Environmental Checklist 1 / 4

ANNEX-5

Category	Environmental Item	Main Check Items	Confirmation of Environmental Considerations
1 Permits and Explanation	(1) EIA and Environmental Permits	① Have EIA reports been officially completed? ② Have EIA reports been approved by authorities of the Zambia government? ③ Have EIA reports been unconditionally approved? If conditions are imposed on the approval of EIA reports, are the conditions satisfied? ④ In addition to the above approvals, have other required environmental permits been obtained from the appropriate regulatory authorities of the government?	①EIS Report have not completed. EIS report will be approved in April 2011. ② EIS report will be approved in February 2011. Draft EIS document for the Project have been submitted in January 2011 and the final report will be approved in April 2011. ③ Not yet. ④Not applicable.
	(2) Explanation to the Public	① Did implementing agency explain contents of the project and the potential impacts adequately to the public based on appropriate procedures concerning information disclosure? Did participants understand what to be explained? ② Are proper responses made to comments from the public and regulatory authorities?	①2 Stakeholder Meetings were held at LCC, in addition, 3 Focus Group Meetings have been held along the project area for PAPs. The purpose of meetings were to inform stakeholders about the project implementation, route alternatives, receive comments, route selection process , design results and land expropriation procedure. Suggestions that have been received from attendees were on the land acquisition issue and environmental mitigation measures. Focus Group Meeting was held along the Project Road which is newly proposed such as Inner Ring and Ben Bella Extension road according to the schedule. ②LCC has responded to all the inquiry.
2 Mitigation Measures	(1) Air Quality	① Is there any possibility that air pollutants emitted from various sources, such as vehicle traffic, may affect ambient air quality? Does ambient air quality comply with the country's ambient air quality standards? ② Where industrial areas already exist near the route, is there a possibility that the project make air pollution worse?	① The project site is considered fair since the site does not have any major polluting source such as industrial areas or heavy traffic. During construction period, dust of works may effect ambient, so periodical measures such as water spray around work site and installing sheet cover on a truck is necessary. Pollution of exaust from vehicles such as NO_2 will be within ambient air quality standards considering with ambient air quality level monitored in Lusaka city center during construction and operation period. ②No industrial area exists along the Project alignment.
	(2) Water Quality	① Is there any possibility that soil runoff from the bare lands resulting from landslide, such as cutting and filling works, may cause water quality degradation in downstream water areas? ② Is there a possibility that surface runoff from roads may contaminate water sources such as groundwater? ③ Do effluents from various facilities, such as stations and parking areas/service areas, comply with the country's effluent standards and ambient water quality standards? Is there a possibility that the effluents may cause areas that do not satisfy with the country's ambient water quality standards?	①Earth work won't be carried out during rainy season and filled soil will be protected by grouted riprap, so there is no possibility of soil runoff and water quality degradation in downstream water area. ②Surface runoff water from roads during operation period will be designed to be drained as public water, and periodical cleaning on road is on menu. Influence of surface runoff water is little. Contamination of groundwater is negligible. ③There is no facilities along the road.

Environmental Checklist 2 / 4

ANNEX-5

Category	Environmental Item	Main Check Items	Confirmation of Environmental Considerations
	(3) Noise and Vibration	① Do noise and vibrations from vehicle traffic satisfy with the country's standards?	①During construction period, especially land preparation and structural works (with the full use of heavy equipments), noise level at a nearest residence from road alignment, will exceed international standards. Low noise construction equipment should be used especially near sensitive facilities such as school. During operation period, noise level in the area immediate to the road will be the same as present condition of other roads existing districts. The project may cause insignificant impact of vibration to community or structures.
3 Natural Environment	(1) Protected Areas	① Is the project site located in protected areas designated by the country's laws or international treaties and conventions? Is there a possibility that the project may affect the protected areas?	①No. The Project site is not in protected area.
	(2) Ecosystem	① Does the project site encompass primeval forests, tropical rain forests, ecologically valuable habitats (e.g., coral reefs, mangroves, or tidal flats)? ② Does the project site encompass the protected habitats of endangered species designated by the country's laws or international treaties and conventions? ③ If significant ecological impacts are anticipated, are adequate protection measures taken to reduce the impacts on the ecosystem? ④ Are adequate protection measures taken to prevent impacts, such as disruption of migration routes, habitat fragmentation, and traffic accident of wildlife and livestock? ⑤ Is there a possibility that installation of roads will cause impacts such as destruction of forest, poaching, desertification, reduction in wetland areas, and disturbance of ecosystems due to introduction of exotic (non-native invasive) species and pests? Are adequate measures taken in order to prevent such impacts considered? ⑥ In cases where the project site is located at undeveloped areas, is there a possibility that the new development will result in extensive loss of natural environments?	①There is no primeval, tropical forest, nor ecological valuable habitat in the project area or nearby. ②Project site does not encompass protected area based on Law in Zambia and no species of Red List based on IUCN 2008. ③No significant ecological impacts are anticipated. ④Disruption of migration routes, habitat fragmentation and so on are not anticipated. The project area is located in the urban areas of the capital city. ⑤They are not anticipated. ⑥The project alinement pass through existing road for local people and housing land developemet.
	(3) Hydrology	① Is there a possibility that change of topographic features and installation of structures such as tunnels may adversely affect surface water and groundwater flows?	①There might be no impact to surface hydrology and underground hydrology due to the road design considered drainage structures.
	(4) Topography and Geology	① Is there a soft ground on the route that may cause slope failures or landslides? Are adequate measures considered to prevent slope failures or landslides if needed? ② Is there any possibility that civil works such as cutting and filling will cause slope failures or landslides? Are adequate measures considered to prevent slope failures or landslides? ③ Is there any possibility that soil runoff will result from cutting and filling areas, waste soil disposal sites, and borrow sites? Are adequate measures taken to prevent soil runoff?	①There is no soft ground on the route of the Project. ②There is no possibility of slope failure or landslides because project road will be desined as flat or low embankment structure. ③Adequate measures will be taken to prevent soil runoff during construction. The earthwork will be carried out in dry season in principal.

ANNEX-5

Category	Environmental Item	Main Check Items	Confirmation of Environmental Considerations
4 Social Environment	(1) Resettlement	① Is involuntary resettlement caused by project implementation? If yes, are adequate efforts made to minimize the impacts? ② Is adequate explanation on relocation and compensation given to affected persons prior to resettlement by responsible agency? ③ Is the resettlement plan, including proper compensation, restoration of livelihoods and living standards developed based on socioeconomic studies? ④ Does the resettlement plan pay particular attention to vulnerable groups or persons, including women, children, the elderly, people below the poverty line, ethnic minorities, and indigenous peoples? ⑤ Are agreements with the affected persons obtained prior to resettlement? ⑥ Is the organizational framework established to properly implement resettlement? Are the capacity and budget secured to implement the plan? ⑦ Is a plan developed to monitor the impacts of resettlement?	①Yes, but adequate efforts have been taken by LCC. ②Yes. Adequate explanation was given to affected persons by LCC by holding the consultation meeting with project affected people. ③Proper compensation will be paid which was calculated based on full replacement cost. ④There is no vulnerable person around resident of Inner Ring Road because they have a budget for construction of a houses by themselves. Around Benbela Extension Link there are some of vulnerable people, however, the road alignment will affect only one residential house. It is necessary to pay special attention for the resettlement such as offering of accomodation and introduction of a job. There is no ethnic minorities and indigenous people living aroud project area. ⑤Yes. LCC will have gotten agreement with all the households to be affected by the Project for resettlement and land acquisition, although 51 houses and land will be affected. ⑥MLGH should be responsible for overall resource for mobilization, coordination and financing of implementation of resettlement programme as a lead organization of the project. LCC should be responsible for the implementation of resettlement such as progress management, monitoring and report ⑦Regarding the progress of (a) resettlement of households/structures, executing agency LCC will monit
	(2) Living and Livelihood	① In a place where roads are newly installed, is there any possibility that the project may affect the existing means of transportation and the associated workers? Is there any possibility that the project may cause significant impacts, such as extensive alteration of existing land uses, changes in sources of livelihood, or unemployment? Are adequate measures considered for preventing these impacts? ② Is there any possibility that the project may adversely affect the living conditions of inhabitants other than the affected inhabitants? Are adequate measures considered to reduce the impacts if necessary? ③ Is there any possibility that diseases, including communicable diseases, such as HIV may be introduced due to immigration of workers associated with the project? Are adequate considerations given to public health if necessary? ④ Is there any possibility that the project may adversely affect road traffic in the surrounding areas (e.g., by causing increases in traffic congestion and traffic accidents)? ⑤ Is there any possibility that roads and may cause impede the movement of inhabitants? ⑥ Is there any possibility that structures associated with bridge may cause a sun shading and radio interference?	①The Project may not affect any activities. ②The Project may bring some adverse environmental impacts such as noise, air quality, to residents near the Project site. So these impacts may affect adversely to residents, but these are not significant. When noise level will exceed international standard LCC will receive complaints from the neighboring people during construction and operation stage. ③No. There is no possibility to be brought communicable diseases. ④No. The Project will bring about positive impacts to traffic around Project site. However, there might have certain negative impact to traffic during the construction period. Allocation of people who control traffic is necessary to reduce traffic jam. ⑤Same as the above. ⑥No bridge is planned in this project.
	(3) Heritage	① Is there a possibility that the project may damage the local archeological, historical, cultural, and religious heritage sites? Are adequate measures considered to protect these sites in accordance with the country's laws and JICA Guidelines for Environmental and Social Considerations?	①No. There is a church nearby the project site, however, adequate mitigation measures will be taken.

