8.4 Evaluation of Preferred Possible Alignments

The 9 (nine) preferred possible alignments are compared using a grade-point rating system. That is, the relative impacts for each of the alignments are first evaluated using a non-metric grading system (i.e., A, B, C, etc.) for the following factors:

① Construction Cost

② Land Acquisition and Compensation Cost

③ Traffic Impacts

The assigned grades for each of the factors are then converted into metric scores. Each grade has been assigned the following score:

A^+	98,	A	95,	A^-	92
B^+	88,	B	85,	B^-	82
C^+	78,	C	75,	C^-	72

The most preferred alignment is selected based on the summation of these scores. The alignment with the highest total number of points is considered to be the most appropriate OCH alignment. A comparison of the 9 (nine) alignments using this system is described below.

(1) Engineering and Cost

Comparable costs for all 9 alignments have been developed based on construction quantities obtained from a 1/10,000 scaled topographic map. The Highway Schedule of Rate of the RDA for 1998 applies to the unit cost for the estimation. Land acquisition cost has been newly worked out employing 1994 aerial photograph maps, which indicate the land-use pattern for 1994. Land use consists of such categories as urban areas, homesteads, rubber and coconut land settlements, etc.

As a result of the engineering costs estimation, A7, A8, and A9 were determined to be the most economical alignments, since use of existing highway A8 would be possible. A1, A4 and A7 would be comparatively costly, since these are longer alignments and much excavation work is anticipated.

In terms of engineering evaluation, there are some different observations regarding these alignments concerning the proposed bridge crossing of the Bolgoda River. A1, A2, and A3 would require long-span bridges to cross the Bolgoda River, since their alignments pass over wider sections of the river. On the other hand, A4, A5 and A6 would be located at the narrowest cross-sections of the Bolgoda River.

As for the evaluation based on engineering and costs for the alignments, excluding A7, A8 and A9, alignment A6 has the greatest merit. The reason why alignment A6 is the most preferred, is its comparatively shorter alignment, resulting in lower direct construction costs. Alignments A5 and A9 are the second most appropriate alignments in terms of engineering and costs.

On the other hand, alignment A9 is the most cost-effective, since it would utilize the existing Route A8. However, it has the fatal defect of requiring high compensation costs due to its running through highly populated areas. Alignment A5, although it is comparatively long, is cost-effective due to a superior design profile. However, A5 will require soft-soil countermeasures.

(2) Traffic Impacts

Based on an evaluation of the traffic impacts for the 9 alternative OCH alignments is carried out in Tab. 8.2 below.

Tab.8.2 Evaluation of the Traffic Impacts for the 9 OCH Alternative Alignments

Impact Evaluation Item	A1	A2	A3	A4	A5	A6	A7	A8	A9
Impact on Area-Wide Traffic	B (85)	B (85)	B (85)	B (85)	B (85)	B (85)	B (85)	B (85)	B (85)
Impact on OCH Traffic	B- (82)	B- (82)	B- (82)	B+ (88)	B+ (88)	B (85)	C+ (78)	C+ (78)	C+ (78)
Sufficiency as a Green Belt	A (95)	B (82)	C (75)	A (95)	B (85)	C (75)	B+ (88)	B- (82)	C- (72)
Total Score	262	249	242	268	258	245	251	245	235

Note: Score for each grade is given in parentheses.

As indicated on the above, the impact of the 9 different OCH alignments on area-wide traffic would be about the same. On the other hand, the impact of the OCH not being built in Colombo would be significant. That is, without the existence of the OCH in 2010, average daily travel speeds would drop from their present average of 32.7 km/h to about 27.7 km/h, or a decrease of 5.0 km/h. With the construction of the OCH, average area travel speeds in 2010 would drop to somewhere between 30.4 to 30.1 km/h, a decrease of only 2.3 to 2.6 km/h. In an urban setting, this is a substantial difference and, in terms of congestion, roads would be 1.12 to 1.15 times more congested without the OCH. On the other hand, even without the OCH, Colombo would still have average daily travel speeds greater than most other major

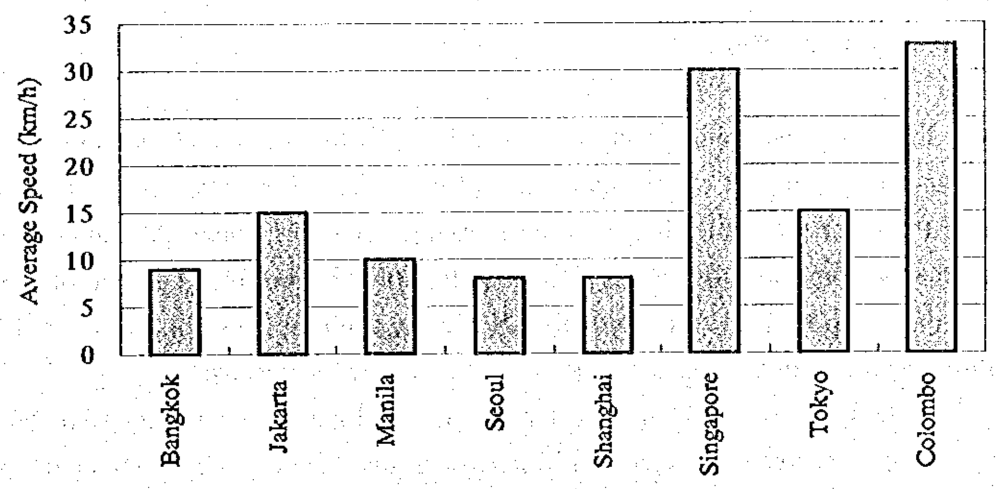


Fig.8.16 Average Daily Travel Speeds in Selected Cities in Asia

Asian cities (see Fig. 8.16).

As for the total evaluation score for each of the 9 alignments in Tab. 8.2, A4 has the highest overall score at 268. However, if only the levels of service of the OCH are considered in terms of congestion and speed, A5 is as superior as A4. That is, either alternative would have a volume-capacity ratio of 0.75 (the lowest of all the alignments), although A4 would be negligibly faster with an average daily travel speed of 49.6 km/h (the fastest of all the alignments) as compared to 49.5 km/h for A5. In general, there is the tendency for the most distant OCH alignments (A1, A4, and A7) to have lower rates of congestion and higher travel speeds as a result of being further out from the center of the city, as compared to the middle distant (A2, A5, and A8) and most proximate (A3, A6, A9) OCH alignments. However, the differences are not large. On the other hand, for those routes that utilize existing Route A8 (i.e., A7, A8, A9), the average rate of congestion for the OCH can be up to 12 percent greater than that for the other alignments.

As for the green belt function, it is indicated that the most distant and middle distant alignments would be able to serve this role best, with the former group being more superior. These alignments are located far enough away from Colombo to serve as a boundary that would contain future urban sprawl and that could support the existence of independent growth centers. The most proximate alignments, A3, A6, and A9, are located too close to Colombo to play such a role. The most highly evaluated alignments in terms of being a green belt are A1 and A4, which are from the group of most distant alignments.

In conclusion A4, because of its highest total evaluation score and rating as a greenbelt, is chosen as being the most preferred alignment from a traffic impact perspective.

(3) General Evaluation

From the above-mentioned analyses, it can be seen that the conclusions of the engineering cost and traffic impact examinations are different. The former recommends Alignment A6, while the latter recommends A4 as the most preferred alignment. Alignment A6 is one the alignments from the group most proximate to Colombo, while A4 is one of the alignments from the group farthest from Colombo. However, from the viewpoint of overall balance and future growth, both of these are rejected for the following reasons:

1) Despite A6 being the most economical alignment, it is incapable of playing the crucial role of a greenbelt. Moreover it, like the other alignments most proximate to Colombo (i.e., A3 and A9), passes over a highly congested section of road (i.e., between Kadawata and Kiribathgoda on Route A1). Therefore this alignment, as well as any of the most proximate alignments, would likely aggravate an already congested situation further, since the OCH will be a substantial source of both traffic attraction and generation.
2) Although the most distant alignments may be superior in terms of average speed and lower congestion, the costs required for their construction are simply too high. In addition, the average level of congestion and travel speeds for the middle distant alignments are quite similar.

Based on the above, it is clear that only a middle distant alignment (A2, A5, and A8) should be considered for construction. For the following reasons, Alignment A5 is recommended as the most preferred alignment:

1) As previously mentioned, Alignment A8 would utilize National Route A8 as the southern part of the OCH. However, as pointed out, Alignment A8 has one of the lowest average OCH speeds and one of the highest rates of congestion. This is due to National Route A8 having insufficient capacity to deal with the traffic that the OCH

will attract and generate. For this reason, it is suggested that this alignment not be considered as a candidate for most preferred route. Moreover, the total score for this alignment is least of all the alignments.

2) As for A2, in addition to its total evaluation score being lower than that for A5, it has an important flaw. That is, the southern tail end of A2 will duplicate or run in parallel with the Southern Transport Corridor, which would be uneconomic and burdensome. That is, the location of the southern tail end of A2 would result in travel inefficiencies, since drivers wanting to access the Southern Transport Corridor via A2, which is another important function of the OCH, would have to backtrack and therefore consume extra time and fuel in reaching their destination.

Alignment A5, which was selected above as the most preferred alignment, is evaluated below from an environmental and social viewpoint as well.

Alignment A5 passes through eight DS Divisions, which are Wattala, Mahara, Kelaniya, Biyagama, Kaduwela, Homagama, Panadura and Bandaragama. The total population, which is affected by the project, is about 1,145,700 (estimated beneficiaries in the year of 2010).

The environmental and social characteristics of each segment have been identified, based on the findings of IEE, as stated below.

a_2– b:

Almost half the length of this segment passes through the Galaudapita Marsh. The impact on the ecosystem, both fauna and flora, is expected to be significant. Many home gardens and marsh vegetation may also be affected. According to the IEE, no species are in danger of extinction, has been identified in the Galaudapita Marsh. However, various kinds of important migratory birds have been identified.

The rest of the segment runs through populated urban areas as well as industrialized areas. Resettlement will be involved for a part of the segment.
There is a milk factory around b, which will cause resettlement and affect local economic activities.

The overall environmental and social impact will not be significant, since appropriate measures can be taken for the marsh and the milk factory can be avoided.

$b - c_1$:

This segment runs through populated urban and industrialized areas. Resettlement will be involved. There are not many minor road crossings. The impact on the ecosystem is insignificant. The segment crosses north of Kadawatha, which may aggravate traffic congestion between Kadawatha and Kibathgoda.

Economic activities will be affected also, due to the fact that the segment passes through urban and industrialized areas.

The overall negative environmental impact can be minimized by shifting the crossing point with A1 further north. There are no other major impacts and hence it is the best segment to use.

$c_1 - e$:

Most of the length of this segment cuts across home gardens, coconut land and small areas of rubber plantation. Consequently, the scale of resettlement will not be significant. However, dust pollution by construction machinery will be higher than other areas.

This segment also has a significant number of minor roads. The proposed project might affect these minor community roads, which will cause significant negative impacts on community life; unless, the project takes into consideration these feeder roads into its planning.

The segment also crosses the Kelani River. Environmental protective measures will be necessary for new bridge construction.

