

2) Skew angle

South four roads meet with Rama IV road at an angle of about 40 degree. North side four roads also have angles of 60 - 80 degrees with Rama IV road.

3) Drainage under Rama IV road

A large drainage pipe is located underneath along Rama IV road. On the construction of a flyover, the diversion or other measures are required.

4) Buildings

There are Lumpini park and a military school to the north of Rama IV road. To the south, permanent buildings are already built-up.

(4) Degree of congestion (existing)

Existing conditions are summarized in Table 5.2.1.

Table 5.2.1 Existing Condition of Intersections

Item	Characteristics			
	Si Phraya	Surawong	Silom	Sathon
1) Peak hour (A.M)	8.00-9.00	9.00-10.00	9.00-10.00	8.30-9.30
Max. Traffic (A.M) (PCU/hr)	2,594 (WB)	3,288 (EB)	3,290 (EB)	4,217 (WB)
2) Peak hour (P.M)	18.00-19.00	17.00-18.00	16.00-17.00	17.00-18.00
Max. Traffic (P.M) (PCU/hr)	3,010 (EB)	3,276 (EB)	4,001 (EB)	4,722 (EB)
3) Saturation degree (A.M)	0.687	1.011	1.136	1.156
(P.M)	0.738	0.907	1.090	1.278
4) Max. Queue length (P.M)	250 m (EB)	500 m (EB)	600 m (NB), 300 m (EB)	800 m (NB), 700 m (EB)
	16.30-18.00	16.00-17.00	16.00-18.00	17.00-18.00
5) Max. Stopped delay (P.M)	5min.30sec (EB)	10min. (EB)	10min.(NB) 4min.(EB)	12min.(NB) 10min.(EB)
6) Cycle length (A.M)	207 sec. regular	378 sec. regular	236 sec. regular	460 sec. irregular
(P.M)	262 sec. irregular	380 sec. irregular	248 sec. regular	212 sec. regular

### 1) Saturation degree

Saturation degrees of Surawong, Silom and Sathon are more than 0.9. They are definitely to be improved. Comparing with the three intersections, the Si Phraya's degree seems relatively small, less than 0.8. But it still has long queues ranging 200 - 300 m. The reason of the smallnesses is considered that the Rama IV Rd. is fully occupied by the stopped vehicles during evening peak hours. Therefore, vehicles cannot enter the Si Phraya intersection, then the saturation degree is kept low.

In conclusion, considering the above reason, all the four intersections are to be improved.

### 2) Queue length

The queue of Sathon road is the longest, 500 - 900 m for two and half hours in the evening peak hours (Figure 5.2.3). It is because the Sathon road has large traffic turning movement to Rama IV road (1,462 PCU/hr) but the longer green time cannot be allocated for it due to more traffic volume in Rama IV itself (2,500 PCU/hr). In the evening peak hours, traffic queues almost occupy the road areas between the four intersections (Figure 5.2.3).

### 3) Stopped delay

Max. stopped delay was recorded at Surawong, Silom and Sathon, more than 10 min. If only those of east bound along Rama IV road are picked up, the average stopped delay in the evening are as follows.

Si Phraya	-	Surawong	-	Silom	-	Sathon
5 min. 30 sec.		10 min.		4 min.		10 min.

4 - 10 min. stopped delays in Rama IV road cause a great nuisance to the road users. Improvement of the four intersections is inevitable for this reason.

### (5) Cycle time analysis

#### 1) Si Phraya Intersection

When green time ratio and flow ratio are compared, the north bound is given 26% of green time against 13% of flow ratio. It is unbalanced. At the intersection, traffic signals are controlled manually and irregularly in the evening.

2) Surawong Intersection

Green time allocation is good. But the cycle time is rather long, 380 seconds both in the morning and the evening.

3) Silom Intersection

Green time allocation is good. Cycle length is acceptable.

4) Sathon Intersection

Morning cycle time of 460 seconds is the longest of the surveyed 22 intersections. Green time allocation is good.

(6) Planning of improvement alternatives

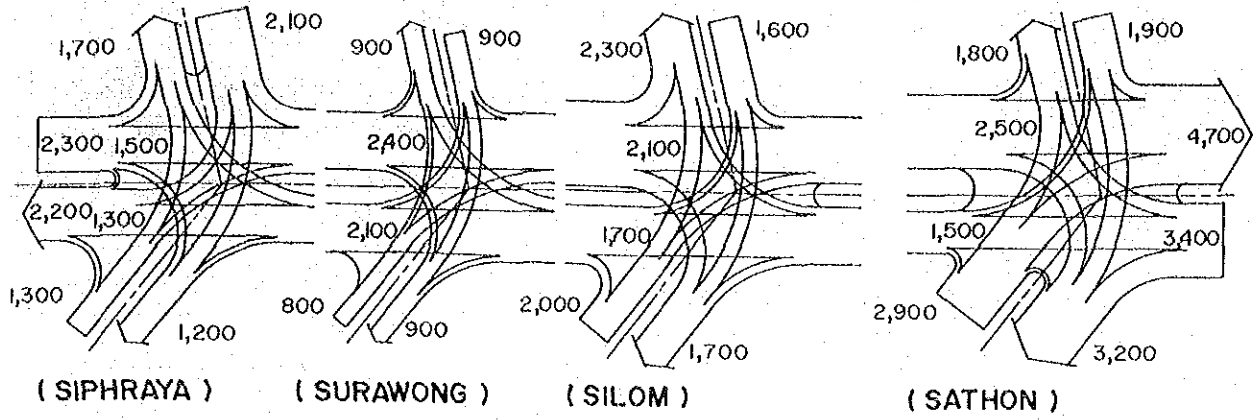
1) Points of planning

First, as mentioned in General Description, Belgian government promised to donate a flyover at Sathon intersection which is considered to be a given condition.

The second, Rama IV road has a second largest traffic volume next to Middle Ring road, ranging 50,000 - 60,000 PCU/12 hours. It is considered to be a major road. Therefore, a flyover is more preferable to other at-grade improvement as a solution of the traffic congestion.

The third, the distance between the intersections is important. The intersection distance between Surawong and Silom is only 350 m. Two separate flyover cannot be constructed in such short distance, then a flyover covering the two intersections is proposed as one of the alternatives.

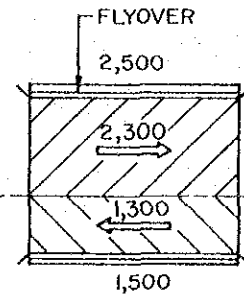
The fourth, Mass Transit System is planned along Rama IV road. The close coordination with ETA is required.



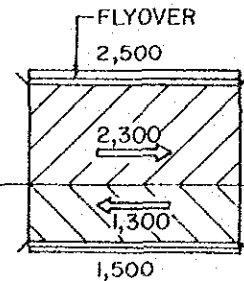
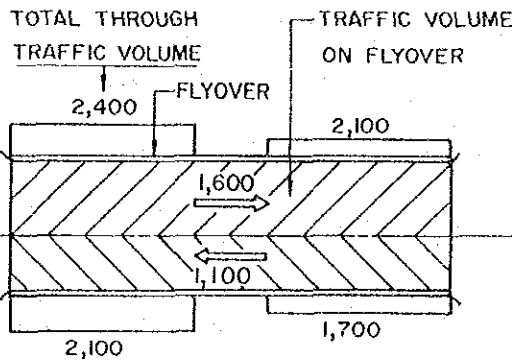
TRAFFIC VOLUME AT EACH INTERSECTION

PM PEAK  
17.00-18.00  
UNIT : PCU/hr

ALT-1



ALT-2



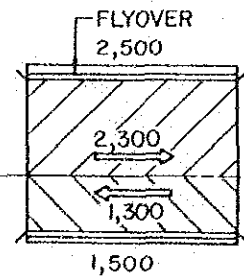
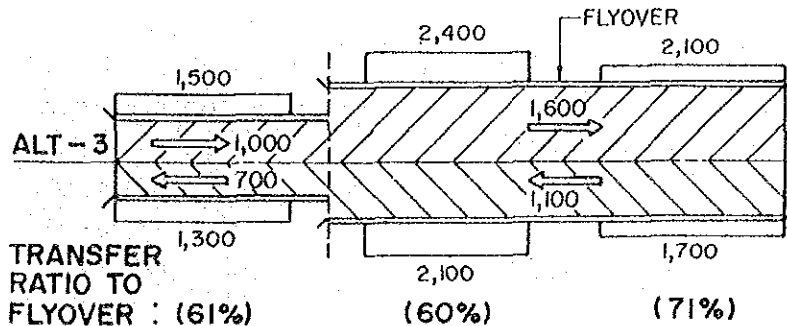
( SIPHRAYA )

( SURAWONG )

( SILOM )

( SATHON )

ALT-3



TRANSFER  
RATIO TO  
FLYOVER : (61%)

(60%)

(71%)

(90%)

Figure 5.2.5 Flyover Traffic Volume of Each Alternative (Estimate)

## 2) Alternative planning

The following three alternative flyover plans are studied and compared each other.

Alt. 1 : A flyover at Sathon road (Two-way, 4-lane)

Alt. 2 : Alt. 1 plus a flyover at Surawong/Silom roads  
(Two-way, 4-lane)

Alt. 3 : Alt. 1 plus a flyover at Si Phraya/Surawong/  
Silom roads (Two-way, Si Phraya : 2-lane,  
Surawong/Silom : 4 lane)

The above alternatives are illustrated in Figure 5.2.5.

## 3) Description of Alt.1

Alt.1 is to construct only one flyover at Sathon road. The flyover will be donated by Belgian government. In this alternative, 90% of through traffic volume at Sathon intersection will use the flyover as shown in Figure 5.2.5. It means the efficient use of the flyover. In the evening peak hour, traffic of 2,300 PCU/hr will flow into the flyover. Therefore, it should have four lanes, dualway. Traffic flow after the completion of the flyover is shown in Figure 5.2.6. Turning movement is still large because Sathon road leads to Taksin bridge to connect Thonburi side.

## 4) Alt.2

Alt.2 is to construct two flyovers, one at Sathon, the other at Surawong/Silom. In this alternative, 60% and 71% of through traffic will transfer to the flyover at Surawong and Silom, respectively (Figure 5.2.5).

In terms of weaving length between Silom and Sathon, the estimated distance between both flyover ends is about 300 m. Required weaving length calculated according to HCM 1985 is 250 m. Therefore, the weaving is possible between them.

## 5) Alt.3

Alt.3 is to construct two flyovers, one at Sathon and the other at Si Phraya/Surawong/Silom. In this alternative, the flyover has 4-lane between Silom and Surawong, but between Surawong and Si Phraya, 2-lane only. This is because Si Phraya traffic volume is smaller than others and a continuous 4-lane will not be economical. By providing on/off ramps between Si Phraya and Surawong, traffic volume on flyover becomes larger than that of continuous 4-lane one.

NO. 023

RAMA IV / SATHON RD.

RAMA IV FLYOVER

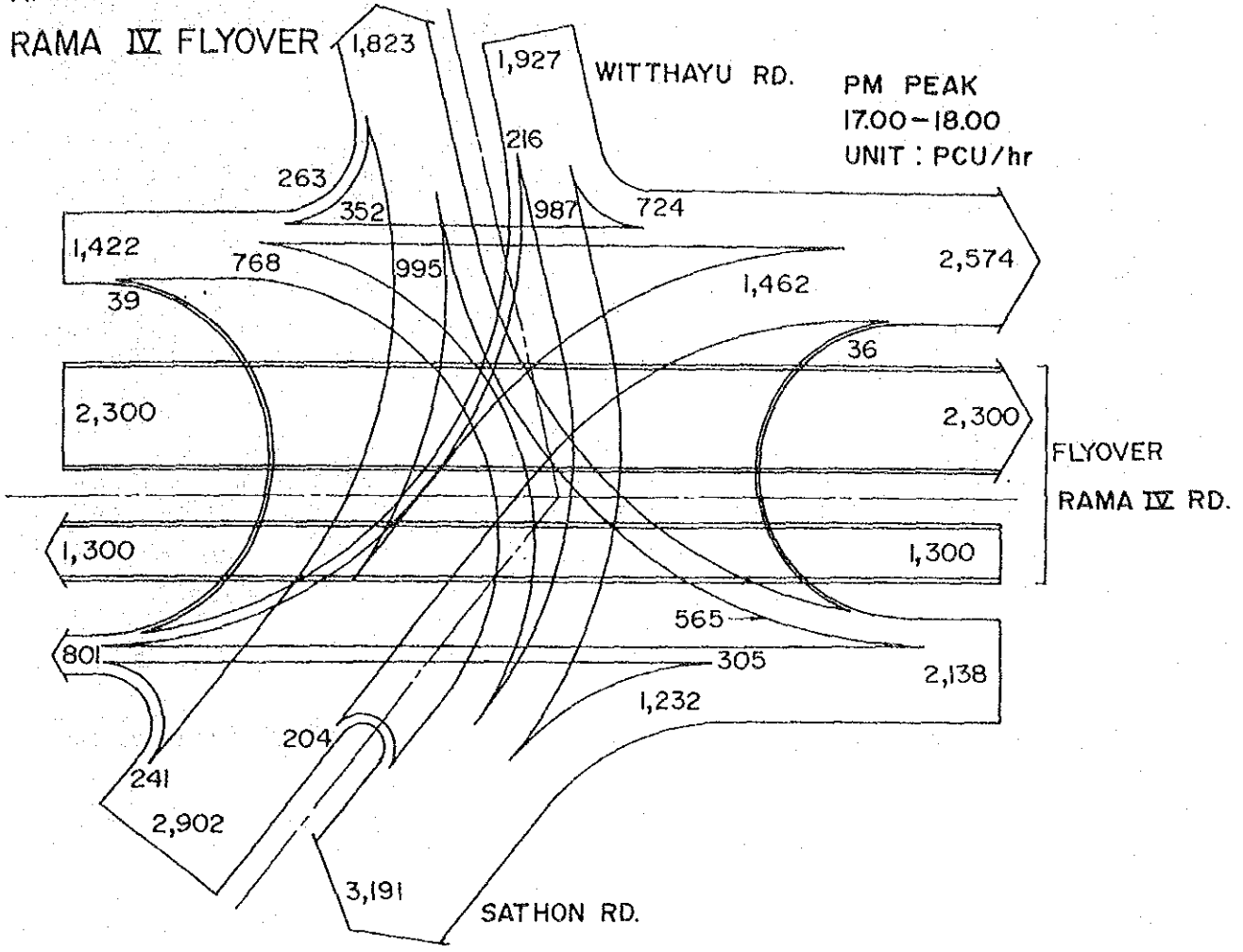


Figure 5.2.6 Proposed Traffic Volume at Sathon

## (7) Effects of improvement (Figure 5.2.7)

### 1) Traffic flow

Traffic flow of each alternative is shown in Figure 5.2.5.