ANNEX-5

Category	Environmental Item	Main Check Items	Confirmation of Environmental Considerations
	(4) Landscape	① Is there a possibility that the project may adversely affect the local landscape? Are necessary measures taken?	①There might be no impact.
	(5) Ethnic Minorities and Indigenous Peoples	① Where ethnic minorities and indigenous peoples are living in the rights-of-way, are considerations given to reduce the impacts on culture and lifestyle of ethnic minorities and indigenous peoples? ② Does the project comply with the country's laws for rights of ethnic minorities and indigenous peoples?	①There is no minorities and indigenous people in the area. ②Not applicable.
5 Others	(1) Impacts during Construction	① Are adequate measures considered to reduce impacts during construction (e.g., noise, vibrations, turbid water, dust, exhaust gases, and wastes)? ② If construction activities adversely affect the natural environment (ecosystem), are adequate measures considered to reduce impacts? ③ If construction activities adversely affect the social environment, are adequate measures considered to reduce impacts? ④ If necessary, is health and safety education (e.g., traffic safety, public health) provided for project personnel, including workers?	①Yes.Adequate measures such as periodical water spray and sheet cover on track will be employed to reduce dust. ②No significant impact might be anticipated. ③The Construction activity in this kind of works will not affect significant adverse impact to social environment. ④The construction contractor will establish sanitary system .n the existing construction site, construction office and construction camp.
	(2) Monitoring	① Does the proponent develop and implement monitoring program for the environmental items that are considered to have potential impacts? ② Are the items, methods and frequencies included in the monitoring program, judged to be appropriate? ③ Does the proponent establish an adequate monitoring framework (organization, personnel, equipment, and adequate budget to sustain the monitoring framework)? ④ Are any regulatory requirements pertaining to the monitoring report system identified, such as the format and frequency of reports from the proponent to the regulatory authorities?	①Yes. Environmental monitoring programs consist of air quality, noise level. ②Yes. JICA and executing agency agreed the monitoring format, including the appropriate assignment/recruitment of the necessary staff/personnel. ③Yes. LCC will establish monitoring organization by using the equipment prepared by ECZ and by personnel of ECZ. LCC will prepare Budget for Monitoring during operation period. ④Yes. Concrete measures are described in monitoring format.
6 Note	Reference to Checklist of Other Sectors	① Where necessary, pertinent items described in the Forestry Projects checklist should also be checked (e.g., projects including large areas of deforestation). ② Where necessary, pertinent items described in the Power Transmission and Distribution Lines checklist should also be checked (e.g., projects including installation of power transmission lines and/or electric distribution facilities).	①No Relation with Forestry. ②Relocation of Electric Pole & Cable, Water Pipe, Telecommunication Pole & Cable and Street Light will be implemented by the Zambian side.
	Note on Using Environmental Checklist	① If necessary, the impacts to transboundary or global issues should be confirmed (e.g., the project includes factors that may cause problems, such as transboundary waste treatment, acid rain, destruction of the ozone layer, or global warming).	No concern.

1) Regarding the term "Country's Standards" mentioned in the above table, in the event that environmental standards in the country where the project is located diverge significantly from international standards, appropriate environmental considerations are made, if necessary.
In cases where local environmental regulations are yet to be established in some areas, considerations should be made based on comparisons with appropriate standards of other countries (including Japan' experience).
2) Environmental checklist provides general environmental items to be checked. It may be necessary to add or delete an item taking into account the characteristics of the project and the particular circumstances of the country and locality in which it is located.