Around c_1, near Makola South Town, there are some commercial buildings, which might be resettled. There is also a low-tension line crossing at this point, which the project should take into consideration.

Moreover, at the crossing point along Athurugiriya Road, there is a high-tension line, which the project should take into consideration.

The expected overall environmental and social impact is moderate.

$e - f_3$:

Since most of the length of this segment cuts across paddy field, which are part of large land holdings, the scale of resettlement will not be significant.

Some impact on economic activities is expected where large tracts of cultivated land is acquired.

Impact on fauna and flora is insignificant.

At Kottawa, near the Manchi Biscuit Factory, there is the Sri Lanka Broadcasting Transmission Center and telecom lines.

In Diyagama, Watara Temple, Atagahawatta, Polkotuwa, Kamburugoda, Pitolagoda and Maswick, there are high-tension power lines, which the project should take into consideration.

The overall environmental and social impact is moderate.

f_3 - h_2:
This segment mostly passes through paddy land, and home gardens close to Aluthgama, Bellana, Eriyawatta and Pinwatta. Accordingly, it is considered that the scale of resettlement will not be significant.

However, this segment passes through marshy areas close to the northern periphery of the Bolgoda Lake, which is designated as a national conservation area. The impact on the ecosystem of the marsh area may be significant.

The overall environmental and social impact may be moderate.

Consequently, it is confirmed that **Alignment A5** should be recommended as the most appropriate alignment for the Outer Circular Highway. The feasibility study, which includes analyses of economic benefits and financial return on investment, should be performed for Alignment A5. If the results are acceptable, an implementation plan for the most appropriate highway alignment would be drawn up taking into consideration the financial capabilities of the project, its appropriate phasing, and the most cost-effective work packaging and work breakdown.

CHAPTER 9

ENGINEERING STUDY

CHAPTER 9 ENGINEERING STUDY

9.1 Geometric Features for Outer Circular Highway(OCH)

9.1.1 General

Geometric design is the process whereby the layout of a road for a particular terrain is designed to meet the needs of road users. Principal geometric features are the horizontal alignment, vertical alignment, and road cross-section. The objectives of geometric design for this Study are as follows:

- To ensure minimum levels of safety and comfort for drivers by taking into consideration adequate sight distances, coefficients of friction, and road space for vehicle maneuvering.
- To ensure that the road design is economical.
- To ensure uniformity of alignment

Geometric design criteria must also take into account the characteristics and behavior of drivers. The interdependence between drivers and geometric features is
The Japanese standards for the OCH were selected from the "Annotations and Application summarized in Tab 9.1.

RDA Highway Design Standards 1998 are applicable for all roads excluding expressways. As for deciding the geometric design criteria for OCH, since the RDA stated that the RDA Highway Design Standard is not applicable for an expressway (including the OCH), another acceptable standard should be applied.

The Study Team, after examining various standards, decided that the geometric design criteria should be based on Japanese Standards. The Japanese standards for the OCH were selected from the "Annotations and Application of the Road Structure Ordinance" of the Japan Road Association" (February 1983) and the "Geometric Design Standard of High Standard Arterial Expressways" of the Japanese Ministry of Construction (September 1989). A comparison of the geometric standards for some developed countries and Sri Lanka is shown in Tab. 9.2.

Tab. 9.1 Driver Vehicle and Road Characteristics in Geometric Design

Geometric design	Driver characteristics considered	Vehicle characteristics considered	Road characteristics considered
Minimum safe stopping distance	Perception – reaction time	Layout of controls, braking systems, condition, tread pattern	Skid resistance of road surface, design speed
Minimum safe passing distance	Judgement of gap availability and vehicle capability	Acceleration capability	Design speed
Driver eye level	Physiology	Dimensions	-
Object height	-	Dimensions for passing	-
Horizontal geometry			
Superelevation (emax)	Consistency of steering effort on successive curves	-	Urban/ rural environment, climatic conditions, curvature
Coefficient of friction (fmax)	Comfort	-	Skid resistance of road surface, open highway/ intersection
Radius (Rmin)	-	-	Design speed, open highway/ intersection
Transition curves	Behavior on entering curves, comfort	-	Appearance of carriageway edges, design speed
Phasing	Response to visual detects and hazards	-	Appearance, creation of visual defects and hazards, design speed
Vertical geometry			
Crest curves	Speeds during nighttime compared with daytime Comfort	Headlight height, proportion of stopping distance illuminated by headlights	Drainage, appearance of road, design speed
Sag curves	Comfort	Headlight height, beam divergence, distance illuminated by headlights	Drainage, appearance of road, design speed
Gradients	Behavior on approach to gradients	Passenger car and truck performance, power/ weight dimensions	Crawler lanes provide overtaking opportunity, design speed
Cross-section			
Number of lanes	Comfort, ability to maneuver in traffic stream and maintain desired speed	-	Urban rural environment design speed
Lane width	Sensitivity to restricted width	Dimensions of design vehicle	-
Lateral clearance	Sense of restriction	-	Nature of lateral obstruction
Shoulder width	Sense of restriction	Dimensions of design vehicle	Urban/ rural environment, type of facility
Median width	Sense of well-being	Vehicle / barrier collision	Type of facility, terrain. Urban/ rural environment, appearance
Crossfall	-	-	Drainage, type of facility
Vertical clearance	Sense of restriction	Dimensions of design vehicle	Future resurfacing

Tab.9.2 Comparison of Standards

Design Speed(Km/h)	100					80					60				
Source	J	A	N	U	SR	J	A	N	U	SR	J	A	N	U	SR
Radius of curve(m)※															
Desirable Minimum	700 (6)	475	550	720		400 (7)	300	350	510		200 (8)	175	130	255	
Minimum	460 (6)				420 (6)	280 (6)				255 (6)	150 (6)				130 (6)
Absolute Minimum	380 (10)	330	450	510		230 (10)	210	300	360		120 (10)	130	105	180	
Minimum length of transition curve(m)	85	105	60	110		70	85	50	90	50	50	60	30	65	
Minimum radius to omit a transition curve(m)	3000		700	2040		2000		500	1020		1000		300	720	40
Minimum radius to omit a superelevation (m) (※)	5000				2250	3500				1440	2000				810
Maximum grade(%)															
Desirable Maximum	3	3	3	3	3	4	4	4	4	3	5	5	6	4	3
Absolute Maximum	6	6	5	4	4	7	7	6	8	4	8	8	8	8	5to6
K values(m/% change)															
Crest															
Passing		524	1109	400	542		320	532	285	307		223	220	142	139
Desirable Minimum	100	122		100	191	45	49		55	89	20	24		17	33
Absolute Minimum	65	70	63	55	97	30	34	24	30	45	14	18	9	10	17
Sag															
Minimum Value	45	45	150	26	50	30	30	74	20	32	15	20	28	13	17
Minimum length of Vertical curve(m)	85	55	90	140		70	45	70	100		50	35	45	85	
Minimum sight distance(m)															
Stopping sight distance	160	168	170	160	205	110	122	105	120	140	75	84	65	70	85
Passing sight distance															
Desirable	700	701	1010	580	690	550	549	700	490	520	350	457	450	345	350
Mimimum	500		750		410	350		450		280	250		300		170

Remarks J:JRSO A:AASHTO N:NAASRA U:DEPARTIMENTAL STANDARD DEPARTMENT OF TRANSPORT,LONDON SR:SRILANKA

※ Figure in ( ) is superelevation (%) which determines radius of curve.
JRSO: Japanese Road Structure Ordinance, 1983
AASHTO: American Association of State Highway and Transportation Officials
NAASRA: National Association of Australian State Road Authorities
SR: Geometric Design Standards of Road, Road Development Authority, 1998

9.1.2 Geometric Design Standards

The geometric design standard for the OCH and its ramps is shown below.

(1) Outer Circular Highway

Road standard				Type 1, class 3		Remarks
Design speed				80km/ h		
Design value				Standard	Exceptional	
Horizontal alignment (Min.)	Radius of curve		m	400 (7%)	230 (10%)	( ) Superelevation
	Min. curve length	$\theta \geq 7^{0}$	m	140	-	θ : Inter Angle
		$\theta < 7^{0}$	m	1000/θ	140	
	Transition curve length		m	70	-	
	Radius of curve which allows omission of transition curve		m	2000	-	
Longitudinal alignment	Max. vertical gradient		%	4	7	
	Min. vertical curve	Crest	m	4500	3000	
		Sag	m	3000	2000	
	Min. curve length		m	70	-	
Standard crossfall			%	2.5	-	RDA Standard
Max. Superelevetion			%	7	10	
Max. Composite gradient			%	10.5	-	

Note: The setting of the maximum vertical gradient for ramps (including loop portions) must be less than the maximum composite gradient.

*Source: The Geometric Design Standard of High Standard Arterial Expressway, September 1989, Japanese Ministry of Construction

(2) Interchange

Interchange standard				Class 1		Remarks
Design speed				V = 40 km/ h		
Elements				Reference value		
				Standard	Exceptional	
Horizontal alignment	Minimum radius of curvature		m	50(9%)	40(10%)	
	Min. parameter of clothoid curve		m	35	-	
	Radius of curvature which allows omission of transition curve		m	140	-	
	Min. parameter at off ramp nose		m	60	50	
	Radius of curve at off ramp nose		m	170	-	
	Allowable radius of curve of the inverted superelevation		m	800	-	
Longitudinal alignment	Maximum gradient		%	6	Up slope 7 Down slope 8	
	Min. radius of vertical curve	Crest	m	900	450	
		Sag	m	900	450	
	Min. vertical curve length		m	40	35	
	Min. vertical curve near the nose	Crest	m	1600	800	
		Sag	m	1400	700	
		Curve length	m	60	40	
Standard crossfall			%	2.5	-	RDA Standard
Maximum superelevatio			%	9.0	10.0	
Maximum composite gradient			%	11.0	-	

Note: The setting of the maximum vertical gradient for ramps (including loop portions) must be less than the maximum composite gradient.

* Source: The Geometric Design Standard of High Standard Arterial Expressway, September 1989, Japanese Ministry of Construction

9.1.3 Related Geometric Design Condition

The geometric design conditions for the junction with the Colombo - Katunayake Expressway (CKE) and Southern Highway (SH) are shown below.

(1) Summary of Geometric Design Conditions for CKE Junction

Taking into account that vehicles will stop at tollbooths and applying the design parameters for the interchange with the OCH, design speed was set at 40 km/h.

Item	Standard	Exceptional	Remarks
Design speed	OCH: 80 CKE 110		
No. of main line lanes	OCH:4(6) CKE: 4		() = future no. of lanes
Classification of interchange	Class 1		
Design speed	40		
Ramp standard	A standard		
No. of ramp lanes	Single lane		Capacity per lane: 1200 Veh./hr.
Segregated/non-segregated ramp	Segregated		
Ramp width	7 m		One lane in each direction
Minimum radius of curve	50 (9%)	40 (10%)	( ): Superelevation
Maximum gradient	6%	Up slope: 7% Down slope: 6%	3% or less
Min. radius of vertical curve, Crest	900	450	
Min. radius of vertical curve, Sag	900	450	
Min. vertical curve length	40	35	
Max. superelevetion	9.0%	10.0%	
Max. composite gradient	11.0%	-	
Min. deceleration lane length excluding the tapered lane	OCH: 80 CKE : 90		
Min. acceleration lane length excluding the tapered lane	OCH: 160 CKE: 180		
Min. tapered length	OCH: 50 CKE: 60		
Max. exit angle	OCH: 1/20 CKE: 1/25		

Note: The setting of the maximum vertical gradient for ramps (including the loop portion) must be less than the maximum composite gradient.