### 2) Saturation degree of intersection

As shown in Figure 5.2.7, the saturation degree of each intersection will decrease.

The degree of Sathon is still high (0.897) after the construction of the flyover. It is because the Belgian flyover is a temporary one and its piers are located in the intersection area. Turning movement, which is prevailing there, will be interfered by that.

### 3) Queue length

Queue length of east bound (Rama IV direction, outbound) will decrease significantly in all alternatives. Roughly speaking, existing several hundreds meter queues will decrease to less than a hundred meter.

### 4) Stopped delay

Existing 10 minutes stopped delay will be decreased to around 1 minute time in each alternative.

## (8) Selection of an Alternative

Comparison of three alternatives are summarized in Table 5.2.2.

In this selection, Alternative 2 and 3 are proceeded to economic analysis due to following reasons.

### Reasons

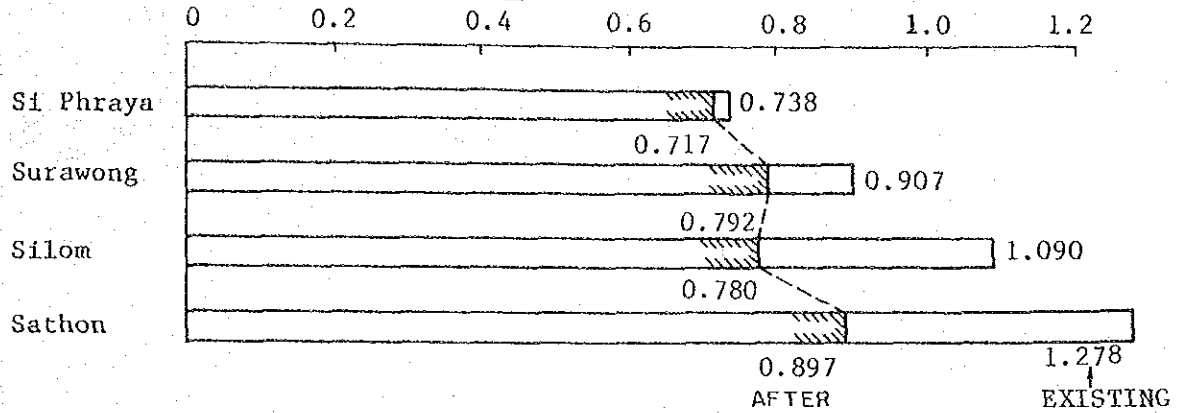
- 1) Alt-1 improves Sathon intersection only. Other two intersections, Silom and Surawong, have still high saturation degrees, 1.090 and 0.907, respectively.
- 2) Alt-2 and 3 improve two or three more intersections. The saturation degrees of Silom and Surawong decrease to 0.780 and 0.791 respectively.

Figure 5.2.7

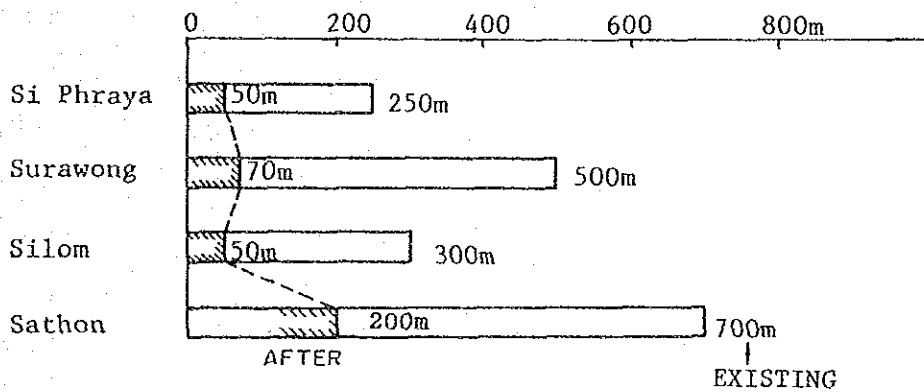
Improvement Effects

Intersection : Rama IV/Si Phraya - Sathon Rd. (No. 020 - 023) (P.M. Peak)

1. Saturation Degree of Intersection



2. Max. Queue Length (EB)



3. Max. Stopped delay (EB)

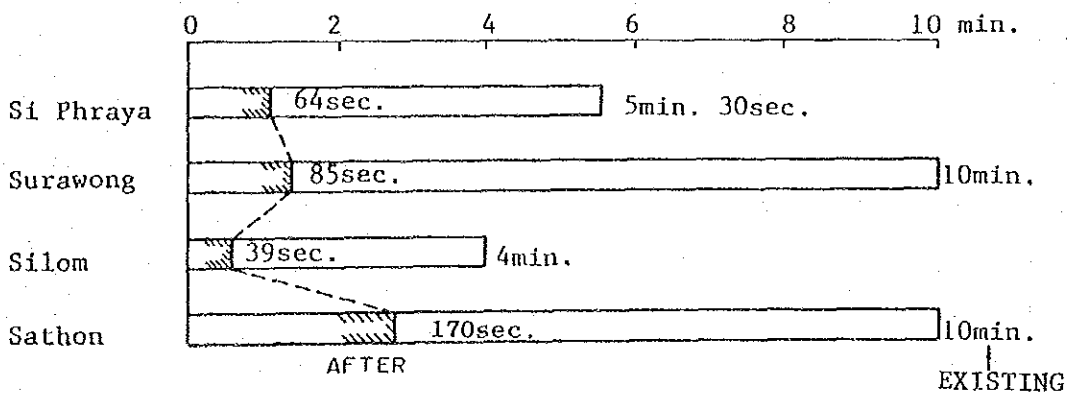
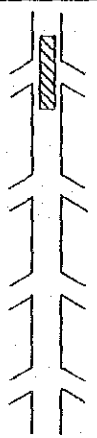
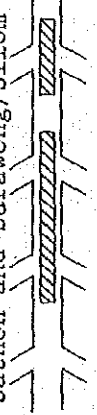
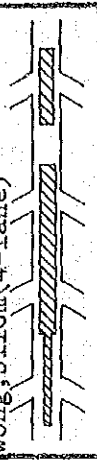




Table 5.2.2 Comparison of Alternative Plans

Intersection : Rama IV/Si Phraya - Sathon Rd. (No. 020 - 023)

Alternatives		1	2	3 (Recommended)
Improvement Plan	A 4-lane flyover at Sathon			
	Construction Cost	-	302.5	361.7
Project Cost (Million Baht)	Land Acq. Cost	-	0	0
	Total	(Belgian government donation)	302.5	361.7
Construction Period	Maintenance Cost per annum	-	3.7	3.9
		-	2 years	2 years
Evaluation	Improvement Effect (Evening peak)	<p>Saturation degree</p> <p>Sathon 1.278 → 0.897                      Silom 1.090 } no change                      Surawong 0.907 } change                      Si Phraya 0.738 }                      Stopped delay (Rama IV, Max)                      Sathon 10 min. → 44 sec.                      Others: no change</p>	<p>Saturation degree</p> <p>Sathon 1.278 → 0.897                      Silom 1.090 → 0.780                      Surawong 0.907 → 0.792                      Si Phraya 0.738: no change                      Stopped delay (Rama IV, Max)                      Sathon 10 min. → 44 sec.                      Silom 4 min. → 39 sec.                      Surawong 10 min. → 85 sec.                      Si Phraya 5.5 min.: no change</p>	<p>Stopped. Satura- delay tion (RamaIV, Max) ratio</p> <p>Sathon 0.897 44 sec.                      Silom 0.780 39 sec.                      Surawong 0.792 85 sec.                      Si Phraya 0.717 64 sec.                      (After improvement)</p>
	Major Constraints	Drainage pipe under RamaIV	Drainage pipe under RamaIV	Drainage pipe under RamaIV
Advantage/Disadvantage	Best for Sathon but other three intersections are not improved.	Additional two intersections are improved but still one is not improved.	All intersections improved and cost saved at Si Phraya Highest total cost.	

(9) Economic Analysis

For the selected two alternatives, economic analysis is carried out. The result is shown in Table 5.2.3.

Table 5.2.3 Economic Analysis (in 10 years)

Item	Alt-2	Alt-3
Initial Cost	302 Mil.B.	361 Mil.B.
Cost in Present Value (C)	318 Mil.B.	377 Mil.B.
Benefit in Present Value (B)	840 Mil.B.	994 Mil.B.
Net Benefit (B-C)	522 Mil.B.	617 Mil.B.
B/C	2.64	2.64
IRR	0.235	0.233

Although both B/C and both IRR are the almost same, the net benefit of Alt-3 is 20% larger than Alt-2. Therefore, Alt-3 (continuous flyover) is recommended for the future execution.

### 5.3 Ratchadamnoen Klang/Ratchadamnoen Nai Rd., No.202

#### (1) General description (Figure 5.3.1)

This intersection is one of the most historical and beautiful intersections in Bangkok. In the west side, Royal square called Sanam Luang is located, where royal ceremonies are taken place every year. From the square, the famous Wat Phra Keo can be seen most impressively. Several government buildings are also located in the north and south side. Royal ceremonial parade also takes place and passes here every year.

The environmental condition and the security of the parade have the first priority in the planning. Therefore, an underpass was planned instead of a flyover. It will not disturb the people's view and is appropriate for the parade.

#### (2) Traffic flow

Major traffic flow is the Phrapinklao Bridge - Ratchadamnoen Klang Rd. direction both in the morning and the evening (Figure 5.3.2). Therefore, the intersection has a smoother alignment for that direction so as to make the traffic flows fast.

The Phrapinklao bridge is one of the most important bridges connecting Bangkok with Thonburi side over the Chaophraya River.

The queue length is shown in Figure 5.3.3. In the morning peak hour, the queue length of 400 m was recorded in the Phrapinklao bridge direction (inbound). In the evening, the queue length of Ratchadamnoen Nai Rd. is the longest, recorded 300 - 450 m for two hours.