5. 技術資料

5. 技術資料

資料 5-1 交通量調査結果および将来交通量の予測

(1) 交通量調査結果

交通量調査項目および調査位置を図 A5-1-1 に示す。断面交通量調査結果を表 A5-1-1 に示す。

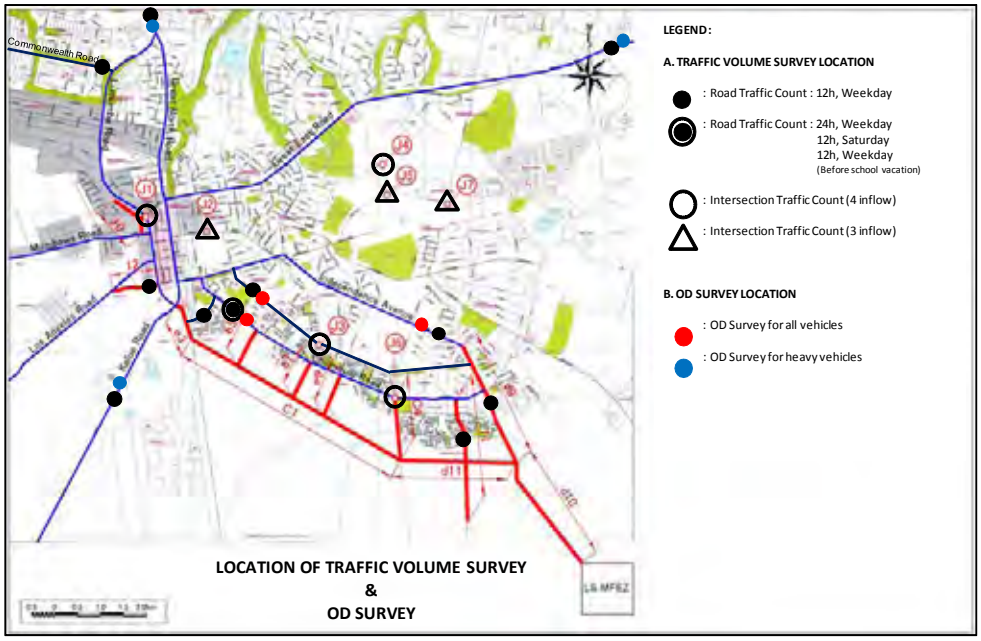


図 A5-1-1　交通量調査地点位置図

(2) OD ゾーニング

OD ゾーニングを表 A5-1-2 に示す。OD ゾーンマップを図 A5-1-2 に示す。

表 A5-1-1　断面交通量調査結果

	Passenger Car	Taxi	Pick-up	Mini Bus	Medium Bus	Large Bus	2-Axle (SingleRearAxle) Truck	3-Axle (DoubleRearAxle) Truck	4,5-Axcle Trailer Truck	6-Axcle more Trailer Truck	Motor Bike	Bicycle / Tricycle	Pedestrian	TOTAL
pcu ratio	1.00	1.00	1.00	1.50	2.00	3.00	3.00	4.50	6.00	6.00	0.50			
Burma Rd.		(12 hour survey)												
PCU係数	1.00	1.00	1.00	1.50	2.00	3.00	3.00	4.50	6.00	6.00	0.50			
to BCD	2,946	46	1,031	1,052	35	19	182	20	10	3	20	134	656	
from BCD	2,888	67	969	1,016	127	25	236	27	16	11	29	97	679	
2-Direct'n	5,834	113	2,000	2,068	162	44	418	47	26	14	49	231	1,335	
ADT	8,343	162	2,860	2,957	232	63	598	67	37	20	70			15,409
pcu/day	8,343	162	2,860	4,436	464	189	1,794	302	222	120	35			18,927
Chilimbulu Rd. (24 hour survey)														
to BCD	3,749	220	1,371	1,524	219	57	333	94	33	14	50	235	765	
from BCD	3,711	241	1,314	1,495	311	63	387	101	39	22	59	198	788	
2-Direct'n	7,460	461	2,685	3,019	530	120	720	195	72	36	109	433	1,553	
ADT	7,460	461	2,685	3,019	530	120	720	195	72	36	109			15,407
pcu/day	7,460	461	2,685	4,529	1,060	360	2,160	878	432	216	55			20,296
Commowealth Rd.		(12 hour survey)												
to BCD	2,586	88	604	1,994	209	38	334	42	25	25	114	36	146	
from BCD	2,278	36	511	2,266	174	7	319	18	11	18	13	29	66	
2-Direct'n	4,864	124	1,115	4,260	383	45	653	60	36	43	127	65	212	
ADT	6,956	177	1,594	6,092	548	64	934	86	51	61	182			16,745
pcu/day	6,956	177	1,594	9,138	1,096	192	2,802	387	306	366	91			23,105
Great East Rd.		(12 hour survey)												
to BCD	394	7	303	153	23	35	144	28	16	10	9	57	155	
from BCD	539	4	319	199	86	59	231	80	62	71	8	55	65	
2-Direct'n	933	11	622	352	109	94	375	108	78	81	17	112	220	
ADT	1,334	16	889	503	156	134	536	154	112	116	24			3,974
pcu/day	1,334	16	889	755	312	402	1,608	693	672	696	12			7,389
Great North Rd.		(12 hour survey)												
to BCD	538	9	551	391	79	79	193	109	70	240	3	83	464	
from BCD	565	12	642	270	103	31	280	41	41	100	2	103	381	
2-Direct'n	1,103	21	1,193	661	182	110	473	150	111	340	5	186	845	
ADT	1,577	30	1,706	945	260	157	676	215	159	486	7			6,218
pcu/day	1,577	30	1,706	1,418	520	471	2,028	968	954	2,916	4			12,592
Indipendence Ave.		(12 hour survey)												
to BCD	3,171	31	1,856	233	33	7	186	11	0	0	13	48	301	
from BCD	2,528	24	1,785	132	37	6	176	13	0	0	20	68	345	
2-Direct'n	5,699	55	3,641	365	70	13	362	24	0	0	33	116	646	
ADT	8,150	79	5,207	522	100	19	518	34	0	0	47			14,676
pcu/day	8,150	79	5,207	783	200	57	1,554	153	0	0	24			16,207
Kafue Rd.		(12 hour survey)												
to BCD	3,935	74	3,005	2,136	393	25	1,101	111	162	0	73	319	1,438	
from BCD	4,201	32	3,184	3,184	540	84	1,140	180	374	0	155	308	1,642	
2-Direct'n	8,136	106	6,189	5,320	933	109	2,241	291	536	0	228	627	3,080	
ADT	11,634	152	8,850	7,608	1,334	156	3,205	416	766	0	326			34,447
pcu/day	11,634	152	8,850	11,412	2,668	468	9,615	1,872	4,596	0	163			51,430
Chongwe Rd.		(12 hour survey)												
to BCD	2,292	44	926	264	32	7	425	13	0	0	77	326	1,677	
from BCD	1,597	109	1,078	330	29	93	469	14	5	0	173	418	1,026	
2-Direct'n	3,889	153	2,004	594	61	100	894	27	5	0	250	744	2,703	
ADT	5,561	219	2,866	849	87	143	1,278	39	7	0	358			11,407
pcu/day	5,561	219	2,866	1,274	174	429	3,834	176	42	0	179			14,754
Mosi-Oa-Tunya Rd.		(12 hour survey)												
to BCD	2,241	25	811	768	35	7	200	14	0	0	14	34	369	
from BCD	1,463	20	777	660	36	3	169	10	10	4	8	50	323	
2-Direct'n	3,704	45	1,588	1,428	71	10	369	24	10	4	22	84	692	
ADT	5,297	64	2,271	2,042	102	14	528	34	14	6	31			10,403
pcu/day	5,297	64	2,271	3,063	204	42	1,584	153	84	36	16			12,814
Shantumbu Rd.		(12 hour survey)												
to BCD	1,014	8	343	315	8	3	107	10	8	2	4	138	846	
from BCD	901	28	244	116	17	2	101	9	11	2	7	99	918	
2-Direct'n	1,915	36	587	431	25	5	208	19	19	4	11	237	1,764	
ADT	2,738	51	839	616	36	7	297	27	27	6	16			4,660
pcu/day	2,738	51	839	924	72	21	891	122	162	36	8			5,864
Ben Bella Link		(12 hour survey)												
PCU係数	1.00	1.00	1.00	1.50	2.00	3.00	3.00	4.50	6.00	6.00	0.50			
to BCD	564	26	292	221	26	2	149	11	4	4	9	188	2,249	
from BCD	622	16	232	243	27	3	121	24	3	5	16	214	2,646	
2-Direct'n	1,186	42	524	464	53	5	270	35	7	9	25	402	4,895	
ADT	1,696	60	749	664	76	7	386	50	10	13	36			3,747
pcu/day	1,696	60	749	996	152	21	1,158	225	60	78	18			5,213

表 A5-1-2　OD ゾーニング

Zone No.	Place	(THE STUDY ON COMPREHENSIVE URBAN DEVELOPMENT PLAN FOR THE CITY OF LUSAKA IN THE REPUBRIC OF ZAMBIA 2009)
1	Within Lusaka	Z0601
2		Z0802
3		Z1609 Z1612
4		Z3103
5		Z1903 Z1904 Z2001 Z2002 Z2804 Z2805 Z2807 Z2808
6		Z1502
7		Z1508 Z1509 Z1510 Z1511 Z1512
8		Z2401 Z2402 Z2403 Z2404 Z2501 Z2502 Z2503 Z2504 Z2505 Z2601 Z2602 Z2603 Z2604 Z2605 Z2606 Z2701 Z2702 Z2703 Z2704 Z2705 Z2706 Z2707 Z2809 Z2811
9		Z1001 Z1002 Z1003
10		Z1007 Z1008 Z1009 Z1201
11		Z0201 Z0202 Z0203 Z0204 Z0205 Z0206 Z0207 Z0301 Z0302 Z0303 Z0304 Z0401 Z0402 Z1202 Z1203 Z1204
12		Z1802 Z1902 Z1906 Z1907
13		Z1703 Z1704 Z1705 Z1706 Z1707
14		Z1614
15		Z1702 Z2101 Z2102 Z2103 Z2104 Z2201 Z2202 Z2203 Z2204 Z2205 Z2301 Z2302 Z2303 Z2304 Z2305
16		Z1613
17		Z3201 Z3202 Z3203 Z3204 Z3301 Z3302 Z3303 Z3304 Z3305 Z3306 Z3307
18		Z2901 Z2902 Z2903 Z2904 Z2905 Z2906 Z2907 Z2908 Z2909 Z2910 Z3002 Z3003 Z3004 Z3005 Z3006 Z3007 Z3008
19		Z1701 Z1801 Z1803 Z1804
20		Z0101 Z0102 Z0103 Z0104 Z0105 Z1114 Z1115 Z1116 Z1117 Z1118 Z1119
21		Z0501 Z0502 Z0503 Z1401 Z1409
22		Z0504 Z0602 Z0701 Z0702 Z0703 Z0901
23		Z0505 Z0902 Z0903 Z0904
24		Z0801
25		Z0803 Z0804
26		Z1004 Z1005 Z1006 Z1107 Z1112 Z1113
27		Z1101 Z1102 Z1103 Z1106 Z2802 Z2803 Z2810
28		Z1104 Z2801
29		Z1105 Z1108 Z1110 Z1111 Z1411 Z1412 Z1413 Z1414
30		Z1109
31		Z1302 Z1303 Z1405 Z1805 Z1901
32		Z1301 Z1402 Z1407 Z1408 Z1905 Z2806
33		Z1403 Z1410
34		Z1404 Z3104 Z3106
35		Z1406 Z1501 Z1507 Z1513
36		Z1503 Z1504 Z1505 Z1506
37		Z1514 Z1515 Z1601 Z3101 Z3105
38		Z1602 Z1604 Z1606
39		Z1603 Z3001 Z3102
40		Z1605
41		Z1607
42		Z1608
43		Z1610
44		Z1611
45	Outside Lusaka	Z7110 Z7199 Z7999 Z8500 Z8600 Z8800 Z8900 Z9160 Z9170 Z9200
46		Z6240 Z6270 Z8400 Z9180
47		Z6210 Z6220 Z6230 Z8300 Z9130 Z9140 Z9190 Z9300
48		Z6280 Z9120
49		Z6120 Z6130 Z6140 Z6199 Z6300 Z8700 Z9110 Z9150
50		Z6110 Z6250 Z6260
51	LS-MFEZ	Chibwa Road
52		Nationalist Road
53		Yotam Mulea Road
54		Kasama Road
55		Shantumbu Road
56		Mosi-Oa=Tuna Road
57		LS-MFEZ
58		

Traffic Zone No.	Ward
Z0101 - Z0105	Nkoloma
Z0201 - Z0207	Chawama
Z0301 - Z0304	John Howard
Z0401 - Z0402	Lilayi
Z0501 - Z0505	Kamwala
Z0601 - Z0602	Kabwata
Z0701 - Z0703	Libala
Z0801 - Z0804	Chilenje
Z0901 - Z0904	Kamulanga
Z1001 – Z1009	Kanyama
Z1101 – Z1119	Harry Mwaanga Nkumbula
Z1201 – Z1204	Munkolo
Z1301 – Z1303	Silwizya
Z1401 - Z1414	Independence
Z1501 – Z1515	Lubwa
Z1601 – Z1614	Kabulonga
Z1701 - Z1707	Roma

Traffic Zone No.	Ward
Z1801 - Z1805	Mulungushi
Z1901 - Z1907	Ngwerere
Z2001 - Z2002	Chaisa
Z2101 - Z2104	Justine Kabwe
Z2201 - Z2205	Raphael Chota
Z2301 - Z2305	Mpulungu
Z2401 - Z2404	Muchinga
Z2501 - Z2506	Kapwepwe
Z2601 - Z2606	Lima
Z2701 – Z2707	Mwembeshi
Z2801 – Z2811	Matero
Z2901 - Z2910	Chainda
Z3001 - Z3008	Mtendere
Z3101 - Z3106	Kalingalinga
Z3201 - Z3204	Chakunkula
Z3301 – Z3307	Munali