Source:The Geometric Design Standard of High standard Arterial Expressway September 1989, Japanese Ministry of Construction.

(2) Summary of Geometric Design Conditions for Southern Highway (SH) Junction

Item	Standard	Exceptional	Remarks
Design speed	OCH: 80 SH: 80		Southern Hwy. Design speed not set
No. of main line lanes	OCH: 4 (6) SH: 4 (4)		( ) No. of lanes in future
Classification of Junction	Class 2		
Design speed	50		
Ramp standard	A standard		
No. of ramp lanes	Single lane		Capacity per lane: 1200 vehicles/hour
Segregated/non-segregated ramp	Segregated		
Ramp width	7 m		One lane in each direction
Minimum radius of curve	100^{m} (9%)	80^{m} (10%)	( ) superelevetion
Maximum vertical gradient	5.5 %	6.0 %	
Min. radius of vertical curve, crest	1200^{m}	800^{m}	
Min. radius of vertical curve, Sag	1000^{m}	700^{m}	
Min. vertical curve length	60^{m}	40^{m}	
Max. Superelevetion	9%	10%	
Max compsit gradient	10.5	-	
Min. deceleration lane length excluding the tapered lane	80^{m}	-	
Min. acceleration lane length excluding the tapered lane	160^{m}	-	
Min. tapered length	50^{m}	-	
Max. exit angle	1/20	-	

Note: The setting of the maximum vertical gradient for ramps (including the loop portion) must be less than the maximum composite gradient.

Source: Same as table on page 9-5.

9.1.4 Design Vehicle Dimensions

The dimensions of design vehicles form the basis for geometric features. The design dimensions applied are based on AASHTO94.

9.1.5 Design Speed

Design speed for a particular road classification is usually selected according to the terrain and traffic volume. To provide consistency for the design elements, general controls for the recommended that the design speed chosen be consistent with the speed a driver is likely to expect.

As for the OCH, it would have a significant role in the collection and distribution of traffic from/to the arterial roads that radiate from Colombo. In addition, the OCH will play the crucial role of alleviating traffic congestion and encouraging more balanced urban development.

Based on the above, it can be said that the OCH is different from a typical intercity expressway that links different urban areas. That is, the primary focus of the OCH is on serving intra-city traffic and not intercity traffic and on providing better access between arterial roads and present/future economic growth zones near the OCH.

The design speed for the carriageway, junctions, interchanges, of the OCH are described below.

Route name	Road standard	Design speed
Outer Circular Highway	Class 1, type 3 for Japanese roads	80 km/ h
OCH Interchange	Class 1 Japanese interchange	40 km/ h

Source: Japan Road Structure Ordinance, 1983.

9.1.6 Cross Road Elements

(1) Cross-Section Elements

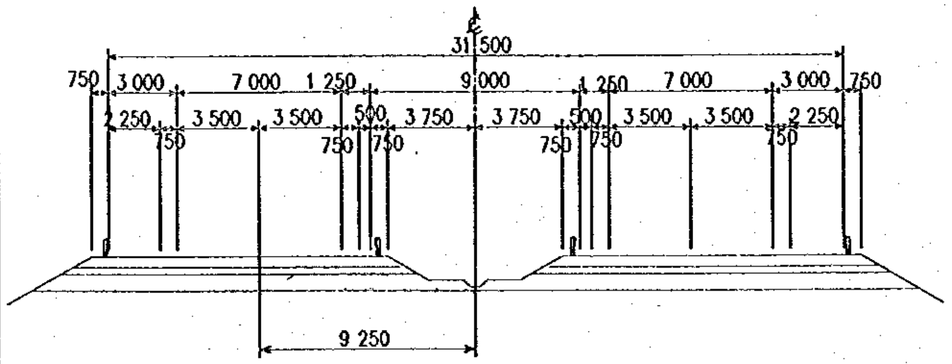
The cross-section of the OCH is composed of the following elements:

- Carriageway
- Center Median
- Shoulder (include stopping lane)
- Frontage Road (for pedestrian & bicycle use also)
- Green Area

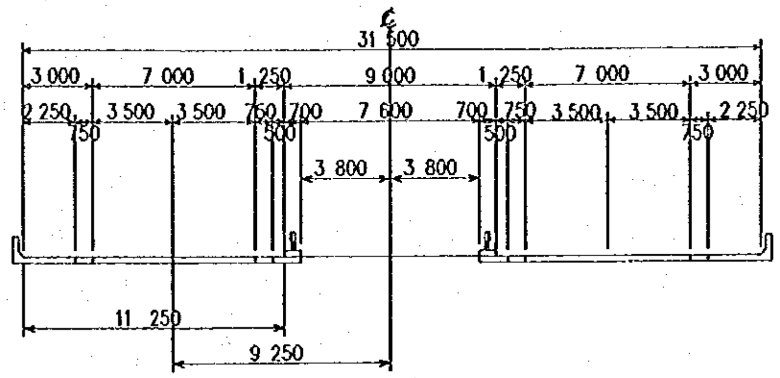
The cross section elements for the OCH are shown in Fig.9.1 and Fig. 9.2, for four-lane and six-lane structures respectively. The design concepts for deciding the elements of the cross-section are described below.

Fig.9.1 STANDARD CROSS SECTION (1)
4 LANES ⇒ 6 LANES

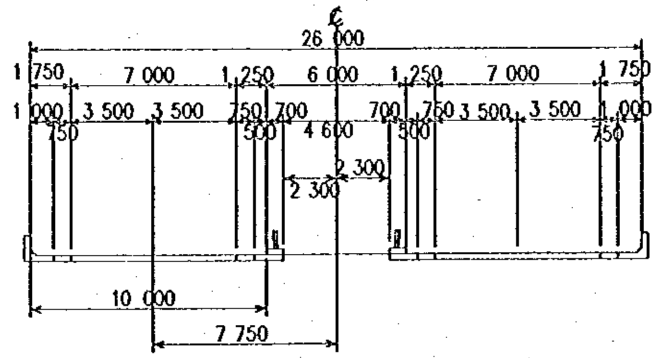
(OPERATION WITH 4 TRAFFIC LANES)
TYPE-4L



VIADUCT
(OPERATION WITH 4 TRAFFIC LANES)
TYPE-Vi-4A



BRIDGE
(OPERATION WITH 4 TRAFFIC LANES)
TYPE-Br-4A

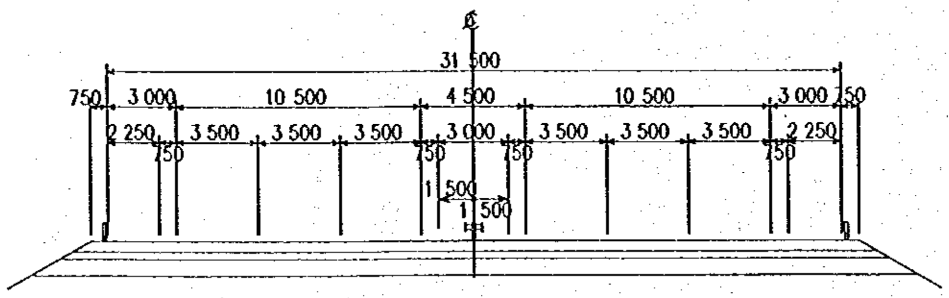


TO BE WIDEN TOWARD THE CENTER

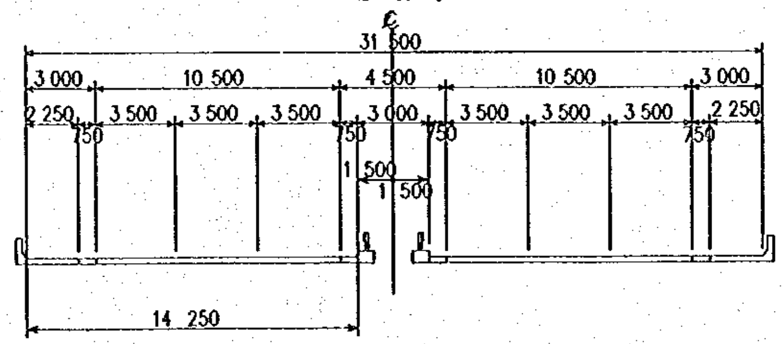
TO BE WIDEN TOWARD THE CENTER

TO BE WIDEN TOWARD THE CENTER

(OPERATION WITH 6 TRAFFIC LANES)
TYPE-6L



(OPERATION WITH 6 TRAFFIC LANES)
TYPE-Vi-6



(OPERATION WITH 6 TRAFFIC LANES)
TYPE-Br-6

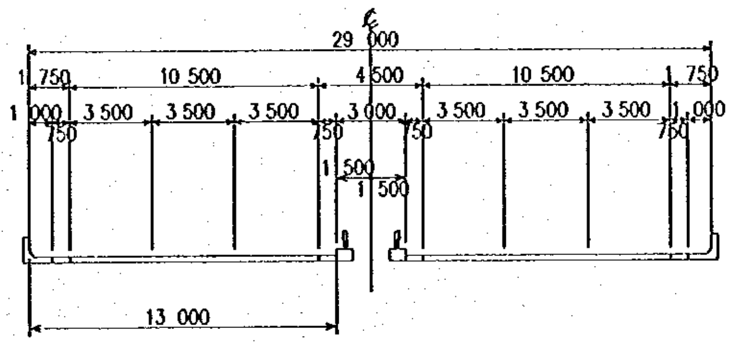
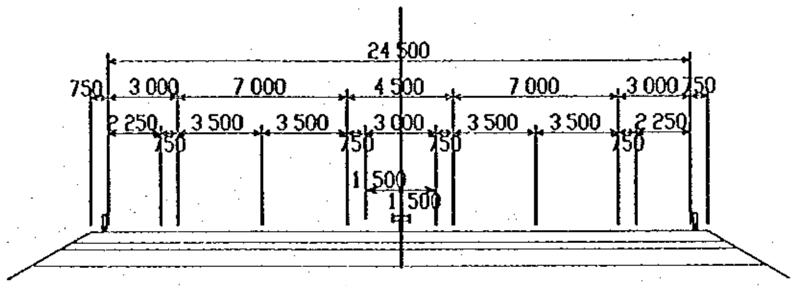


Fig.9.2 STANDARD CROSS SECTION (2)

4 LANES

(OPERATION WITH 4 TRAFFIC LANES)

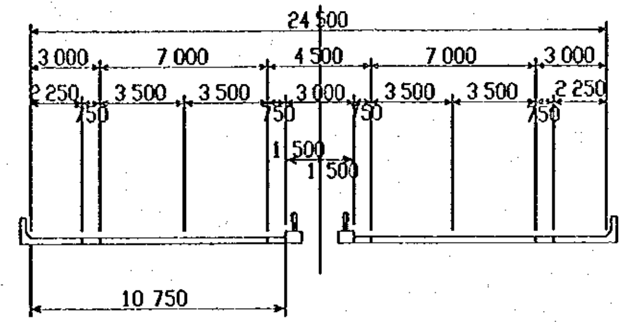
TYPE-4L



VIADUCT

(OPERATION WITH 4 TRAFFIC LANES)

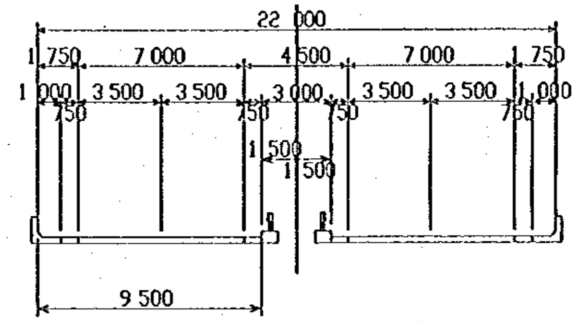
TYPE--Vi--4



BRIDGE

(OPERATION WITH 4 TRAFFIC LANES)

TYPE--Br--4



1) Carriageway

OCH traffic lane width is to be 3.5 meters, which is in accordance with the Japanese standards that are to be applied to the OCH. For reference, a simple comparative study on RDA, Japanese, Austrian, US, and British standards was carried out. It was determined that the Japanese standard was the most economical.