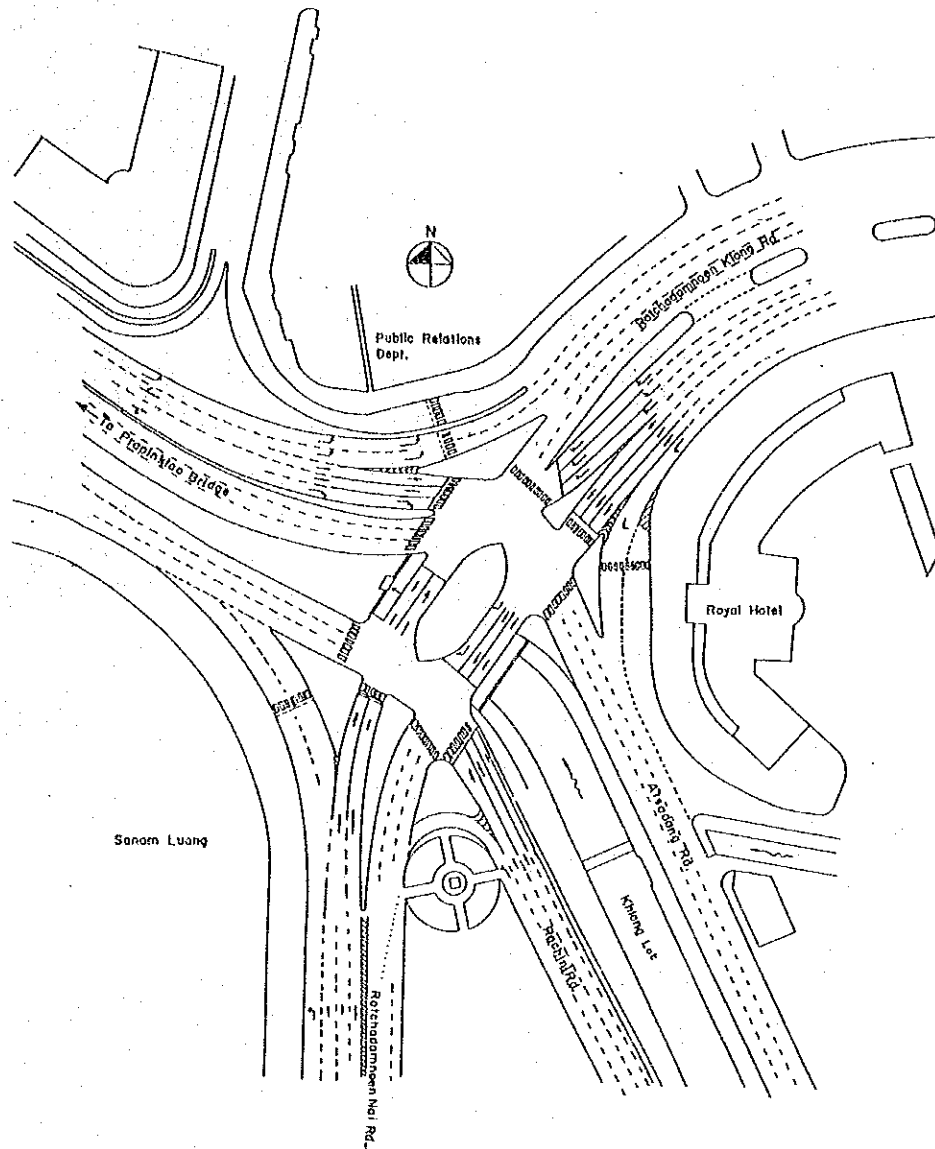
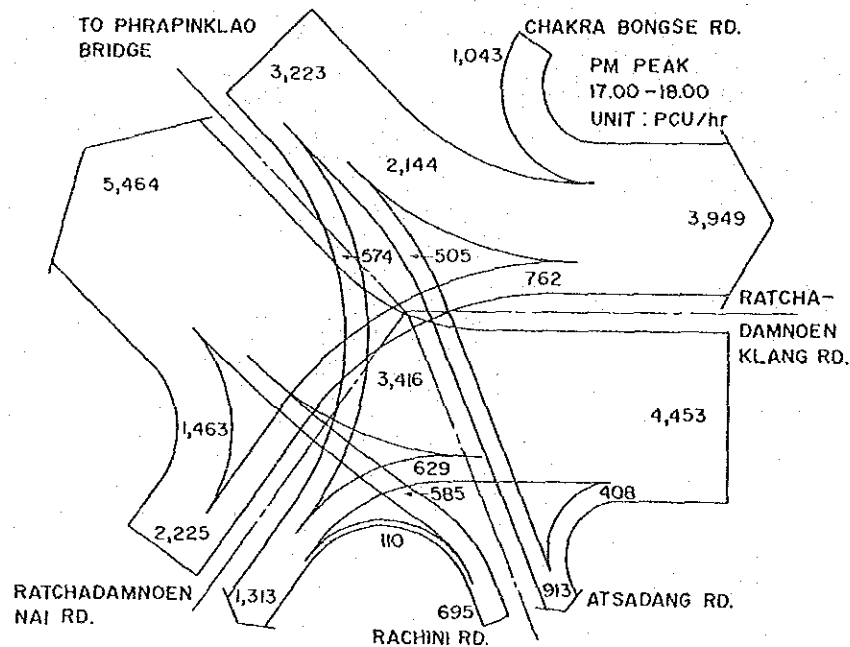
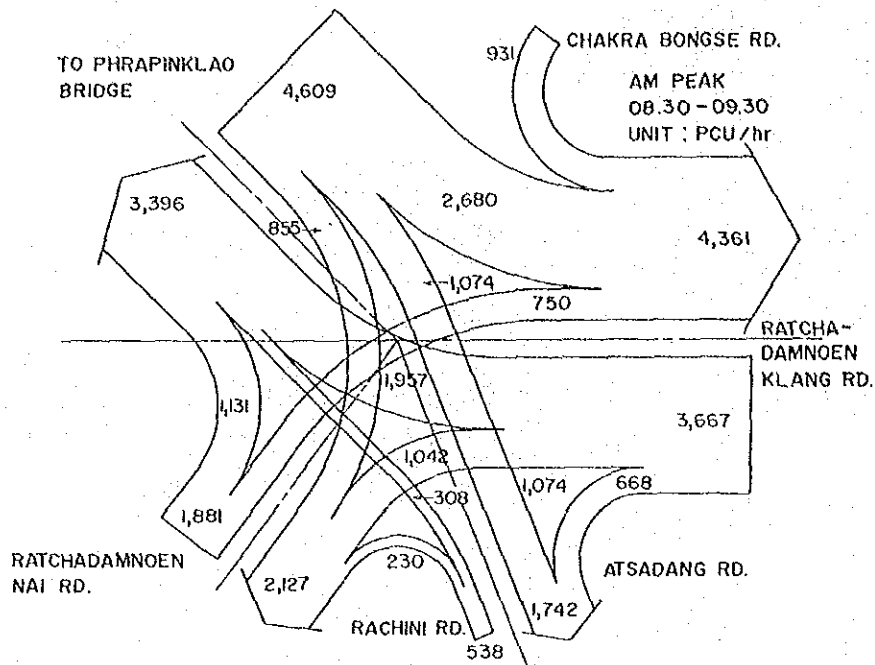
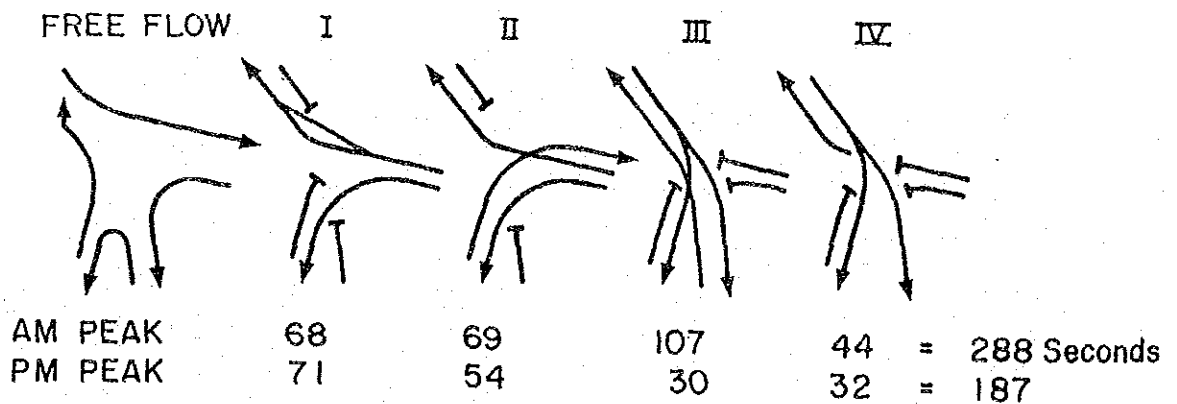


Figure 5.3.1 Ratchadamnoen Intersection

Figure 5.3.2 No. 202  
 Traffic Volume at Ratchadamnoen Klang/Ratchadamnoen Nai Rd.



**EXISTING SIGNAL PHASE**



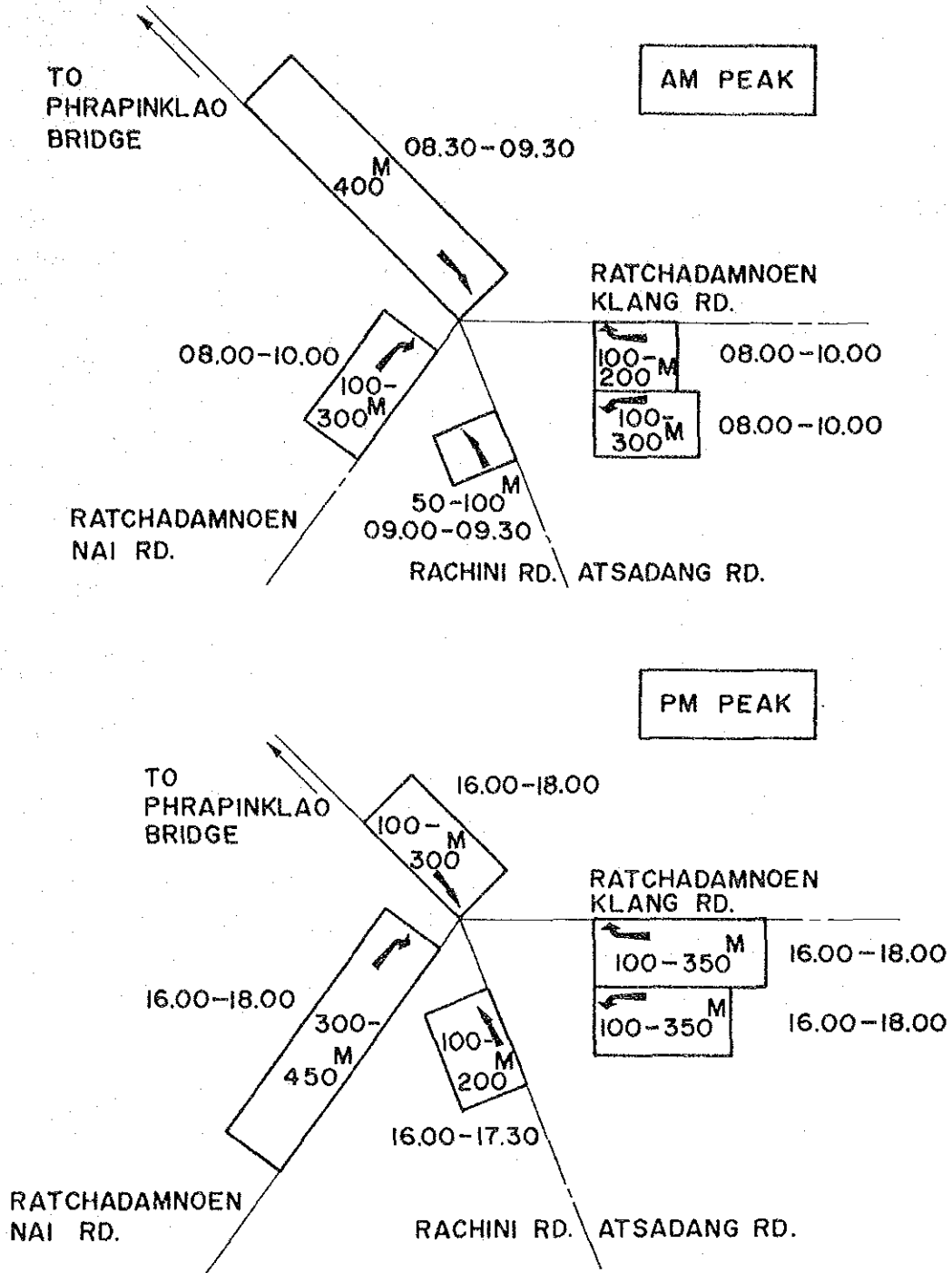


Figure 5.3.3 No. 202  
Ratchadamnoen Klang/Ratchadanoen Nai Rd. Queue Length

### (3) Constraints

#### 1) Khlong Lot and underpass

Khlong Lot flows in the north-south direction as an open channel. It is located between and along Atsadang Rd. and Rachini Rd. in the south 13 m in width.

To the north of the intersection, the khlong flows in a underground box culvert until the south abutment of the Phrapinklao bridge.

From the abutment to the Chaophraya River, the khlong becomes an open channel again and flows just under the bridge in the width of 20 m.

If an underpass is to be constructed, underpasses of east-north and east-west directions will have to cross the existing box culvert of the khlong. A siphon facility or other drainage structures will be required for the crossing.

#### 2) View and flyover

If a flyover is constructed, it will disturb the view of Wat Phra Keo and other beautiful buildings around Sanam Luang. For the security and convenience of the parades, the flyover will not be suitable, either.

#### 3) Sanam Luang

Sanam Luang is a historical and royal ceremonial - use square, which should not be changed except underground structures, such as a tunnel.

#### 4) Permanent buildings

Several governmental buildings and the Royal Hotel are located to the north of intersection.

To the south between Ratchadamnoen Nai Rd. and Rachini Rd., Ministry of Justice building is located.

### (4) Degree of congestion (Existing)

Existing conditions are summarized in Table 5.3.1.

Table 5.3.1 Existing Condition of Intersection

Item	Characteristics	
1) Morning peak hour	08:30 - 09:30	
2) Evening peak hour	17:00 - 18:00	
3) Max. Traffic flow	Morning	Evening
Phrapinklao		
-Ratchadammen Klang Rd.	2,680 PCU/hr	2,144 PCU/hr
Ratchadammen Klang Rd.		
-Phrapinklao	1,957 PCU/hr	3,416 PCU/hr
4) Saturation degree of intersection	0,990	0,924
5) Max. Queue length		
Morning	Phrapinklao - Atsadang Rd. 400 m, 08:30 - 09:30	
Evening	Ratchadammen Nai Rd. - Ratchadammen Klang Rd. 300 - 450 m, 16:00 - 18:00	
6) Max. Stopped delay	Phrapinklao - Atsadang Rd. 11 min. 10 sec.	
Morning		
7) Cycle length		
Morning	288 sec. (irregular)	
Evening	184 sec. (regular)	

(5) Cycle time analysis

- Green time is properly arranged to each direction.
- Morning cycle length is very long, 288 seconds.

(6) Planning of improvement Alternatives

1) Points of planning

As this intersection has the largest traffic inflow (3,000 - 5,000 PCU/hr in one direction), drastic improvement plan is required together with at-grade one.

Environmental condition has also to be considered, therefore a flyover will not be suitable for this location. The intersection area can be made compact to increase its capacity.



## 2) Planning of improvement alternatives

Based on the above mentioned points, following three alternatives are made for comparison.

Alternative 1 : Making the intersection smaller than  
(At-grade) existing one to achieve the faster traffic flow.

Alternative 2 : Two detours are planned to make the two  
(At-grade) major flows (East - North direction)  
free.

Alternative 3 : One-way, 3-lane underpass in east-north  
(Underpass) direction.

## 3) Description of Alt-1 (At-grade)

This alternative is to make the intersection area smaller to reduce the vehicles' travel time in the intersection. Therefore, the existing traffic movement is not changed as shown in Figure 5.3.4.

Traffic islands and lane directions are revised as shown in Fig.5.3.5.

## 4) Description of Alt-2 (At-grade)

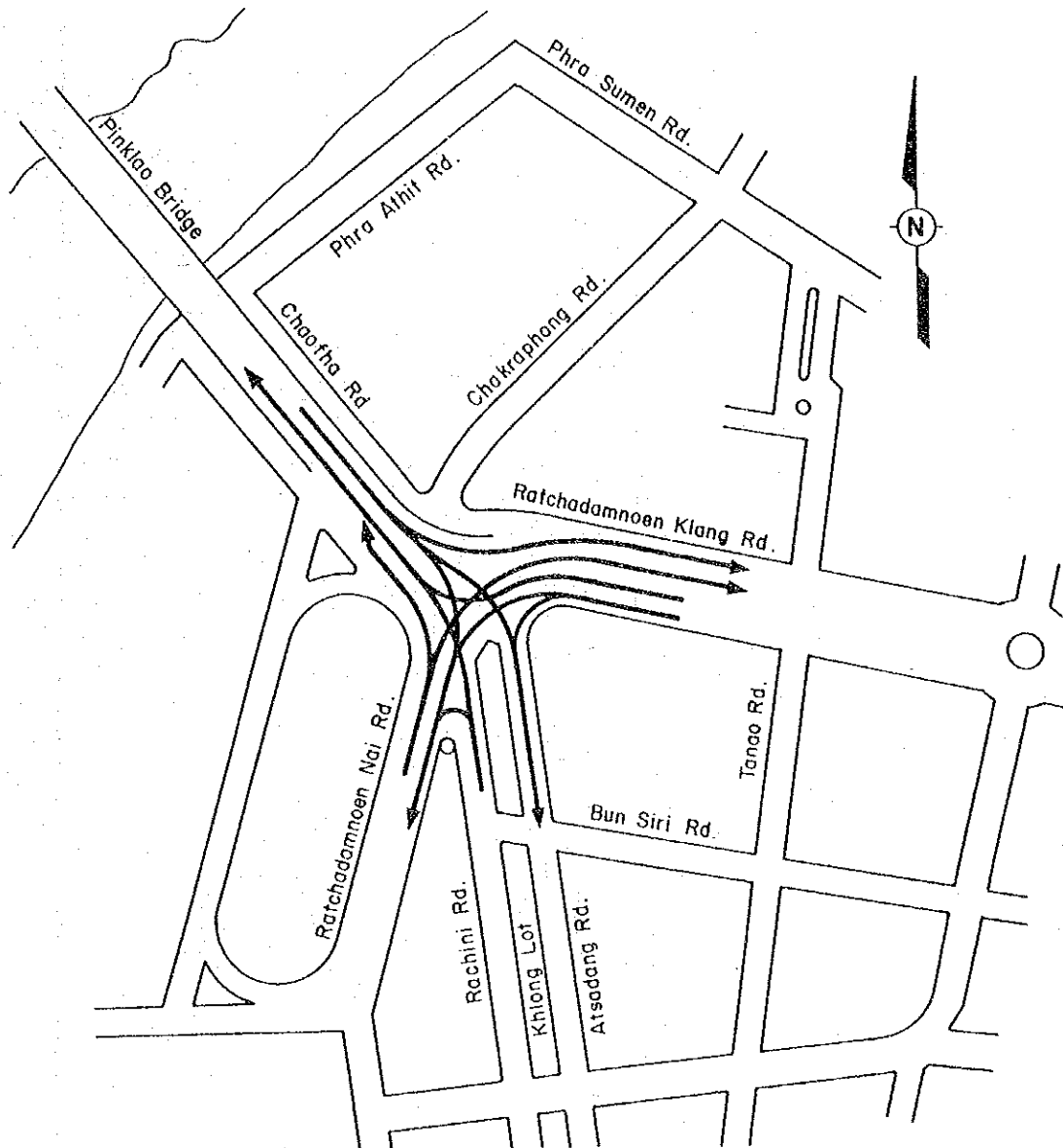
This is a plan which makes two major flows, the Phrapinklao bridge - Ratchadamnoen Klang Rd. in both directions, flow in free lanes (Figure 5.3.6 and 5.3.7).