Source: JICA Study Team

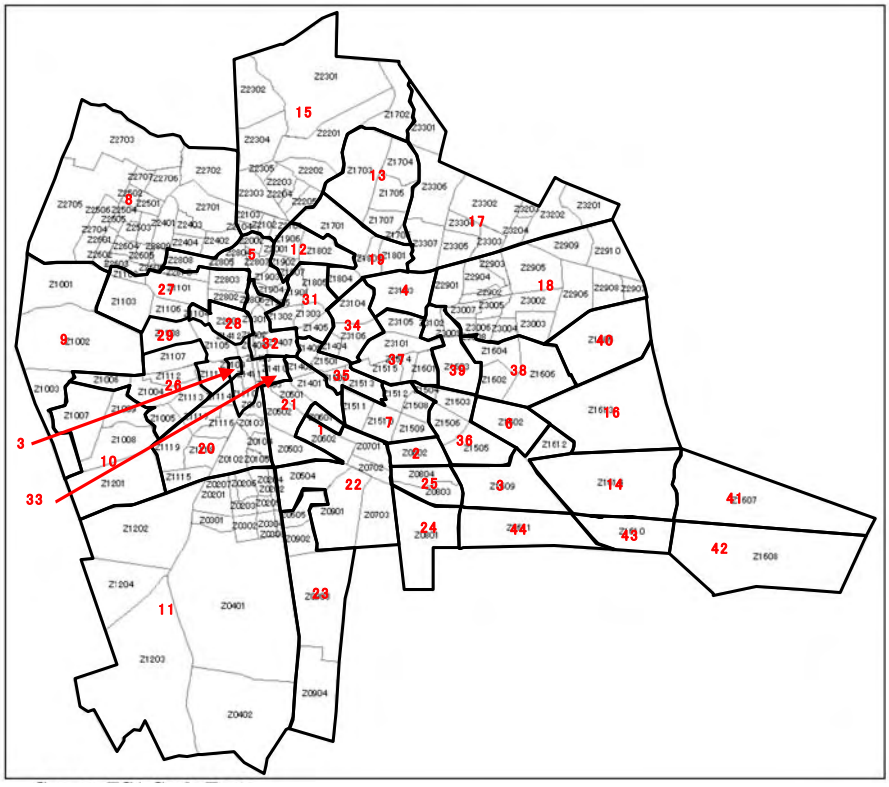


図 A5-1-2　OD ゾーンマップ

(3) OD 表の作成

６地点の OD 調査結果を OD 表にまとめた。OD 調査はサンプル調査なので、通過台数が少ない車種はとらえ切れていないため、３車種（Car, Small Truck, Large Truck）に統合する。

表 A5-1-3　OD 表（例：Berma Road の一部）

Origin	Deisti'n	Car	Taxi	Pick-up & Others	2-Ax Truck	3 or more Ax Truck	Articulated Truck
Z0101	Z1413				1		
Z0204	Z2401				1		
Z0401	Z1413			1			
Z0502	Z0502	2		3			
Z0502	Z1101	1					
Z0502	Z1303	1					
Z0502	Z1409			1			
Z0502	Z1411			1			
Z0502	Z1413	4		1			
Z0502	Z2404	1					
Z0502	Z2804			1			
Z0502	Z7199			1			
Z0601	Z0502	1					
Z0601	Z1002			1			
Z0601	Z1002			1			
Z0601	Z1101	2		1			
Z0601	Z1105				1		
Z0601	Z1110				1		
Z0601	Z1202	1					
Z0601	Z1301	1					
Z0601	Z1303	1		1			

(4) 交通増加率

交通増加率は、「ルサカ市総合都市開発 M/P」報告書(A1-54 頁)に示されているルサカ地区の交通発生増加率（Trip Generation）を参照する。

表 A5-1-4　将来交通量の伸び率

Year	Growth Rate	Trip/Day
2007		2,023,191
2008		2,075,277
2009		2,127,362
2010	1.000	2,179,448
2011		2,231,533
2012		2,283,619
2013		2,335,704
2014		2,387,790
2015	1.119	2,439,875
2016		2,530,495
2017		2,621,115
2018		2,711,735
2019		2,802,355
2020		2,892,975
2021		3,050,332
2022		3,207,689
2023		3,365,047
2024		3,522,404
2025	1.688	3,679,761
2026		3,837,118
2027		3,994,475
2028		4,151,833
2029		4,309,190
2030	2.049	4,466,547

(5) 内環状道路の南側地区の開発交通量

内環状道路の南側地区は現在道路が整備されていないため、道路整備後の発生交通量を、既に道路が整備されており社会経済状態が類似しているルサカ市西部地区の Commonwelth Road 沿線地区をサンプルに、面積当たりの車種別発生交通量を推計する。なお、現在はサンプルの 30%、内環状道路完成時の 2015 年は 50%、10 年後の 2025 年は 100%が発生すると仮定する。

表 A5-1-5　内環状道路の南側地区の開発交通量の推計(2025 年)

	Passenger Car	Taxi	Pick-up	Mini Bus	Medium Bus	Large Bus	2-Axle (SingleRearAxle) Truck	3-Axle (DoubleRearAxle) Truck	4,5-Axcle Trailer Truck	6-Axcle more Trailer Truck	Motor Bike
Commowealth Rd. (Area =14 Km2)											
	6,956	177	1,594	6,092	548	64	934	86	51	0	182
Chibwa Road Extension Area=1.5 km2											
	745	19	171	653	59	7	100	9	5	0	20
Nationalist Road Extension Area=3.5 km2											
	1,739	44	399	1,523	137	16	234	22	13	0	46
Yotam Mulea Road Extension Area=6.0 km2											
	2,981	76	683	2,611	235	27	400	37	22	0	78
Kasama Road Extension Area=4.5 km2											
	2,236	57	512	1,958	176	21	300	28	16	0	59
Shantumbu Road Extension Area=3.0 km2											
	1,491	38	342	1,305	117	14	200	18	11	0	39
Mosi-Oa=Tuna Road Extension Area=3.3 km2											
	1,640	42	376	1,436	129	15	220	20	12	0	43

(6) LS-MFEZ の開発交通量

「ルサカ市総合都市開発 M/P」報告書(2-2 頁)によると、LS-MFEZ の開発スケジュールは表 A5-1-6 のとおり示されている。また、同報告書によると、工業団地の発生交通量は単位面積当たり 41pcu/ha/day と仮定されている。推計した LS-MFEZ の開発交通量を表 A5-1-6 に示す。

表 A5-1-6　LS-MFEZ の開発スケジュールと発生交通量(pcu/day)

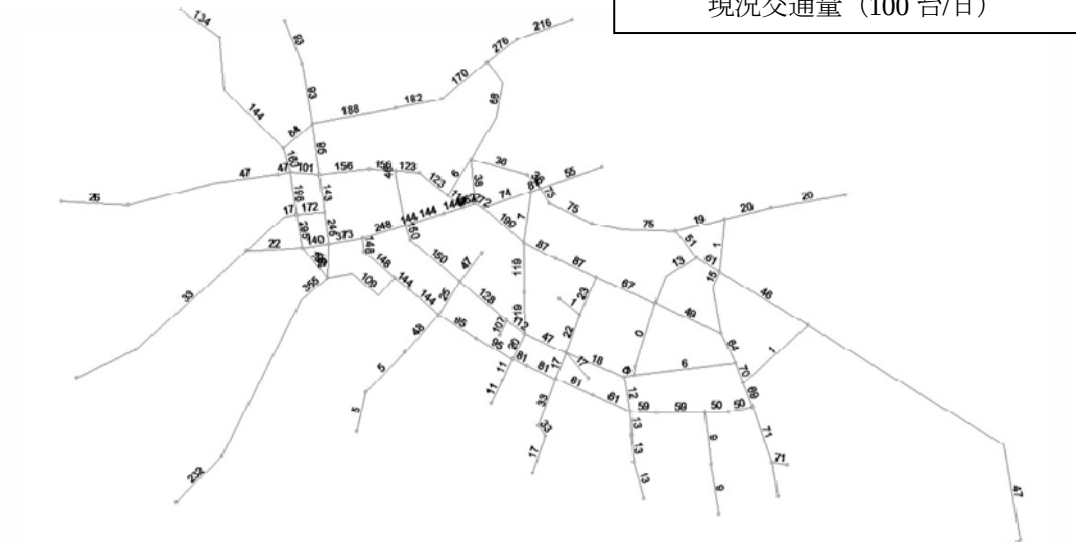
年	開発面積(ha)	LS-MFEZ の発生交通量
2015	30	1,230
2020	240	9,840
2025	320	13,120
2030	400	16,400