(i) Vehicle speed: Maximum design speed of 80 km/ h

(ii) Classification of road

The OCH is categorized as a limited access controlled road, and therefore does not require a full range of expressway characteristics.

(iii) Traffic

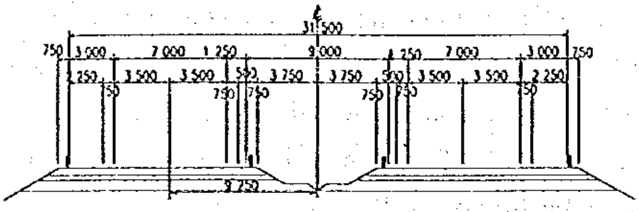
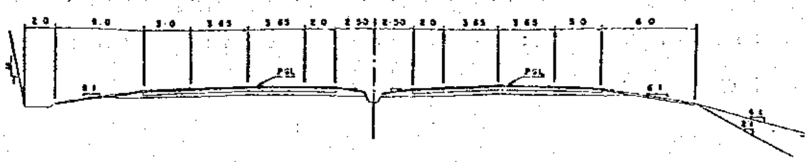
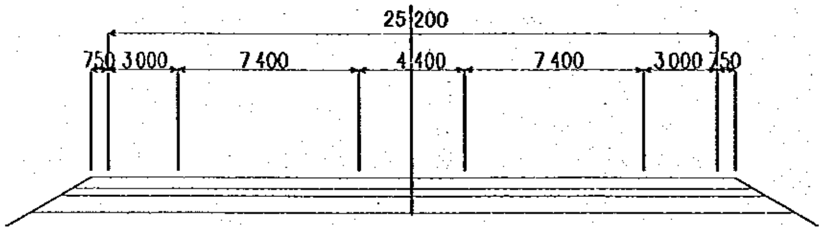
A large number of heavy vehicles is expected to use the OCH.

(iv) Vehicle dimensions

Sri Lankan vehicle dimensions are set with AASHTO94.

Setting the width and formation of the carriageway should also take into account other road projects, such as the Southern Transport Corridor and the Colombo Katunayake Expressway (see Table on next page).

Comparison of Cross-Sections

OUTER CIRCULAR HIGHWAY	
Carriageway	Initial 4 traffic lanes Dual Carriageway (completely 6 lanes) with Grade Separated Intersection
Cross Section	
Width of Roadway	31.5 meters
Width of Traffic Lane	3.5 meters ×2
Width of Center Median	4.5 m (including right shoulder width 0.75 m) for completely, 9.0 m for temporarily
Width of Shoulder	3.0 meters
Height of Embankment	5.0 meters
Type of Intersection	Grade separated (Diamond Type)
Service Road	5.5 meters wide Front Road
SOUTHERN TRANSPORT CORRIDOR (Northern Section: JBIC Portion)	
Carriageway	Initial 4 traffic lanes Dual Carriageway (completely 6 lanes) with Grade Separated Intersection
Cross Section	
Width of Roadway	29.6 meters (41.6 m including recovery zone)
Width of Traffic Lane	3.65 meters ×2
Width of Center median	5.0 m (including right shoulder width 2.0 m)
Width of Shoulder	3.0 meters
Height of Embankment	2.0 meters
Type of Intersection	Grade separated
Service Road	Provided as required (6 meter wide recovery zone)
COLOMBO – KATUNAYAKE EXPRESSWAY	
Carriageway	Completely 4 traffic lanes Dual Carriageway with Grade Separated Intersection
Cross Section	
Width of Roadway	26.7 meters
Width of Traffic Lane	3.7 meters ×2
Width of Center median	4.4 m (including right shoulder width 1.20 m)
Width of Shoulder	3.0 meters
Height of Embankment	2.0 ~ 5.0 meters
Type of Intersection	Grade separated
Service Road	Very restricted

2) Shoulder Width

Wide shoulders enable a vehicle to pull off the travel lanes of a carriageway and to stand clear of moving traffic, thus avoiding the creation of a hazard and maintaining the capacity of the travel lanes. They also enable a driver to deviate to avoid a collision with an object on the road and allow room for regaining control of the vehicle. Wide shoulders also create a sense of openness and hence add to driver comfort as well as improving sight distances on horizontal curves. OCH shoulder width is determined by these functions.

Most passenger cars in Sri Lanka are Japanese vehicles, while many of the truck are imported from India. Indian trucks are slightly wider than the 2.5 meter-wide Japanese trucks meaning, that a 3.00 m wide shoulder is required to provide adequate space.

The right shoulder is not installed if the standard cross section has center median. However, for roads with a grade separation and those where the two directions of traffic are separated by means other than a center median, the shoulder is installed on the right side of the lanes in that direction. Width is determined by the requirement for lateral clearance on the right side of the outer lane and is as shown in Fig. 9.3. The shoulder includes a marginal strip, the function of which is the same as that of the center median. The thickness of the pavement of the shoulder is the same as that of the roadway itself. (Fig.9.4).

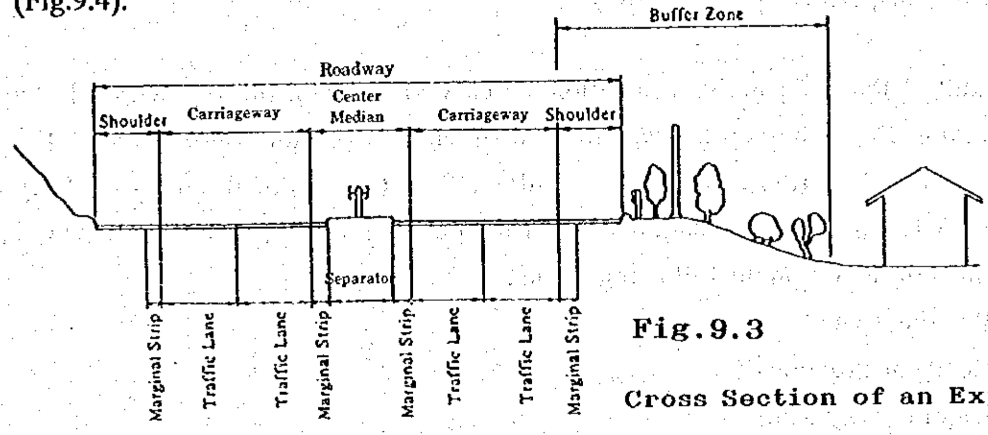


Fig.9.3

Cross Section of an Expressway

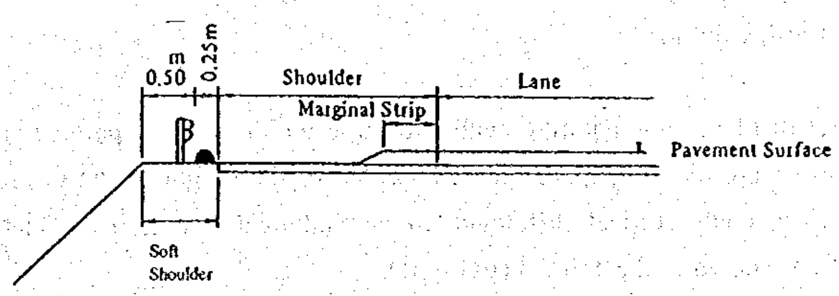


Fig. 9.4 **Standard Shoulder**

3) Center Median

This consists of a separator and marginal strip. The separator separates the two directions of traffic, prevents turns, minimizes disorder in the traffic flow and increases driving safety. The separator is provided with a guard fence to ensure these functions. The separator has the function of maintaining lanes by indicating clearly the external boundary of the traffic line, guiding the driver's vision, increasing driving safety and providing a lateral clearance.

To increase visibility, a white line 20cm wide indicating the outer line of the carriageway is drawn on the marginal strip. The basic width of the separatpr is 3.0 m. This is sufficient to ensure that lateral clearance will not be affected by the guard fence or plants inside the separator.

The minimum width of a separator for expressways is in general 2.0 m. This is because it is sufficient for any safety facility to be installed within the separator. Two types of separators (flat and mound-up) are considered as alternatives. A comparative review of these types is carried out and the best option selected. The results of the comparison, which took into account the items below, is shown in Tab. 9.3.

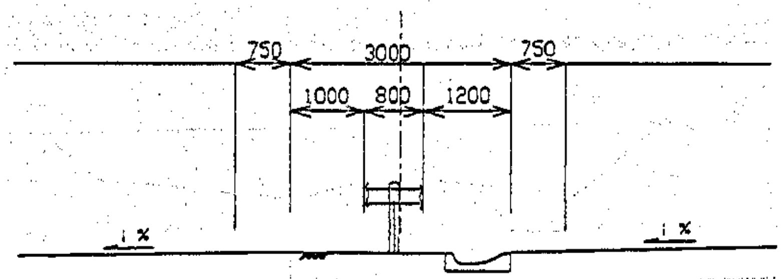
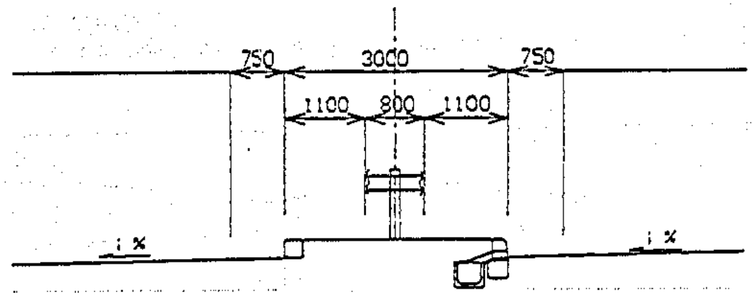
- Drainage structure
- Maintenance
- Running performance and safety

As a result of the comparative evaluation, an easy-to-maintain flat type was selected for the separator. Depending on the type of road structure, separator width can vary. For this study, either a 2 m (the Japanese standard) or 3 m (the width desired by RDA) was possible. A comparative evaluation was carried out (see Tab. 9, 4) for these two values taking into consideration the following points:

