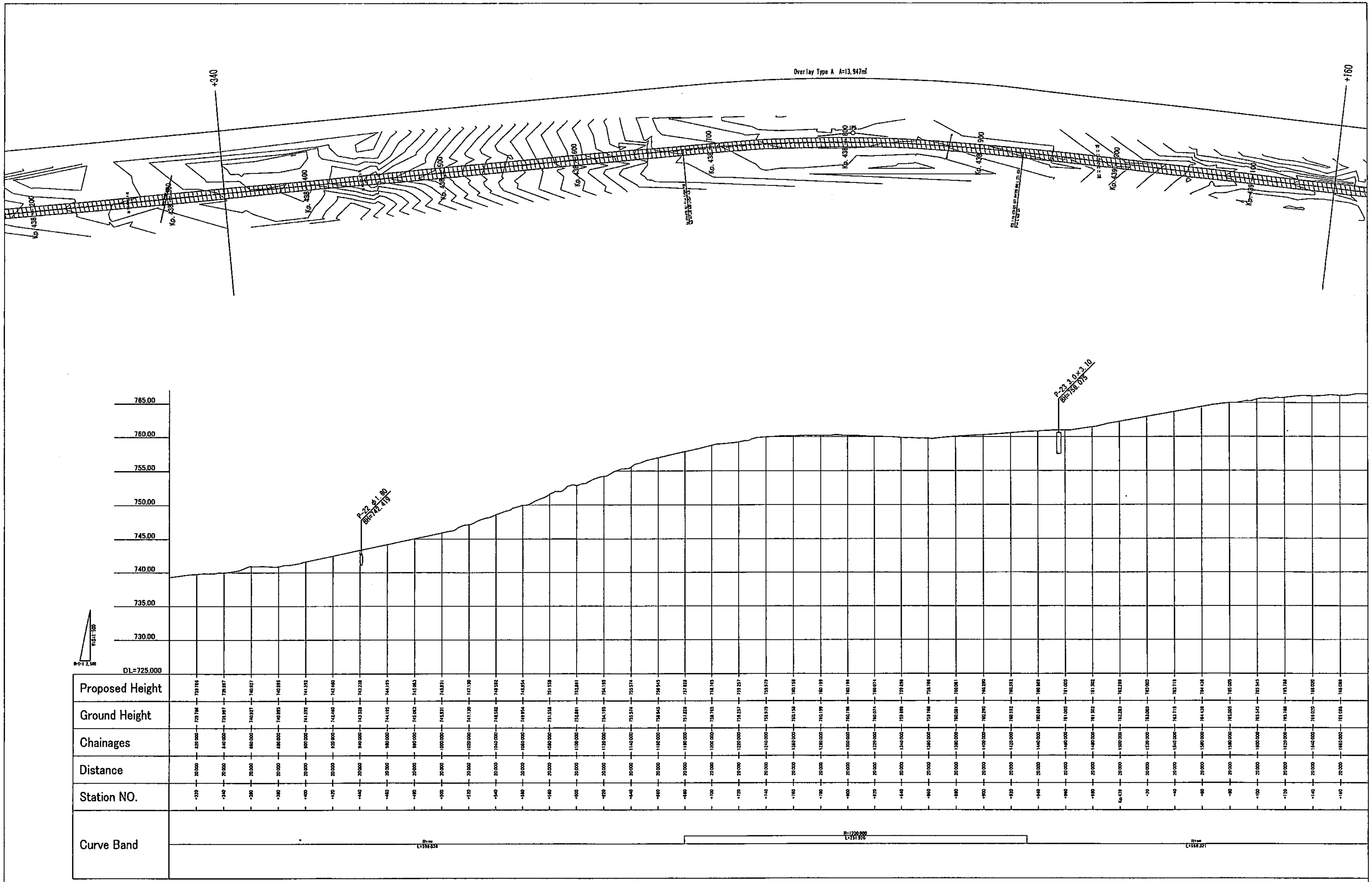
Moreover, it is explained the following consideration matters are incorporated in a detail design stage and construction stage about the reduction of the effect to environment generated along with road construction.

