CHAPTER 7

FORMULATION OF ROAD DEVELOPMENT MASTER PLAN

7. FORMULATION OF ROAD DEVELOPMENT MASTER PLAN

7.1 Proposal for Future Road Development Plan

The future road development plan has been formulated taking into consideration such factors as the future traffic pattern, present road condition, future urban land use plan, and the expected improvement to be brought about with the introduction of each development scheme. The timing of implementation of individual development schemes (short term or long term) has been determined.

The basic road development objectives set up for the master plan are as follows:

To Enhance Road User Benefit

- improvement of bottleneck points in urban traffic
- enhancement of capacities of linehaul
- diversion of traffic from the city centre

To Enhance Road Safety and Roadside Environment

- enhancement of road safety
- protection of roadside environment

The road development concept with the above targets has been prepared as shown in Table 7.1, where probable measures to attain the targets are being proposed.

The road development master plan prepared in this context is presented in Fig. 7.1 and Table 7.2.

Table 7.1 Road Development Proposal

Planning Horizon	Target of Development	Management Measure			Physical/Infrastructural Measure
		Legal/Administrative Measure	Institutional Measure	Facility Improvement	
Short Term	- Improvement of Bottleneck Points - Enhancement of Road Safety Level - Protection of Roadside Environment - Upgrade of Linehaul	- Strict enforcement of traffic law - Control on roadside parking - Introduction of one way traffic regulation	- Enhancement of road maintenance capacity - Enforcement of traffic education - Introduction of car inspection system	- Installation of traffic signals - Provision of signs, markings, guardrails - Designation of pedestrian crossing points - Installation of bus bays - Planting of trees along road sides	- Improvement of intersection geometry - Improvement of sidewalks - Improvement of drainage system - Raising of carriage ways
Long Term	- Upgrade of Linehaul - Improvement of Road Facilities - Diversion of Traffic from City Centre	- Route regulation for heavy vehicles - Strict enforcement of zoning system	- Establishment of self-sustaining road management system - Functional specification of roads	- Introduction of cycling routes - Introduction of coordinated signals	- Rehabilitation/ reconstruction of urban corridor (north-south, east-west) - Rehabilitation/ reconstruction of urban artery (radial roads) - Introduction of bypass - Introduction of circular roads

Table 7.2 (1) Components of Road Development Plan

		Location	Administration		Proposed in 10-year road development plan	Present Issues	Measures for Improvement
			MOWTC	KCC			
Improvement of Bottle neck	Junction	B-1 Port Bell Junction		○	○	1. Traffic congestion due to right turn vehicles from city center	1. Improvement of horizontal alignment of the junction; addition of one lane for right turn vehicles from the city centre 2. Establishment of traffic signals
		B-2 Jinja Rd. Round about		○		1. Traffic congestion 2. Flood in rainy season	1. Expansion of the roundabout 2. Improvement of roundabout to four legs junction with traffic signals. 1. Improvement of the vertical alignment. 2. Improvement of drainage system around the junction based on the scheduled improvement of whole drainage system for Kampala city.
		B-3 Clock Tower Round about		○	○	1. Traffic congestion 2. Flood in rainy season	1. Expansion of the roundabout. 2. Improvement of horizontal shape. 3. Construction of pedestrian bridge for congestion through traffic. 1. Improvement of the vertical alignment. 2. Improvement of drainage system aground the junction based on the scheduled improvement of whole drainage system for Kampala city.
		B-4 Kibuya Round about	○		○	1. Traffic congestion	1. Expansion of the roundabout 2. Improvement of horizontal shape 3. Relocation of side ditches. 4. Improvement of junction from roundabout type to four leg junction type with traffic signals.
		B-5 Natete Round about	○		○	1. Traffic congestion	1. Improvement of junction from roundabout type to four leg junction type with traffic signals. 2. Setting up parking lanes along the Masaka road. 3. Relocation of side ditches.
		B-6 Wandegeya Round about		○	○	1. Traffic congestion	1. Expansion of the roundabout 2. Improvement of junction from roundabout type to four leg junction type with traffic signals.
		B-7 Makerere Round about	○		○	1. Traffic congestion	1. Expansion of the roundabout 2. Improvement of junction from roundabout type to four leg junction type with traffic signals.
	Flood Area	B-8 Senterna Rd.		○		1. Flood in rainy seasons 2. Impassability by car in rainy season	1. Raising of vertical alignment 1. Additional pipe culverts for drainage. 2. Replacement of existing pipe culvert by big one.
		B-9 Hoima Rd.	○		○	1. Flood in rainy seasons 2. Impassability by car in rainy season	1. Raising of vertical alignment 1. Additional pipe culverts for drainage. 2. Replacement of existing pipe culvert by big one.
		B-10 Bombo Rd.	○		○	1. Flood in rainy seasons 2. Impassability by car in rainy season	1. Raising of vertical alignment 1. Additional pipe culverts for drainage. 2. Replacement of existing pipe culvert by big one.
		B-11 Jinja Rd. (A)	○		○	1. Flood in rainy seasons 2. Impassability by car in rainy season	1. Raising of vertical alignment 1. Additional pipe culverts for drainage. 2. Replacement of existing pipe culvert by big one.
		B-12 Jinja Rd. (B)	○		○	1. Flood in rainy seasons 2. Impassability by car in rainy season	1. Raising of vertical alignment 1. Additional pipe culverts for drainage. 2. Replacement of existing pipe culvert by big one.
		B-13 Gaba Rd.	○		○	1. Flood in rainy seasons 2. Impassability by car in rainy season	1. Raising of vertical alignment 1. Additional pipe culverts for drainage. 2. Replacement of existing pipe culvert by big one.
		B-14 Natete Rd. (A)		○	○	1. Flood in rainy seasons 2. Impassability by car in rainy season	1. Raising of vertical alignment 1. Additional pipe culverts for drainage. 2. Replacement of existing pipe culvert by big one.
		B-15 Natete Rd. (B)		○	○	1. Flood in rainy seasons 2. Impassability by car in rainy season	1. Raising of vertical alignment 1. Additional pipe culverts for drainage. 2. Replacement of existing pipe culvert by big one.

Table 7.2 (2a) Components of Road Development Plan

		Location	Administration by MOWTC	Administration by KCC	Proposed in 10-year road development plan	Present Issues	Measures for Improvement
Reinforce of Linehaul	Regional	R-1 Gaba Road	○		○	1. Surface of pavement - Cracks, - Pot holes, - Rough surface, - Deterioration of pavement edge 2. Shoulder - Deterioration 3. Side ditch - Nil, - Buried, - Deterioration	1. Overlay 2. Setting up of kerb stone at pavement edge 1. Improvement of shoulder with Asphalt surface dressing. 1. Cleaning or reconstruction of side ditch
		R-2 Natete Road		○	○	1. Surface of pavement - Cracks, - Pot holes, - Rough surface, - Deterioration of pavement edge 2. Shoulder - Deterioration 3. Side ditch - Nil, - Buried, - Deterioration 4. Side walk Nil, - Deterioration	1. Reconstruction 2. Setting up kerb stone at pavement edge 1. Reconstruction with Asphalt surface dressing 1. Reconstruction of side ditch 2. Setting up of drainage pipe culverts 1. Construction or reconstruction.
		R-3 Sentema Road		○		1. Surface of pavement Completely destroyed 2. Shoulder - Deterioration 3. Side ditch - Nil, - Buried, - Deterioration	1. Reconstruction 1. Reconstruction with Asphalt surface dressing 1. Reconstruction of side ditch
		R-4 Kira Road		○		1. Surface of pavement - Cracks, - Pot holes, - Rough surface, - Completely Destroyed, - Deterioration of pavement edge 2. Shoulder - Deterioration 3. Side ditch - Nil, - Buried, - Deterioration 4. Side walk - Deterioration, - Nil	1. Overlay or Reconstruction 1. Improvement of shoulder with Asphalt surface dressing 1. Cleaning or reconstruction 1. Reconstruction or construction.
		R-5 Port Bell Road	○		○	1. Surface of pavement - Cracks, - Pot holes, - Rough surface, - Deterioration of pavement 2. Shoulder - Deterioration 3. Side ditch - Nil, - Buried, - Deterioration 4. Side walk - Deterioration, - Nil	1. Overlay or Reconstruction 1. Improvement of shoulder with Asphalt surface dressing 1. Cleaning or reconstruction 1. Reconstruction or construction.
		R-6 Jinja - Kampala - Bombo Road		○		1. Surface of pavement - Cracks, - Pot holes, - Rough 2. Shoulder - Deterioration 3. Side ditch - Deterioration 4. Side walk - Deterioration	1. Overlay or Reconstruction 1. Reconstruction with Asphalt surface dressing 1. Reconstruction of side ditch 2. Setting up drainage pipe culverts 1. Rehabilitation or Reconstruction

Table 7.2 (2b) Components of Road Development Plan

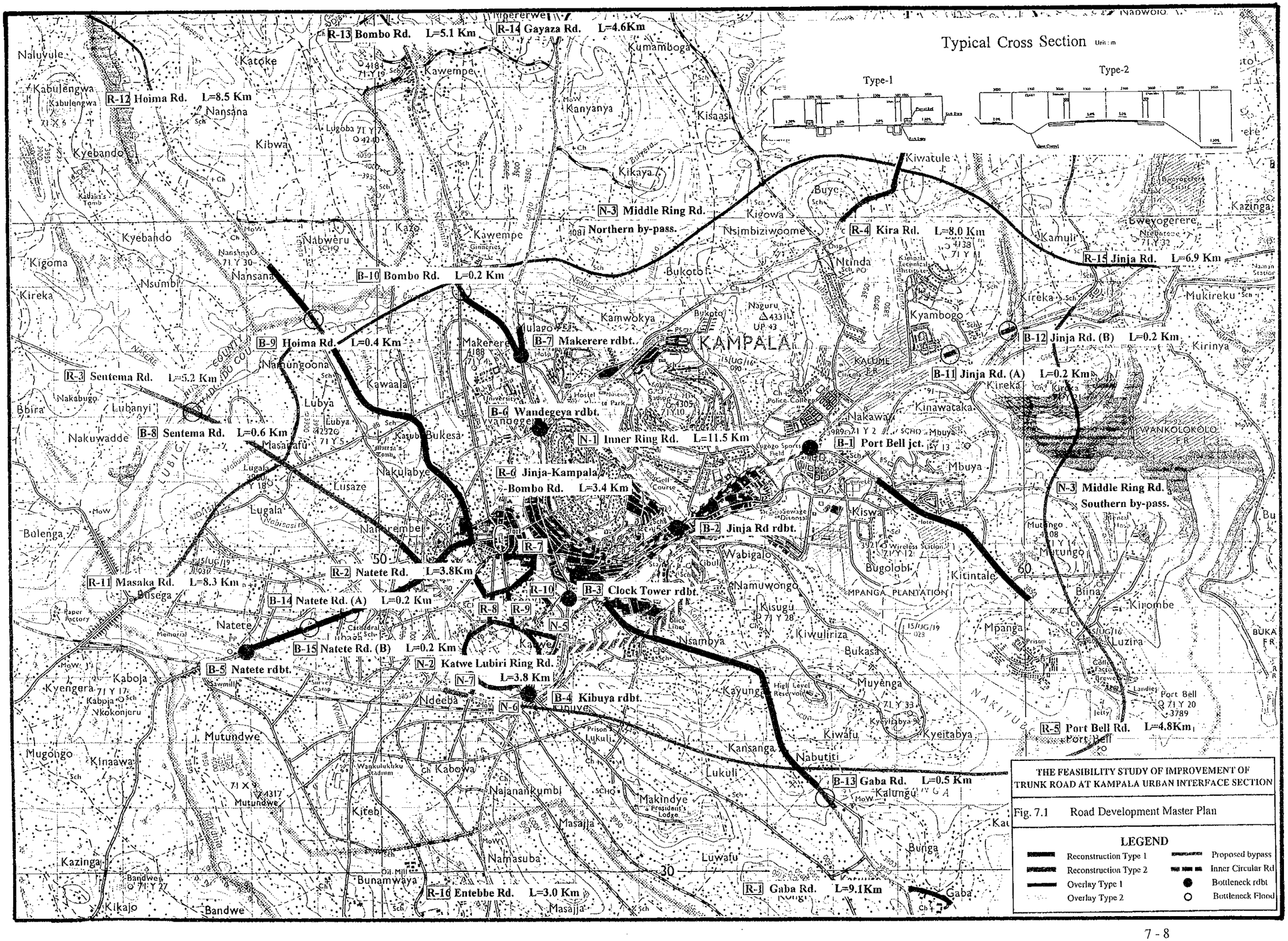
		Location	Administration by MOWTC	Administration by KCC	Proposed in 10-year road development plan	Present Issues	Measures for Improvement
Reinforce of Linehaul	Regional	R-7 Butikiro - Kisenyi Road		○		1. Surface of pavement - Deterioration of pavement 2. Shoulder - Deterioration 3. Side ditch - Nil, - Buried, - Deterioration 4. Side walk - Nil	1. Reconstruction 1. Reconstruction with Asphalt surface dressing. 1. Reconstruction of side ditch 1. Construction or Reconstruction
		R-8 Musajja - Alumbwa Road		○		1. Surface of pavement - Deterioration 2. Shoulder - Deterioration 3. Side ditch - Deterioration 3. Side ditch - Deterioration	1. Reconstruction 1. Reconstruction with Asphalt surface dressing. 1. Reconstruction of side ditch 2. Setting up drainage pipe culverts 1. Construction or Reconstruction
		R-9 Muwanga Road		○		1. Surface of pavement - Deterioration of pavement 2. Shoulder - Deterioration 3. Side ditch - Deterioration 4. Side walk - Deterioration	1. Reconstruction 1. Reconstruction with Asphalt surface dressing. 1. Reconstruction of side ditch 1. Construction or Reconstruction
		R-10 Mengo-Kisenyi Road		○		1. Surface of pavement - Deterioration of pavement 2. Shoulder - Deterioration 3. Side ditch - Deterioration 4. Side walk - Deterioration	1. Reconstruction 1. Reconstruction with Asphalt surface dressing. 1. Reconstruction 2. Setting up drainage pipe culverts 1. Construction or Reconstruction