- Planting space
- Road construction
- Right-of-way width
- Earth volume

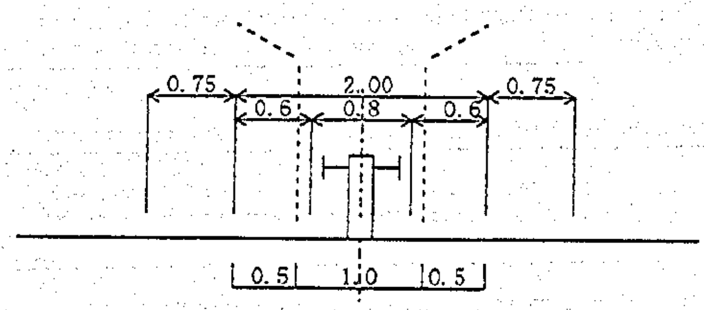
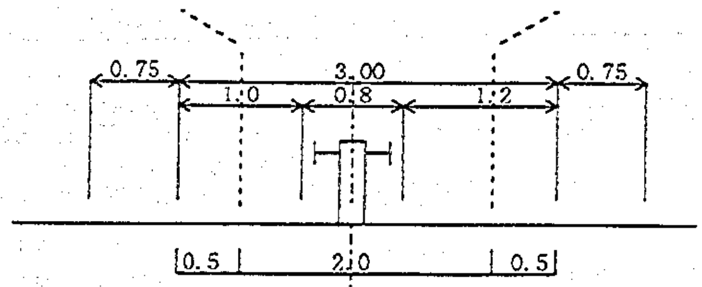
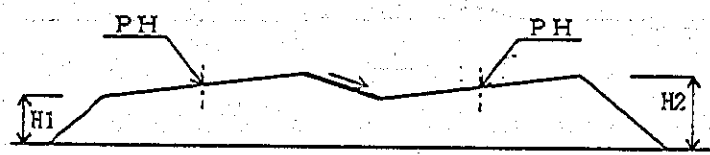
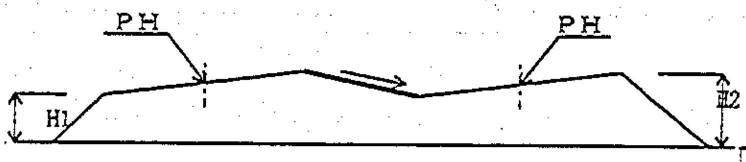
As a result of the comparative evaluation, the width of the separator is set at 3.0 m, in order to secure planting space and safety. As for the height of the pavement line, a plan ensuring a small vertical difference in embankment height in the lateral direction is selected as shown in the Tab.9.3 (flat type).

Tab. 9.3 Comparative Study on Center Median for Outer Circular Highway

Type	Flat Type	Mound-up Type
Sketch		
Summary	• Flat type separator • Drain from driveway at a superelevation is to be received by rolled gutter	• Mount-up type separator • Drain from driveway at a superelevation is to be received by circular waterway.
Drainage System	• Water collected with the rolled gutter is fed into the catch basin at set intervals and discharged in the cross direction. • Cross-sectional area for water flow:0.073m3 (W=0.7m, D=0.15m) • Good workability B	• Water collected with the circular waterway is fed into the catch basin at set intervals and discharged in the cross direction. • Cross-sectional area for water flow: • Special inner frame A
Maintenance	• Drainage facility is of an open construction, allowing easy maintenance. A	• Drainage facility is of a closed conduit construction, making maintenance difficult. C
Running Characteristics & Safety Issue	• In the case of emergency, a driver can stop a vehicle by rubbing its body against the guardrail, preventing overturn or going over guardrail. • The width of water flow for surface drainage is not included in the driveway, enabling high-speed running and safety. A	• The vehicle may overturn or go over the guardrail when it bumps into the block. • The width of water flow for surface drainage is included in the driveway, resulting in inferior high-speed running and safety. C
Practical Use in Japan	• This type of center median presently prefers to apply in Japan because of effectiveness of reducing initial cost and easy maintenance.	• This type of center median is no longer applied in Japan due to high initial cost and redundant function.

Legend: A: Good B: Slightly inferior C: Inferior

Tab. 9.4 Comparative Study on Width of Center Median for Outer Circular Highway

	Case 1 : Width = 2.0 m	Case 2 : Width = 3.0 m
Cross-Section		
Plantation	· Narrow planting space · Narrow planting space may hinder clearance due to spreading branches or leaves. C	· Wide planting space · Wide planting space minimizes the possibility of hindrance of clearance due to spreading branches or leaves A
Planning Height at Center of Carrigeway	· Narrow median strip width causes steep gradient of median strip, making installation of guardrails or construction of drainage facility difficult structurally.  B	· Wide median strip width causes gentle gradient of median strip, facilitating installation of guardrails and construction of drainage facility.  A
Right of Way	· The land acquisition costs could comparatively be saved due to 1.0 meter narrower than Case 2. A	· The land acquisition costs would be higher because the width is 1.0 meter wider than Case 1. B
Volume of Earthwork	· The volume of earthworks could comparatively be reduced due to narrower width. A	· The volume of earthworks would be comparatively bigger due to wider width. B
Evaluation	Two meters wide of center median is slightly narrow not to be practical use for OCH resulting from aforementioned. B	Three meter wide of center median is applicable for OCH in terms of their merit such as cost saving and practical use in developed country. A

Legend: A: Good B: Slightly inferior C: Inferior

4) Frontage Road

The OCH frontage road plays two major functional roles:

- To provide access along the OCH route from the proposed interchanges to the residential, commercial, industrial areas, and planned development areas (such as a free-trade zone or other growth center).
- To provide access to residents whose previous travel route or property has been severed by the OCH.

Any vehicle can use the frontage road instead of the main OCH carriageway, which restricts 3-wheelers and motorcycles under 250cc from entering. Frontage roads will be built on either side of the OCH to enhance access. However, the length shall be minimized whenever possible via the use of existing roads in order to reduce costs. The cross-section of the OCH frontage road is shown in Fig. 9.5. It is a single two-way road 5.50 meters in total width, with a hard shoulder on either side.

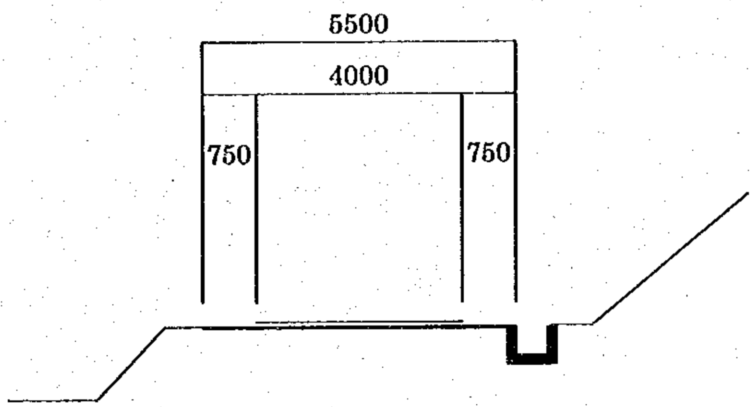


Fig. 9. 5 Cross Section of Frontage Road

5) Green Area

To alleviate noise, air and landscape problems, the installation of a green area has been considered for the OCH. However, due to the difficulty in acquiring land because of the high land costs in Colombo, the Study Team has recommended instead that OCH embankments be used as green areas or barriers.

6) Surface drainage

The surface drainage method for OCH embankments and cutting is described below.

(a) For surface drainage, shoulders are provided with a drainage function.
(b) For embankments, water collected in the shoulder is directed to the toe of the slope and discharged through the gutter there. The water collected in the rolled gutter is provided to the median strip is directed to catch basins arranged in 100 – 200 m intervals for discharge in the cross direction.
(c) For cuts, catch basins are provided at 50 m intervals in the shoulder. The water is directed through the longitudinal pipe to the embankment section to be discharged to the toe of the slope.

The construction described above is shown in Fig. 9.7 and Fig. 9.8.

7) Fencing

Fencing is required for traffic safety purposes in order to prevent animals or other things from disrupting traffic unexpectedly. Fencing shall also define the boundary of the OCH

Fencing will be on both sides of a slope and the height shall be not less than 2.0 m as shown Fig. 9.6.