注：2025 年は補完した値である。

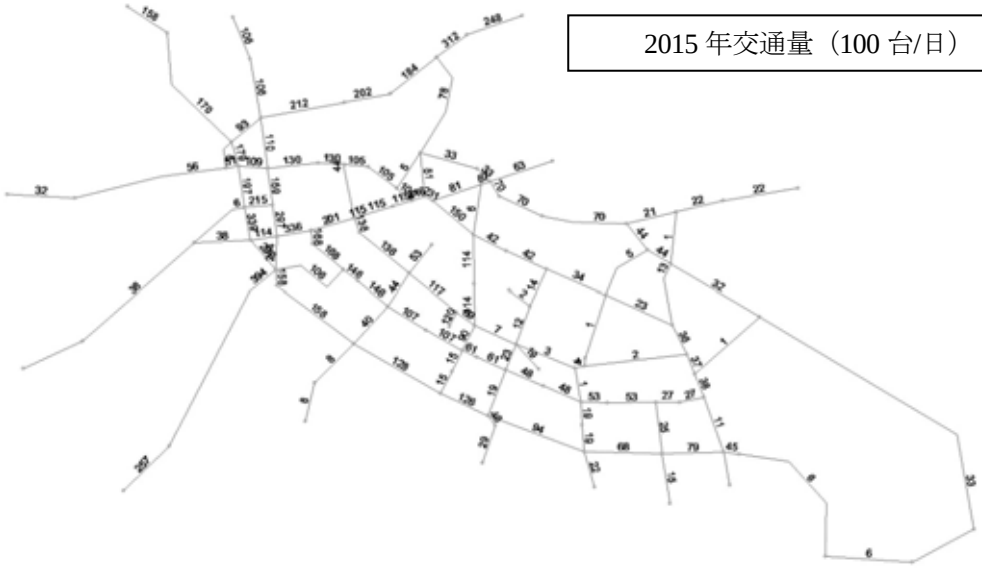
(7) 交通量推計

JICA STRADA を適用して、現在(2010 年)、本プロジェクト完成直後（2015 年)、本プロジェクト完成の 10 年後（2025 年）について交通量を推計した。結果を図 A5-1-3 に示す。

現況交通量（100 台/日）



2015 年交通量（100 台/日）



2025 年交通量（100 台/日）

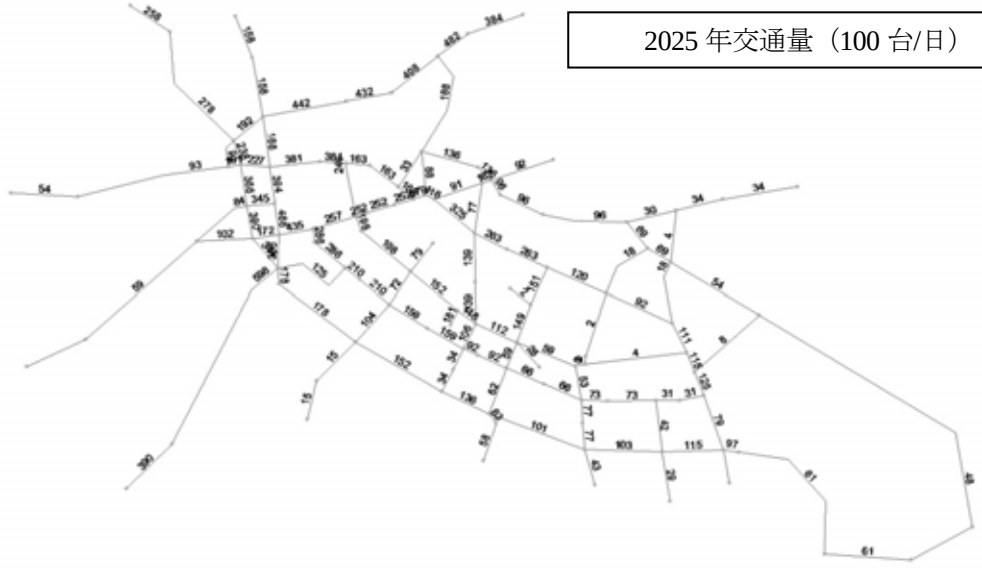


図 A5-1-3　交通量解析結果

(8) プロジェクト道路の車種別交通量

プロジェクト道路について、交通解析した 3 車種分類から、内環状道路～LS-MFEZ アクセス道路の車種別分布はグレートノース道路の分布を参考に、その他の集散道路と街路はチリンブル道路の車種別分布を参考に 10 車種分類に割り戻した。プロジェクト対象道路の 2015 年と 2025 年の車種別交通量の推計を表 A5-1-8～9 に示す。

表 A5-1-8　プロジェクト対象道路の車種別交通量の推計(2015 年)

	Passenger Car	Taxi	Mini Bus	Medium Bus	Large Bus	Pick-up	2-Axle (SingleRearAxle) Truck	3-Axle (DoubleRearAxle) Truck	4,5-Axcle Trailer Truck	6-Axcle more Trailer Truck	TOTAL
Inner Ring Road	5,793	110	3,471	955	577	3,128	1,240	125	92	283	15,774
Inner Ring Extension	2,738	52	1,640	451	272	1,805	715	69	50	155	7,947
LS-MFEZ Access Road	210	4	126	35	21	160	63	16	4	2	640
Mini Bypass Link	5,793	110	3,471	955	577	3,128	1,240	125	92	283	15,774
Brn Bella Road	1,480	91	599	105	24	826	302	243	90	45	3,805
Chibwa Road	1,685	32	1,010	278	168	626	225	7	0	0	4,031
Nationalist Road	610	12	366	101	61	244	80	6	0	0	1,480
Yotam Muleya Road	592	11	355	98	59	589	219	4	0	0	1,927

表 A5-1-9　プロジェクト対象道路の車種別交通量の推計(2025 年)

	Passenger Car	Taxi	Mini Bus	Medium Bus	Large Bus	Pick-up	2-Axle (SingleRearAxle) Truck	3-Axle (DoubleRearAxle) Truck	4,5-Axcle Trailer Truck	6-Axcle more Trailer Truck	TOTAL
Inner Ring Road	6,511	124	3,902	1,073	648	3,481	1,380	162	120	366	17,767
Inner ring Road Extension	3,884	74	2,328	640	387	2,657	1,053	126	94	286	11,529
LS-MFEZ Access Road	1,915	36	1,147	316	191	1,598	633	212	61	30	6,139
Mini Bypass Link	6,511	124	3,902	1,073	648	3,481	1,380	162	120	366	17,767
Brn Bella Road	4,105	254	1,661	292	66	2,441	735	411	152	76	10,193
Chibwa Road	4,363	83	2,615	719	434	1,585	558	23	0	0	10,380
Nationalist Road	1,361	26	815	224	135	631	208	18	0	0	3,418
Yotam Muleya Road	2,194	42	1,315	362	218	1,459	541	20	0	0	6,151

技術資料 5-2 舗装構造設計

(1) 車種別の１台当たり ESAL

車種別の１台当たり 18 キロポンド単軸荷重等価換算値(ESAL)は、「ウドラ市及びキトウェ市道路網整備計画調査基本設計調査報告書」に示されている軸重調査結果を基にえられた値を適用する。

表 A5-2-1　車種別の１台当たり ESAL

	Mini Bus	Med. Bus	Large Bus	2-Ax Truck	3-Ax Truck	Trailer
ESAL	0.0003	0.045	0.46	0.44	1.00	3.36

(2) 舗装設計荷重の計算

舗装設計期間(2015-2030)の道路片側車線当たりの舗装設計荷重の計算を表 A5-2-2 に示す。交通量は表 A5-1-8～9 を参照。

表 A5-2-2　舗装設計荷重の計算

Design Section			Traffic Volume (Veh./Day)						Ave. ESAL per Day (2015-2030)	Total ESAL (2015-2030)	Total ESAL (per Direction)
		Vehicle Type	Mini Bus	Med. Bus	Large Bus	2-Ax Truck	3-Ax Truck	Trailer			
		ESAL per Vehicle	0.0003	0.045	0.46	0.44	1.00	3.36			
1	Inner Ring Road	ADT (2015)	3,471	955	577	1,240	125	375			
		ADT (2025)	3,902	1,073	648	1,380	162	486			
		Ave. (2015-2030)	3,758	1,034	624	1,333	150	449	2,580	12,112,204	6,056,000
2	Inner Ring Road Extension	ADT (2015)	1,560	429	256	767	71	214			
		ADT (2025)	2,138	588	355	1,193	154	462			
		Ave. (2015-2030)	1,945	535	322	1,051	126	379	2,036	9,559,546	4,780,000
3	LS-MFEZ Access Road	ADT (2015)	28	13	72	53	17	13			
		ADT (2025)	295	136	766	567	180	136			
		Ave. (2015-2030)	206	95	535	395	126	95	869	4,079,555	2,040,000
4	Ben Bela Road	ADT (2015)	599	105	24	302	243	135			
		ADT (2025)	1,661	292	66	735	411	228			
		Ave. (2015-2030)	1,307	230	52	591	355	197	1,311	6,157,307	3,079,000
5	Chibwa, Nationalist, Yotam Mulea	ADT (2015)	1,010	278	168	225	7	0			
		ADT (2025)	2,615	719	434	558	23	0			
		Ave. (2015-2030)	2,080	572	345	447	18	0	400	1,875,953	938,000
		Note: It is assumed that ADT will not increase after 2025 because Middle Ring Road and Outer Ring Road will be constructed.									