### Detour

For that revision, three crossing movements are prohibited (marked by cross x) and detoured as shown in the figure. North detour length is 1.1 km and 750 PCU/hr will pass in one lane. East detour is 1.5 km in length and it will increase the crossing vehicles at Tanao Rd. intersection. The estimated detour volume is 1,900 PCU/hr. Therefore, Tanao Rd. and Bun Siri Rd. have to be changed to one-way from the existing two-way.

### Pedestrian Underpass

To make two major flows free, a pedestrian underpass is inevitable in front of Public Relations Department. The number of pedestrians crossing there is about 450 persons/hr during 16:00 - 18:00 p.m.



**SIGNAL PHASE**

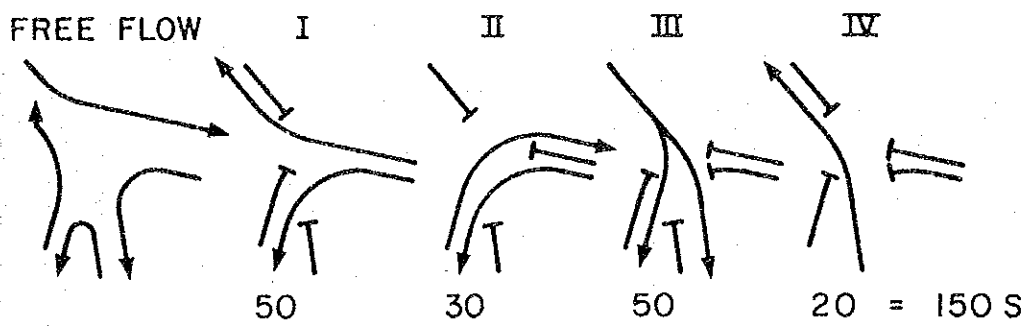


Figure 5.3.4 Ratchadamnoen Klang/Ratchadamnoen Nai Rd. Intersection, Alternative 1

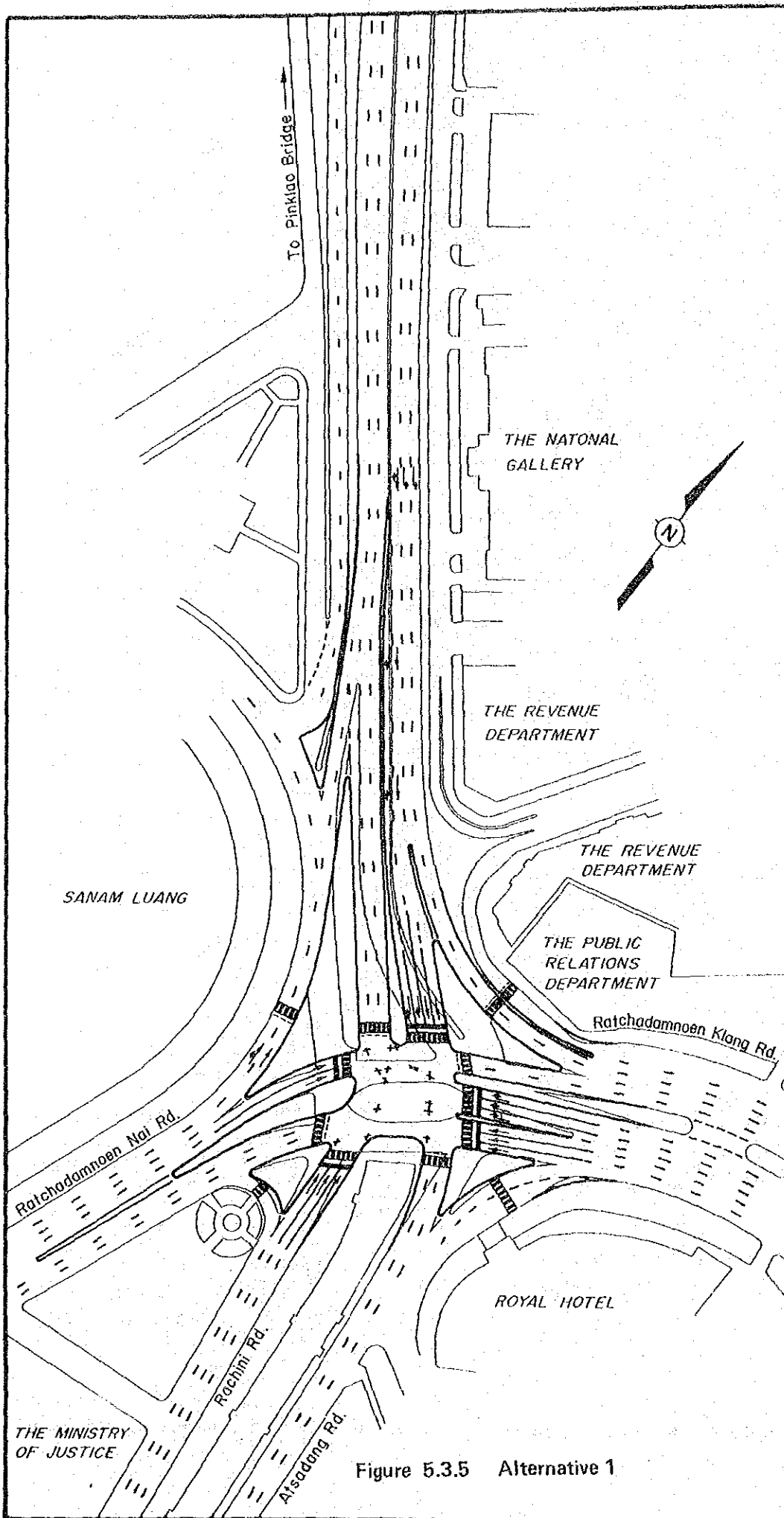


Figure 5.3.5 Alternative 1

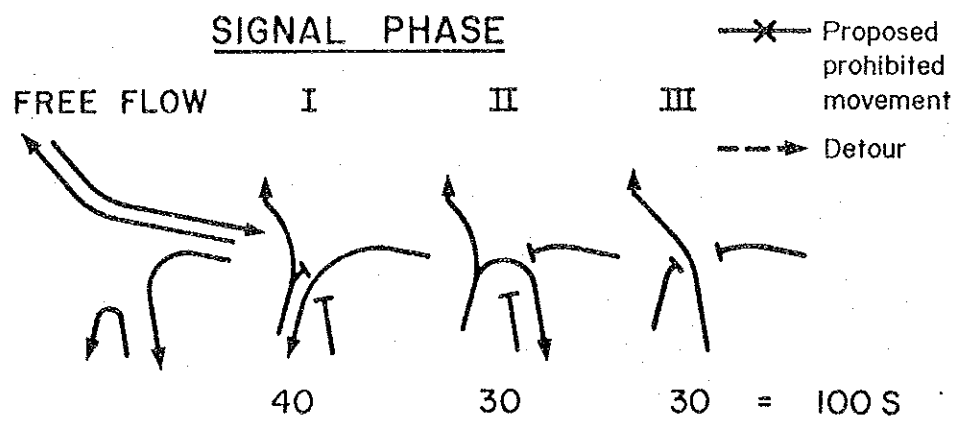
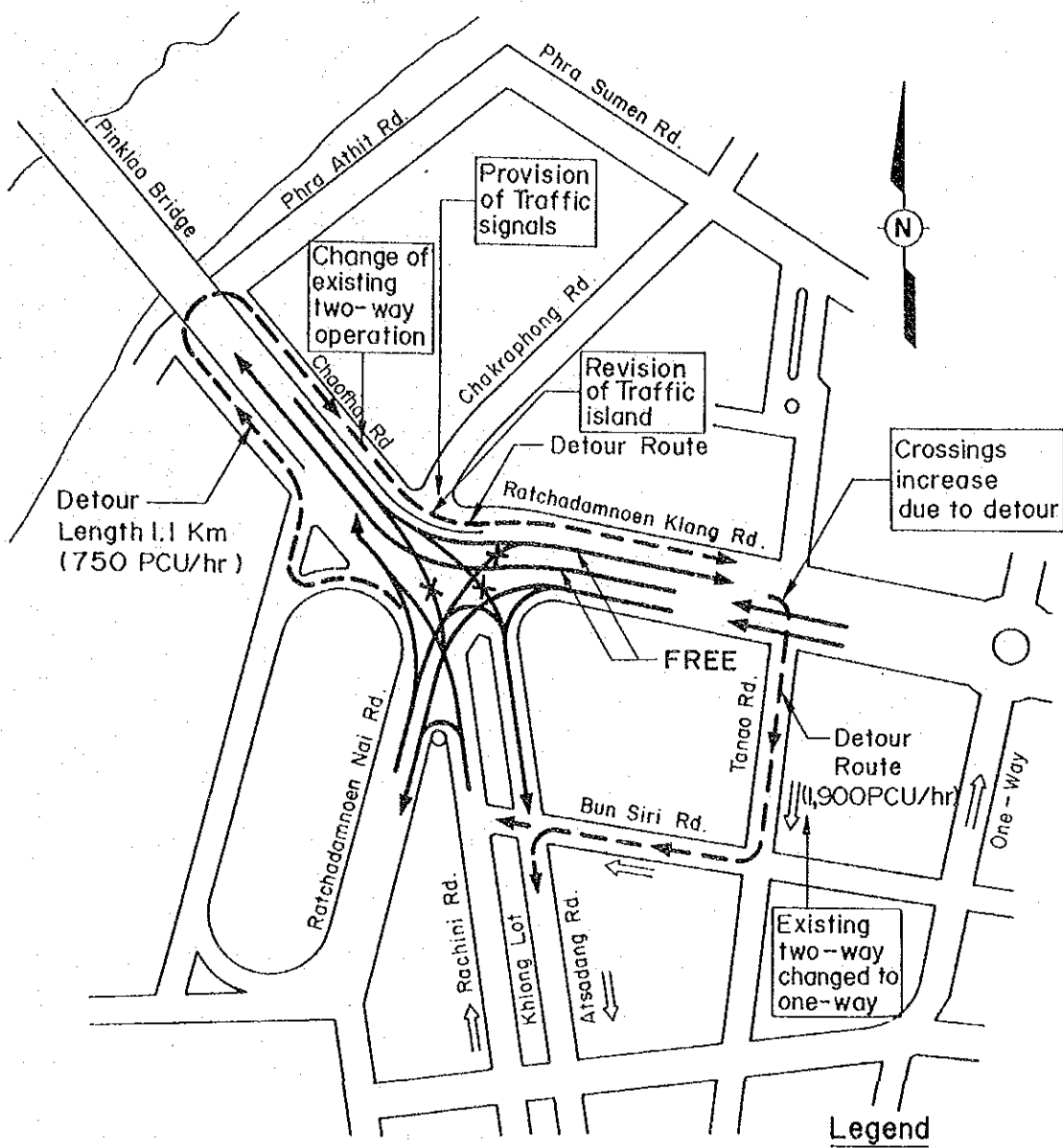


Figure 5.3.6 Ratchadamnoen Klang/Ratchadamnoen Nai Rd. Intersection, Alternative 2