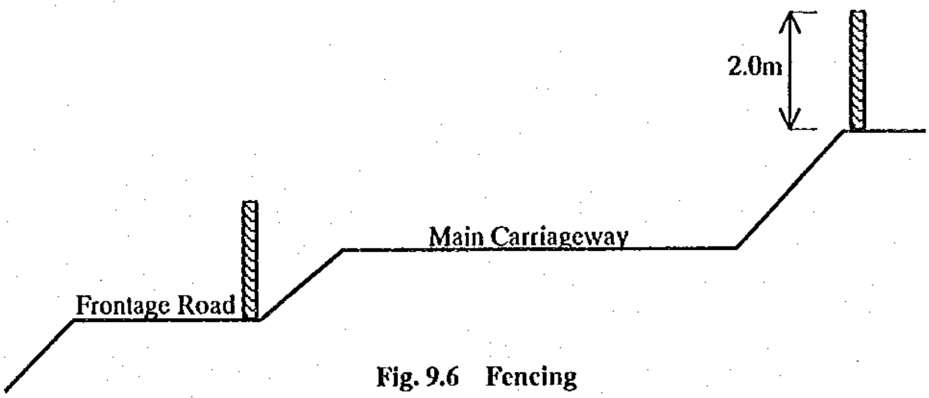


Fig. 9.6 Fencing

Fig.9.7 DRAINAGE CONNECTION AT TEMPORARILY 4 TRAFFIC LANES(EMBANKMENT) SCALE 1:50

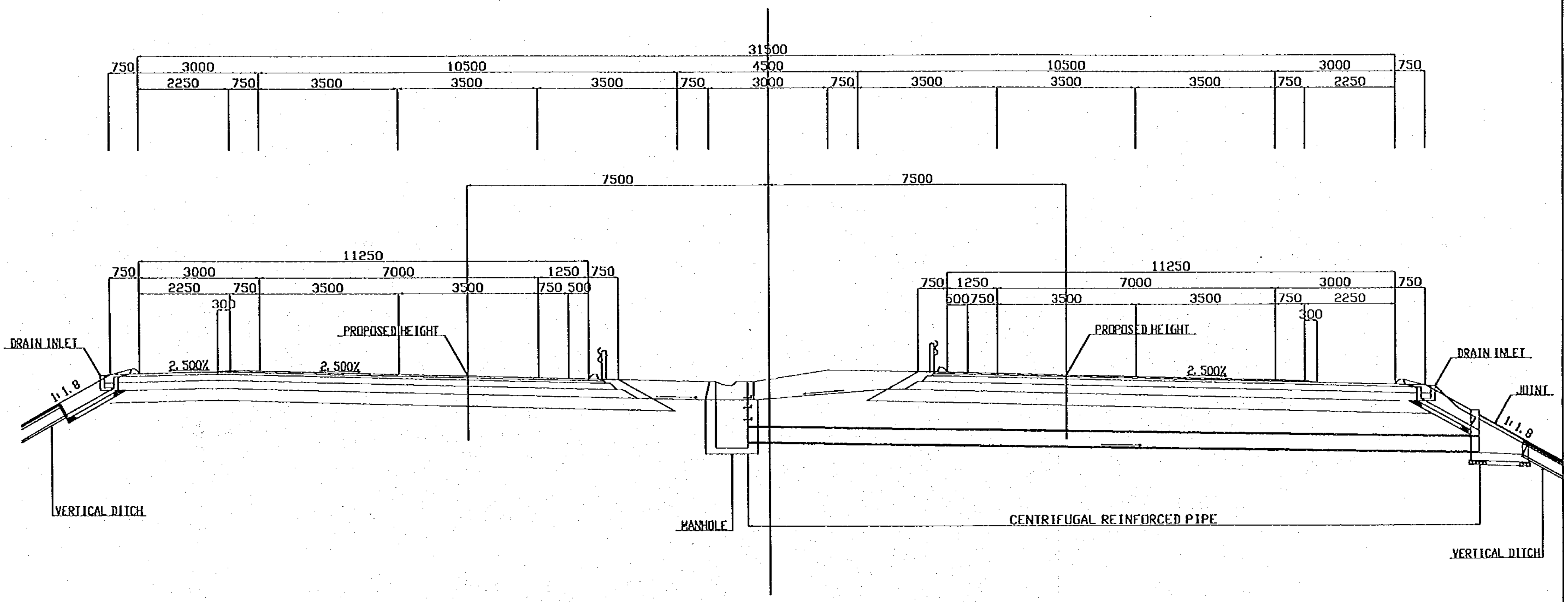
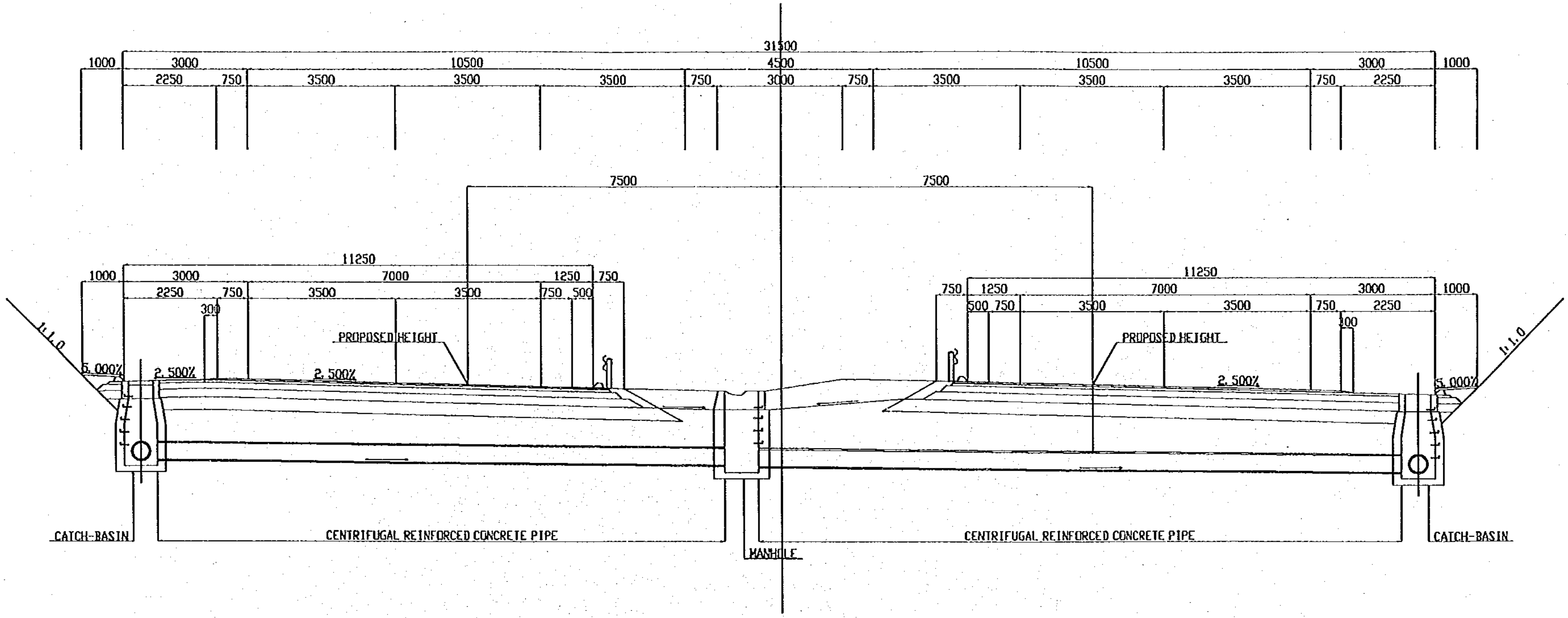


Fig.9.8 DRAINAGE CONNECTION AT TEMPORARILY 4 TRAFFIC LANES (CUT)

SCALE 1:50



9.2 Earthworks

As a result of field surveys and geological study results, the major geological feature of the OCH is that it consists of either sandy or clayey soil. The slope ratio for either cutting and embankment are as follows.

9.2.1 Slope Ratio of Embankment

Slope Ratio 1:1.8

Embankment materials	Embankment height	Gradient	Remarks
Sand of satisfactory grading (S), gravel, and gravel mixed with fine particles	5m or less	1:1.5 - 1:1.8	Applicable to embankments where the foundation has a sufficient bearing capacity and there is no inundation.
	5 - 15 m	1:1.8 - 1:2.0	
Sand of unsatisfactory grading (SG)	10 m or less	1:1.8 - 1:2.0	The unified soil classification shown in parentheses is representative and provided for reference.
Rock (including waste rock)	10 m or less	1:1.5 - 1:1.8	
	10 - 20 m	1:1.8 - 1:2.0	
Sandy soil (SF), hard clayey soil, hard clay (hard clayey soil of diluvial stratum, clay, and Kanto Loam)	5 m or less	1:1.5 - 1:1.8	A stability test must be executed when the value falls outside of the standard slope gradient range.
	5 - 10 m	1:1.8 - 1:2.0	
Volcanic cohesive soil	5 m or less	1:1.8 - 1:2.0	

Note: Geometric Design Standard for High Standard Arterial Expressways, September 1989, and the Guideline for Road Earthworks, Japan Road Association.

9.2.2 Slope Ratio of Cutting

Slope Ratio 1 :1.0

Ground soil		Cut height	Gradient
Hard rock			1:0.3 - 1:0.8
Soft rock			1:0.5 - 1:1.2
San	Not compacted sand whose grading distribution is unsatisfactory		1:1.5 -
Sandy soil	Compacted	5 m or less	1:0.8 - 1:1.0
		5 - 10 m	1:1.0 - 1:1.2
	Not compacted	5 m or less	1:1.0 - 1:1.2
		5 - 10 m	1:1.2 - 1:1.5
Gravel or sandy soil mixed with rocks	Compacted or with satisfactory grading distribution	10 m or less	1:0.8 - 1:1.0
		10 - 15 m	1:1.0 - 1:1.2
	Not compacted or with unsatisfactory grading distribution	10 m or less	1:1.0 -1:1.2
		10 - 15 m	1:1.2 - 1:1.5
Cohesive soil		10 m or less	1:0.8 - 1:1.0
Rock or cohesive soil mixed with boulders		5 m or less	1:1.0 - 1:1.2
		5 - 10 m	1:1.2 - 1:1.5

9.3 Pavement

9.3.1 Design Conditions

The pavement thickness is designed on the basis of the design CBR of the subgrade and the number of 10 ton equivalent axle load applications in one direction during ten years.

The following figure shows this design method, which was established through original methods and experiences of the Japan Highway Public Corporation, on the basis of ASSHTO Road Test results.

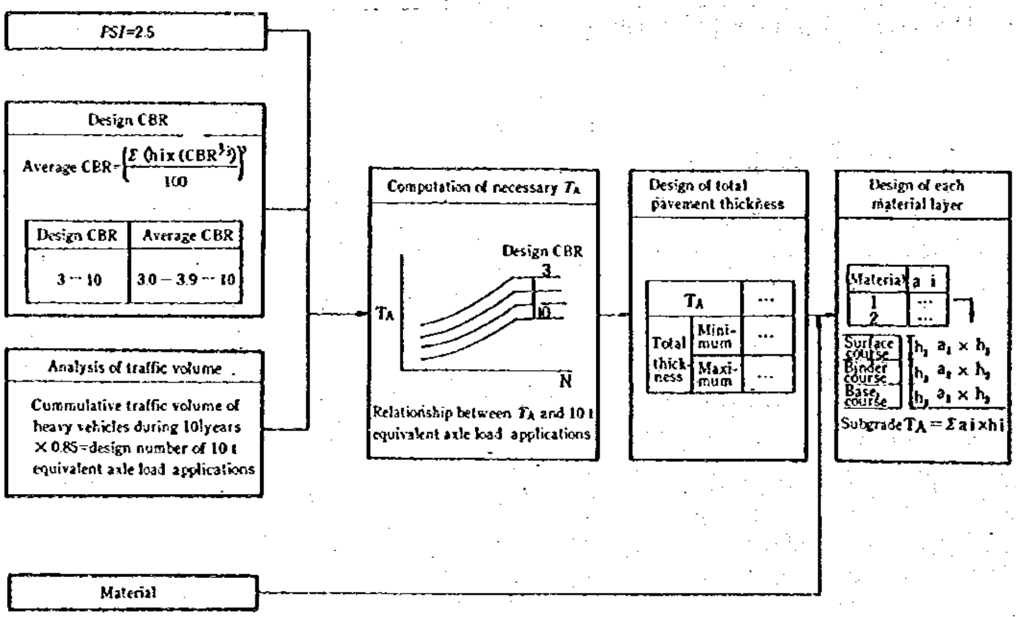


Fig. 9.9 Structure Design Method of Asphalt Pavement for Expressways

(1) Design CBR: 6%

As the result of the CBR test, the design CBR at subgrade was determined to be 6 as described in Chapter 6.

(2) Design Method:

"Manual for Asphalt Pavement" published by Japan Road Association

The manual, which is established based on the AASHTO, shall apply for the road design and construction field in Japan. It will also be of great help to accelerate technical exchange across the boundaries of all international community in this field.

(3) Design Period: 10 years

The design period of 10 years that conforms to the manual is adapted to the pavement structure of the Outer Circular Highway.

(4) Heavy Vehicle Traffic:

A pavement standard shall be determined from the heavy vehicle traffic on the basis of the estimation of one-way daily traffic volume of heavy vehicles in the fifth year of operation. The heavy vehicle traffic on the Outer Circular Highway estimates as shown in the Tab.9.5 which indicated the average of the heavy vehicles as per day.