Table 7.2 (2c) Components of Road Development Plan

		Location	Administration by MOWTC	Administration by KCC	Proposed in 10-year road development plan	Present Issues	Measures for Improvement
Reinforce of Linehaul	Inter Regional	R-11 Masaka Road	○		○	1. Surface of pavement - Cracks, - Pot holes, - Rough surface 2. Shoulder - Deterioration 3. Side ditch - Nil, - Buried, - Deterioration 4. Side walk - Deterioration	1. Overlay 2. Setting up of kerb stone at pavement edge 1. Reconstruction with Asphalt surface dressing. 1. Reconstruction of side ditch 2. Setting up of drainage pipe culverts 1. Construction or reconstruction.
		R-12 Hoima Road	○		○	1. Surface of pavement - Cracks, - Pot holes, - Rough surface, - Deterioration of pavement 2. Shoulder - Deterioration 3. Side ditch - Nil, - Buried, - Deterioration 4. Side walk - Deterioration	1. Overlay 2. Setting up kerb stone at pavement edge 1. Reconstruction with Asphalt surface dressing 1. Reconstruction of side ditch 2. Setting up drainage pipe culverts 1. Construction or reconstruction.
		R-13 Bombo Road	○		○	1. Surface of pavement - Cracks, - Pot holes, - Rough surface, - Deterioration of pavement 2. Shoulder - Deterioration 3. Side ditch - Nil, - Buried, - Deterioration 4. Side walk - Deterioration	1. Overlay 2. Setting up kerb stone at pavement edge 1. Reconstruction with Asphalt surface dressing 1. Reconstruction of side ditch 2. Setting up drainage pipe culverts 1. Construction or reconstruction.
		R-14 Gayaza Road	○		○	1. Surface of pavement - Cracks, - Pot holes, - Rough surface, - Deterioration of pavement 2. Shoulder - Deterioration 3. Side ditch - Nil, - Buried, - Deterioration 4. Side walk - Nil	1. Overlay 2. Setting up kerb stone at pavement edge 1. Reconstruction with Asphalt surface dressing 1. Reconstruction of side ditch 2. Setting up drainage pipe culverts 1. Construction.
		R-15 Jinja Road	○		○	1. Surface of pavement - Cracks, - Pot holes, - Rough surface, - Deterioration of pavement 2. Shoulder - Deterioration 3. Side ditch - Nil, - Buried, - Deterioration 4. Side walk - Deterioration	1. Overlay 2. Setting up kerb stone at pavement edge 1. Reconstruction with Asphalt surface dressing 1. Reconstruction of side ditch 2. Setting up drainage pipe culverts 1. Construction or reconstruction.
		R-16 Entebbe Road	○			1. Surface of pavement - Cracks, - Pot holes, - Rough 2. Shoulder - Deterioration 3. Side ditch - Nil, - Buried, - Deterioration 4. Side walk - Deterioration	1. Overlay 2. Setting up kerb stone at pavement edge 1. Reconstruction with Asphalt surface dressing 1. Reconstruction of side ditch 2. Setting up drainage pipe culverts 1. Construction or reconstruction.

Table 7.2 (3) Components of Road Development Plan

		Location	Administration by MOWTC	Administration by KCC	Proposed in 10-year road development plan	Present Issues	Measures for Improvement
Strengthening of Road Network	Ring Road	N-1 Ring Road		○		1. Surface of pavement - Cracks, - Pot holes, - Rough surface, - Deterioration of pavement 2. Shoulder - Deterioration 3. Side ditch - Nil, - Buried, - Deterioration 4. Side walk - Deterioration	1. Overlay 2. Setting up of kerb stone at pavement edge 1. Reconstruction with Asphalt surface dressing. 1. Reconstruction of side ditch 2. Setting up of drainage pipe culverts 1. Construction or reconstruction.
		N-2 Katwe Lubiri Ring Road		○	○	1. Surface of pavement - Cracks, - Pot holes, - Rough, - Deterioration of pavement 2. Shoulder - Deterioration 3. Side ditch - Nil, - Buried, - Deterioration 4. Side walk - Deterioration	1. Overlay 2. Setting up kerb stone at pavement edge 1. Reconstruction with Asphalt surface dressing 1. Reconstruction of side ditch 2. Setting up drainage pipe culverts 1. Construction or reconstruction.
		N-3 Middle Ring Road	○			1. To avert through traffic from city centre	1. Construction
		N-4 Katwe Road	○		○	1. Surface of pavement - Cracks, - Pot holes, - Rough surface, - Deterioration of pavement 2. Shoulder - Deteriorated 3. Side ditch - Nil, - Buried, - Deterioration 4. Side walk - Nil	1. Overlay 2. Setting up of kerb stone at pavement edge 1. Reconstruction with Asphalt surface dressing 1. Reconstruction of side ditch 2. Setting up of drainage pipe culverts 1. Construction.
		N-5 Motebi Road	○		○	1. Surface of pavement - Cracks, - Pot holes, - Rough surface, - Deterioration of pavement 2. Shoulder - Deterioration 3. Side ditch - Nil, - Buried, - Deterioration 4. Side walk - Nil	1. Overlay 2. Setting up of kerb stone at pavement edge 1. Reconstruction with Asphalt surface dressing 1. Reconstruction of side ditch 2. Setting up of drainage pipe culverts 1. Construction
		N-6 Lubiri Ring - Queens Way	○		○	1. Surface of pavement - Cracks, - Pot holes, - Rough surface, - Deterioration of pavement 2. Shoulder - Deterioration 3. Side ditch - Nil, - Buried, - Deterioration 4. Side walk - Nil	1. Overlay 2. Setting up of kerb stone at pavement edge 1. Reconstruction with Asphalt surface dressing 1. Reconstruction of side ditch 2. Setting up of drainage pipe culverts 1. Construction
		N-7 Lubiri Ring - Masaka Road	○			1. Surface of pavement - Cracks, - Pot holes, - Rough surface, - Deterioration of pavement 2. Shoulder - Deterioration 3. Side ditch - Nil, - Buried, - Deterioration 4. Side walk - Nil	1. Overlay 2. Setting up of kerb stone at pavement edge 1. Reconstruction with Asphalt surface dressing 1. Reconstruction of side ditch 2. Setting up of drainage pipe culverts 1. Construction


Typical Cross Section Unit : m
Type-1
Type-2
R-13 Bombo Rd. L=5.1 Km
R-14 Gayaza Rd. L=4.6Km
R-12 Hoima Rd. L=8.5 Km
N-3 Middle Ring Rd.
Northern by-pass.
R-4 Kira Rd. L=8.0 Km
R-15 Jinja Rd. L=6.9 Km
B-10 Bombo Rd. L=0.2 Km
B-9 Hoima Rd. L=0.4 Km
B-7 Makerere rdbt.
KAMPALA
B-12 Jinja Rd. (B) L=0.2 Km
R-3 Sentema Rd. L=5.2 Km
B-11 Jinja Rd. (A) L=0.2 Km
B-6 Wandegeya rdbt.
B-8 Sentema Rd. L=0.6 Km
N-1 Inner Ring Rd. L=11.5 Km
B-1 Port Bell jct.
R-6 Jinja-Kampala Bombo Rd. L=3.4 Km
N-3 Middle Ring Rd. Southern by-pass.
B-2 Jinja Rd rdbt.
R-7
R-2 Natete Rd. L=3.8Km
R-11 Masaka Rd. L=8.3 Km
B-3 Clock Tower rdbt.
B-14 Natete Rd. (A) L=0.2 Km
R-10
R-8
R-9
N-5
B-15 Natete Rd. (B) L=0.2 Km
N-2 Katwe Lubiri Ring Rd. L=3.8 Km
B-5 Natete rdbt.
N-7
N-6
B-4 Kibuya rdbt.
R-5 Port Bell Rd. L=4.8Km
B-13 Gaba Rd. L=0.5 Km
R-1 Gaba Rd. L=9.1Km
R-16 Entebbe Rd. L=3.0 Km
Naluvule
Katoke
Kawempe
Kumamboga
Kabulengwa
Nansana
Kanyanya
Kisaasi
Kibwa
Kyebando
Kikaya
Kivatule
Buye
Kigowa
Kazinga
Kigoma
Nsimbiziwoome
Kamuli
Nsumbi
Nabweru
Kazo
Bukoto
Ntinda
Kireka
Kyambogo
Mukireku
Kamwokya
Naguru
Mulago
Makerere
Kawaala
Namungoona
Kirinya
Nakabugo
Lubanyi
Bbira
Lubya
Kinawataka
Nakawa
Nakuwadde
Masajjafu
Kasubi
Bukesa
Nakulabye
Mbuya
Lusaze
Kiswa
Lugala
Nabirembe
Bulenga
Wabigalo
Bugolobi
Kitintale
Namuwongo
Busega
MPANGA PLANTATION
Kisugu
Biina
Kinombe
Natete
Kiwuliriza
Mpanga
Luzira
Nsambya
Bukasa
Kaboja
Kyengera
Muyenga
Kayunga
Ndeeba
Port Bell
Mutundwe
Kiwafu
Kyeitabya
Mugoigo
Kinaawa
Kansanga
Nabutiti
Wankulukuku Stadium
Kabowa
Lukuli
Najanankumbi
Kalungu
Makindye
Kiteb
Masajja
Namasuba
Luwafu
Bunga
Kazinga
Bunamwaya
Gaba
Kikajo
Bandwe
THE FEASIBILITY STUDY OF IMPROVEMENT OF TRUNK ROAD AT KAMPALA URBAN INTERFACE SECTION
Fig. 7.1 Road Development Master Plan
LEGEND
Reconstruction Type 1
Reconstruction Type 2
Overlay Type 1
Overlay Type 2
Proposed bypass
Inner Circular Rd
Bottleneck rdbt
Bottleneck Flood

7.2 Future Road Traffic on Proposed Road Network

7.2.1 Engineering Consideration

As the base for the future traffic simulation, preliminary road engineering design was carried out as described below:

(1) Number of Traffic Lanes

The traffic lanes of the present road network in the Study area were investigated by the Study Team through the road inventory survey and the results are presented in Chapter 4.

The required number of traffic lanes for each road development plan was studied and determined for the year 2015 taking into consideration prospect of future traffic volume. As the result, it was found the existing lane numbers for each of the proposed roads could accommodate increasing number of traffic on the following condition:

- Such new road links as inner ring road and North, South bypasses are realized by the year 2015. The capacities of these new road links have to be greater than 5,600 pcu/hr.
- Carriageway widths of all the existing trunk roads have to be widened up to be 3.5 m and more.

(2) Typical Cross-section

Two prototypes cross-section were proposed taking into account location of roads including landuse pattern of the nearby area.

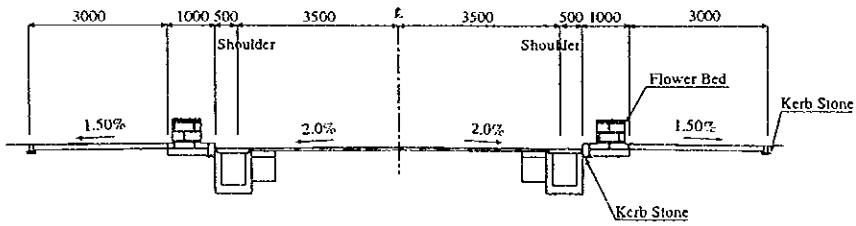
Two prototypes of cross-section applied here are shown in Fig. 7.2.

7.2.2 Methodology of Future Road Traffic Estimate

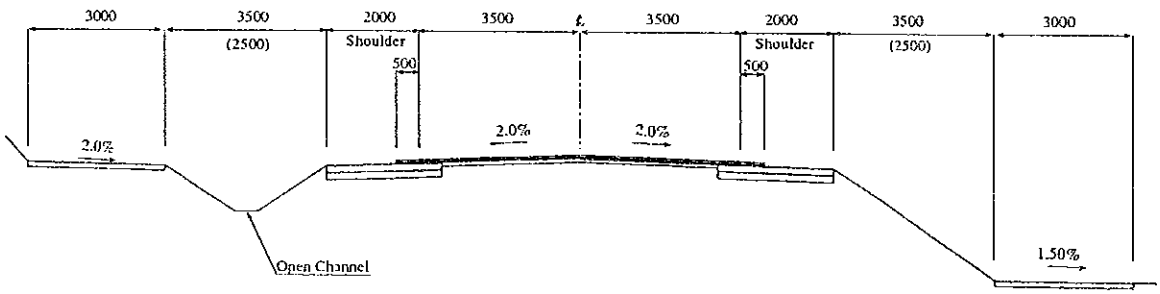
Improved road links have been represented in the traffic model by increasing their capacities by 25%, except where widening is proposed, in which case a greater increase in capacity was assumed. Because junctions were not modelled explicitly, at junction improvement sites all links joined to the junction were allocated 25% more capacity. These principles were applied to both the 2005 and 2015 networks. A 25% increase generally ensures that capacity reaches the MOWTC specified level, which is taken to be the achievable capacity for a well designed road operated efficiently.