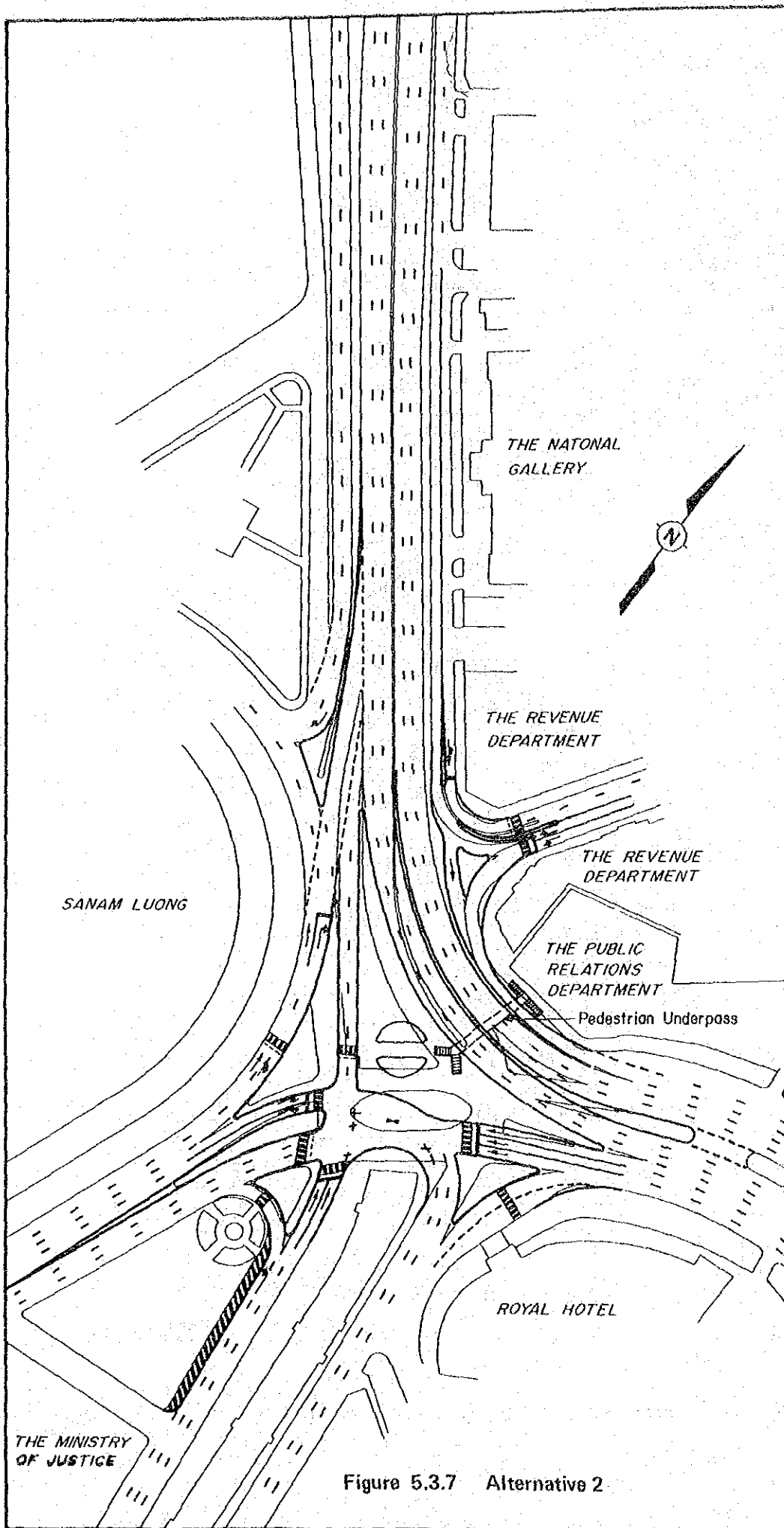


Figure 5.3.7 Alternative 2

## 5) Description of Alt-3 (Underpass)

### Direction of underpass

This plan is designed to construct a one-way 3-lane underpass in the direction from Ratchadamnoen Klang Road to the Pinklao Bridge as shown in Figure 5.3.8 and 5.3.9. It will separate the most prevailing flow at the intersection.

### Crossing Khlong Lot

Since the planned underpass is interfered by the existing canal (Khlong Lot), its construction work is considered to be complicated and expensive, requiring some canal reconstruction. Possible measures for this problem will be;

- Blockade and fill-up of canal at the intersection, which is the easiest way, but requires coordination with DDS.
- Relocation of the canal to the Sanam Luang side prior to commencement of the underpass construction. It will be most practical and favourable for the traffic channelization during construction.
- Reconstruction of the canal on Chaofha Road side and install a siphon pipe below the underpass.

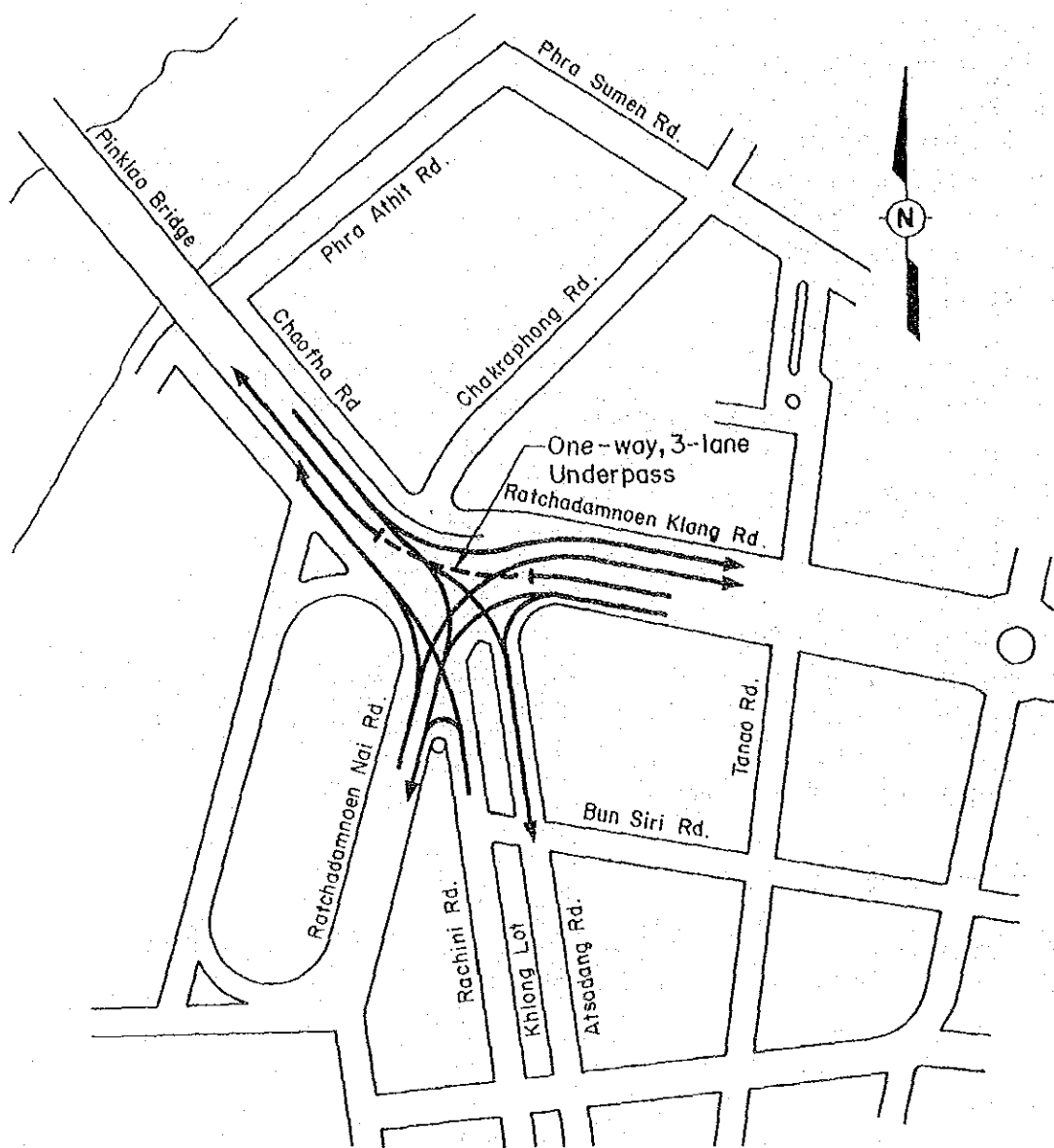
## 6) Other not selected measures

Other measures are also studied preliminarily but not picked up as alternatives because they are considered not feasible.

Those two not-selected measures are shown in Appendix 5.3.1 with their reasons.

## (7) Effects of improvement (Figure 5.3.10)

Effects of improvement is summarized in Figure 5.3.10.



**SIGNAL PHASE**

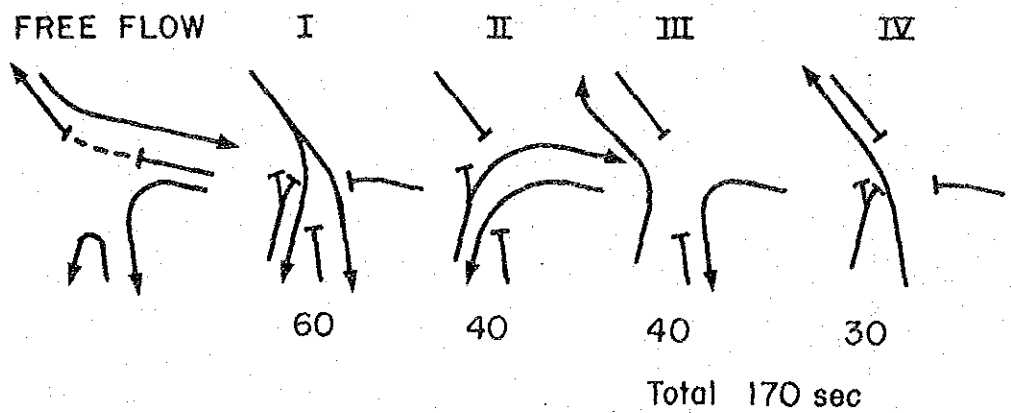


Figure 5.3.8 Ratchadamnoen Klang/Ratchadamnoen Nai Rd. Intersection, Alternative 3

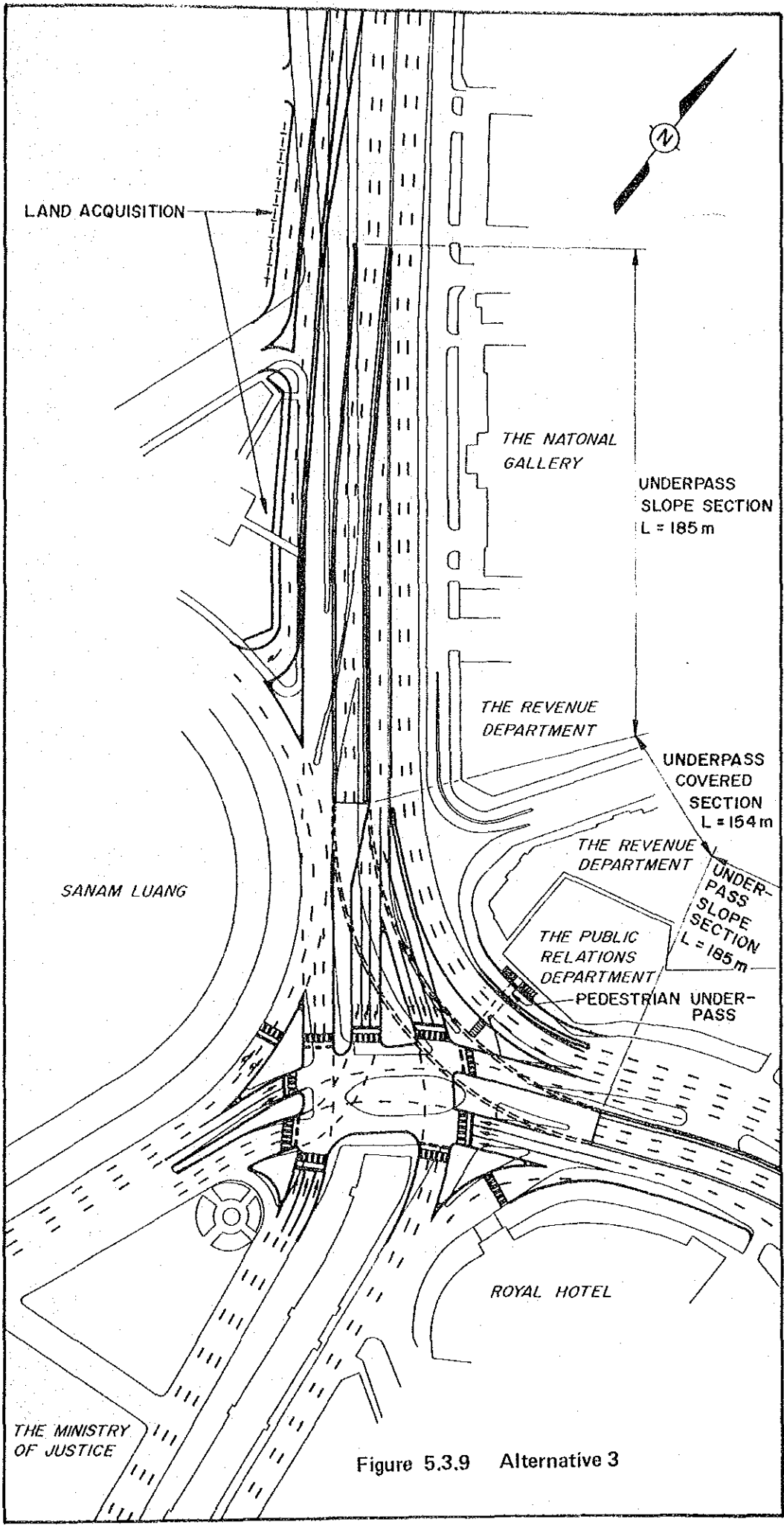
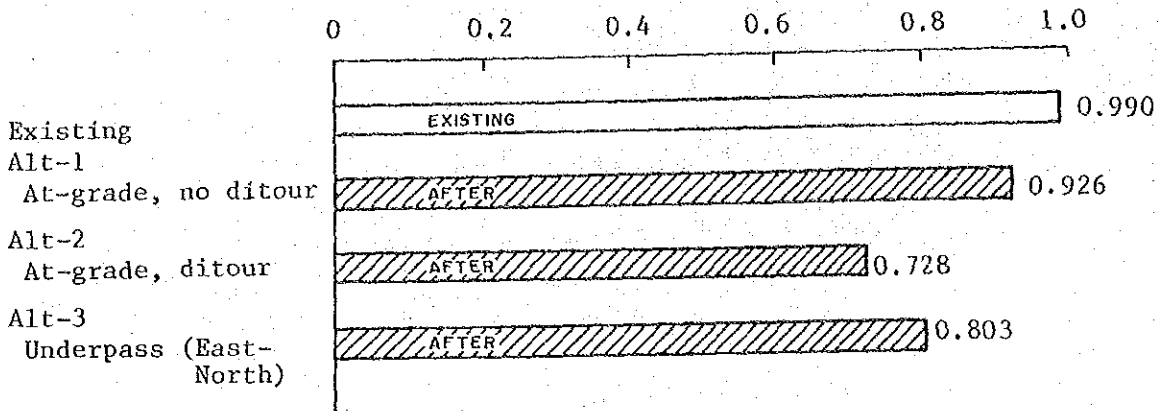