Tab. 9.5 Estimated Traffic Volume of the Heavy Truck and Bus

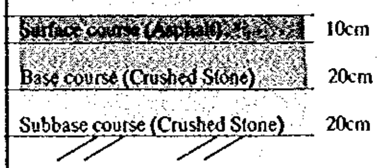
unit: vehicles/ day

	Year	Truck	Bus	Total	Class
One-way daily traffic	2010	240	705	945	B Traffic

9.3.2 Pavement Design

The design CBR and the road classification indicated in the above Tab. 9.5 shall conduct to the target value as T_A =21cm, with total thickness H= 38cm. According to the manual, the minimum thickness of the surface course and binder course amounts to 10cm. The total pavement structure T_A' satisfies the required value of T_A as follows:

Pavement Structure for the Outer Circular Highway



Pavement Structure	Thickness	T_A'	T_A
Asphalt Concrete	10 cm	1.00 x 10	
Base course	20 cm	0.35 x 20	
Subbase course	20 cm	0.25 x 20	
Total	50 cm	T_A'=22	T_A=21 H=38cm

9.2.2 Slope Ratio of Cutting

Slope Ratio 1 :1.0

Ground soil		Cut height	Gradient
Hard rock			1:0.3 - 1:0.8
Soft rock			1:0.5 - 1:1.2
San	Not compacted sand whose grading distribution is unsatisfactory		1:1.5 -
Sandy soil	Compacted	5 m or less	1:0.8 - 1:1.0
		5 - 10 m	1:1.0 - 1:1.2
	Not compacted	5 m or less	1:1.0 - 1:1.2
		5 - 10 m	1:1.2 - 1:1.5
Gravel or sandy soil mixed with rocks	Compacted or with satisfactory grading distribution	10 m or less	1:0.8 - 1:1.0
		10 - 15 m	1:1.0 - 1:1.2
	Not compacted or with unsatisfactory grading distribution	10 m or less	1:1.0 -1:1.2
		10 - 15 m	1:1.2 - 1:1.5
Cohesive soil		10 m or less	1:0.8 - 1:1.0
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9.3 Pavement

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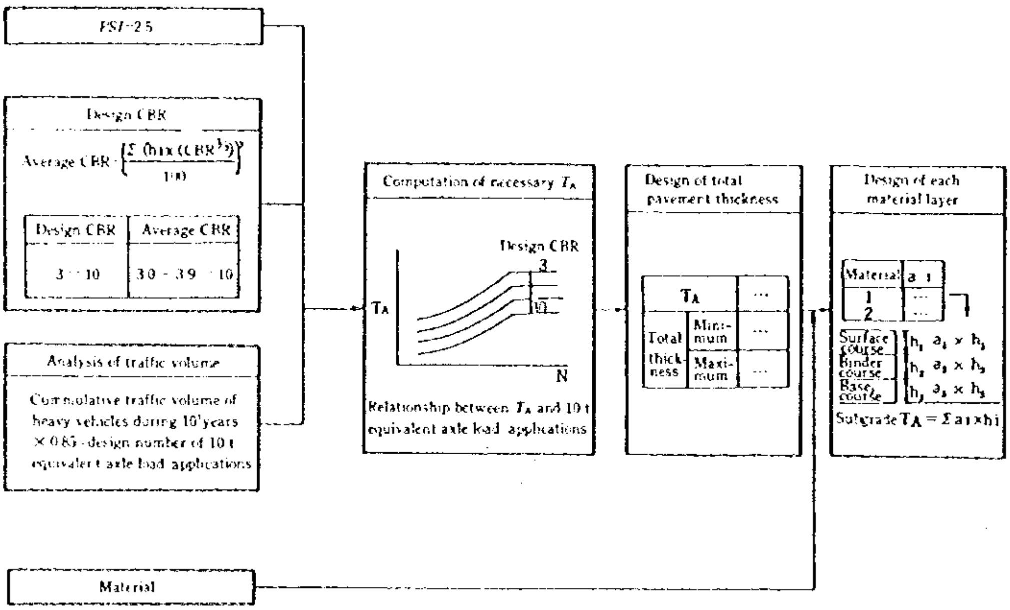
The following figure shows this design method, which was established through original methods and experiences of the Japan Highway Public Corporation, on the basis of ASSHTO Road Test results.



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	Year	Truck	Bus	Total	Class
One-way daily traffic	2010	240	705	945	B Traffic

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Pavement Structure for the Outer Circular Highway

		Pavement Structure	Thickness	T_A'	T_A
Surface course (Asphalt)	10cm	Asphalt Concrete	10 cm	1.00 x 10	
Base course (Crushed Stone)	20cm	Base course	20 cm	0.35 x 20	
Subbase course (Crushed Stone)	20cm	Subbase course	20 cm	0.25 x 20	
		Total	50 cm	T_A'=22	T_A=21 H=38cm

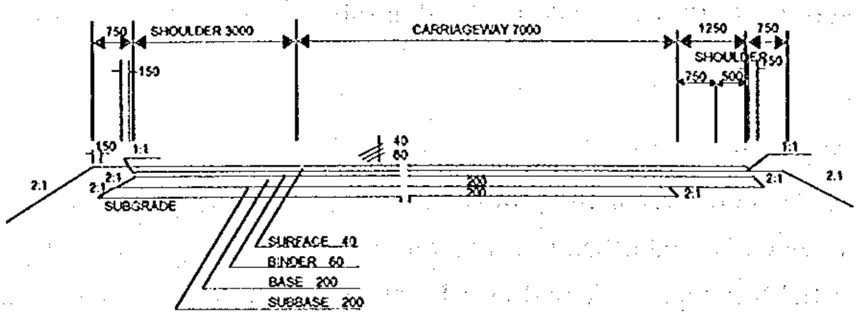


Fig. 9.10 Pavement Structure

9.4 Horizontal Alignment

9.4.1 Basic Concept

The basic concept for the determination of the OCH horizontal alignment is described below.

<Basic concept>

- The alignment must take into account the connection with the CKE .
- The alignment must take into account the connection with the Southern Transport Corridor.
- The alignment must take into account the type of intersection and connection with each arterial road. (Intersecting roads: Colombo-Katunayke Expressway, Rt.A3, Rt. A1, Rt. B214, Rt. A11, Rt. A4, Rt. B84, Rt. A8, Southern Transport Corridor, and Rt. A2.)
- Due care must be taken to minimize the effects on structures and houses along the route by having the OCH pass through non-inhabited areas.
- The alignment must be such that the amount of cutting is increased to compensate for the projected shortage of fill.

9.4.2 Control Points

Control points to be taken into account for determining the horizontal alignment are as follows:

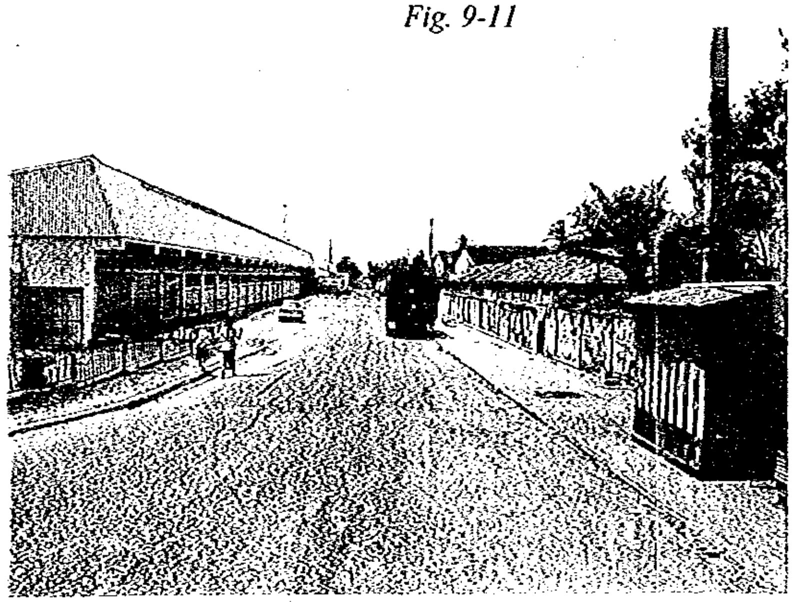
<Control points>

- Buildings, Buddhist temples, Hindu shrines, Christian churches, graveyards, schools, hospitals, plants, markets, military facilities
- Power transmission and steel towers
- Points to cross the Kelani and Bolgoda rivers are as originally selected, so that the road runs straight.
- Dividing villages must be avoided as much as possible.
- When crossing a railway, grade separation must be selected so that the road runs straight.
- To avoid crossing lakes and rivers as much as possible.

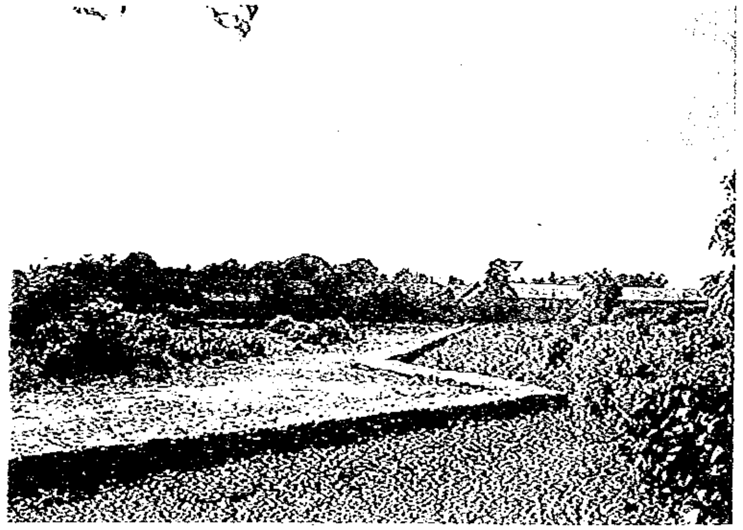
Control points are shown in Fig. 9.11 – 9.25.