Typical Cross Section

Type-1



Type-2



THE FEASIBILITY STUDY ON IMPROVEMENT OF TRUNK ROAD AT KAMPALA URBAN INTERFACE SECTION	
Fig. 7. 2 Typical Cross Section	LEGEND Unit : mm

For traffic assignments, the technique used was the same as that used for the base year 1997. However, assumed increases in per capita income are consistent with increased values of time. This was represented by reducing the distance weighting in the generalised cost function.

The assignment for year 2005 is reported in Appendix 7 (a). The remainder of this description refers to the network and assignment for the master plan year 2015. The network for 2015 includes an urban ring road around central Kampala in order to reduce congestion and allow the city to develop.

Several alignments are under consideration and the one tested includes a new single carriageway road south of Kibuye roundabout, thereby giving relief to the Kibuye and clock tower roundabouts. The ring also includes existing roads improved to dual carriageway standard with improved junctions where necessary. In anti-clockwise progression, starting from the Nsambya police training school, the ring road tested is as follows :

- dual carriageway standard along Press House Road, Access Road, Kitante Road, Mulago Hill Road, Makerere Hill Road, Balintuma Road and continuing southwards across Rubaga Road up to the Kabusa Road/Nabunya Road junction. Such roads were modelled as having a capacity of 2800 pcus/hr in each direction.

- single carriageway standard, crossing Masaka Road near the current Stensera Road/Nabunya Road junction, looping round to cross Entebbe Road, then heading north-east across Gaba Road to join the dual carriageway road at the start of Press House Road. Such roads were modelled as having a capacity of 1250 pcus/hr in each direction.

The 2015 network includes the European Union's proposed northern by-pass. The southern route would not be compatible with the southern half of the ring road as tested, and a smaller ring, with the southern portion lying to the north of Kibuye junction and relieving only clock tower roundabout, would be substituted if the EU were to select the southern by-pass route.

7.2.3 Future Traffic on Proposed Road Network

The result of traffic assignment on the proposed road network in 2015 is shown in Fig. 7.3 and Table 7.3, from which the following could be pointed out:

The inclusion of the European Union's northern by-pass helps our master development plan to work well. With its inclusion, average vehicular speeds are similar to those in the base year. Without it speeds are 20% lower than in the base year. Both the figure and the table demonstrate that the flows are in harmony with the proposed capacity. The proposed ring road is well used but only over a short section (Access Road just south of Jinja Road) is the flow in excess of capacity. Traffic on Jinja Road to the west of the start of the by-pass is of a similar level to that in the base year. Flows forecast for the main east west route, Jinja Road - Entebba Road - Queens way - Masaka Road are generally within capacity, although the portion of Jinja Road between Port Bell Road and Kitante Road will require more capacity then is indicated in Table 7.3. Inside the proposed ring road, the roads showing large increases over the base year flows are either in the vicinity of the reconstructed Katwe Lubiri circular road or are feeders to the ring road.

The flows indicated in Fig. 7.3 and in Table 7.3 are in waits of pcus/hour. Elsewhere in this report, average daily traffic (ADT) is displayed. ADT in vehicles is computed as 12.76 times pcus/hour.

7.4 Selection of High Priority Projects

(1) Methodology

Determination of priority projects were done applying a scoring method. The criteria introduced for the determination are as the follow*:

	Items of Evaluation	Score
1.	Engineering View Point	(60)
1.1	Deterioration Level of Pavement	(15)
	- Totally Destroyed	15
	- Very Bad	15
	- Bad	15
	- Good	10
	- Fair	5
1.2	Traffic Volume	(30)
	- ADT > 20,000	30
	- 20,000 > ADT > 10,000	25
	- 10,000 > ADT > 5,000	20
	- 5,000 > ADT > 1,000	15
	- 1,000 > ADT > 100	10
	- ADT < 100	5

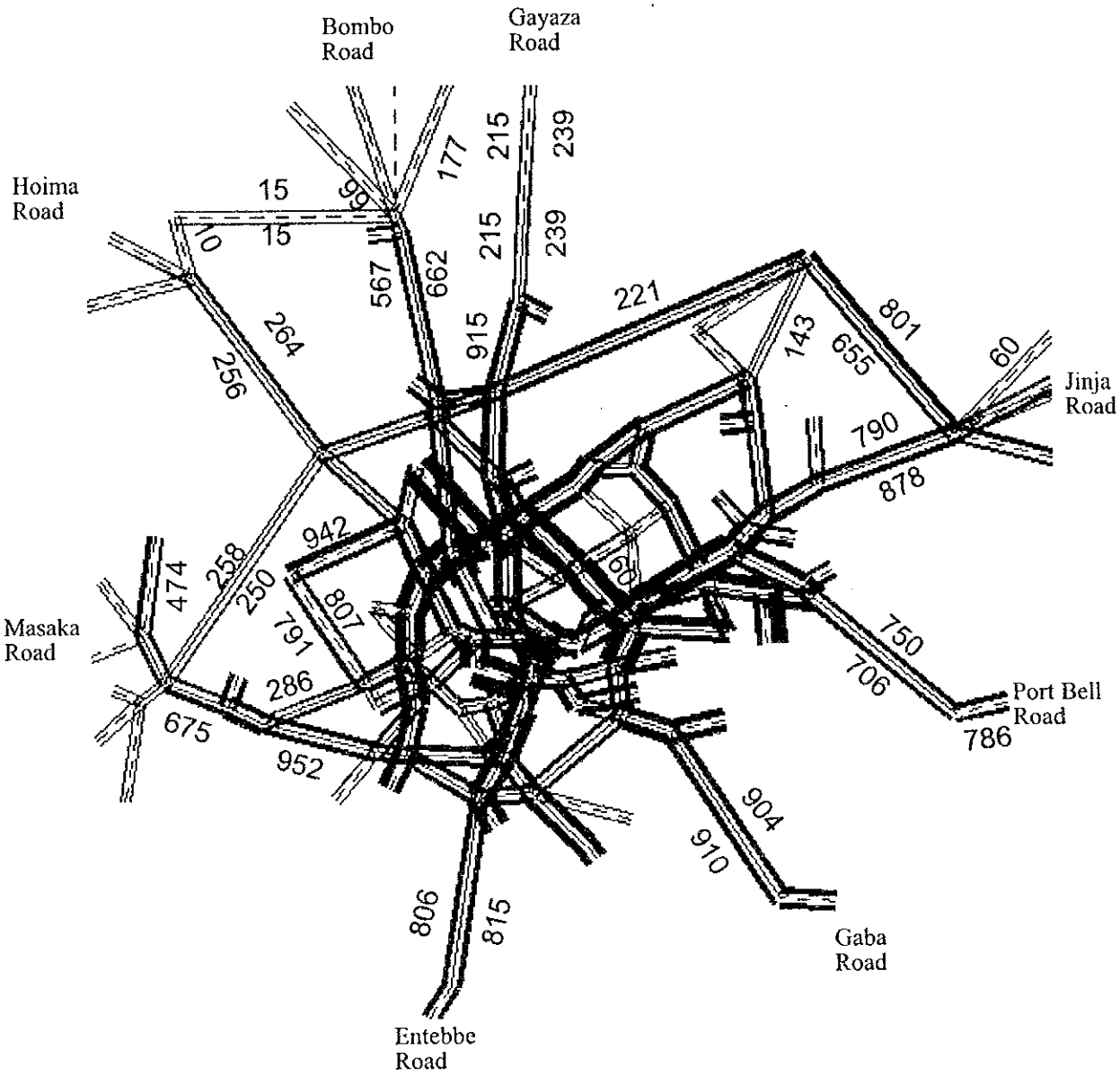


Fig. 7.3 Assignment to Proposed 2015 Network (pcu/hr)

Table 7.3 Results of the 2015 Assignment

Site Reference	Site Description	Assigned Flow in 1997 (Pcus/hr)	Assigned Flow in 2015 (Pcus/hr)	Percentage increase	Nominal capacity (Pcus/hr)	Flow to capacity ratio
Ring road						
	Press House Road	1520	4751	213%	5600	0.85
P10	Access Road	2768	6146	122%	5600	1.10
	Kitante Road	2634	5188	97%	5600	0.93
C14	Kitante Road	2000	4750	138%	5600	0.85
C21	Kitante Road	1388	4258	207%	5600	0.76
P2	Mulago Hill Road	2327	5318	129%	5600	0.95
	Makerere Hill Road	2188	5878	169%	5600	1.05
C18	Makerere Hill Road	1112	3120	181%	5600	0.56
	Makerere Hill Road	1204	5300	340%	5600	0.95
	Balintuma Road	502	4205	738%	5600	0.75
	Balintuma Road	338	3672	986%	5600	0.66
	North of Natate Road		3477		5600	0.62
	South of Natate Road		3554		5600	0.63
	Nabunya Road	467	3298	606%	5600	0.59
	Nabunya Road		2454		2500	0.98
	Masaka Road to Entebbe Road		1439		2500	0.58
	Entebbe Road to Makindye Road		1439		2500	0.58
	Makindye Road to Gaba Road		1146		2500	0.46
	Gaba Road to Press House Road		2041		2500	0.82
Jinja Road - Entebbe Road - Queensway - Masaka Road						
C1	Jinja Road	1822	1668	-8%	3000	0.56
C25	Jinja Road	2687	4498	67%	3700	1.22
C11	Jinja Road	3374	4608	37%	3700	1.25
P9	Jinja Road	2350	2510	7%	3700	0.68
P7	Entebbe Road	1997	2604	30%	2800	0.93
P16	Entebbe Road	3865	4714	22%	4000	1.18
C9	Queensway	2065	2365	15%	3000	0.79
P22	Masaka Road	1007	1704	69%	3000	0.57
C4	Masaka Road	810	1350	67%	3000	0.45
Inside the Ring Road						
C10	Katwe Road	1454	3456	138%	3500	0.99
C13	Kampala Road	3292	3557	8%	4000	0.89
C15	Bombo Road	2484	3348	35%	4000	0.84
C16	Hoima Road	839	2054	145%	2500	0.82
P5	Namirembe Road	1723	1498	-13%	2000	0.75
P6	South Street	1868	2111	13%	2000	1.06
P13	Kibuli Road	1192	1467	23%	2500	0.59
P14	Nsambya Road	1672	2421	45%	2500	0.97
P15	Kibuli Road	1621	2020	25%	2000	1.01
P17	Mengo Hill Road	1478	2617	77%	2800	0.93
P18	Katwe Lubiri Ring Road	221	830	276%	2800	0.30
P19	Katwe Lubiri Ring Road	149	961	545%	2800	0.34
P20	Makindye Road	816	2148	163%	2800	0.77
P21	Entebbe Road	1923	3094	61%	3000	1.03
P23	Katwe Lubiri Ring Road	6	96	1500%	2800	0.03
P24	Rubaga Road	673	1516	125%	1280	1.18
P25	Natete Road	1265	1865	47%	1600	1.17

1.3	Deterioration Level of Drainage	(15)
	- Flood area	15
	- Area without drainage	15
	- Area with partially malfunctioning drainage/Area with poor drainage	10
	- Other than the above	5
2.	Socio-economic View Points	(20)
2.1	Function of Road	(10)
	- Inter Regional Arterial	10
	- Regional Arterial Road	5
	- City/town Road	5
	- Feeder/Access Road	0
2.2	Land Use Pattern	(10)
	- Commercial/industry/densely populated Area	10
	- Residential Area	5
	- Less Developed Area	0
3.	Satisfaction of Basic Human Need	(10)
	- Large impact on low income group	10
	- Medium impact on low income group	5
	- Less impact on low income group	0
4.	Development Policy of MOWTC	(10)
	- Highest priority	10
	- High priority	5
	- Others	0
	Total	100

* The criteria of the scoring method introduced here are not universal ones and are subject to change with the type and content of projects to be evaluated.

Results of scoring based on the above are presented in Table 7.4.

(2) Selected High Priority Projects

High priority projects were selected on the basis of the sizes of the scores obtained. these projects include:

Improvement of Bottlenecks

- Junction
  - Port Bell Junction
  - Jinja Rd. Roundabout

- Kibuya Roundabout
- Natete Roundabout
- Wandegeya Roundabout
- Makerere Roundabout

- Flood Area
  - Hoima Road (0.4 km: Lubigi Channel Crossing Part)
  - Natete Road (A) (0.2 km: Lubaga Area)
  - Natete Road (B) (0.2 km: Lunguja Area)
  - Gaba Road (0.5 km: Kalungu Channel Crossing Part)

Reinforcement of Linehaul

- Gaba Road (4.1 km)
- Natete Road (3.8 km)
- Port Bell Road (4.8 km)
- Hoima Road (8.5 km)
- Gayaza Road (4.6 km)

Location of the above high-priority projects are shown in Fig. 7.4.