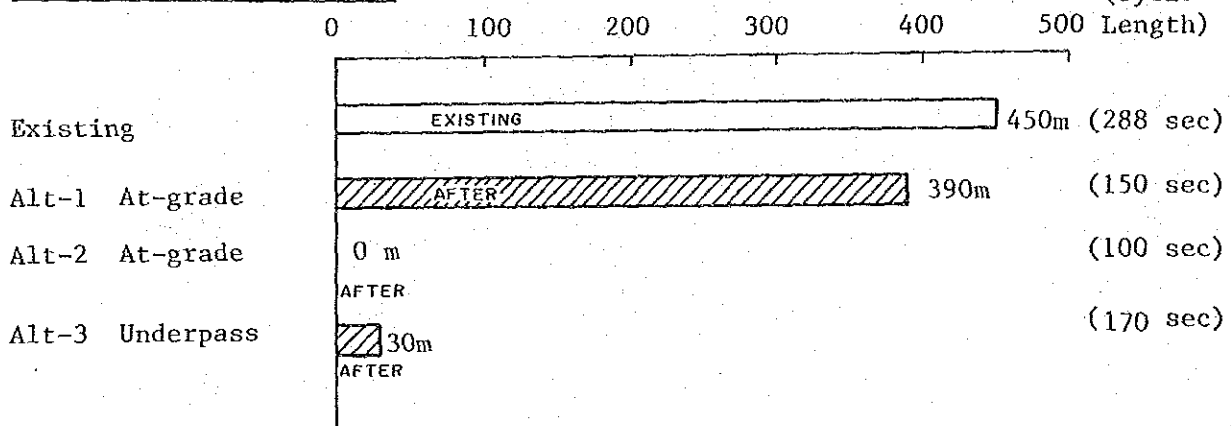
Figure 5.3.10 Improvement Effects

Intersection : Ratchadamnoen Klang/Ratchadamnoen Nai Rd. (No.202)  
 (Morning peak only)

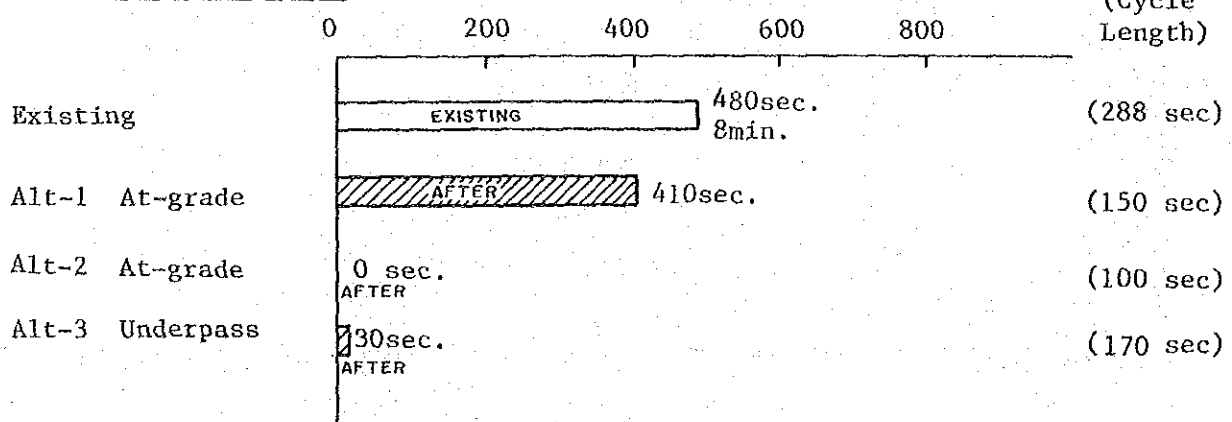
1. Saturation Degree of Intersection



2. Max. Queue Length (m) - South bound, Straight



3. Max. Stopped delay South bound, Straight (second/Vehicle)



### 1) Saturation ratio of intersection

At-grade improvement of Alt-1 decreases the existing degree from 0.990 to 0.926, only 6% decreases.

Alt-2 decreases it by 26% to 0.728 but the detour of 1.1 km is required.

Alt-3 is construction of an underpass. It will decrease the degree to 0.803.

### 2) Queue length and stopped delay

In all the three improvement alternatives, the cycle lengths are reduced from the existing one as shown in Figure 5.3.10.

In Alt-2 (at-grade improvement), south bound straight traffic is diverted to left turn free lane. Therefore, no queue and no stopped delay are expected theoretically. In Alt-3 (underpass), major traffic uses free lanes and the underpass. The queue length and the stopped delay will reduce to 10 m and 17 sec., respectively.

### (8) Selection of an Alternative

Comparison of three alternatives is summarized in Table 5.3.2.

After the comparison, Alternative 3 is selected for the further economic analysis. The reasons of the selection are as follows.

#### Reasons

- 1) Alternative 1 (At-grade) costs only 4.7 Mil.Baht but the saturation degree decreases to only 0.926.
- 2) Alternative 2 (At-grade) reduces the saturation degree to 0.728 but max. 1.5 km detour is required. Congestion will shift to east Tanao Rd. intersection. The detour of more than 1 km will be inconvenient for road users.
- 3) Alternative 3 (Underpass) reduces the saturation degree to 0.803 in the morning and 0.840 in the evening. It will not harm the environmental conditions. Crossing the Khlong will not be a problem and it can be solved by using siphons.

### (9) Economic analysis

For the selected Alt-3, the economic analysis is carried out. The results are shown in Table 5.3.3.

Table 5.3.2 Comparison of Alternative Plans

Intersection: Ratchadamnoen Klang/Ratchadamnoen Nai Rd. (No. 202)

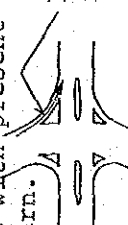
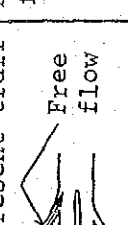
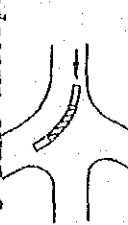
Alternatives		1	2	3 (Recommended)
Improvement Plan	At-grade with present traffic pattern.		At-grade, two largest flows are detoured	One-way, 3-lane underpass.
	Free flow		Free flow	
Project Cost. (Million Baht) 1986 price	Construction Cost	4.7	6.3	126.7
	Land Acq. Cost	-	-	5.5
	Total	4.7	6.3	132.2
	Maintenance Cost per annum	1.6	1.6	4.2
Construction Period	3 months	6 months	3 years	
Evaluation	Improvement Effect (Morning peak)	Saturation degree 0.990 → 0.926 Max. queue length (SB) 450m → 25m Max. Stopped delay (SB) 11min. 10sec. → 38sec.	Saturation degree 0.990 → 0.728 Max. queue length (SB) 450m → 0m Max. Stopped delay (SB) 11min. 10sec. → 0sec.	Saturation degree 0.990 → 0.803 Max. queue length (SB) 450m → 10m Max. Stopped delay (SB) 11min. 10sec. → 17sec.
	Major Constraints	Revision of traffic islands required.	Traffic islands revision and a pedestrian underpass are required.	Underpass crosses at an existing box culvert of Khlong Lot.
	Advantage/Disadvantage	Easiest improvement but a little improvement effect.	Major flows become free but three traffic directions are detoured by max. 1.5km.	Large effects but constraint due to box culvert of Khlong Lot.

Table 5.3.3 Economic Analysis

Item	10 years	20 years
Initial Cost	134 Mil.B.	134 Mil.B.
Cost in Present Value (C)	150 Mil.B.	171 Mil.B.
Benefit in Present Value (B)	146 Mil.B.	285 Mil.B.
Net Benefit (B-C)	-3 Mil.B.	114 Mil.B.
B/C	0.98	1.67
IRR	0.031	0.107

The net benefit is negative, the B/C is less than 1.0 and the IRR is small in ten years. The reason of this low benefit is high initial cost (134 Mil. Baht). It is about two or three times cost of a flyover (40 - 70 Mil. Baht).

In twenty (20) years, the net benefit turns out to be positive, the B/C is 1.67 and the IRR is 0.107.

In spite of the high cost, the underpass is still recommended because this is the most historical and monumental place and the environmental effect is much more important than the economic effect.

## 5.4 Dindaeng/Ratchaprarop Rd., No.613

### (1) General description

This intersection is located between the Victory monument and the Expressway. The traffic movement diagrams (Figure 5.4.1) show the close relation of the traffic movement with the intersection at the Expressway because the two right turn movements are strongly indicated.

It is a three-leg intersection with a narrow (one-lane) Soi in the north. The three legs have angles of more than 90 degree with each other.

### (2) Traffic flow

The major traffic flows are in east-west, south-east and west-east directions (evening time only). Ratchawithi Road in the west is controlled by one-way (except bus lane) in the morning and the afternoon. From 16:00 to 19:00 (except Saturday and Sunday), the road is used as a dual way. Therefore, the traffic diagrams of morning and evening are much different in west-east direction, i.e. 342 PCU/hr in the morning and 2,020 in the evening peak hour.

The queue length is shown in Figure 5.4.2.

### (3) Constraints

#### Ratchaprarop Rd.

Ratchaprarop Rd. in the south has 5 lanes only, while Ratchawithi Rd. (east) with 6 lanes and Dindaeng Rd. with 8 lanes.

Ratchaprarop Rd. is the narrowest of the three.

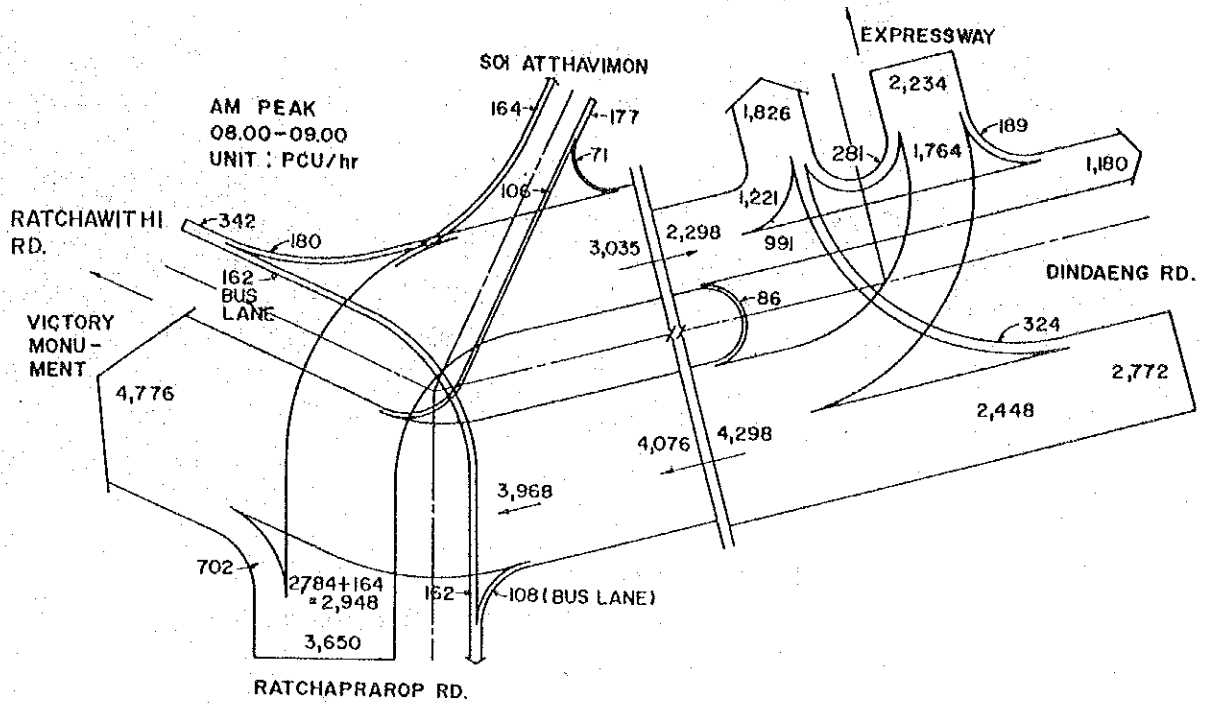
The sidewalk in the road is 5.5 m wide and the number of pedestrians is not large. Therefore, the sidewalk width can be narrowed to increase the capacity of the intersection.

#### Intersection at the Expressway

The east intersection at the Expressway is 3-leg and congested as well. Its saturation degree is 0.802 in the morning and 1.012 in the evening. If only the Dindaeng/Ratchaprarop intersection is improved, the traffic inflow and outflow will be still disturbed at the Expressway intersection.

### (4) Degree of congestion (existing)

Existing conditions are summarized in Table 5.4.1.



NO. 613  
DINDAENG / RATCHAPRAROP RD.

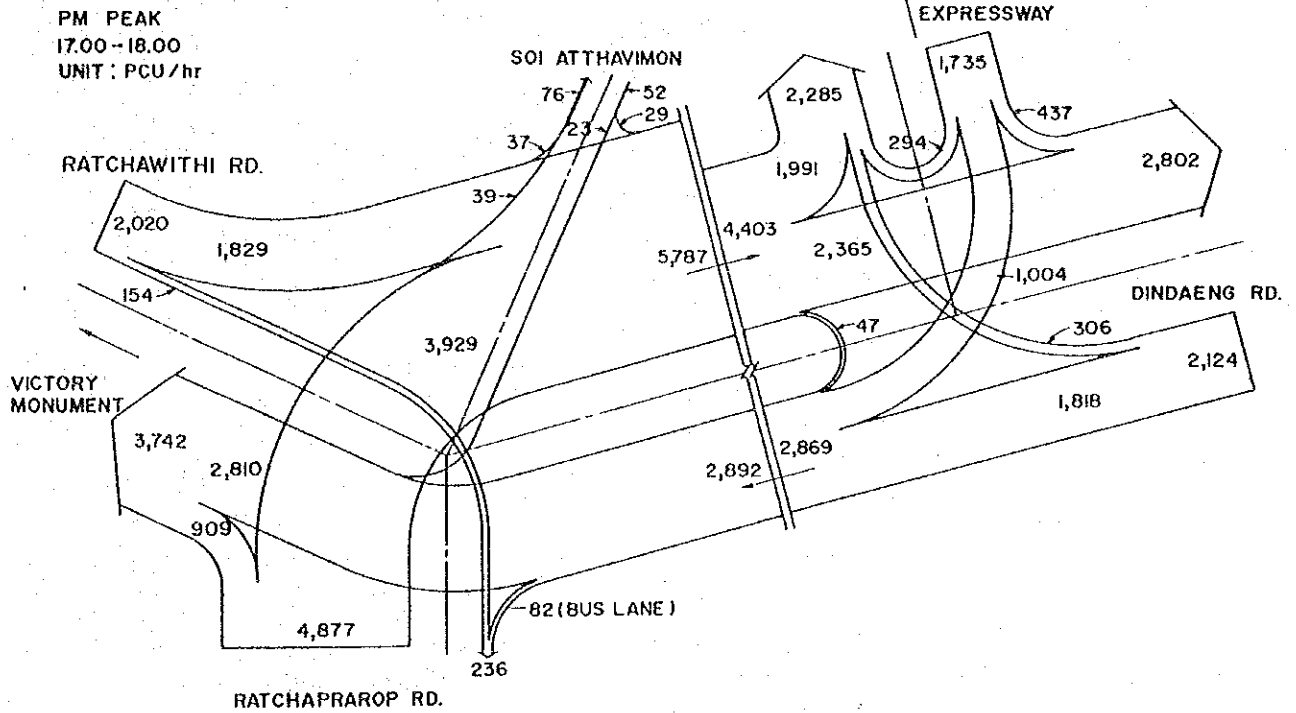


Figure 5.4.1 No. 613  
Traffic Volume at Dindaeng/Ratchaprarop Rd.