Fig. 9-11

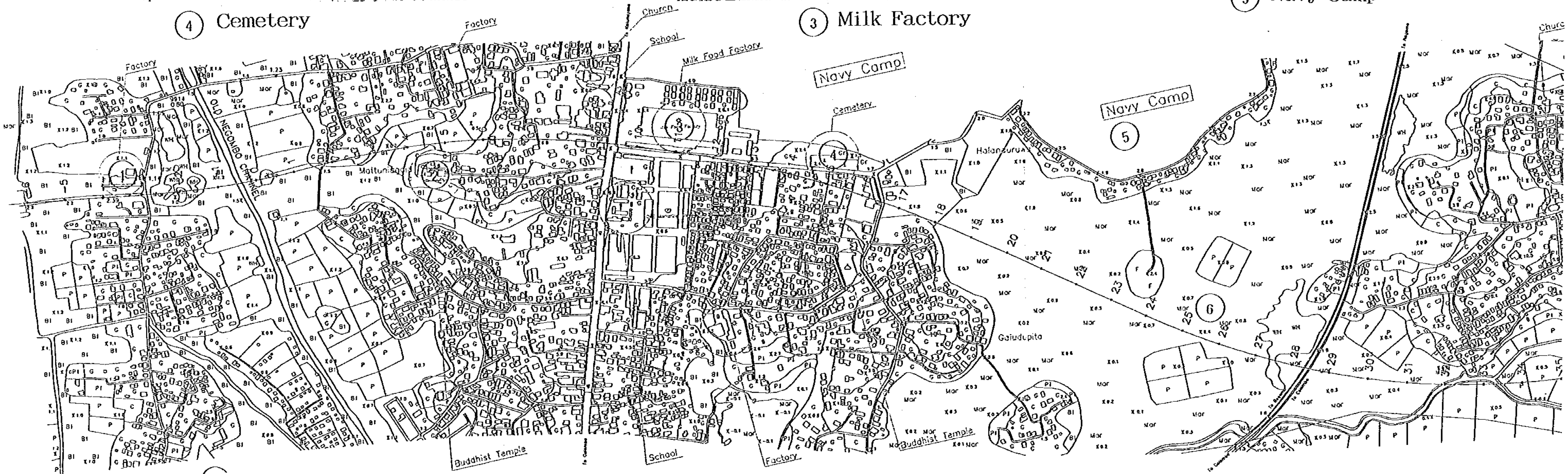
(4) Cemetery



(3) Milk Factory



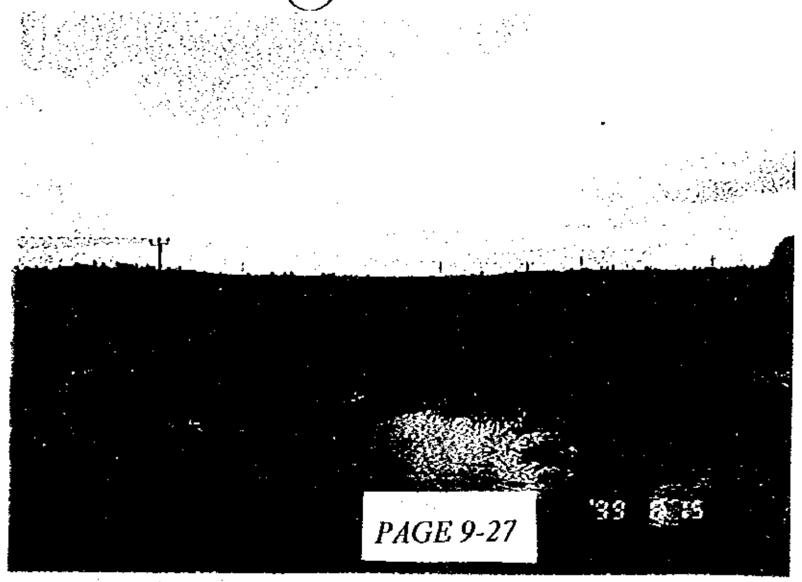
(5) Navy Camp



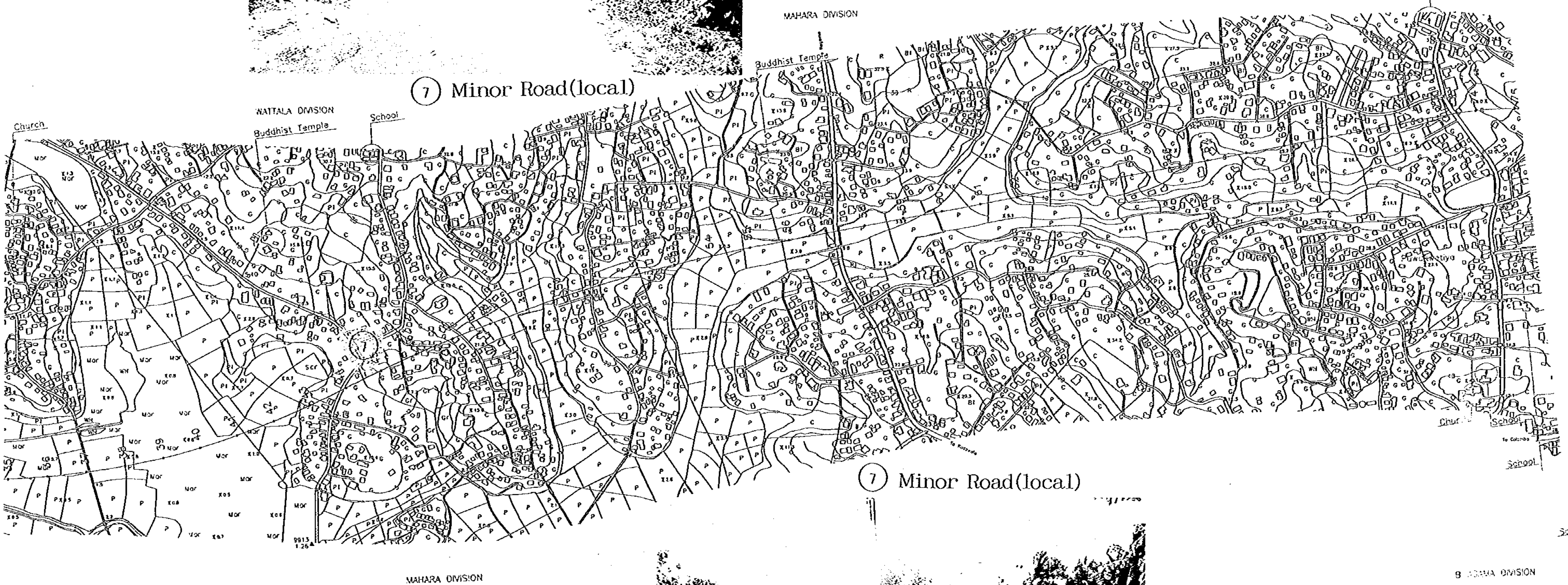
(1) Factory

(2) Buddhist Temple

(6) Marsh

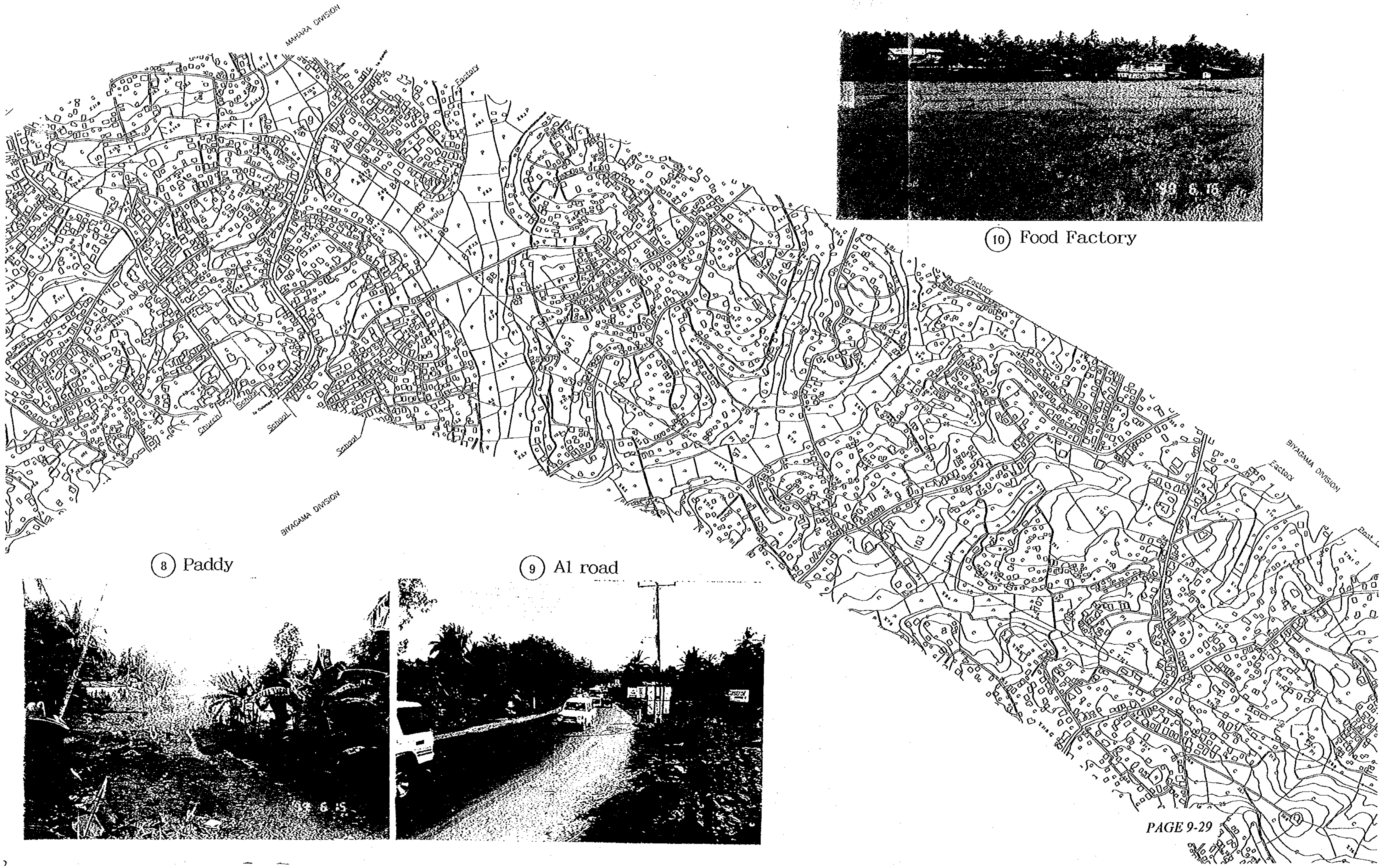


⑦ Minor Road(local)



⑦ Minor Road(local)

Fig. 9-13



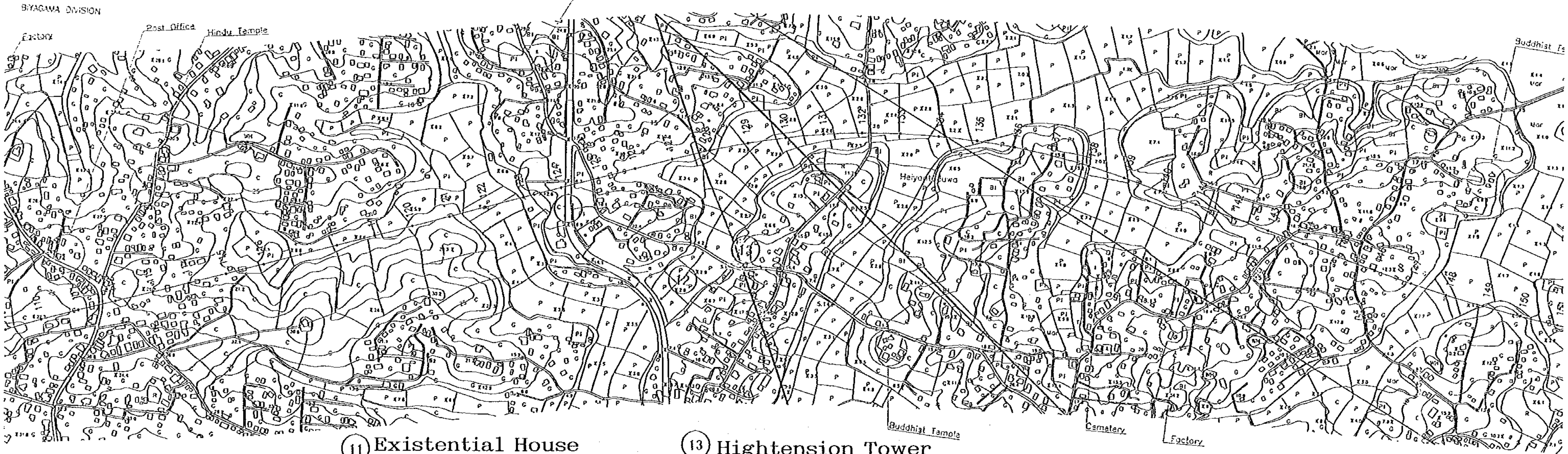
(10) Food Factory

(8) Paddy

(9) A1 road

Fig. 9-14

(12) Paddy



(11) Existential House

(13) Hightension Tower