- It sets in a detailed design stage and is fully take account of about corrosion prevention of a proper configuration of drainage facilities, face of slope at valley side, and arrangement of traffic safety facilities, etc.
- In a construction stage, the proper management by the Ministry of Works and the consultant is carried out about a proper treatment of wastes (excess soil, removal asphalt, the slush, waste water, etc.) besides use of low-pollution facilities.
- About the abandonment method and an abandonment place for removed asphalt or soil, it shall be based on an instruction of Ministry of Works.
- Also about a camp site, a plants yard, borrow pits, and quarry site, the effect on local residents is avoided as much as possible, and is planned.

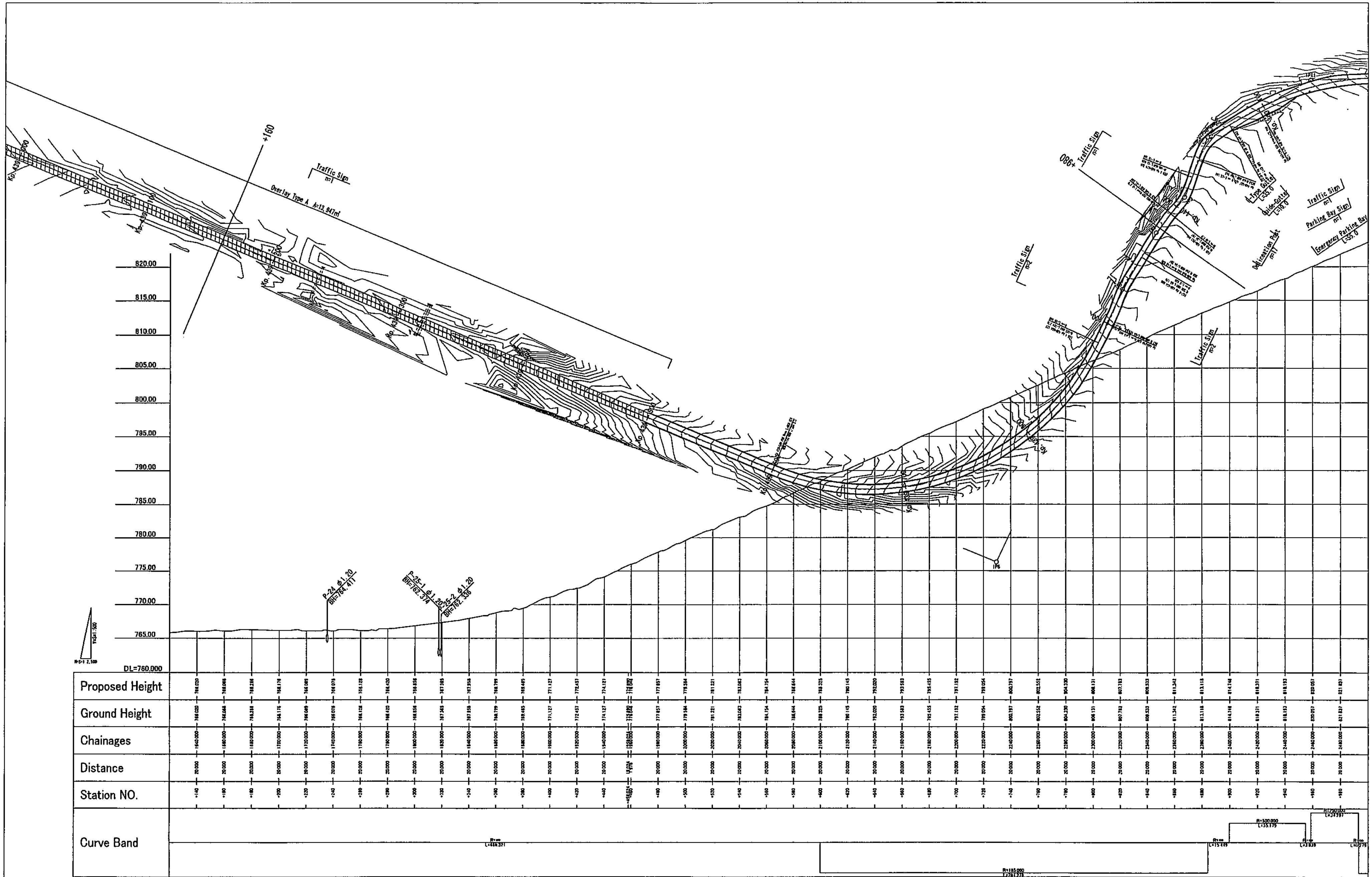
### 2-2-3 Basic Design Drawings



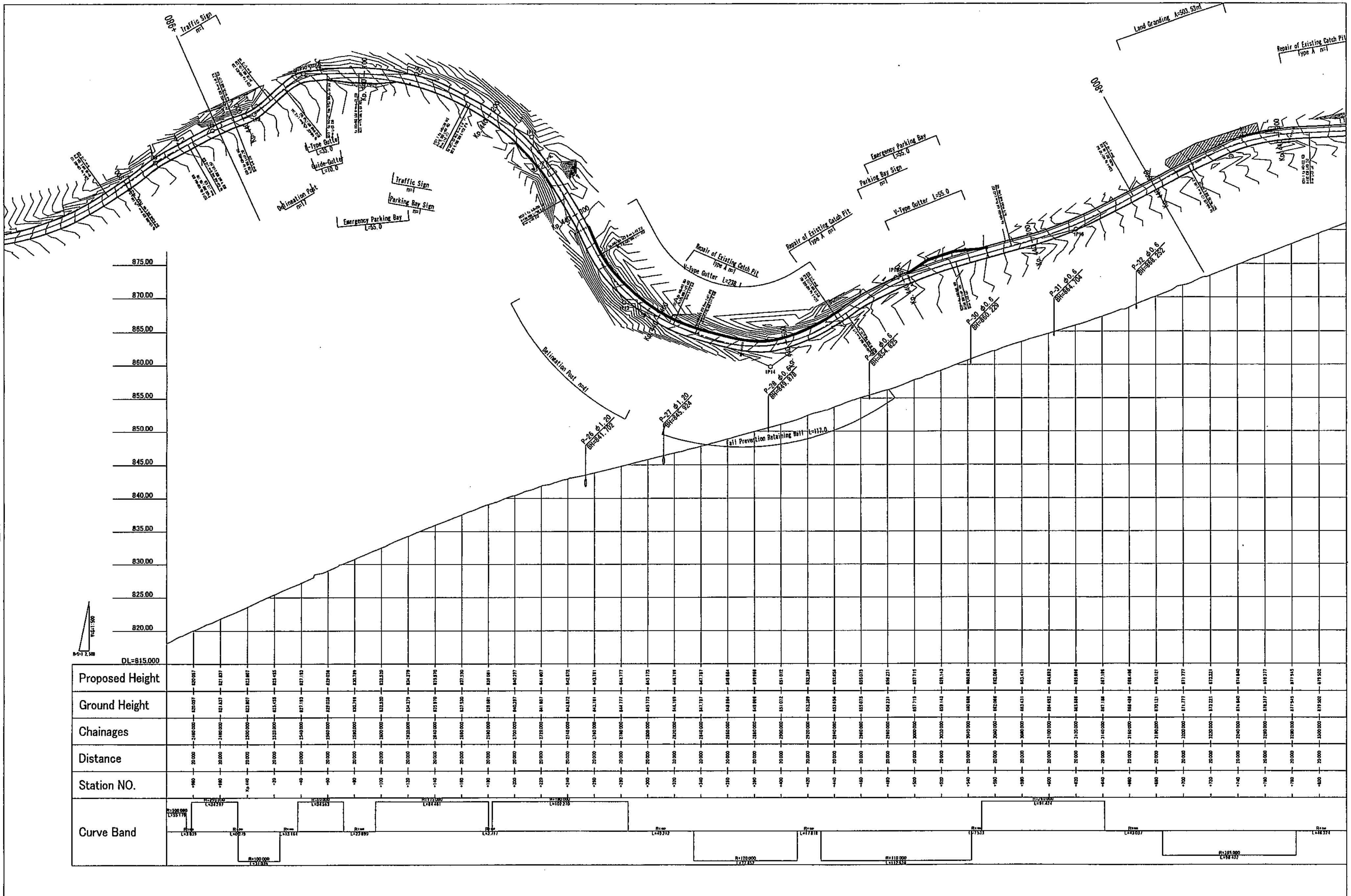

| MINISTRY OF WORKS<br>THE UNITED REPUBLIC OF TANZANIA | THE PROJECT FOR REHABILITATION OF TANZAM HIGHWAY (KITONGA GORGE SECTION) IN THE UNITED REPUBLIC OF TANZANIA | NIPPON KOEI CO.,LTD IN ASSOCIATION WITH JAPAN ENGINEERING CONSULTANTS CO.,LTD | Plan & Profile (1/13) | SCALE<br>H=S=1:2,500<br>V=S=1:500 | MINISTRY OF WORKS THE UNITED REPUBLIC OF TANZANIA | APPROVED<br>DATE | NIPPON KOEI CO.,LTD IN ASSOCIATION WITH JAPAN ENGINEERING CONSULTANTS CO.,LTD | PREPARED CHECKED<br>SUBMITTED | DATE<br>Dec.2001 | SHEET NO |
|---|---|---|---|---|---|---|---|---|---|---|