(3) 路床土の設計 CBR の設定

路床土の室内 CBR 試験結果および設計 CBR の設定を表 A5-2-3 に示す。

LS-MFEZ アクセス道路の高圧送電線～LS-MFEZ ゲート区間の路床土の設計 CBR が 2 と小さいため良質土(CBR>8)を 65cm 盛土して路床を構築する。構築路床の設計 CBR は 5 となる。

表 A5-2-3　設計 CBR の設定

Design Section	Road Name	Pit No.	Soil Type	CBR	CBR ave.	CBR dev.	Design CBR
1	Mini Bypass Inner Ring Road	23	Sandy Soil	30	14.3	8.0	6
		24	Sandy Soil	24			
		5	Sandy Soil	6			
		6	Sandy Soil	13			
		7	Sandy Soil	6			
		8	Sandy Soil	6			
		9	Sandy Soil	14			
		10	Sandy Soil	10			
		11	Sandy Soil	10			
		12	Sandy Soil	26			
		13	Brown soil	14			
		14	Sandy Soil	8			
		15	Sandy Soil	22			
		16	Brown soil	11			
2	Inner Ring Road Extension	17	Sandy Soil	9	7.8	1.8	6
		18	Sandy Soil	8			
		19	Sandy Soil	10			
		20	Sandy Soil	6			
		31	Sandy Soil	6			
		32	Sandy Soil	8			
3	LS-MFEZ Access Road	33	Brown soil	6	4.2	1.7	2 (5) (see Note)
		34	Sandy Soil	6			
		35	Brown soil	2			
		36	Brown soil	3			
		37	Sandy Soil	5			
		38	Brown soil	3			
4	Ben Bella Road	1	Gray soil	12	19.3	12.1	7
		2	Rocky Clay	30			
		3	Sandy Soil	6			
		4	Sandy Soil	29			
5	Chibwa Road, Nationalist Road, Yotam Muleya Road	25	Brown soil	6	15.5	10.5	5
		26	Gray soil	5			
		27	Sandy Soil	20			
		28	Sandy Soil	29			
		29	Sandy Soil	25			
		30	Brown soil	8			

Note: The subgrade of LS-MFEZ Access Road will be improved to be CBR=5 by embanking 65cm thick selected soil (CBR>8) .

LS-MFES アクセス道路高圧送電線沿線～LS-MFEZ ゲート区間の構築路床の設計 CBR

構築路床 CBR = ((21/3 x 35cm + 81/3 x 65cm) / 100cm) = 5

(4) 舗装構造厚の計算

設計荷重に対して必要な舗装構造厚の計算を表 A5-2-4 に示す。

表 A5-2-4　舗装構造厚の計算

Calculation of Required SN

		1	2	3	4	5
Design Section		Inner Ring Road, Mini Bypass	Inner Ring Road Extension	LS-MFEZ Access Road	Bem Bela Road	Chibwa, Nati't, Yotam
18kip Equivalent Single Axle Load	W18	6,056,000	4,780,000	2,040,000	3,079,000	938,000
Reliability	R (%)	85	85	85	85	85
Standard deviation	ZR	-1.037	-1.037	-1.037	-1.037	-1.037
Combind standard erro	S0	0.45	0.45	0.45	0.45	0.45
Initial serviceability index	P0	4.2	4.2	4.2	4.2	4.2
Terminal serviceability index	P1	2.0	2.0	2.0	2.0	2.0
P0-P1	ΔPSI	2.2	2.2	2.2	2.2	2.2
Subgrade CBR	CBR	6	6	5	7	5
Resilient modulus	MR	9,000	9,000	7,500	10,500	7,500
Required SN	SN	**3.919**	**3.786**	**3.557**	**3.367**	**3.168**

ここに、 $Log_{10}(W_{18})=Z_R\times S_0+9.36\times Log_{10}(SN+1)-0.20+[Log10[⊿PSI/(4.2-1.5)]/[0.40+1094/(SN+1)^{5.19}]]+2.32\times Log_{10}(M_R)-8.07$

Left value (log10(W18)=	6.782	6.679	6.310	6.488	5.972
Right value=	6.782	6.679	6.310	6.488	5.972

Proposed Pavement Thickness (cm) and SN

Pavement Structure (new pavement)	Drainage coefficient	Layer coefficient	1	2	3	4	5
Design Section			Inner Ring Road, Mini Bypass	Inner Ring Road Extension	LS-MFEZ Access Road	Bem Bela Road	Chibwa, Nati't, Yotam
Asphalt concrete surface	-	0.440	10.0	10.0	10.0	10.0	10.0
Base course	0.9	0.140	20.0	15.0	20.0	20.0	15.0
Subbase course	0.8	0.110	35.0	40.0	25.0	25.0	20.0
Proposed pavement SN			**3.94**	**3.86**	**3.59**	**3.59**	**3.17**

ここに、 SN=a1*D1+a2*m2*D2+a3*m3*D3

Proposed Overlay Thickness (cm) and SN

Pavement Structure (overlay)	Drainage coefficient	Layer coefficient		2
Design Section				Inner Ring Road Extension
AC overlay	-	0.440		10.0
Base course (new))	0.9	0.140		15.0
Cement Stab'd Base (exist)	0.9	0.200		15.0
Subbase course (existing)	0.8	0.100		15.0
Proposed AC Overlay SN				**4.09**

ここに、 SN=a1*D1+a2*m2*D2+a3*m3*D3+a4*m4:D4

技術資料 5-3 交差点の混雑度評価

(1) 交差点の混雑度評価結果一覧

調査対象交差点の混雑度評価結果を A5-3-1 に示す。

A5-3-1　交差点混雑度評価結果一覧

交差点番号	交差道路	最大待時間(分)	最大渋滞長(m)	ピーク時交差点飽和度
J1	Lumumba Rd/Kalambo Rd	4.0	420	0.701
J2	Church Rd/Makishi Rd	10.0	800	0.871
J3	Nationalist Rd/Burma Rd	3.5	240	0.802
J4	Nangwenya Rd/Thabo Mbeki Rd	3.5	300	1.323（無信号）
J5	Thabo Mbeki Rd/Alick Nkhata Rd	4.5	490	0.772
J6	Chilimburu Rd/Kasama Rd	4.0	400	1.120（無信号）
J7	Alick Nkahata Rd/Kamloops Rd	8.0	1000	0.794

注：最大待時間と渋滞長は 2010 年８月６～10 日の週日朝夕ピーク時に測定した値である。

調査対象交差点の渋滞時の最大待時間は３～10 分である。渋滞長は 200～1000ｍである。すべての交差点が飽和に近い状態である。無信号交差点は信号設置等により交通制御が必要である。

(2) 交差点飽和度解析

交差点飽和度解析を表 A5-3-2 に示す。

表 A5-3-2 (1)　Intersection Analysis of J1: Lumumba Rd/Kalambo Rd

Result of Intersection Analysis (J1)

	Approach	①		②		③	
	Type of lane	LT+TH	Through	Left Turn	Right Turn	Through	Right Turn
	Number of lanes	1	1	1	2	2	1
S_R	Saturation flow rate per approach (1 lane)	2000	2000	1800	1800	2000	1800
W	Lane width (m)	3.00	3.00	3.00	3.00	3.00	3.00
α_W	Adjustment factor on lane width	1.00	1.00	1.00	1.00	1.00	1.00
I	Approach grade(%)	0.00	0.00	0.00	0.00	0.00	0.00
α_I	Adjustment Factor on approach grade	1.00	1.00	1.00	1.00	1.00	1.00
T	Heavy vehicle ratio (%)	0.00	0.00	0.00	0.00	0.00	0.00
α_T	Adjustment factor on heavy vehicle rate	1.00	1.00	1.00	1.00	1.00	1.00
G	Effective duration of the green phase (s)	45	45	55	30	70	70
C	Cycle time (s)	115	115	115		115	115
L	Left turn vehicle ratio(%)	43.21	0.00	0.00	0.00	0.00	0.00
	Pedestrian flow (person/cycle)	0		0			
f_P	Decreasing rate by pedestrian	0.00		0.00			
G_P	Pedestrian greed phase (s)	0		0			
E_{LT}	Coefficient to convert left turn vehicle	0.00		1.00			
α_{LT}	Adjustment factor to TH & LT ratio	0.87					
α_{LT}	Adjustment factor on left turn lane						
R	Right turn vehicle ration(%)	0.00	0.00	0.00	100.00	0.00	100.00
q	Opposite coming through traffic (veh/h)				0		1585
f	Probability of right turns				1.00		0.00
K_{ER}	Queue volume for right turn (veh/cycle)				2		2
E_{RT}	Coefficient to convert right turn vehicle						
α_{RT}	Adjustment factor to TH & RT ratio						
t	Green phase for right turn				30		25
α_B	Adjustment factor on bus stop location	1.00	1.00	1.00	1.00	1.00	1.00
S_A	Saturation flow rate(veh/h)	1747	2000	1800	3600	4000	1800
q	Traffic volume (veh/h)		1811	243	320	1441	295
ρ	Normalized traffic ratio		0.483	0.135	0.089	0.360	0.164
	Green phase saturation rate						
	1 Phase		0.483			0.231	0.105
	2 Phase			0.061		0.129	0.059
	3 Phase			0.074	0.089		
	Intersection saturation rate			**0.701**			