Table 7.4 Selection of High Priority Project

Classification		Project Component		Items and Criteria of Scoring																									
				1-1. Degree of Pavement Deterioration						1-2. Traffic Volume			1-3. Drainage Condition		2-1. Road Classification		2-2. Land use	3. Basic Human Needs		4. Ugandan Government Priority	Total	High Priority Roads	Remarks
				PSI Value						Present Traffic	Future Traffic		Present		Classification			Facility					
				1.0<PSI<1.3	1.3<PSI<2.0	2.0<PSI<3.5	3.5<PSI<4.0	4.0<PSI.5.0	Score	(ADT)	in 2015(ADT)	Score	Condition	Score		Score	Score		Score	Score	Score	Selected	
Improvement of Bottleneck	Junction	B-1	Port Bell jct.				○		10	38,000	67,600	30		5	Trunk	10	10	Bus Route	10	10	85	○	
		B-2	Jinja Rd rdbt.				○		10	71,000	118,400	30		5	Trunk	10	10	Bus Route	10	10	85	○	
		B-3	Clock Tower rdbt.					○	5	57,600	74,700	30	Flooded	10	Trunk	10	10	Bus Route	10	10	85		
		B-4	Kibuya rdbt.			○			15	46,500	82,000	30		5	Trunk	10	10	Bus Route	10	10	90	○	
		B-5	Natete rdbt.			○			15	16,100	29,600	30		5	Primary	5	10	Bus Route	10	10	85	○	
		B-6	Wandegeya rdbt.				○		10	55,100	116,700	30		10	Secondary	5	10	Bus Route	10	10	85	○	
		B-7	Makerere rdbt.				○		10	20,500	50,100	30		10	Secondary	5	10	Bus Route	10	10	85	○	
	Flood Area	B-8	Sentema Rd.			0.6			15		5,500	20	Flooded	15	Secondary	5	5		5	0	65		
		B-9	Hoima Rd.					0.4	5	4,700	11,200	25	Flooded	15	Trunk	10	10	Bus Route	10	10	85	○	
		B-10	Bombo Rd.					0.2	5	13,100	15,300	25	Flooded	15	Primary	5	5	Bus Route	10	10	75		
		B-11	Jinja Rd. (A)					0.2	5	22,900	20,800	30	Flooded	10	Trunk	10	5	Bus Route	10	10	80		
		B-12	Jinja Rd. (B)					0.2	5	22,900	20,800	30	Flooded	10	Trunk	10	5	Bus Route	10	10	80		
		B-13	Gaba Rd.			0.5			15	11,000	23,700	30	Flooded	15	Primary	5	5	Bus Route	10	10	90	○	
		B-14	Natete Rd. (A)		0.2				15	8,500	7,600	20	Flooded	15	Primary	5	10	Bus Route	10	10	85	○	
		B-15	Natete Rd. (B)			0.2			15	8,500	7,600	20	Flooded	15	Primary	5	10	Bus Route	10	10	85	○	
Reinforce of Line haul	Regional	R-1	Gaba Rd.	1.5		2.5	6.0	1.0	11	11,600	72,500	30	Flooded	15	Primary	5	5	Bus Route	10	10	86	○	
		R-2	Natete Rd.		1.0	3.0			15	17,200	23,700	30		10	Primary	5	10	Bus Route	10	10	90	○	
		R-3	Sentema Rd.		4.6	0.6			15		5,500	20		15	Secondary	5	5		5	0	65		
		R-4	Kira Rd.	2.7			1.3	4.0	9	15,960	47,100	30		10	Secondary	5	5		5	0	64		
		R-5	Port Bell Rd.			2.7	2.25	1.75	11	7,800	18,600	25		15	Primary	5	10	Bus Route	10	10	86	○	
		R-6	Jinja-Kampala-Bombo Rd.				1.2	2.5	7	28,700	30,900	30		5	Primary	5	10	Bus Route	10	0	67		
		R-7	Butikiro-Kisenyi Rd.		0.4		1.7		11					15	Tertiary	0	5		0	5	36		
		R-8	Musajja-Alumbwa Rd.			0.5			15				No Facility	15	Feeder	0	5	School Zone	5	5	45		
		R-9	Mwanga Rd.		0.6				15				No Facility	15	Feeder	0	5		0	5	40		
		R-10	Mengo-Kisenyi Rd.		0.7				15					10	Feeder	0	5		0	5	35		
	Inter-regional	R-11	Masaka Rd.			5.0	1.2	2.1	12	22,600	30,100	30		10	Trunk	10	10	Bus Route	10	10	92		
		R-12	Hoima Rd.			1.0	3.3	4.2	8	9,900	25,600	30	No Facility	10	Trunk	10	10	Bus Route	10	10	88	○	
		R-13	Bombo Rd.				1.1	4.0	6	18,300	30,700	30	No Facility	15	Primary	5	5	Bus Route	10	10	81		
		R-14	Gayaza Rd.			4.65		1.25	13	15,700	35,000	30		15	Primary	5	5	Bus Route	10	10	88	○	
		R-15	Jinja Rd.			2.0	3.0	1.9	9	30,900	56,500	30		10	Trunk	10	5	Bus Route	10	10	84		
		R-16	Entebbe Rd.			1.0	2.0		12	24,100	38,900	30		15	Trunk	10	10	Bus Route	10	0	87		
Strengthening of Road Network	Circular	N-1	Inner Ring Rd.				4.5	7.0	7	35,100	83,000	30		10	Secondary	5	5	Bus Route	10	5	72		
		N-2	Katwe Lubiri Ring Rd.	3.8					15	1,700	12,800	25	No Facility	15	Tertiary	0	5		0	10	70		
		N-3	Middle Ring Rd.																		0		Committed
	Access	N-4	Katwe Rd.				1.6		10	17,500	42,400	30		5	Secondary	5	10	Bus Route	10	10	80		
		N-5	Motebi Rd.		0.4				15				No Facility	15	Feeder	0	5		0	5	40		
		N-6	Lubiri ring-Queens way		0.3				15				No Facility	15	Feeder	0	5		0	5	40		
		N-7	Lubiri ring-Masaka Rd.		0.2				15				No Facility	15	Feeder	0	5		0	5	40		

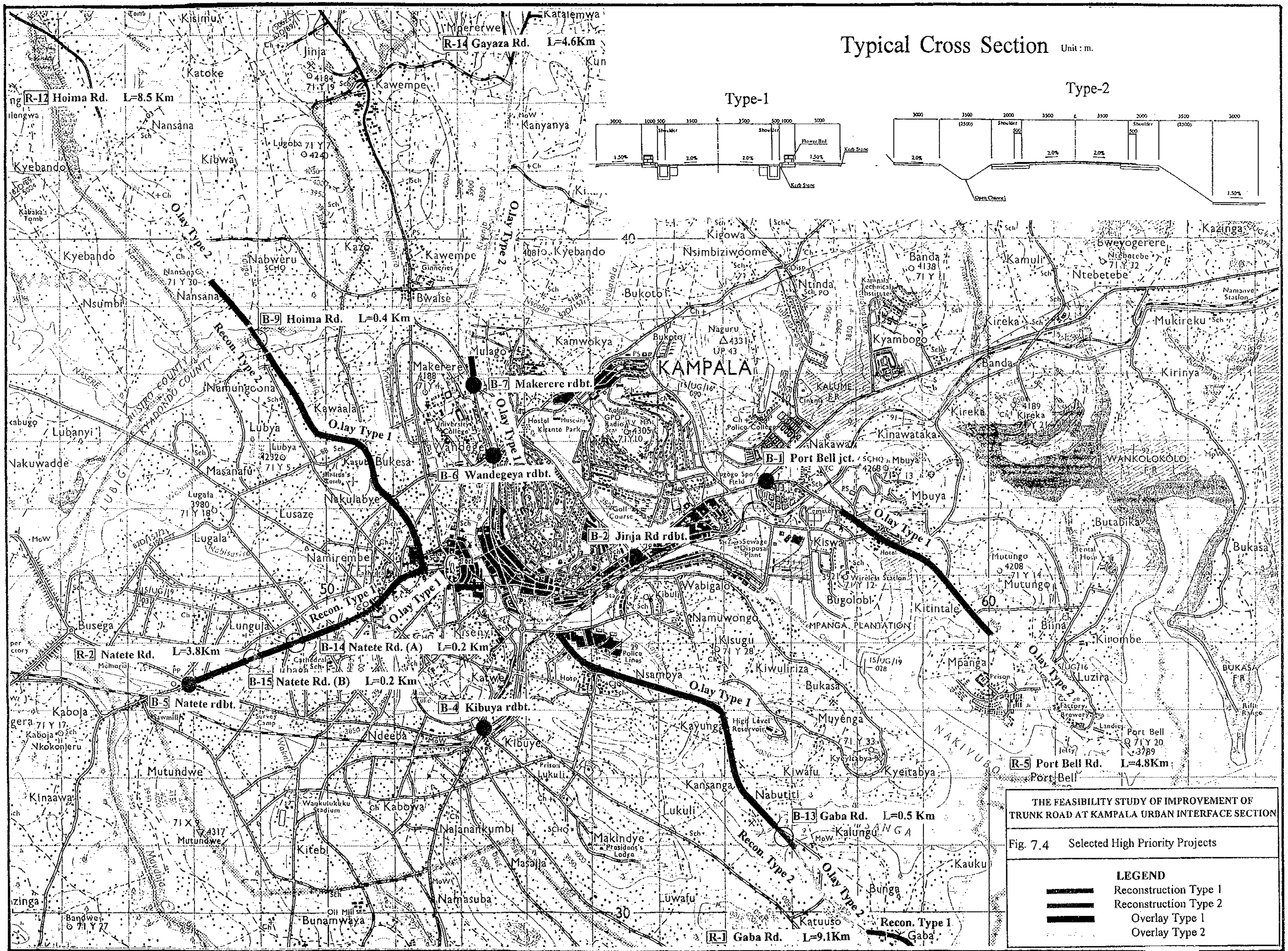
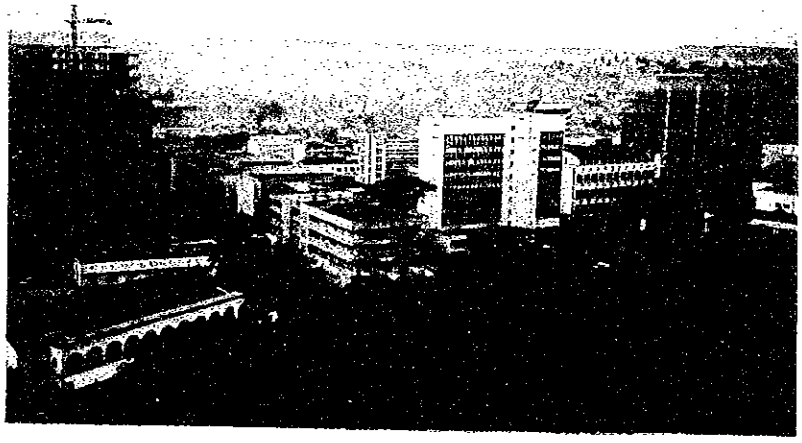


Fig. 7.4 Selected High Priority Projects

PART B: FEASIBILITY STUDY

CHAPTER 8

INTRODUCTION



8. INTRODUCTION

8.1 General

As the result of the Master Plan Study (Part A of the Study), high priority projects to be implemented in the short term plan were selected.

The high priority projects selected in the Master Plan Study consists of two (2) types of projects; namely, (A) Improvement of bottleneck points in urban traffic and (B) Improvement of road sections as the linehaul of the urban traffic as described below:

A. Bottleneck Point Improvement Plan.

- Natete Junction Improvement
- Makerere Junction Improvement
- Kibuye Junction Improvement
- Port Bell /Jinja Road Junction Improvement
- Wandegeya Junction Improvement
- Jinja Road Junction Improvement

B. Road Section Improvement

- Natete Road Improvement (including two (2) raising works of carriage ways at low areas).
- Gaba Road Improvement (including one (1) raising work of carriage way at low areas)
- Port Bell Road Improvement
- Gayaza Road Improvement
- Hoima Road Improvement (including one (1) raising work of carriage way at low area)

8.2 Purpose of the Feasibility Study

The purpose of the feasibility study in the Part B of the Study is to investigate the technical and economic viability's of the selected projects. All the findings during the

study and issues and problems relating to the study are presented in Chapter 8 and afterwards as Part B: Feasibility Study for High Priority Projects.

8.3 Project Descriptions for the Feasibility Study

Project descriptions for the Feasibility Study are as follows:

(Bottleneck Junction Improvement)

- Natete Junction Improvement

  To convert the existing roundabout to a signal controlled one with enlarged traffic capacity and safety measures.

- Makerere Junction Improvement

  To increase the traffic capacity of the junction via improvement of the existing roundabout with the provision of safety measures.

- Kibuye Junction Improvement

  To increase the traffic capacity of the junction via improvement of the existing roundabout with the provision of safety measures.

- Port Bell /Jinja Road Junction Improvement

  To convert the existing junction to a signal controlled one with enlarged capacity and improved safety measures.

- Wandegeya Junction Improvement

  To convert the existing rotary junction to a signal controlled one with enlarged traffic capacity and improved safety measures.

- Jinja Road Junction Improvement

  To increase the traffic capacity of the junction via improvement of the existing roundabout and improved safety measures.

(Road Section Improvement)

- Natete Road Improvement (L = 3.8 Km)

  Overlay of surface pavement on road section of 3.8 Km and uniform widening of carriage way to 7.0m, reconstruction of shoulder, side ditch and sidewalk,

and raising of carriage way at two (2) sections of the road. Total length of the section of raising is 0.4 Km.

- Gaba Road Improvement (L = 9.1 Km)

  Overlay of surface pavement on road section of 9.1 Km, and widening of carriage way to 7.0m. Improvement of shoulder, side ditch and side walk. Raising of carriage way at one section, with length of 0.5 Km.

- Port Bell Road Improvement (L = 4.8 Km)

  Overlay of surface pavement on road section of 4.8 Km, and widening of carriage way to 7.0 m, reconstruction of shoulder, side ditch and side walk.

- Gayaza Road Improvement (L = 4.6 Km)

  Overlay of surface pavement on road section of 4.6 Km. Widening of carriage way to 7.0 m. Improvement of shoulder, side ditch and side walk.

- Hoima Road Improvement (L = 8.5 Km)

  Overlay of surface pavement on road section of 8.5 Km. Widening of carriage way to 7.0 m. Improvement of shoulder, side ditch and side walk. Raising of carriage way at one section, with length of 0.4 Km.

CHAPTER 9

DESIGN STANDARD

9 DESIGN STANDARD

9.1 General

In this chapter, the basic engineering aspects including design standards and typical cross sections to be applied for the proposed roads have been studied. The design was carried out in consideration of the present right-of-way for the identified roads and junctions.