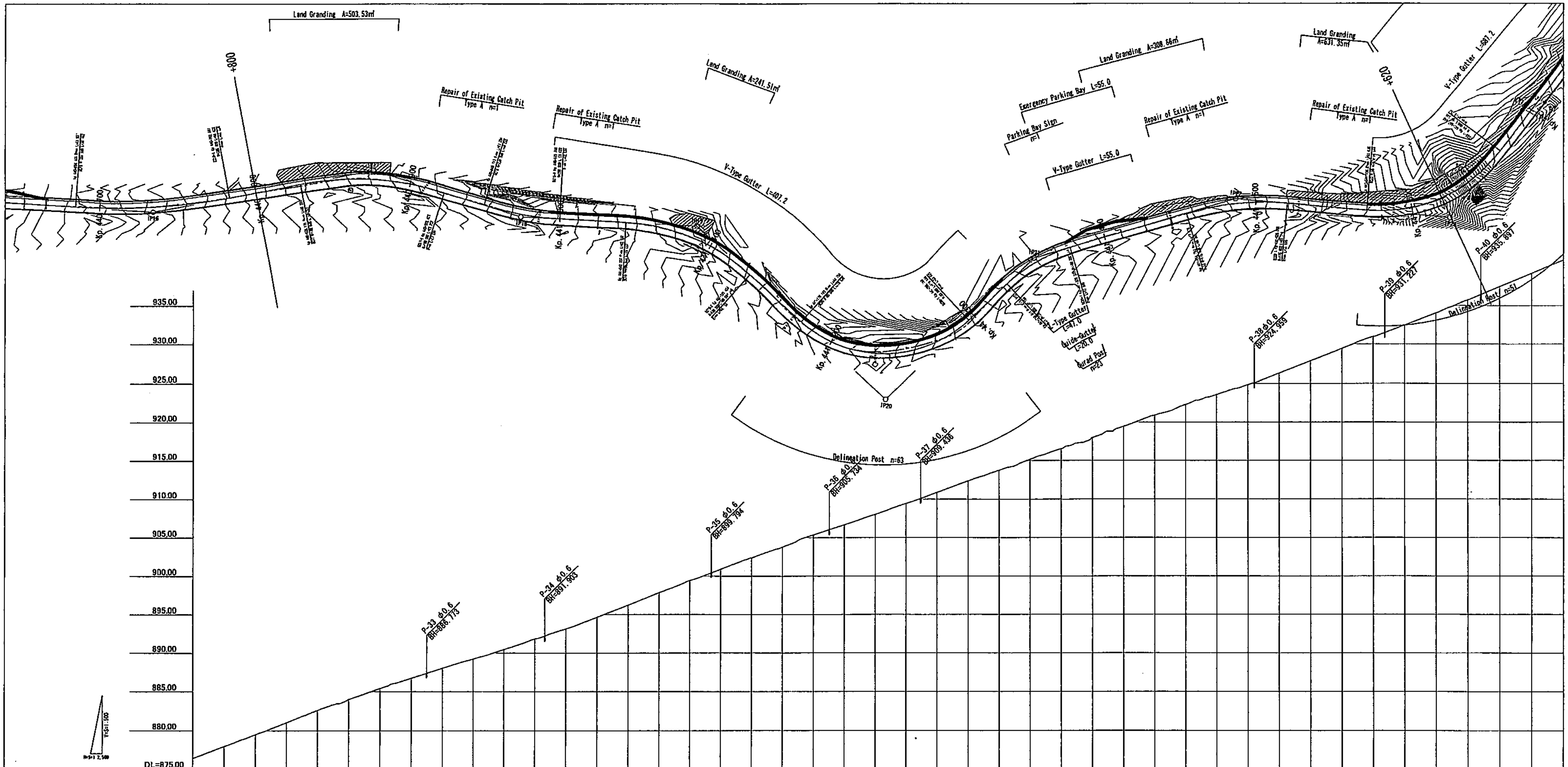

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| MINISTRY OF WORKS<br>THE UNITED REPUBLIC OF TANZANIA | THE PROJECT FOR REHABILITATION OF<br>TANZAM HIGHWAY (KITONGA GORGE SECTION)<br>IN<br>THE UNITED REPUBLIC OF TANZANIA | NIPPON KOEI CO.,LTD<br>IN ASSOCIATION WITH<br>JAPAN ENGINEERING CONSULTANTS CO.,LTD | Plan & Profile (2/13) | SCALE<br>H=S=1:2,500<br>V=S=1:500 | MINISTRY OF WORKS<br>THE UNITED REPUBLIC<br>OF TANZANIA | APPROVED<br>DATE | NIPPON KOEI CO.,LTD<br>IN ASSOCIATION WITH<br>JAPAN ENGINEERING CONSULTANTS CO.,LTD | PREPARED CHECKED<br>SUBMITTED | DATE<br>Dec.2001 | SHEET NO |




| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| MINISTRY OF WORKS<br>THE UNITED REPUBLIC OF TANZANIA | THE PROJECT FOR REHABILITATION OF TANZAM HIGHWAY (KITONGA GORGE SECTION)<br>IN<br>THE UNITED REPUBLIC OF TANZANIA | NIPPON KOEI CO.,LTD<br>IN ASSOCIATION WITH<br>JAPAN ENGINEERING CONSULTANTS CO.,LTD | Plan & Profile (3/13) | SCALE<br>H=S=1:2,500<br>V=S=1:500 | MINISTRY OF WORKS<br>THE UNITED REPUBLIC OF TANZANIA | APPROVED<br>DATE | NIPPON KOEI CO.,LTD<br>IN ASSOCIATION WITH<br>JAPAN ENGINEERING CONSULTANTS CO.,LTD | PREPARED CHECKED<br>SUBMITTED | DATE<br>Dec.2001 | SHEET NO |