		Going to			
		N	E	S	W
Come from	N		C	D	
	E	B		A	
	S	F	E		
	W				

Traffic Volume

		Out Flow			
		1	2	3	Total
In Flow	1		226	1585	1811
	2	320		243	563
	3	1441	295		1736
	TL	1761	521	1828	4110

Peak hour: 17:00 - 18:00

表 A5-3-2 (2)　Intersection Analysis of J2: Church Rd/Makishi Rd

Result of Intersection Analysis (J2)

	Approach	①		③		②	
	Type of lane	LT+TH	Through	Left Turn	Right Turn	Through	Right Turn
	Number of lanes	1	1	1	1	1	1
S_B	Saturation flow rate per approach (1 lane)	2000	2000	1800	1800	2000	1800
W	Lane width (m)	2.75	2.75	2.75	2.75	2.75	2.75
α_W	Adjustment factor on lane width	0.95	0.95	0.95	0.95	0.95	0.95
I	Approach grade(%)	0.00	0.00	0.00	0.00	0.00	0.00
α_I	Adjustment Factor on approach grade	1.00	1.00	1.00	1.00	1.00	1.00
T	Heavy vehicle ratio (%)	0.00	0.00	0.00	0.00	0.00	0.00
α_T	Adjustment factor on heavy vehicle rate	1.00	1.00	1.00	1.00	1.00	1.00
G	Effective duration of the green phase (s	50	50	40	25	65	65
C	Cycle time (s)	105	105	105		105	105
L	Left turn vehicle ratio(%)	41.49	0.00	0.00	0.00	0.00	0.00
	Pedestrian flow (person/cycle)	0		0			
f_P	Decreasing rate by pedestrian	0.00		0.00			
G_P	Pedestrian greed phase (s)	0		0			
E_{LT}	Coefficient to convert left turn vehicle	0.00		1.00			
α_{LI}	Adjustment factor to TH & LT ratio	0.88					
α_{LT}	Adjustment factor on left turn lane						
R	Right turn vehicle ration(%)	0.00	0.00	0.00	100.00	0.00	100.00
q	Opposite coming through traffic (veh/h)				0		187
f	Probability of right turns				1.00		0.82
K_{ER}	Queue volume for right turn (veh/cycle)				2		2
E_{RT}	Coefficient to convert right turn vehicle						
α_{RT}	Adjustment factor to TH & RT ratio						
t	Green phase for right turn				25		0
α_B	Adjustment factor on bus stop location	1.00	1.00	1.00	1.00	1.00	1.00
S_A	Saturation flow rate(veh/h)	1666	1900	1710	1710	1900	1710
q	Traffic volume (veh/h)		440	951	452	355	701
ρ	Normalized traffic ratio		0.123	0.556	0.264	0.187	0.410
	Green phase saturation rate						
	1 Phase		0.123			0.144	0.315
	2 Phase			0.209		0.043	0.095
	3 Phase			0.348	0.264		
	Intersection saturation rate			0.871			

		Going to			
		N	E	S	W
Come from	N		A		B
	E	E			F
	S				
	W	C	D		

Traffic Volume

		Out Flow			
		1	2	3	Total
In Flow	1		951	452	1403
	2	701		355	1056
	3	253	187		440
	TL	954	1138	807	2899

Peak hour: 16:00 - 17:00

表 A5-3-2 (3) Intersection Analysis of J3: Nationalist Rd / Thabo Mbeki Rd

Result of Intersection Analysis (J3)

	Approach	①		②	③	④
	Type of lane	Left Turn	RT+TH	Through	Through	Through
	Number of lanes	1	1	1	1	1
S_B	Saturation flow rate per approach (1 lane)	1800	2000	2000	2000	2000
W	Lane width (m)	3.00	3.00	3.00	3.00	3.00
α_W	Adjustment factor on lane width	1.00	1.00	1.00	1.00	1.00
I	Approach grade(%)	0.00	0.00	0.00	0.00	0.00
α_I	Adjustment Factor on approach grade	1.00	1.00	1.00	1.00	1.00
T	Heavy vehicle ratio (%)	0.00	0.00	0.00	0.00	0.00
α_T	Adjustment factor on heavy vehicle rate	1.00	1.00	1.00	1.00	1.00
G	Effective duration of the green phase (s)	45	45	75	45	75
C	Cycle time (s)	135	135	135	135	135
L	Left turn vehicle ratio(%)	0.00	0.00	0.88	47.36	0.43
	Pedestrian flow (person/cycle)	0		0	0	0
f_P	Decreasing rate by pedestrian	0.00		0.00	0.00	0.00
G_P	Pedestrian greed phase (s)	0		0	0	0
E_{LT}	Coefficient to convert left turn vehicle	1.00		0.00	0.00	0.00
α_{LT}	Adjustment factor to TH & LT ratio			1.00	0.86	1.00
α_{LI}	Adjustment factor on left turn lane					
R	Right turn vehicle ration(%)	0.00	86.87	9.43	13.85	49.78
q	Opposite coming through traffic (veh/h)		101	498	182	486
f	Probability of right turns		0.90	0.60	0.83	0.60
K_{RR}	Queue volume for right turn (veh/cycle)		2	2	2	2
E_{RT}	Coefficient to convert right turn vehicle		1.23	2.24	1.32	2.19
α_{RT}	Adjustment factor to TH & RT ratio		0.84	0.90	0.96	0.63
t	Green phase for right turn					
α_B	Adjustment factor on bus stop location	1.00	1.00	1.00	1.00	1.00
S_A	Saturation flow rate(veh/h)	1800	1671	1788	1648	1253
q	Traffic volume (veh/h)	312	284	686	277	788
ρ	Normalized traffic ratio	0.173	0.17	0.383	0.168	0.629
	Green phase saturation rate					
	1 Phase	0.173	0.170		0.168	
	2 Phase			0.306		0.503
	3 Phase			0.077		0.126
	Intersection saturation rate			**0.802**		

		Going to			
		N	E	S	W
Come from	N		A	B	C
	E	K		G	J
	S	H	L		I
	W	D	E	F	

Traffic Volume

		Out Flow				
		1	2	3	4	Total
Come from	1		312	182	102	596
	2	43		157	486	686
	3	101	55		121	277
	4	75	498	215		788
	TL	219	865	554	709	2346

Peak hour: 16:00 – 17:00

表 A5-3-2 (4)　Intersection Analysis of J4: Nangwenya Rd / Thabo Mbeki Rd

Intersection Analysis (J4) (No signal intersection)

Intersection capacity of no-signal intersection is given by the following formula:

$$C = \frac{Q e^{-\mu tc}}{1 - e^{-\mu hr}}$$

Where,

C : Traffic capacity of non-priority road (veh./h)
Q : Traffic volume of priority road (veh./h)
μ : Q/3600
tc : Minimum time for a vehicle to cross priority road = 7 sec. (usually 5 - 7 sec. is used)
hr : Maximum time for a vehicle to wait for crossing priority road = 3 sec. (usually 2 -3 sec. is used)

Check 1: V/C of approach road ①
Q (②+④) =253+464=717

Q	717	(veh/h)	e-μtc	0.248
tc	7	(sec)	e- μ hr	0.550
hr	3	(sec)		

$$C = \frac{717 \times 0.248}{1 - 0.550} = 396 \text{ (veh./h)}$$

V(①) = 57 (veh./h)
V／C = 0.144

Check 2: V/C of approach road ②
Q (①+③) =57+524=581

Q	581	(veh/h)	e-μtc	0.323
tc	7	(sec)	e- μ hr	0.616
hr	3	(sec)		

$$C = \frac{581 \times 0.323}{1 - 0.616} = 490 \text{ (veh./h)}$$

V(②) = 253 (veh./h)
V／C = 0.516

Check 3: V/C of approach road ③
Q (②+④) =253+464=717

Q	717	(veh/h)	e-μtc	0.248
tc	7	(sec)	e- μ hr	0.550
hr	3	(sec)		

$$C = \frac{717 \times 0.248}{1 - 0.550} = 396 \text{ (veh./h)}$$

V(③) = 524 (veh./h)
V／C = 1.323

Check 2: V/C of approach road ④
Q (①+③) =57+524=581

Q	581	(veh/h)	e-μtc	0.323
tc	7	(sec)	e- μ hr	0.616
hr	3	(sec)		

$$C = \frac{581 \times 0.323}{1 - 0.616} = 490 \text{ (veh./h)}$$

V(④) = 464 (veh./h)
V／C = 0.947

Come from \ Going to	N	E	S	W
N		A	B	C
E	K		G	J
S	H	L		I
W	D	E	F	

Traffic Volume

Come from \ Out flow	1	2	3	4	Total
1		20	24	14	57
2	29		179	46	253
3	179	115		231	524
4	25	278	162		464
TL	233	412	364	290	1298

Peak hour: 17:00 - 18:00

The traffic volume of approach road ② exceeds the capacity as a non-priority road, therefore, giving the priority to road ① and ③ can accommodate the traffic.