9.2 Design Standards

9.2.1 Functional Classification of the Captioned Roads

The functional classification of each project road has been studied referring to the "Road Design Standards" prepared by MOWTC, November 1994 and consultation with the Road Department of MOWTC. All proposed roads can be classified into the categories shown in Table 9.1.

MOWTC is responsible for six (6) of the primary radial roads (Bombo Road, Gayaza Road, Entebbe Road, Port Bell Road, Gaba Road, Hoima Road) in the city. Natete road is under the administration of KCC but at present it is functioning as an alternative route for Masaka Road. Therefore, it could be classified as a primary road in terms of its function.

Table 9.1 Road Classification of Captioned Roads

Road Name	Road Classification
Natete Road	Primary Road (Principal Arterial System)
Gaba Road	- ditto -
Port Bell Road	- ditto -
Gayaza Road	- ditto -
Hoima Road	- ditto -

9.2.2 Design Speed

Design speed is a fundamental factor for road design and is directly related to the geometric elements of the road including, carriageway width, horizontal and vertical alignment, and so on. As the relevant roads are mainly located in the urban area, it is recommended to reduce their design speed for safety reasons.

The design speeds to be applied for each proposed road has been determined considering of the road classification, traffic volume, terrain condition and land use

pattern along the roads referring to such standards as MOWTC's Road Design Manual, Japanese Road Design Standards and the British Road Standards as shown in Table 9.2.

Table 9.2 Proposed Design Speeds

Proposed Road	Classification by MOWTC	Terrain Condition	Land use Pattern	Proposed Design Speed
Natete Road	Primary Road	Rolling/Level	Urban	60-40 km/hr
Gaba Road	Primary Road	Rolling/Level	Urban	60-40 km/hr
			Suburban	60-40 km/hr
Port Bell Road	Primary Rd	Rolling/Level	Suburban	60-40 km/hr
Gayaza Road	Primary Road	Rolling/Level	Urban	60-40 km/hr
			Suburban	80-40 km/hr
Hoima Road	Primary Road	Rolling/Level	Urban	60-40 km/hr
			Suburban	80-40 km/hr

9.2.3 Design Standards

The design standards have been determined based on the MOWTC Road Design Manual considering present speed levels, land-use pattern along the road, characteristics of traffic movement and anticipated future traffic demands.

The main design elements such as the number of lanes, carriageway width, type and dimension of shoulder/verge, sidewalk, bicycle lane, bus lane, and so on were determined as explained below:

(1) Carriageway

The carriageway width has been determined on the basis of traffic characteristics, traffic volume and their speed and the right-of-way situation. Since each of the captioned roads is expected to function as a trunk road catering for heavy traffic, the lane width has been determined at 3.5 m in principle.

(2) Shoulder

Shoulder is proposed to be located along the whole carriageway and its width was proposed to be 2.0 m in principle, referring to the MOWTC Road Design Manual. However, the width of shoulder between carriageway and raised sidewalk in urban areas is proposed to be 0.5 m.

(3) Sidewalk

The sidewalk is proposed to be provided along the whole section with a width of 2.0 m in principle. Wider sidewalks are necessary where there are many pedestrians and/or where under-ground utilities are being provided. The combined usage of sidewalks by bicycles and pedestrians is recommended to reduce construction costs.

(4) Vertical Clearance

According to the MOWTC Road Design Manual, typical maximum truck heights are 4.2 m. The vertical clearance from the top of the pavement shall be greater or equal to 4.2 m considering the local condition of traffic including additional loading on the top of trucks or buses. With this consideration, it is reasonable to adopt a vertical clearance of 5.0m.

9.3 Standard Cross-sections

The Road Design Manual by MOWTC has been prepared for the designing of roads in the nation in general and it gives no specification on road designing in urban areas. The standard cross-sections to be applied for the proposed roads was prepared by the Study Team by referring to Japanese Road Design Standards and British Road Standards.

The width of the carriageway depends largely upon the type of traffic, traffic volume and speed thereon. A standard cross-section to be applied for each project road has been proposed as below:

1) A sidewalk shall be provided at least along one side of the road.

2) Project roads shall have a single carriageway of two lanes with verges, sidewalks, and cycle lanes.

3) The minimum width of a traffic lane should be 3.5 m excluding shoulders.

4) Large open drainage channels with minimum size (upper width: 2.5 m, height: 1.0 m, lower width: 0.5 m) shall be provided for the purpose of easy maintenance.

5) A utility space below the sidewalks should be provided during the stage of design.

6) Trees shall be planted along the verge between the carriageway and sidewalks/ bicycle lanes so as to reduce traffic accidents involving pedestrians and to protect the roadside environment.

Road cross-sections proposed by the Study Team consists of two prototypes: namely,

a) urban street type with mounted sidewalks/cycle-lanes, and

b) rural road type with broad shoulders and sidewalk/cycle lanes as shown in Fig. 9.1.

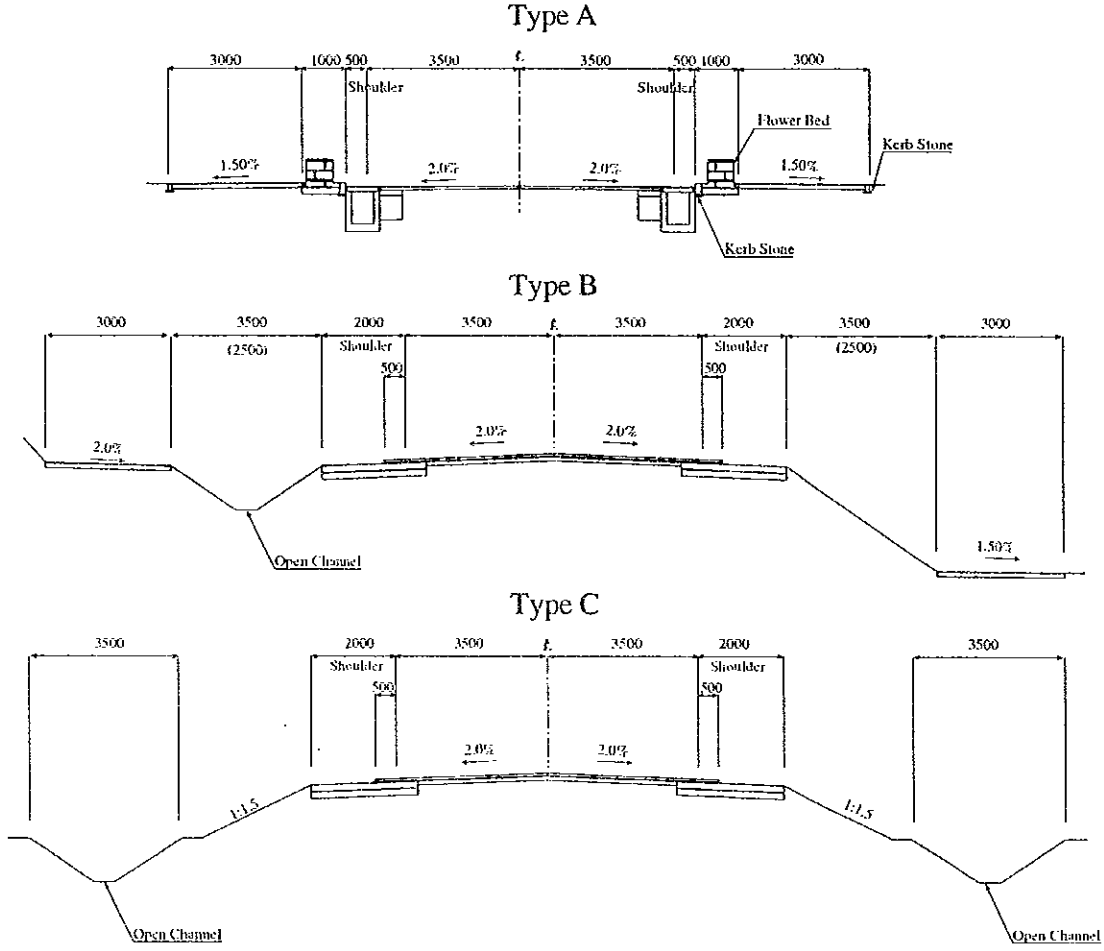


Figure 9.1 Typical Cross Section

Application of them depends upon the land-use pattern nearby the roads, function of the roads and right-of-way condition.

9.4 Right of Way

9.4.1 Basic Concept for Right of Way

The right-of-way is one of the most important factors for road construction and maintenance of road safety. The Road Design Manual by MOWTC defines the criteria of right-of-way as follows:

Class of Road		Right of Way
Bitumen	I	40 m
- ditto -	II	30 m
- ditto -	III	25 m
Gravel	A	30 m
- ditto -	B	25 m
- ditto -	C	15 m

Most of the roads in Kampala City were designed and constructed before the official notice of the Road Design Manual. Therefore, existing right-of-ways for the roads in Kampala City are not conforming to the standard.

With this background the Study Team has established a concept for right-of-way design as follows:

1) The right-of-way for the proposed roads shall be designed in accordance with the MOWTC's standard wherever it is applicable.

2) The road design shall be carried out within the given existing right-of-way as much as possible to minimize the additional land/house acquisitions and compensation for them.

9.5 Junctions

The policies of junction design have been set up as below:

- Existing junction type would be maintained as much as possible.
- Capacity analysis of each of the junctions should be carried out using computer software for junction traffic analysis such as OSCADY 3 and/or ARCADY3, which are internationally authorized junction traffic analysis models.
- Bicycle traffic should be separately handled from motorized traffic.

- If any roundabout junction can not accommodate increased future traffic, it is recommended that it be changed into a signalized junction with optimum size and operation methods.

CHAPTER 10

ENGINEERING SURVEY AND ANALYSIS

10. ENGINEERING SURVEY AND ANALYSIS

10.1 General

The engineering survey was performed to obtain engineering data and information to be used for the preliminary design of the project roads.

The survey consisted of the following:

1) Geological investigation, including subsoil investigations at the bottleneck portions on the proposed roads crossing swamps.

2) Materials investigation, including the subsoil and pavement structure on the proposed roads as well as the investigation of borrow pit areas and quarry sites.

3) Hydrological study and analysis.

4) Topographic survey at intersections and low road sections.

10.2 Geological Investigation

10.2.1 General

The geological investigation was conducted to obtain the basic data for the determination of the foundation works for the crossing culverts and of embankments in swamps, and for the determination of foundation works at the existing piped beam bridge site.

The survey included bore holes using drilling machines, in-situ tests, sampling and laboratory tests at low road sections in swamps and at the existing pipe beam bridge site. All the detailed results obtained throughout the above investigation including the laboratory tests are presented in the Appendix.

10.2.2 Geological Characteristics

A glance at the geological setting of Greater Kampala shows that granitoid gneissies and granites including the Precambrian basement complex are the predominant rock type of the area. There are also Quaternary to recent swampland deposits, such as alluvial and coastline sands, silty clays and gravels, generally covered by papyrus swamps.

Thick laterite duricrust to sandy clays, passing through murram, granite sands and lateritic sandy clays characterize the local natural soil. Lateritic gravel occurs on the

higher ridge crests and slopes and scattered massive outcrops of granite belonging to the basement complex emerge among the sediments. Fig 10.1 is a Geological Map in the Kampala area.

10.2.3 Soil Investigation

(1) Investigation Procedure

The bore holes for the boring test were drilled at each selected site on Hoima Road, Natete Road, Queens Way and Gaba Road. The drilling depths were 6.0m at the site on Hoima Road and 10m at the other 3 sites. The locations of the investigation sites are shown in Fig. 10.2.

Standard Penetration Tests (SPT) were carried out at one-metre depth intervals in each borehole. Two (2) undisturbed samples were also extracted in each borehole.

The samples were tested in accordance with British Standards. The types of the tests carried out are as follows:

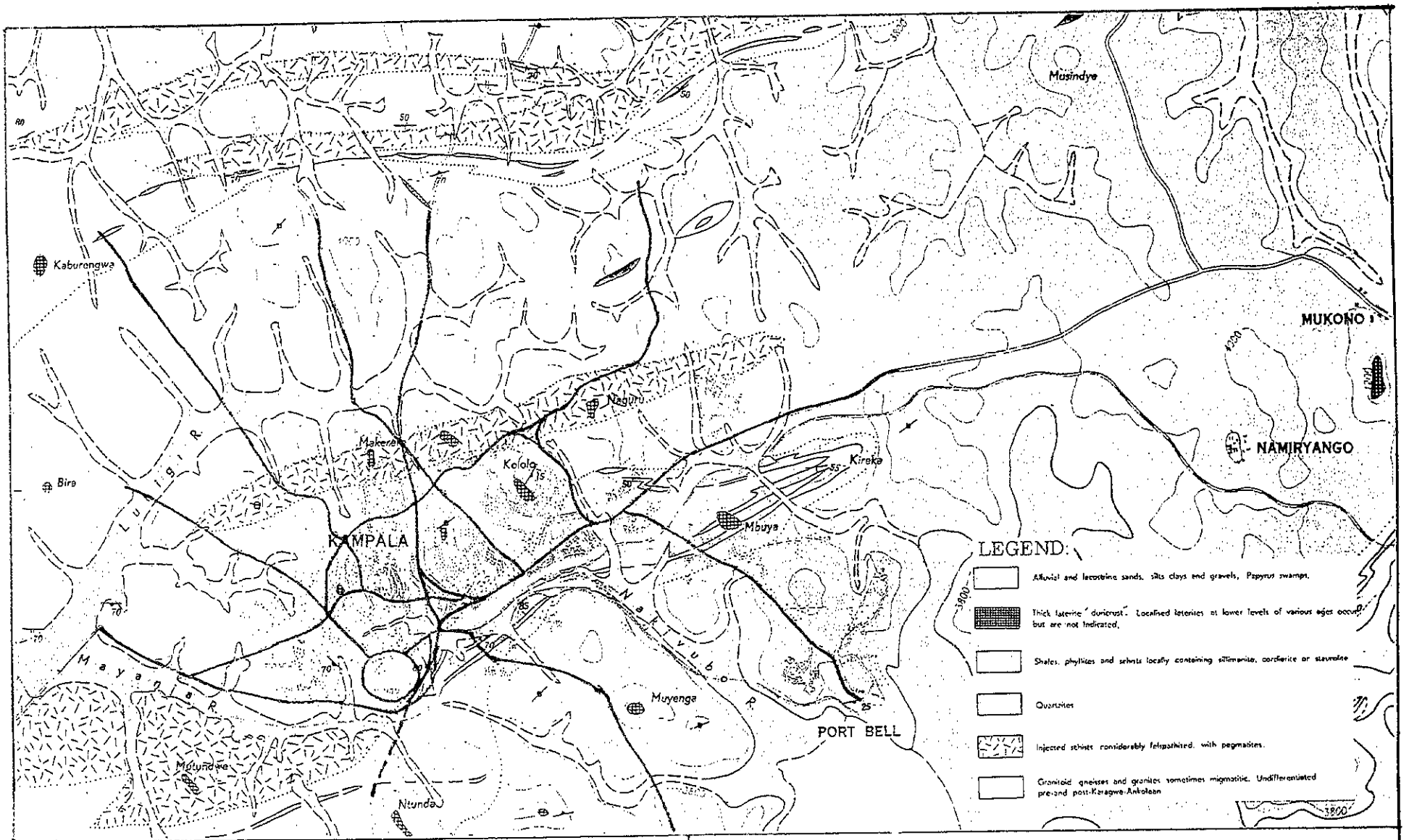
- Grain Size Analysis
- Specific Gravity Test
- Natural Moisture Content (%) Test
- Atterberg Limits (L.L (%), P.L (%), P.I (%)) Test
- Share Strength Test