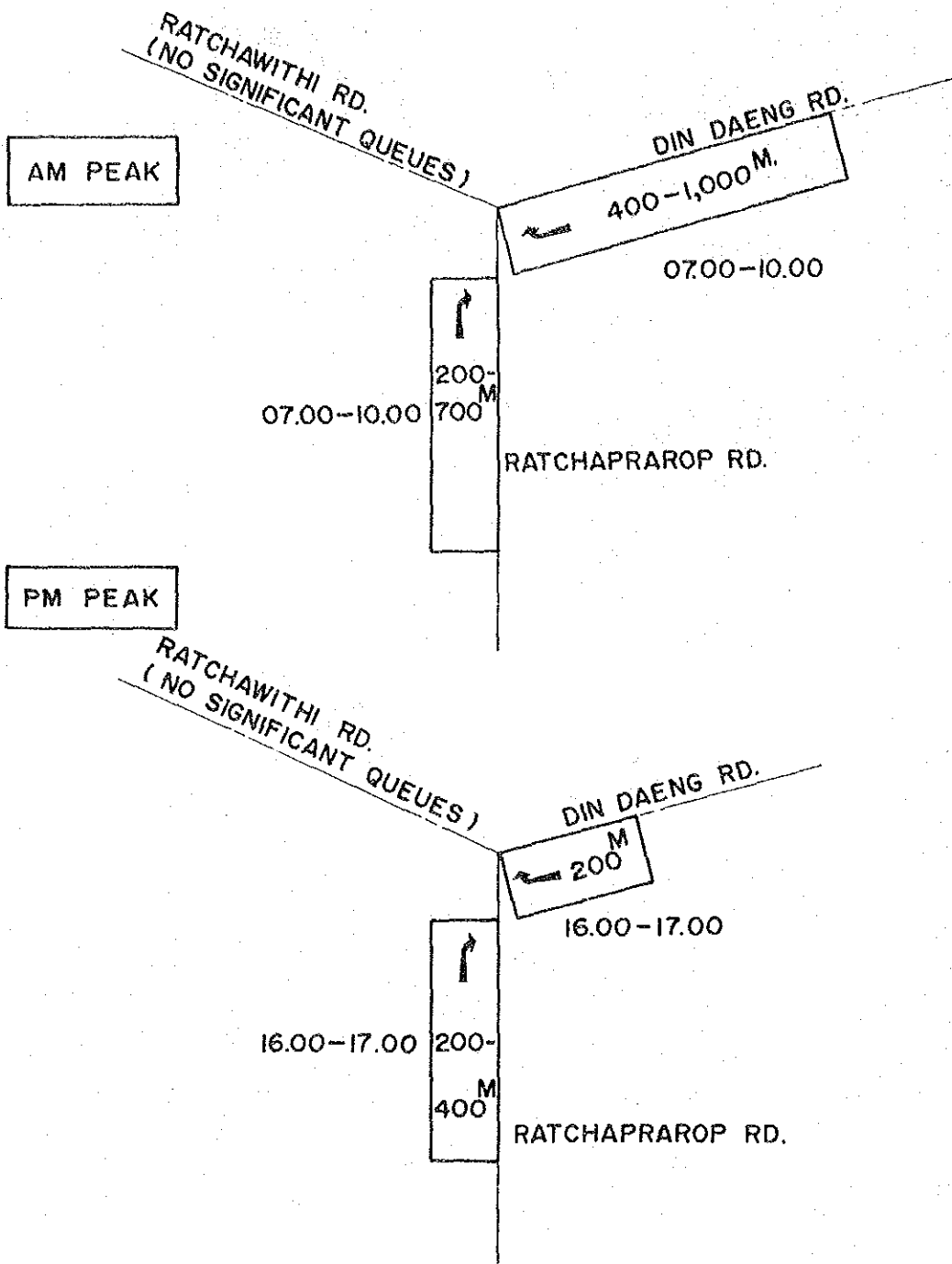


Figure 5.4.2 No. 613  
Din Daeng/Ratchaprarop Rd. Queue Length

As the saturation degree is 0.876 (morning) and 1.057 (evening), the intersection improvement is required.

(5) Cycle Time Analysis

- Green time is properly arranged to each direction.
- Cycle length is long in the morning. It is one of the reasons of long queue length because in the evening, the queue length is less than that in the morning although more vehicles flow into the intersection.

Table 5.4.1 Existing Condition of Intersection

Item	Characteristics
1) Morning peak hour max. traffic	8:00 - 9:00 3,968 PCU/hr in east-west direction
2) Evening peak hour max. traffic	17:00 - 18:00 3,929 PCU/hr in south-east direction
3) Saturation degree Intersection	0.876 (Morning), 1.057 (Evening)
Approach	1.260 (Morning, south-east direction) 0.916 (Morning, east-west direction)
4) Queue length	400-1,000 m from 7:00-10:00 in east-west direction 200-400 m from 16:00-17:00 in south-east direction
5) Stopped delay	4 min. (Morning, east-west direction)
6) Cycle length	326 sec. (Morning) 197 sec. (Evening)



## (6) Planning of improvement alternatives

### 1) Points of planning

#### One-way operation

The problem in this intersection is that the two major traffic flows from Dindaeng and Ratchaprarop are intercrossing there due to one-way operation in the 3-leg intersection. But the change of the one-way operation is not considered because it is out of the scope of this study.

Therefore, the plans are made to increase the capacity of the intersection by constructing a flyover either south-east direction or east-west direction under the present traffic conditions. If the one-way operation is changed in future, the improvement plan should be re-studied.

#### No at-grade improvement

All around the intersection, shop houses are densely built up. Therefore, at-grade improvement is not considered as an alternative.

#### Intersection at the Expressway

Due to the reason mentioned in the Constraints, the intersection at the Expressway should be improved together.

### 2) Planning of improvement alternatives

The following two alternative plans are made for the comparison.

Alt.1 : A flyover in south-east direction  
(Ratchaprarop - Dindaeng)  
and an underpass at the Expressway

Alt.2 : A flyover in east-west direction  
(Dindaeng - Rachawithi)  
and an underpass at the Expressway

### 3) Description of Alt-1 (south-east flyover)

This Alt-1 is made to ease the evening traffic congestion. The flyover direction is south-east and it has one-way, 2-lane due to the existing one-way operation.

At the Expressway intersection, an underpass with one-way, 2-lane (west-east direction) is planned because there is already a flyover of the Expressway in the north-south direction and the traffic flow of east-west direction is already a free flow.

#### 4) Description of Alt-2 (east-west flyover)

Alt-2 is made to ease the morning traffic congestion which has longer queues than the evening. The flyover is east-west direction and one-way, 2-lane, but in the evening peak hours the north lane should be used for the opposite direction traffics. That means the north lane is a reversible one and that the flyover will be used as a two-way in the evening peak.

##### Reversible lane operation

Reversible lane operation on a flyover has not been introduced in Bangkok, while on the several ground roads it has already been practiced by the traffic police.

Therefore, the following measures should be carefully studied, planned and executed.

- Overhead variable traffic sign  
It will indicate "Entry" and "No Entry" signs by the mechanical and electrical operation.
- Physical barrier at the entrance and the exit  
Rubber cones will be set at both the entrance and the exit. Mechanically movable median strip which will be lighted during the operation will be fixed.
- Median strip on the flyover  
Low and round shaped median strip or fencing will be some of the alternatives to separate both the directions of traffics. Traffic marking only will not be effective to avoid head-on collisions of vehicles. It needs some physical separators.

The underpass at the Expressway is the same as that of Alt-1.

#### (7) Effects of improvement

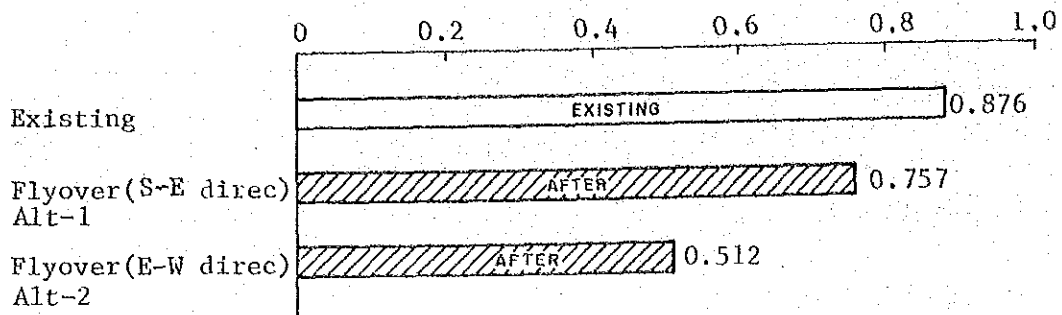
##### 1) Dindaeng/Ratchaprarop intersection (Figure 5.4.3)

By the construction of a flyover either south-east (Alt-1) or east-west (Alt-2) direction, the saturation degree will decrease to 0.757 and 0.512, respectively in the morning.

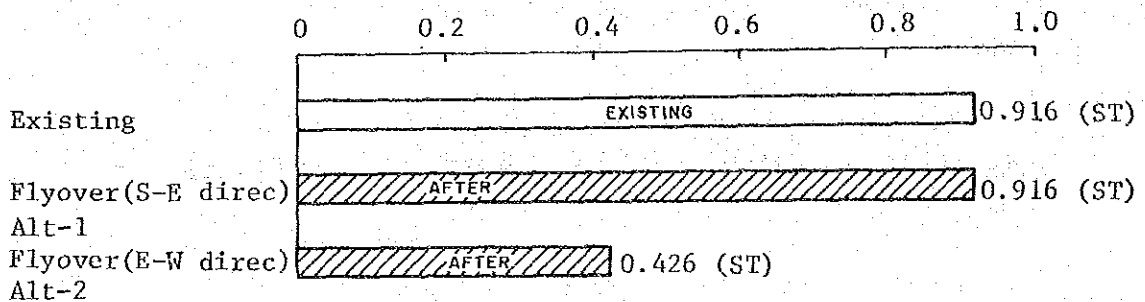
In the morning, a flyover in east-west direction is preferable while in the evening south-east direction is preferable. It is because the directions

Intersection : Dindaeng/Ratchaprarop Rd. (No.613) (A.M. peak)

1. Saturation Degree of Intersection

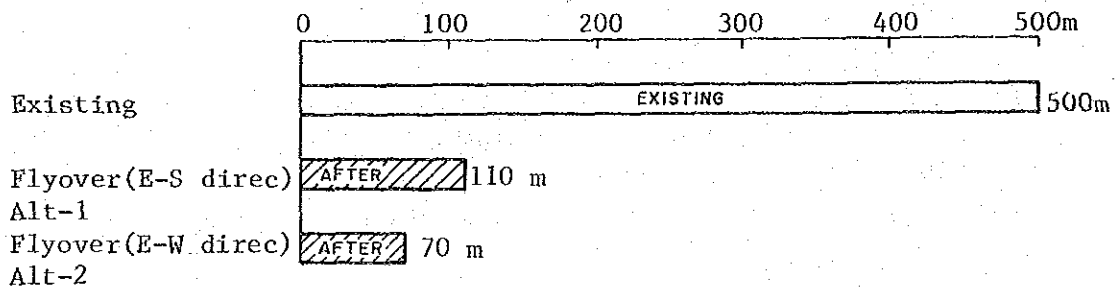


2. Saturation Degree of Critical Approach (WB)



WB : West bound, ST: Straight, LT: Left Turn

3. Queue Length (Max.)-WB



4. Waiting Time (Max., second/vehicle)-WB

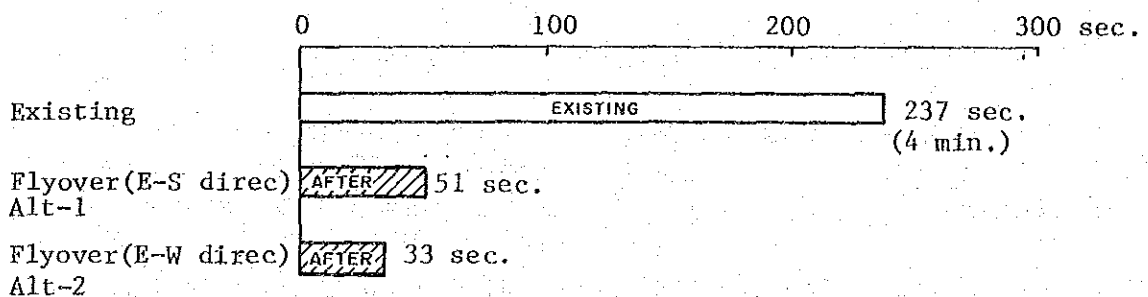


Figure 5.4.3 Improvement Effects

of the major traffic flows are different in the morning and the evening.

Queue length and stopped delay will decrease to about 20% of the existing ones in both alternatives.

## 2) Intersection at the Expressway

The underpass is the same in both Alt-1 and Alt-2. The intersection will be improved significantly by its construction. The saturation degree will decrease from 0.802 to 0.445 in the morning and from 1.012 to 0.342 in the evening.

## (8) Selection of an Alternative

Comparative table of Alt-1 and 2 is shown in Table 5.4.2. After the comparison, Alt-2 is selected for the economic analysis due to following reasons.

### Reasons of selection

#### 1) Project cost

Project costs of Alt-1 and 2 are not much different. Alt-2 is larger than Alt-1 by 14%.

#### 2) Saturation degree

Saturation degree of Alt-2 (0.512) is smaller than Alt-1 (0.757) in the morning. In the evening, that of Alt-2 is 0.815, still acceptable level.