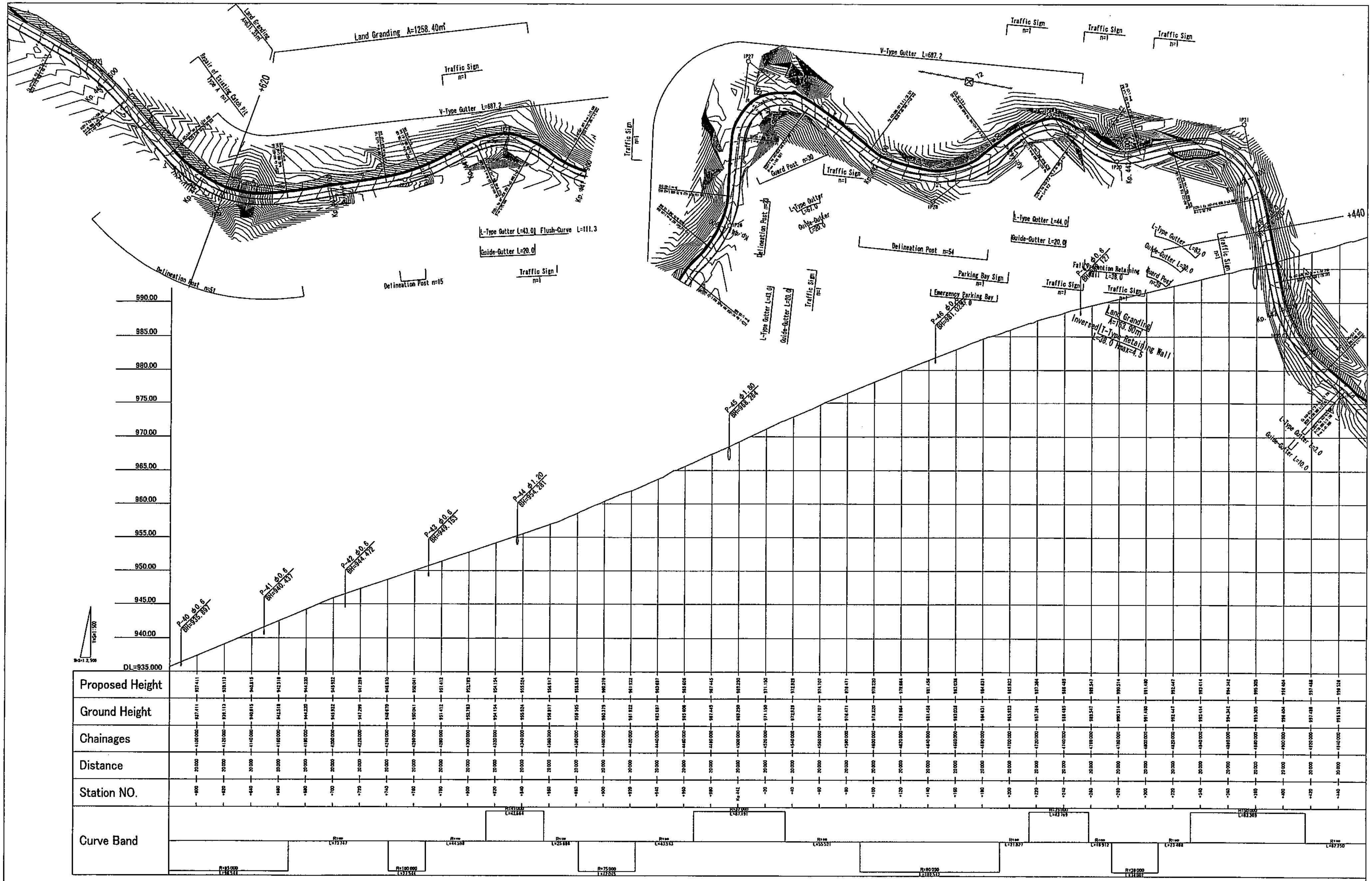

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| MINISTRY OF WORKS<br>THE UNITED REPUBLIC OF TANZANIA | THE PROJECT FOR REHABILITATION OF TANZAM HIGHWAY (KITONGA GORGE SECTION) IN THE UNITED REPUBLIC OF TANZANIA | NIPPON KOEI CO.,LTD IN ASSOCIATION WITH JAPAN ENGINEERING CONSULTANTS CO.,LTD | Plan & Profile (4/13) | SCALE<br>H=S=1:2,500<br>V=S=1:500 | MINISTRY OF WORKS THE UNITED REPUBLIC OF TANZANIA | APPROVED<br>DATE | NIPPON KOEI CO.,LTD IN ASSOCIATION WITH JAPAN ENGINEERING CONSULTANTS CO.,LTD | PREPARED CHECKED<br>SUBMITTED | DATE<br>Dec.2001 | SHEET NO |