(2) Investigation Results

The layers in boreholes were found to be predominantly of clay type, with silty-sandy mixtures of CH class in terms of the unified soil classification system.

The SPT N-values range between 5 and 50 save for the top of the BH, where the SPT N-value is 2. Especially, the layer 3 or 4m below the top of the bore holes, except the bore hole BH_2, is very stiff with an SPT N-value in excess of 14.

The maximum size of the particles of the samples was found to be 0.6 mm and the portion passing BS sieve 0.065 mm for most of the samples was more than 50%. The PI ranged between 20% to 49%.



THE FEASIBILITY STUDY OF IMPROVEMENT
OF TRUNK ROAD AT KAMPALA URBAN INTERFACE SECTION

Figure 10.1 General Geological Map in Kampala Area

THE FEASIBILITY STUDY OF IMPROVEMENT OF TRUNK ROAD AT KAMPALA URBAN INTERFACE SECTION

Figure 10.2
Location of Geotechnical Investigation

(B) Boring Survey (4 point)
(C) CBR TEST TYPE 1 (30 Site)
[C] CBR TEST TYPE 2 (2 Site)
△C CBR TEST TYPE 3 (15 Site)

(3) Evaluation of Foundation

At the locations of BH_1 BH_2 and BH_4, a spread foundation or short end bearing pile is to be considered for the major structures. There seems to be no problem with the embankment foundation.

At the location of BH_2, there is no problem with embankment foundations. Should a major structure be proposed, it will be necessary to carry out a more detailed investigation at the stage of detailed design.

10.3 Material Investigation

10.3.1. General

The material investigation aims to grasp the characteristics required for the designing of project roads.

The survey consisted of the following items:

- Test Pits and site CBR tests at 47 sites selected on the proposed roads. Collection of a sample from each test pit of 32 sites to identify existing pavement structure and subgrade intensity.
- Site checking at 5 borrow pits; collection of two samples from each borrow pit for embankment material.
- Site checking and collection of 2 samples at a quarry for base materials.
- Laboratory tests on the basis of British Standards, on samples collected from bore holes, test pits, borrow pits and a quarry.

10.3.2. Investigation for Existing Pavement Structure and Base Materials

(1) Investigation Procedure

The test pits were dug to a size of 1.0 m width, 1.0 m length and 1.0 m depth at 45 selected points along the proposed roads and at each point of Kibuye Roundabout and Jinja Roundabout. The locations of the test pits are shown in Fig. 10.2. At each test pit, the pavement layer thicknesses were recorded and the soil profiles were observed. At the same time, Dynamic Cone Penetration (DCP) tests, model A2465 manufactured by Leonard Farmell & Co., Ltd., England, were conducted to measure the site CBR. The site CBR tests were carried out for subgrade at 30 points on proposed roads and for base course,

subbase and subgrade at 15 points on 5 high priority roads. The methodology adopted was that being recommended by the Overseas Unit of the UK Transport Research Laboratory. At each point three tests were executed which made the total number of testing points 135.

Two disturbed samples were taken from 32 test pits.

For the samples, the laboratory tests were conducted on the basis of BS1377. The types of the test adopted were as follows:

- Grain size analysis
- Specific gravity
- Natural Moisture Content
- Atterberg Limit (LL (%), PL (%), PI(%))

(2) Investigation Results

The existing pavement is generally composed of a lime stabilized gravel base of minimum thickness 100 mm with a double bituminous surface treatment as a wearing course. However, base course in a section of Bombo Road is made of crushed stone base material. Jinja road uses asphalt concrete for the wearing course. The asphalt concrete was 300 mm to 400 mm deep for road sections and was up to 500 mm at Jinja Road Roundabout.

The average thickness of the base and subbase were 186 mm and 180 mm, and the in-situ CBR of the base and subbase were 98% and 58% respectively. The in-situ CBR of the base was rather low.

The site CBR values of the subgrade are significantly below 2% at Gayaza Road No. 1 and at Bombo Road No. 1, 3 ~ 8% on Port Bell Road and Hoima Road No. 1 and 5% at Jinja Road No. 1 respectively. The CBR value of the remaining road sections are more than 7%, indicating suitability as subgrade material.

The base material and subbase material consist of lime stabilized gravel and natural gravel respectively.

The subgrade material mainly consists of sandy-silty clay of intermediate plasticity. Clay-silts and clayer sands were only encountered occasionally.

Most of samples were classified into CI group. Occasionally, some samples were classified into SM, CL and CH class.

10.3.3 Investigation for Embankment Material and Aggregates

(1) Investigation Procedure

The following borrow pits and a quarry site are available for the execution of the project.

Borrow Pit (1)	Mbuya, Nakawa-along Port Bell Road
Borrow Pit (2)	Katale, Mayanja-along Entebbe Road
Borrow Pit (3)	Mutundwe, Rubaga-along Masaka Road
Borrow Pit (4)	Nansana, Nansana-along Hoima Road
Borrow Pit (5)	Kikaya, Kawempe-along Gayaza Road
Quarry (1)	Kiwatu, Makindye East-along Gaba Road

The locations of these sites are shown in Fig. 10.3. Visual inspection of these sites was carried out to determine their condition, location, distance of transportation, potentiality, and so on.

Two samples were taken at each site for the laboratory test. The samples were tested in accordance with BS 1377. The types of the test undertaken are as follows:

- Grain Size Analysis
- Specific Gravity Test
- Natural Moisture Content Test
- Atterberg Limit (LL (%), PL (%), PI (%)) Test
- CBR (OMC (%), MDD (t/m^3)) Test
- Modified CBR (4 days soaked (%)) Test

A supplemental visual survey was carried out at the following borrow pits and quarries in conjunction with Hoima Road, Gayaza Road, and Natete Road development projects.

Borrow Pit (6)	Lubya, Rubaga-along Hoima Road
Borrow Pit (7)	Kiteeze, Kiteeze-along Gayaza Road
Quarry (2)	Jinja, Kawenpe-along Bombo Road

The location of these sites are shown in Fig. 10.3.

(2) Investigation Results

The results of the survey are described below:

- Borrow pit (2) is far from the project roads. It is expected that the transportation costs would be too high.
- At borrow pit (3) and borrow (5) it is difficult to take materials as they are located in the vicinity of an inhabited area.
- As borrow pit (3) is located on the side of Gayaza Road, it is convenient for taking materials, however its deposit is limited.
- Potential quarries were found to be located nearby Quarry (1).

The materials from the borrow pits were gravels with sandy-clay mixtures, classified into GC, indicating suitability as embankment material. The PI and modified CBR-value of the materials varied between 22% and 28%, and between 20% and 31% respectively.

The crushed stone aggregates from the quarry possess a good quality and strength which meet the specification for road construction work. There are also three other quarries in and around Kampala that produce aggregates with a similar quality. The detailed results of the laboratory test are give in Appendix 10.3.

The Study Team judged that the materials from the supplementary sites investigated are usable for road construction work.

The availability of the 7 borrow pits and the 2 quarries is evaluated as shown in Table 10.1 in terms of potential deposit, hauling distance, and quality of material.

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Figure 10.3 Location of Borrow Pits and Quarry

Borrow Pit

Quarry

Table 10.1 Availability of Borrow Pits and Quarries

Site	Potential Deposit	Hauling Distance	Quality
Borrow Pit (1)	Large	Vicinity of Port Bell Road	Good
Borrow Pit (2)	Large	Far from the project roads	Good
Borrow Pit (3)	Sufficient	Vicinity of Masaka Road	Excellent
Borrow Pit (4)	Limitable	Vicinity of Hoima Road	Good
Borrow Pit (5)	Medium	Vicinity of Gayaza Road	Good
Borrow Pit (6)	Sufficient	Near to Hoima Road	Good
Borrow Pit (7)	Sufficient	Far form the project area	Good
Quarry (1)	Sufficient	Far from the project roads	Excellent
Quarry (2)	Sufficient	Near to Bombo Road	Good

10.4 Hydrological Survey

10.4.1 General

The hydrological survey was carried out to obtain the hydro-meteorological conditions of the area.

The rainfall data at Kampala Sewerage Station and the water level of Lake Victoria at Entebbe Station were collected from the Meteorological Department and Water Resources Department respectively. The site observations of floodmarks, interviewing of local inhabitants in the vicinity were carried out to identify the course and direction of flood water flow, the location of the flooded area, the cause of inundation during flooding, and to identify the size of road crossing culverts to be adopted.

The return period assumed for the hydraulic calculation is 25 years for the major structures such as culverts and 10 years for all other works.

10.4.2 Flood Drainage System

Kampala city is located on a series of hills which have steep slopes in the range of 10-25% and are separated by valleys with varying gradient.

The north-western area of Kampala drains into the Lubigi Swamp through branch channels in the valleys. The Lubigi swamp crosses six main roads and the whole catchment area is about 61.5 sq.km.

Hills along Masaka road drain into the Nalukolongo Channel which connects to the

Lubigi swamp. The total area of the swamp is about 6 sq.km. The basin area of the Kansanga Swamp including Makindye hill and Kongi hill in the southern part of Kampala is about 9.1 sq.km. Some small channels, which start from Naguru hill, Ntinda hill and Banda hill on the northern side of Jinja Road, cross Jinja Road and drain into swamp area.

More than 95% of the central urban area drains its water into the Nakivubo Channel, which starts at the junction of Makerere Road and Bombo Road to the north-west of the city, runs roughly southward to the Clock Tower roundabout, then turns eastwards to drain into Lake Victoria nearby Port Bell. The whole catchment area is about 30 sq. km. The drainage system and the boundary of each catchment area are shown in Figure 10.4 and the catchment areas are shown in Appendix 10.4.5.

During the rainy season, flooding often occurs on the project roads due to poor maintenance of drainage, channel and water courses in swamp areas, and insufficient capacity of drainage facilities. The flooding areas are shown in Fig 10.5.

The flooding problems of the area are categorized into the following three (3) types of problems:

Type 1

This type of problem occurs when flood water overflows on the roads with excess water heads which increases the size of the flooded upstream area, due to insufficient capacity of road crossing culverts. This type of problem occurs on the roads crossing Lubigi swamp, its tributary and Kansanga swamp. The Study Team considers an enlargement of the size of culverts and raising of road levels to be effective measures.

Type 2

This type of problem comes from the thick growth of vegetation such as papyrus at the neck portion of the swamp, which contributes to the elevation of the water level of the upstream swamp area during the rainy season. This type of problem occurs along some portions of Jinja Road in the vicinity of Main Training Centre where a flood depth of 20 cm to 50 cm sometimes prevents cars and light vehicles passing through the area during the rainy season. To solve this problem, it is necessary to dredge the neck portion of the swamp to maintain the water courses.