表 A5-3-2 (5)　Intersection Analysis of J5: Thabo Mbeki Rd / Alick Nkhata Rd

Result of Intersection Analysis (J5)

	Approach	①		②	③
	Type of lane	Left Turn	Right Turn	RT+TH	LT+TH
	Number of lanes	1	1	1	1
S_B	Saturation flow rate per approach (1 lane)	1800	1800	2000	2000
W	Lane width (m)	2.75	2.75	2.75	2.75
α_W	Adjustment factor on lane width	0.95	0.95	0.95	0.95
I	Approach grade(%)	0.00	0.00	0.00	0.00
α_I	Adjustment Factor on approach grade	1.00	1.00	1.00	1.00
T	Heavy vehicle ratio (%)	0.00	0.00	0.00	0.00
α_T	Adjustment factor on heavy vehicle rate	1.00	1.00	1.00	1.00
G	Effective duration of the green phase (s)	30	30	55	45
C	Cycle time (s)	96		96	96
L	Left turn vehicle ratio(%)	0.00	0.00	0.00	78.56
	Pedestrian flow (person/cycle)	0			0
f_P	Decreasing rate by pedestrian	0.00			0.00
G_P	Pedestrian greed phase (s)	0			0
E_{LT}	Coefficient to convert left turn vehicle	1.00			0.00
α_{LT}	Adjustment factor to TH & LT ratio				0.85
α_{LT}	Adjustment factor on left turn lane				
R	Right turn vehicle ration(%)	0.00	100.00	78.56	0.00
q	Opposite coming through traffic (veh/h)		0	465	
f	Probability of right turns		1.00	0.61	
K_{ER}	Queue volume for right turn (veh/cycle)		2	2	
E_{RT}	Coefficient to convert right turn vehicle			2.01	
α_{RT}	Adjustment factor to TH & RT ratio			0.56	
t	Green phase for right turn		30		
α_B	Adjustment factor on bus stop location	1.00	1.00	1.00	1.00
S_A	Saturation flow rate(veh/h)	1710	1710	1061	1615
q	Traffic volume (veh/h)	274	267	625	815
p	Normalized traffic ratio	0.160	0.156	0.589	0.505
	Green phase saturation rate				
	1 Phase			0.482	0.505
	2 Phase	0.160	0.156		
	3 Phase			0.107	
	Intersection saturation rate			0.772	

		Going to			
		N	E	S	W
Come from	N		A		B
	E	E			F
	S				
	W	C	D		

Traffic Volume

		Out Flow			
		1	2	3	Total
Come from	1		274	267	541
	2	274		351	625
	3	350	465		815
	計	624	739	618	1981

Peak hour: 17:00 - 18:00

表 A5-3-2 (6)　Intersection Analysis of J6: Chilimburu Rd / Kasama Rd

Intersection Analysis (J6) (No signal intersection)

Intersection capacity of no-signal intersection is given by the following fomula:

$$C = \frac{Q e^{-\mu t c}}{1 - e^{-\mu hr}}$$

Where,

- C : Traffic capacity of non-priority road (veh./h)
- Q : Traffic volume of priority road (veh./h)
- μ : Q/3600
- t c : Minimum time for a vehicle to cross priority road = 7 sec. (usually 5 - 7 sec. is used)
- h r : Maiximum time for a vehicle to wait for crossing priority road = 3 sec. (usually 2 -3 sec. is used)

Check 1: V/C of approach road ①

Q (②+④) =338+654=992

Q	992	(veh/h)	e-utc	0.145
t c	7	(sec)	e-μ hr	0.438
h r	3	(sec)		

$$C = \frac{992 \times 0.145}{1 - 0.438} = 257 \text{ (veh./h)}$$

V(①) = 218 (veh./h)

V／C = 0.848

Check 2: V/C of approach road ②

Q (①+③) =218+250=468

Q	468	(veh/h)	e-utc	0.403
t c	7	(sec)	e-μ hr	0.677
h r	3	(sec)		

$$C = \frac{468 \times 0.403}{1 - 0.677} = 584 \text{ (veh./h)}$$

V(②) = 338 (veh./h)

V／C = 0.579

Check 3: V/C of approach road ③

Q (②+④) =338+654=992

Q	992	(veh/h)	e-utc	0.145
t c	7	(sec)	e-μ hr	0.438
h r	3	(sec)		

$$C = \frac{992 \times 0.145}{1 - 0.438} = 257 \text{ (veh./h)}$$

V(③) = 250 (veh./h)

V／C = 0.973

Check 2: V/C of approach road ④

Q (①+③) =218+250=468

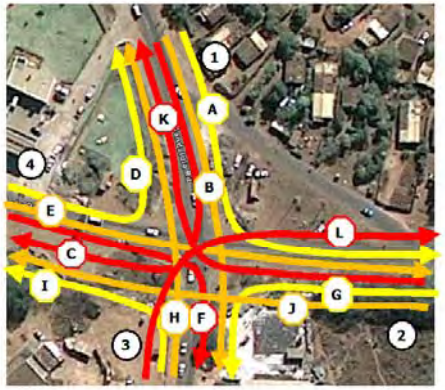
Q	468	(veh/h)	e-utc	0.403
t c	7	(sec)	e-μ hr	0.677
h r	3	(sec)		

$$C = \frac{468 \times 0.403}{1 - 0.677} = 584 \text{ (veh./h)}$$

V(④) = 654 (veh./h)

V／C = 1.120

The traffic volume of approach road ④ exceeds the capacity as a non-priority road, therefore, giving the prioirty to road ② and④ can accommodate the traffic.



Come from \ Going to	N	E	S	W
N		A	B	C
E	K		G	J
S	H	L		I
W	D	E	F	

Traffic Volume

Come from \ Out Flow	1	2	3	4	Total
1		26	150	42	218
2	43		95	200	338
3	85	55		110	250
4	54	350	250		654
TL	182	430	495	352	1459

Peak hour: 16:00 - 17:00

表 A5-3-2 (7)　Intersection Analysis of J7: Alick Nkahata Rd / Kamloops Rd

Result of Intersection Analysis (J7)

	Approach	①		②	③
	Type of lane	Left Turn	Right Turn	RT+TH	LT+TH
	Number of lanes	1	1	1	1
S_R	Saturation flow rate per approach (1 lane)	1800	1800	2000	2000
W	Lane width (m)	2.75	2.75	2.75	2.75
α_W	Adjustment factor on lane width	0.95	0.95	0.95	0.95
I	Approach grade(%)	0.00	0.00	0.00	0.00
α_I	Adjustment Factor on approach grade	1.00	1.00	1.00	1.00
T	Heavy vehicle ratio (%)	0.00	0.00	0.00	0.00
α_T	Adjustment factor on heavy vehicle rat	1.00	1.00	1.00	1.00
G	Effective duration of the green phase (s	25	25	55	45
C	Cycle time (s)	95		95	95
L	Left turn vehicle ratio(%)	0.00	0.00	0.00	27.29
	Pedestrian flow (person/cycle)	0			0
f_P	Decreasing rate by pedestrian	0.00			0.00
G_P	Pedestrian greed phase (s)	0			0
E_{LT}	Coefficient to convert left turn vehicle	1.00			0.00
α_{LT}	Adjustment factor to TH & LT ratio				0.92
α_{LT}	Adjustment factor on left turn lane				
R	Right turn vehicle ration(%)	0.00	100.00	43.27	0.00
q	Opposite coming through traffic (veh/h)		0	538	
f	Probability of right turns		1.00	0.57	
K_{CR}	Queue volume for right turn (veh/cycle)		2	2	
E_{RT}	Coefficient to convert right turn vehicle			2.23	
α_{RT}	Adjustment factor to TH & RT ratio			0.65	
t	Green phase for right turn		25		
α_B	Adjustment factor on bus stop location	1.00	1.00	1.00	1.00
S_A	Saturation flow rate(veh/h)	1710	1710	1240	1750
q	Traffic volume (veh/h)	203	284	639	934
ρ	Normalized traffic ratio	0.119	0.166	0.515	0.534
	Green phase saturation rate				
	1 Phase			0.421	0.534
	2 Phase	0.119	0.166		
	3 Phase			0.094	
	Intersection saturation rate			0.794	

		Going to			
		N	E	S	W
Come from	N		A		B
	E	E			F
	S				
	W	C	D		

Traffic Volume

		Out Flow			
		1	2	3	Total
Come from	1		203	284	487
	2	284		355	639
	3	396	538		934
	計	680	741	639	2060

Peak hour: 17.00 – 18.00