| Station NO. | Distance | Chainages | Ground Height | Proposed Height |
|---|---|---|---|---|
| +780 | 20.000 | 3280.000 | 877.945 | 877.945 |
| +800 | 20.000 | 3300.000 | 879.502 | 879.502 |
| +820 | 20.000 | 3320.000 | 881.044 | 881.044 |
| +840 | 20.000 | 3340.000 | 882.609 | 882.609 |
| +860 | 20.000 | 3360.000 | 884.023 | 884.023 |
| +880 | 20.000 | 3380.000 | 885.417 | 885.417 |
| +900 | 20.000 | 3400.000 | 886.701 | 886.701 |
| +920 | 20.000 | 3420.000 | 887.979 | 887.979 |
| +940 | 20.000 | 3440.000 | 889.203 | 889.203 |
| +960 | 20.000 | 3460.000 | 890.448 | 890.448 |
| +980 | 20.000 | 3480.000 | 891.824 | 891.824 |
| Kp.441 | 20.000 | 3500.000 | 893.133 | 893.133 |
| +20 | 20.000 | 3520.000 | 894.640 | 894.640 |
| +40 | 20.000 | 3540.000 | 896.220 | 896.220 |
| +60 | 20.000 | 3560.000 | 897.859 | 897.859 |
| +80 | 20.000 | 3580.000 | 899.410 | 899.410 |
| +100 | 20.000 | 3600.000 | 900.880 | 900.880 |
| +120 | 20.000 | 3620.000 | 902.355 | 902.355 |
| +140 | 20.000 | 3640.000 | 903.779 | 903.779 |
| +160 | 20.000 | 3660.000 | 905.348 | 905.348 |
| +180 | 20.000 | 3680.000 | 906.662 | 906.662 |
| +200 | 20.000 | 3700.000 | 908.032 | 908.032 |
| +220 | 20.000 | 3720.000 | 909.429 | 909.429 |
| +240 | 20.000 | 3740.000 | 910.874 | 910.874 |
| +260 | 20.000 | 3760.000 | 912.384 | 912.384 |
| +280 | 20.000 | 3780.000 | 913.730 | 913.730 |
| +300 | 20.000 | 3800.000 | 915.166 | 915.166 |
| +320 | 20.000 | 3820.000 | 916.553 | 916.553 |
| +340 | 20.000 | 3840.000 | 917.987 | 917.987 |
| +360 | 20.000 | 3860.000 | 919.450 | 919.450 |
| +380 | 20.000 | 3880.000 | 920.904 | 920.904 |
| +400 | 20.000 | 3900.000 | 922.289 | 922.289 |
| +420 | 20.000 | 3920.000 | 923.556 | 923.556 |
| +440 | 20.000 | 3940.000 | 924.842 | 924.842 |
| +460 | 20.000 | 3960.000 | 926.298 | 926.298 |
| +480 | 20.000 | 3980.000 | 927.856 | 927.856 |
| +500 | 20.000 | 4000.000 | 929.422 | 929.422 |
| +520 | 20.000 | 4020.000 | 930.966 | 930.966 |
| +540 | 20.000 | 4040.000 | 932.459 | 932.459 |
| +560 | 20.000 | 4060.000 | 934.028 | 934.028 |
| +580 | 20.000 | 4080.000 | 935.711 | 935.711 |
| +600 | 20.000 | 4100.000 | 937.405 | 937.405 |
| +620 | 20.000 | 4120.000 | 939.107 | 939.107 |

Curve Band: R=385.000 L=58.407; R=∞ L=46.324; R=190.000 L=93.252; R=∞ L=77.291; R=100.000 L=50.037; R=∞ L=42.591; R=130.000 L=89.037; R=∞ L=44.759; R=80.000 L=118.536; R=∞ L=33.872; R=100.000 L=47.166; R=∞ L=77.876; R=175.000 L=65.318; R=∞ L=51.036; R=93.000

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| MINISTRY OF WORKS<br>THE UNITED REPUBLIC OF TANZANIA | THE PROJECT FOR REHABILITATION OF TANZAM HIGHWAY (KITONGA GORGE SECTION) IN THE UNITED REPUBLIC OF TANZANIA | NIPPON KOEI CO.,LTD IN ASSOCIATION WITH JAPAN ENGINEERING CONSULTANTS CO.,LTD | Plan & Profile (5/13) | SCALE<br>H=S=1:2,500<br>V=S=1:500 | MINISTRY OF WORKS THE UNITED REPUBLIC OF TANZANIA | APPROVED<br>DATE | NIPPON KOEI CO.,LTD IN ASSOCIATION WITH JAPAN ENGINEERING CONSULTANTS CO.,LTD | PREPARED CHECKED<br>SUBMITTED | DATE<br>Dec.2001 | SHEET NO |




| MINISTRY OF WORKS THE UNITED REPUBLIC OF TANZANIA | THE PROJECT FOR REHABILITATION OF TANZAM HIGHWAY (KITONGA GORGE SECTION) IN THE UNITED REPUBLIC OF TANZANIA | NIPPON KOEI CO.,LTD IN ASSOCIATION WITH JAPAN ENGINEERING CONSULTANTS CO.,LTD | Plan & Profile (6/13) | SCALE H=S=1:2,500 V=S=1:500 | MINISTRY OF WORKS THE UNITED REPUBLIC OF TANZANIA | APPROVED / DATE | NIPPON KOEI CO.,LTD IN ASSOCIATION WITH JAPAN ENGINEERING CONSULTANTS CO.,LTD | PREPARED CHECKED / SUBMITTED | DATE Dec.2001 | SHEET NO |
|---|---|---|---|---|---|---|---|---|---|---|