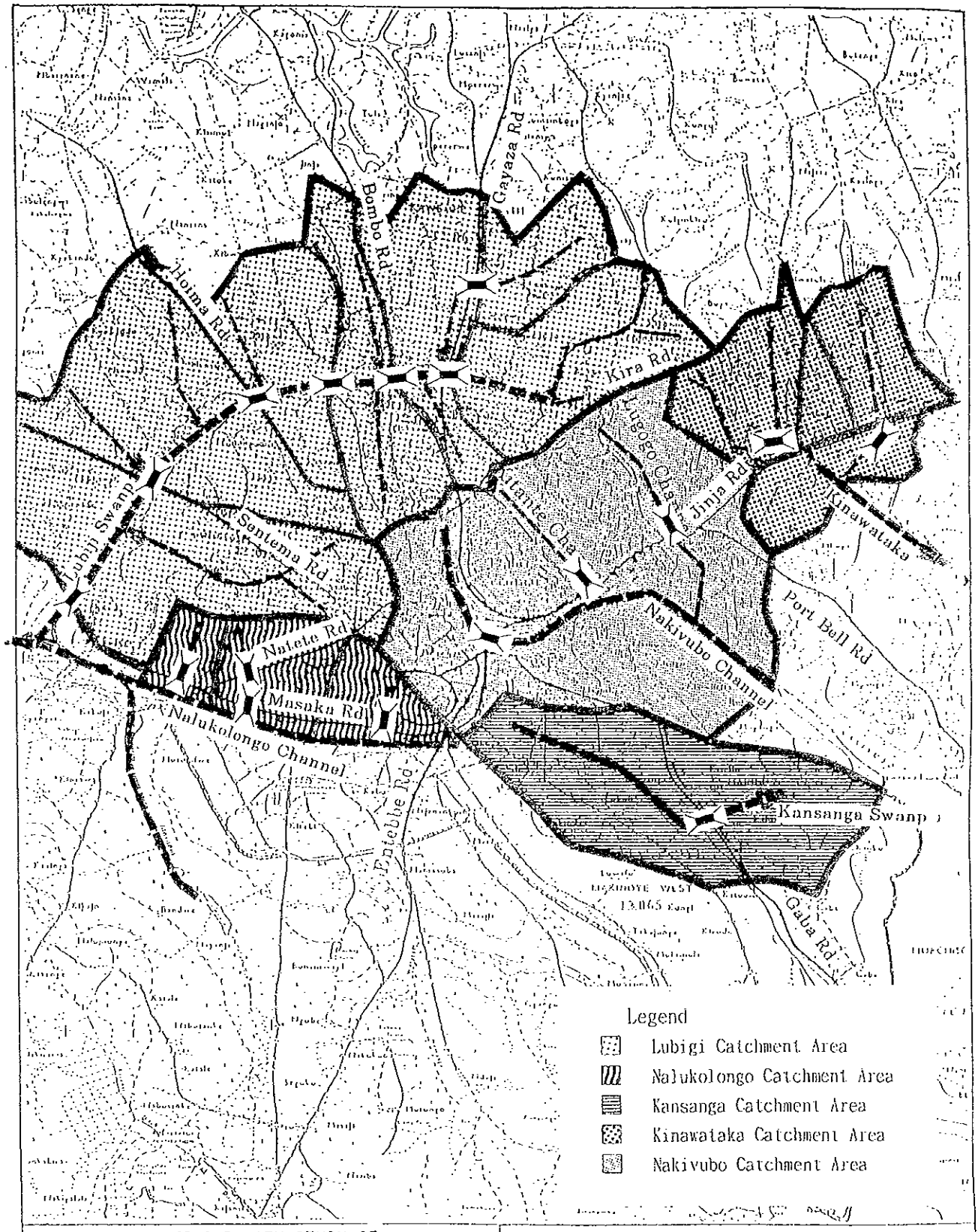

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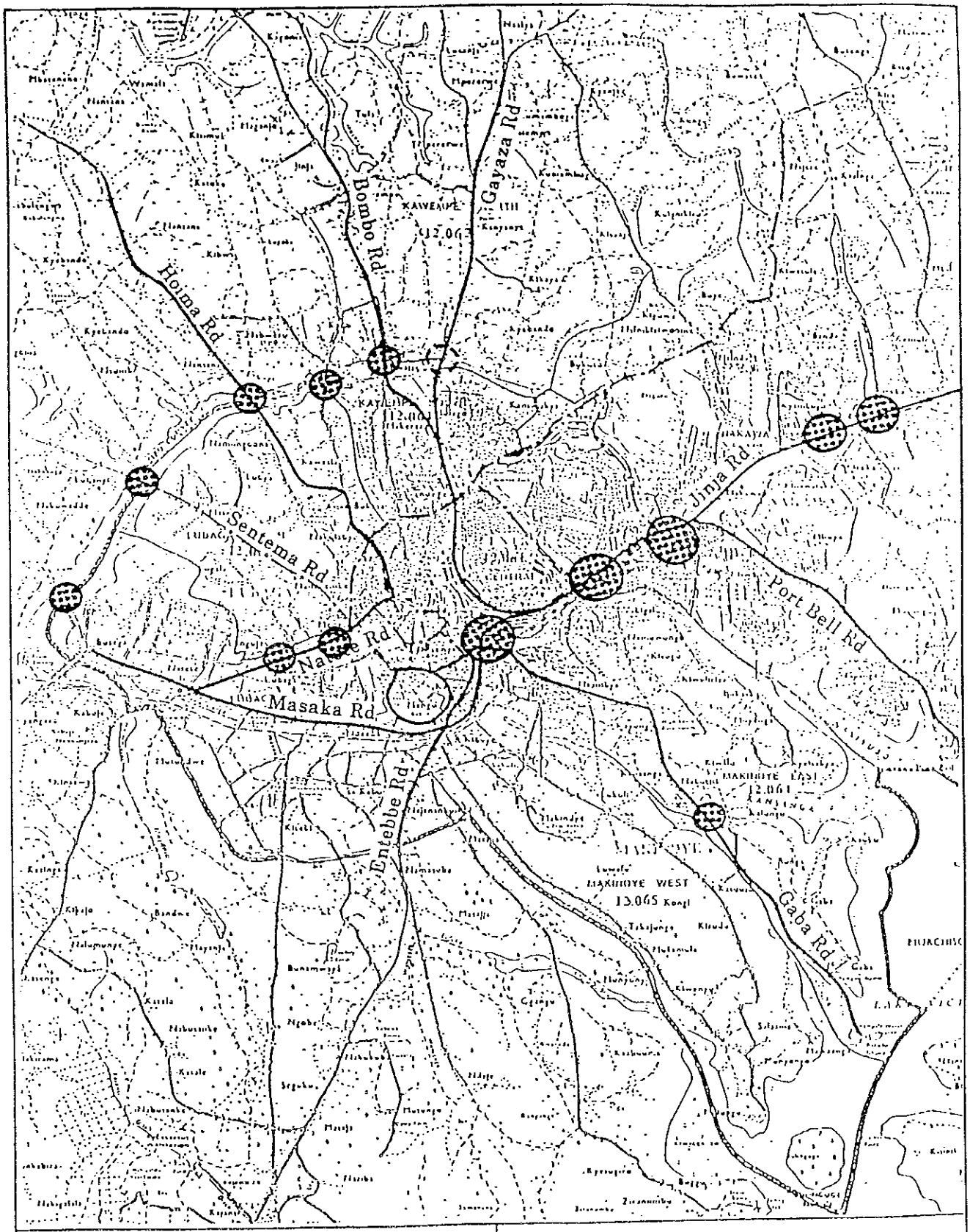
Figure 10.4 Flood Drainage System in Kampala City



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Flood Area on the Roads

Figure 10.5
Flood Area Observed during Rainy Season

Type 3

This type of the problems occurs due to the lack of drainage capacity of the Nakivubo Channel. The flooding depth of 0.5 m - 1.0 m leads to serious disruption of traffic at the Clock Tower roundabout, access roads to Clock Tower and roads along the industrial area. KCC has a plan of rehabilitation for the Nakivubo Channel with EU funds.

10.4.3 Hydrology

(1) Review of Rainfall Data and Probable Rainfall Analysis

The rainfall data from 1974 to 1996 was obtained from the Meteorological Department. According to this data, annual mean rainfall during the past 22 years is more than 1,100 mm.

Frequency analysis was performed applying Hazen, Gumbel and Pearson III methods based on the maximum Daily Rainfall shown in Appendix 10.10. These are shown in Appendix 10.4.4. After the comparison of the results by three methods, the Gumbel method was applied for frequency analysis in the study as shown below:

-	Return Period (Year)	10	20	25	50	100
-	Daily Rainfall (mm)	73.6	81.0	83.4	90.6	97.8

(2) Water Level in Lake Victoria

As most of the flood water from the catchment area drains into Lake Victoria, analysis was focused on the water levels of the lake. Recorded levels of the lake in history vary between 1,133.17 m in February 1923 and 1,136.28 m in June 1964. According to the data during the last 23 years at Entebbe Station obtained by Water Resources Department, the lake levels remain constant throughout the year with a low level during October - April and a maximum in May.

The result of a frequency analysis is summarized as follows:

- Return Period (Year)	10	20	25	50	100
- Daily Water Level (m)	1135.89	1136.23	1136.34	1136.57	1136.99

(3) Design Return Period

According to the road design manual in Uganda, the minimum flood return period for road design is described as below:

Bridge and associated Structure:

Major Bridge	25 to 50 years
Minor Bridge	20 to 25 years

Culverts:

Major Structure	25 years
Minor Structure	10 years

Based on the above criteria, the design return period to be adopted for this study was determined as follows:

Culvert	20 to 25 years
Roadside Structure	10 years

(4) Peak Flood Discharge

Method of Analysis

Peak flood discharge (Q) is estimated by applying following Rational Formula.

$$Q = 0.2778C \cdot r \cdot A$$

Where,

Q:	Peak flood discharge (m^3/s)
C:	Run-off coefficient
r:	Rainfall intensity (mm/hr)
A:	Catchment area (km^2)

Run off coefficient (c) is given by landuse pattern as shown below:

Land Use	Rainfall coefficient
Lawns	0.15 (0.05 ~ 0.25)
Single storeyed housing areas	0.40 (0.30 ~ 0.50)
Apartment dwelling areas	0.60 (0.50 ~ 0.70)
Industry	0.70 (0.50 ~ 0.90)

Business	0.75 (0.50 ~ 0.95)
Undeveloped area (vegetation)	0.10 (0.02 ~ 0.21)
Swamp areas	1.00 (in rainy season)

(Source: MOWTC Road Design Manual)

The major landuse of hills in Kampala city is for residential purpose, and flood water from the area is drained into swamp areas. The swamps are usually filled with flood water in the rainy season and then the rain water directly flows downstream (C = 1.00). On the other hand, thick growth of vegetation such as papyrus in the swamps absorbs run-off during rainfall (C = 0.10). Therefore, in the study, the run-off coefficient is assumed to be at 0.50 as an average for whole catchment area.

On the other hand, rainfall intensity is estimated by landuse pattern applying the following formula:

$$r = R24/24\ (24/t)^{2/3}$$

Where,
- r: Rainfall intensity (mm/hr)
- R24: Probable daily rainfall (mm)
- t: Concentration time (hr)

In the above, time of concentration (t) is given by following formula:

$$t = L/W \text{ (sec)}$$

Where,

$$W = 20\ (H/L)^{0.6} \text{ (m/sec)}$$

- W: Flood run-off velocity
- L: Length of the catchment along the rain water course from the outlet to the most distant ridge (m)
- H: Difference in elevation between the catchment outlet and the most distant ridge (m)

Flood Discharge

Flood discharge at each point in catchment areas was calculated applying the "Rational" formula is shown in the Appendix 10.16.

(5) Hydraulic Structure of Culverts

Hydraulic structure of culverts by project road was determined as below:

1) Culverts on High Priority Proposed Road

Hoima Road

- Proposed Design Discharge (Q)

  $Q = 53.15\ m^3/sec$ (Refer Appendix 10.16)

- Capacity of Existing Culvert

  $1.20\ m \times 1.20\ m \times 3$ vents $(= 12.96\ m^3/sec)$

- Shortage of Design Discharge (Q_s)

  $Q_s = 53.15\ m - 12.96\ m = 40.19\ m^3/sec$

- Required of Size of Additional Culvert

  Required flow area was determined to be $13.4\ m^2$ as below, assuming flow velocity of 3.0 m/sec:

  Required flow area $= 40.21\ m^3/3.0\ m/sec = 13.4\ m^2$

  From the above, it is concluded that 4 of the additional culverts, with dimension of 2.25 m by 1.5 m, can accommodate the surplus of discharge as shown below:

  $2.25\ m \times 1.5\ m \times 4 = 13.5\ m^2\ (>13.4\ m^2)$

Natete Road (1)

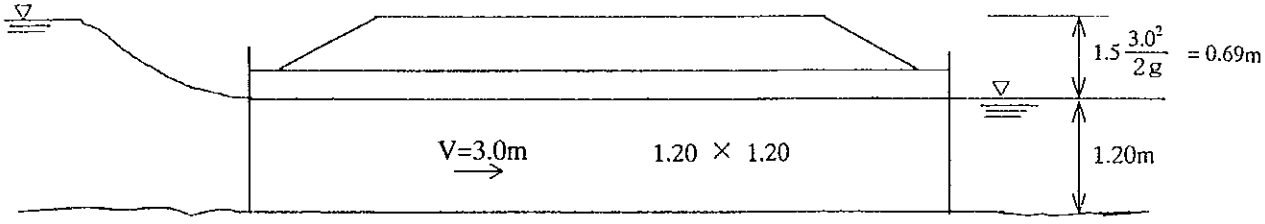
- Proposed Design Discharge (Q)

  $Q = 1.48\ m^3/s$ (Refer Appendix 10.16)

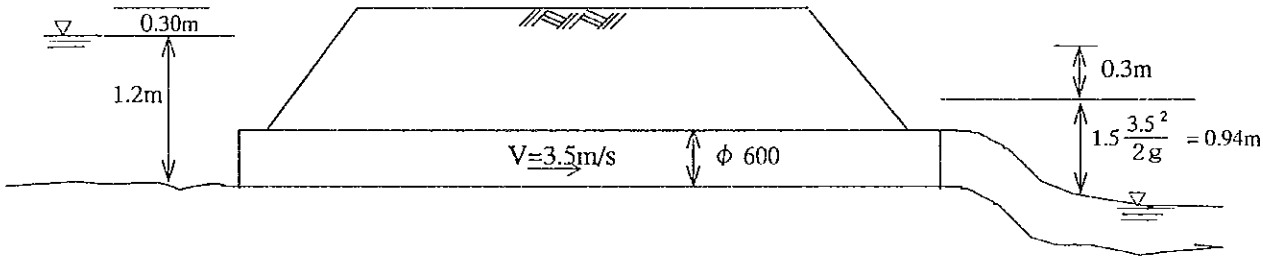
- Capacity of Existing Culvert (ϕ = 600 mm)

  $3.14 \times 0.30^2\ m \times 3.5\ m/sec = 0.99\ m^3/sec$

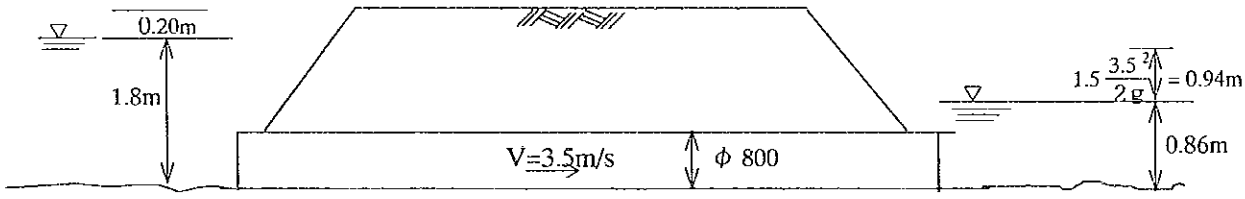
Hoima Road



Natete Road (I)



Natete Road (II)



Gaba Road

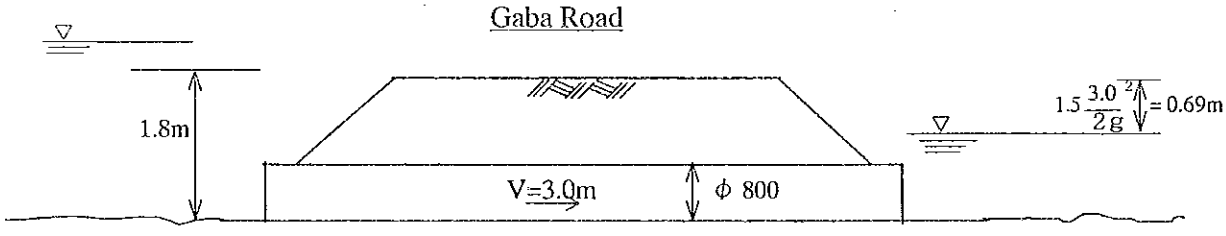
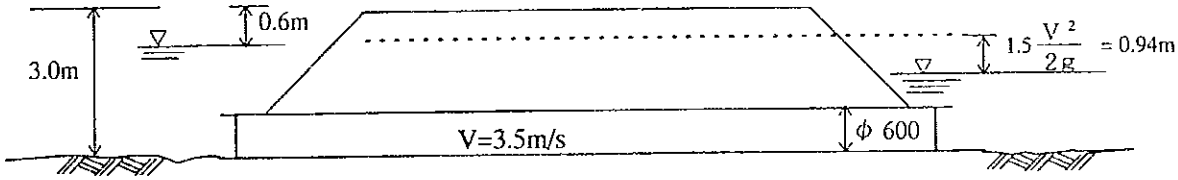
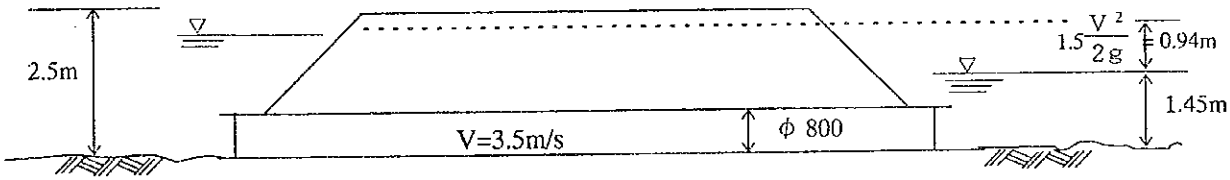


Figure 10.6 Cross Section of Bottle-neck Portion on High Prority Proposed Road

Gayaza Road



Bombo Road



Other Road

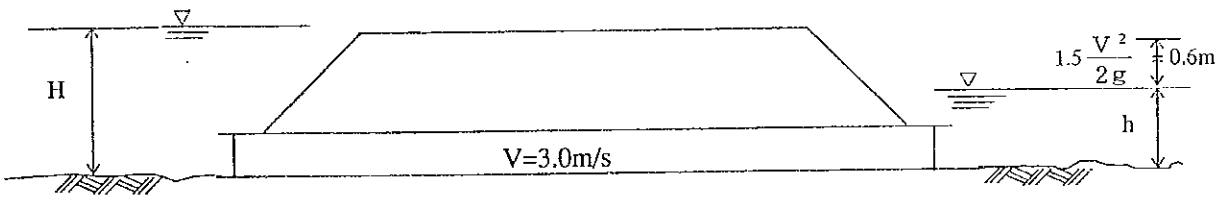


Figure 10.7 Cross Section of Bottle-neck Portion on other Proposed Road

- Shortage of Design Discharge (Qs)

  Qs = 1.48 m^3/sec - 0.99 m^3/sec = 0.49 m^3/sec

- Required Size of Additional Culverts

  Required flow area: 0.49 m^3/sec ÷ 3.5 m/sec = 0.14 m^2

  The above would be accommodated with an additional corrugated pipe with 0.3 m radius as shown below:

  3.14 × 0.3^2 m = 0.28 m^2 (>0.14 m^2)

Natete Road (2)

- Proposed Design Discharge (Q)

  Q =1 0.97 m^3/s (Refer Appendix 10.16)

- Capacity of Existing Culvert (ø = 800 mm)

  3.14 × 0.40^2 m × 3.5 m/sec = 1.76 m^3/sec

- Shortage of Design Discharge (Qs)

  Qs = 10.97 m^3/sec - 1.76 m^3/sec = 9.21 m^3/sec

- Required Size of Additional Culverts

  Required flow area: 9.21 m^3/sec ÷ 3.5 m/sec = 2.62 m^2

  Box culvert required is: 2.2 m × 1.2 m × 1 vent

  2.2 m × 1.2 m = 2.64 m^2 (>2.63 m^2)

Gaba Road

- Proposed Design Discharge (Q)

  Q = 27.27 m^3/s (Refer Appendix 10.16)

- Capacity of Existing Culvert (ø600 mm × 2 vents, 3 nos)

  3.14 × 0.30^2 m × 2 × 3 vent × 3 m/sec = 5.09 m^3/sec

- Shortage of Design Discharge (Qs)

  Qs = 27.27 m^3/sec - 5.09 m^3/sec = 22.18 m^3/sec

- Required Size of Additional Culvert.

  Required flow area: 22.18 m^3/sec/3.0 m/sec = 7.39m^2

  Box culvert required is: 1.80 m × 1.50 × 3 vents = 8.1 m^2 (>7.39 m^2)

2) Culvert on Other Proposed Roads

The result of calculation and the recommended size of additional culvert for other proposed roads are shown in Table 10.2.

10.5 Topographical Survey

10.5.1 General

The objective of this survey was to prepare a topographical map to be used for the preliminary design of intersections and road section passing in low areas. The survey was carried out at seven intersections and at four points applying a Total Survey System consisting of Auto Survey and Auto Cad.

For a Total Survey System, two new control stations, each composed of a 1.5 m long 300 mm mild steel pin driven into 30 square cm by 1.0 m deep concrete, were set up at each intersection.

The National Control System in Universal Transverse Marcator Zone 36 was transferred from the nearest GPS stations to the newly set up station by using the Modern Sokkia Set 2C Total Station. From the new stations, detailed information on the intersection automatically recorded into the Autocad program using a reflector.

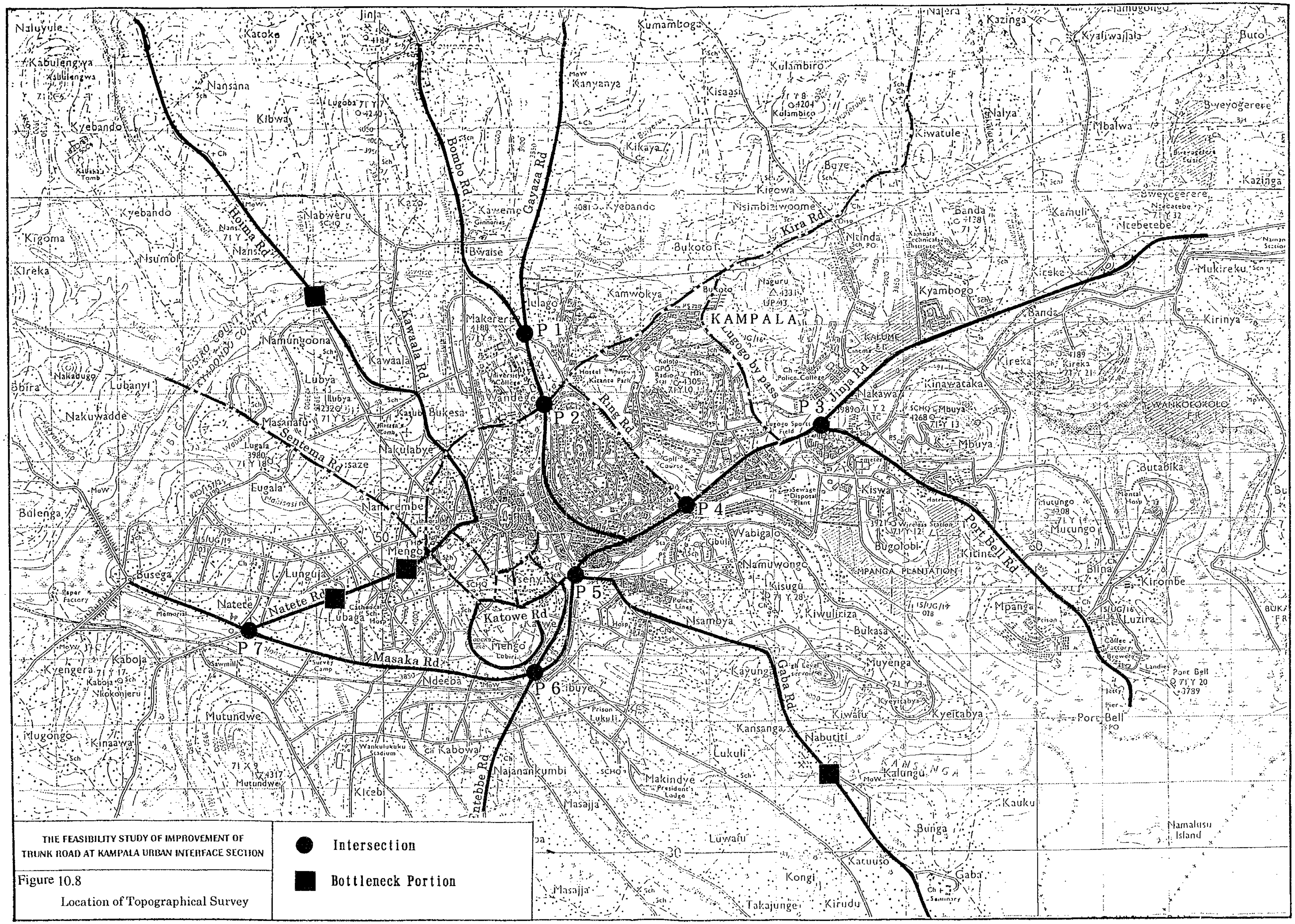
The locations of the topographical survey and benchmarks are shown in Fig. 10.8.

10.5.2 Preparation of the Topographic Map

The topographic maps are prepared with a proper scale for designing each intersection and low road section . The topographic maps include the location of the new benchmarks established on the roadside for each intersection and low road sections.

Table 10.2 Design Discharge and Size of Additional Culvert on Other Proposed Road

Proposed Point	Dischage (m^3/s)	Flow Velocity (m/s)	Size of Existing Culvert	Capacity of Ex. Culvert (m^3/s)	Design Dischage (m^3/s)	Size of Additional Culvert
Mubende	71.39	3.0	φ800×3Vents	4.52	66.87	B.C 2.0m×3.0m×4Vents
Sentema	61.88	3.0	φ800×3Vents	4.52	57.36	B.C 2.0m×2.5m×4Vents
Hawaala	47.83	3.0	φ800×3Vents	4.52	43.31	B.C 2.0m×3.0m×3Vents
Bombo	39.50	3.5	φ800×2Vents	3.52	35.98	B.C 2.0m×3.0m×2Vents
Gayaza (1)	17.99	3.5	φ600×3Vents-3nos	8.90	9.09	B.C 1.2m×1.5m×2Vents
Gayaza (2)	15.25	3.5	φ800×1Vent	1.76	14.75	B.C 1.2m×1.5m×3Vents
Masaka (1)	17.16	3.0	-	-	17.16	B.C 1.2m×1.5m×3Vents
Masaka (2)	26.20	3.0	-	-	26.20	B.C 1.5m×2.0m×3Vents
Masaka (3)	13.29	3.0	-	-	13.29	B.C 1.5m×1.5m×2Vents
Jinja (1)	23.56	3.0	φ800×1Vent	0.85	22.71	B.C 1.5m×2.0m×3Vents
Jinja (2)	4.62	3.0	-	-	4.62	C.S.P.C φ1000×2Vents
Jinja (3)	11.67	3.0	φ800×1Vent	1.50	10.17	B.C 1.2m×1.5m×2Vents
Jinja (4)	6.44	3.0	-	-	6.44	C.S.P.C φ1000×3Vents



THE FEASIBILITY STUDY OF IMPROVEMENT OF TRUNK ROAD AT KAMPALA URBAN INTERFACE SECTION

Figure 10.8
Location of Topographical Survey

● Intersection

■ Bottleneck Portion