#### 3) Others

- Alt-1 has a weaving between the flyover and the underpass, while Alt-2 has no weaving.
- Due to narrow Ratchaprarop Rd., Alt-1 has only one lane beside the flyover. Alt-2 has always two lanes beside the flyover.
- If present one-way operation is changed to two-way in future, Alt-1 has a problem of traffic control. Alt-2 has no problem because the two structures are in different directions.

## (9) Economic Analysis

About selected Alt-2, economic analysis is carried out. The result is shown in Table 5.4.3.

Table 5.4.2 Comparison of Alternative Plans

Intersection : Dindaeng/Ratchaprarop Rd. (No.613)

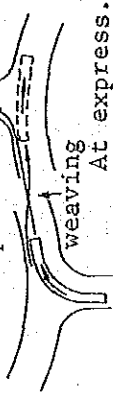
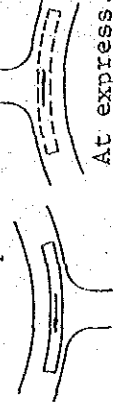
Alternatives		1	2 (Recommended)
Improvement Plan		One-way, 2-lane flyover and underpass  weaving At express.	One-way, 2-lane flyover and underpass  At express.
Construction Cost		83.8	95.6
Project Cost (Million Baht)			
Land Acq. Cost		2.9	2.9
Total		86.7	98.5
Maintenance Cost per annum		3.7	3.7
Construction Period		2.5 years	2.5 years
Improvement Effect (Morning peak)		Saturation degree 0.876 → 0.757 Max.Queue length (WB) 500 m → 110 m Stopped delay (WB) 4 min. → 51 sec.	Saturation degree 0.876 → 0.512 Max.Queue length (WB) 500 m → 70 m Stopped delay (WB) 4 min. → 33 sec.
Major Constraints		Ratchaprarop Rd. has only 5 lanes, not enough for flyover.	Only a flyover is not effective. With underpass at expressway, more effective.
Advantage/Disadvantage		Good for evening peak. Only one lane beside flyover. Weaving is required.	Good for morning peak. Flexible for future dual-way operation. No weaving.

Table 5.4.3 Economic Analysis (in 10 years)

Item	Result
Initial Cost	98 Mil.B.
Cost in Present Value (C)	113 Mil.B.
Benefit in Present Value (B)	252 Mil.B.
Net Benefit (B-C)	138 Mil.B.
B/C	2.23
IRR	0.189

The net benefit is reasonable, the B/C is more than 2.0 and the IRR is 0.189 in 10 years. Therefore, Alt-2 is recommended for future execution.

## 5.5 Pradiphat/Phahon Yothin Rd., No.511

### (1) General description

This intersection is located in the North commercial center of Bangkok called Saphankwai. It is a four-leg intersection with an irregular right-angle-bent in east approach.

### (2) Traffic flow

The major traffic flow is north-south direction (Figure 5.5.1). 400-500m long queue lengths are observed for about one hour in the morning and three hours in the evening, respectively. (Figure 5.5.2)

The percentage of heavy vehicle (mainly buses) amounts 20-25% of total traffics.

### (3) Constraints

As the intersection is in the commercial center, the permanent concrete buildings are existing all along the road. Specially in the northwest corner, a 6-story concrete building containing of shops, residences and a school at the top is located.

Three pedestrian bridges were constructed surrounding the intersection in 1986.

### (4) Degree of congestion (existing)

Existing conditions of the intersection are summarized in Table 5.5.1.

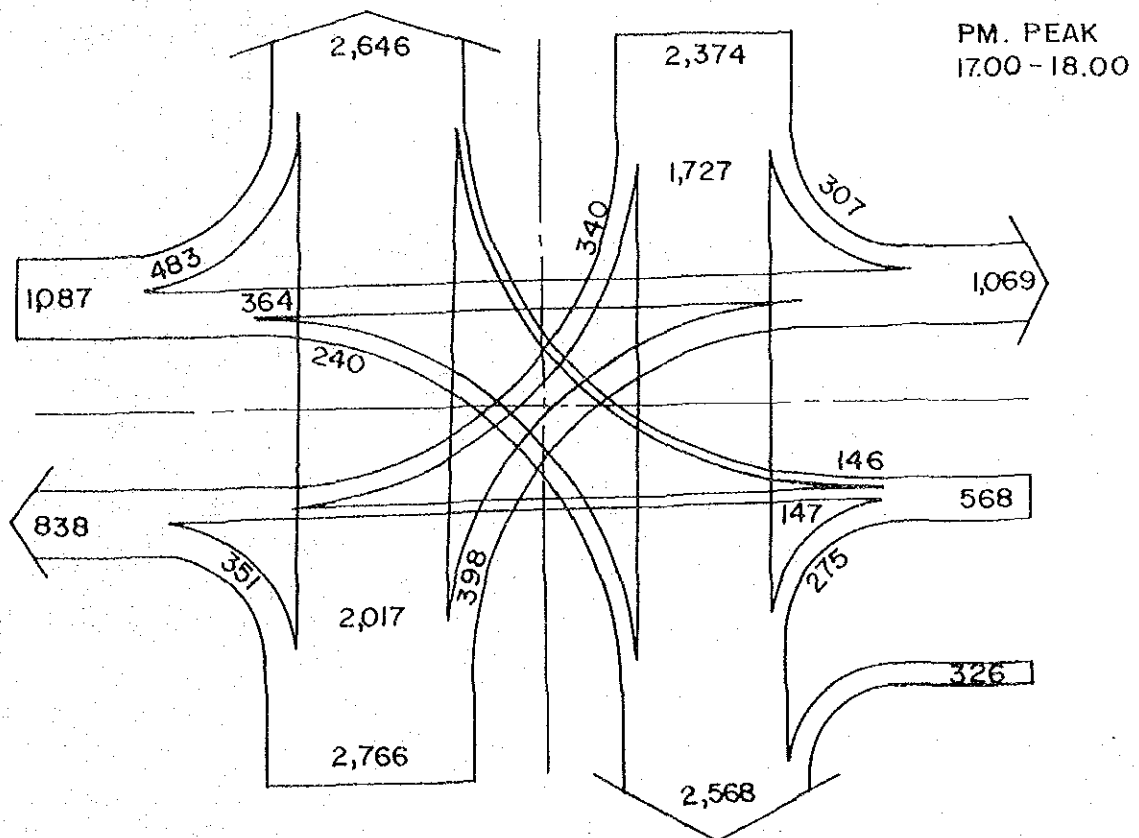
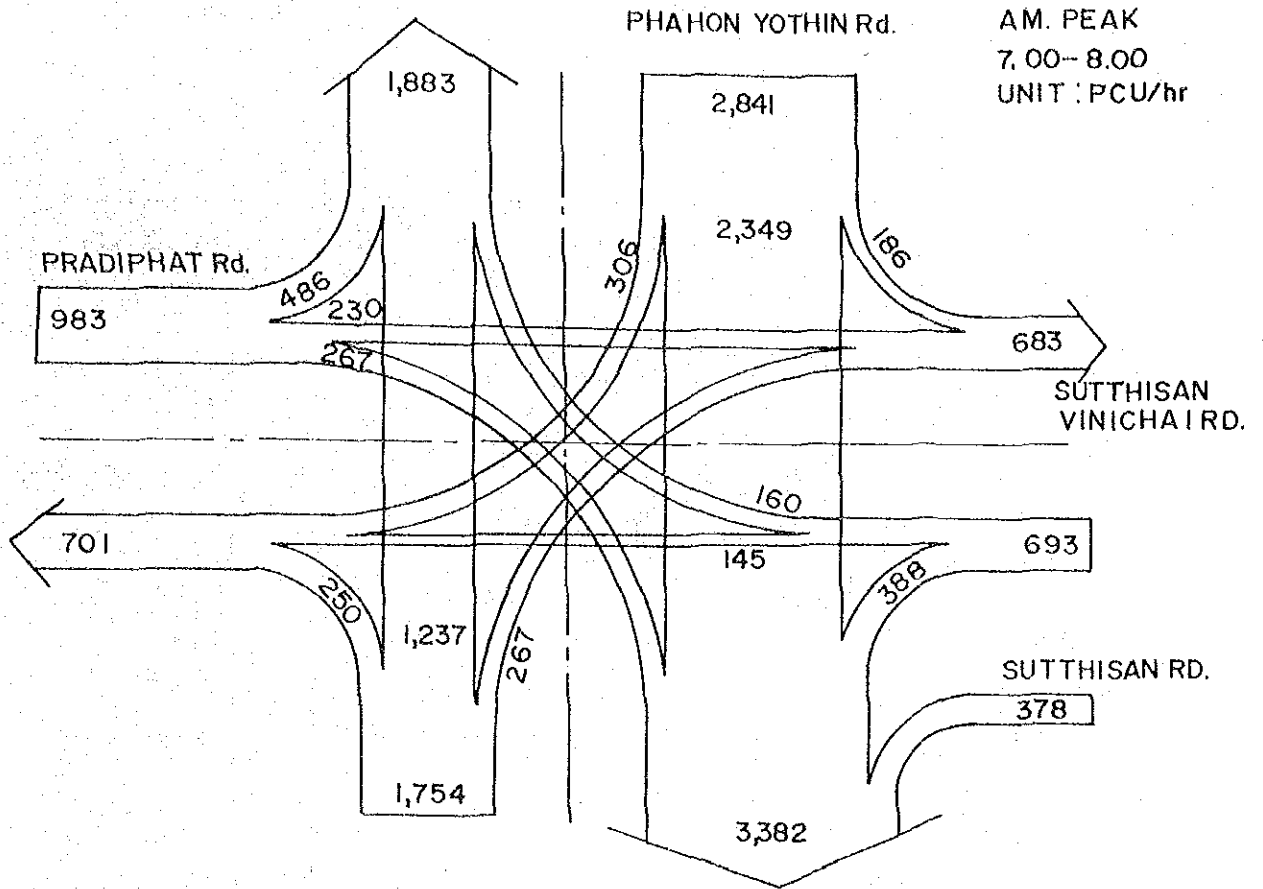
The saturation degree is 0.752 in the morning and 0.802 in the evening. About 500 m long queue was observed in the morning and the evening. Therefore, the improvement of the intersection is required.

### (5) Cycle time analysis

- Green time is properly arranged to each direction.
- Cycle length of 169 sec. in the morning is reasonable. Evening cycle length of 306 sec. is long and irregularly controled.

Figure 5.5.1 No. 511

Traffic Volume at Pradiphat/Phahon Yothin Rd.





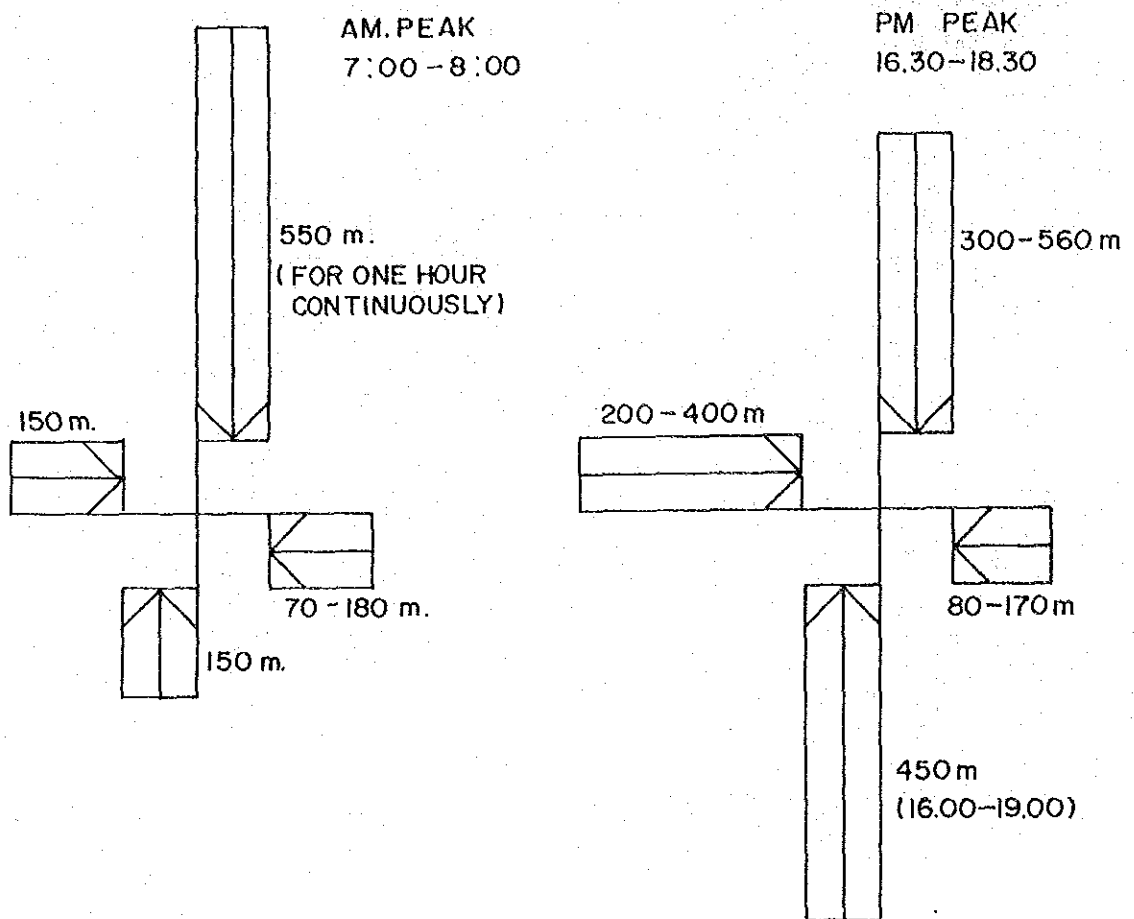


Figure 5.5.2 Pradiphat/Phahon Yothin Road (No.511)  
Queue Length

Table 5.5.1 EXisting Condition of Intersection

Item	Characteristics
1) Morning peak hour max. traffic	7:00 - 8:00 2,349 PCU/hr, south bound
2) Evening peak hour max. traffic	17:00 - 18:00 2,017 PCU/hr, north bound
3) Saturation degree Intersection Approach	0.752 (Morning), 0.802 (Evening) 0.924 (Morning, South bound)
4) Quene length	550 m from 7:00 to 8:00 in south bound 450 m from 16:00 to 19:00 in north bound
5) Stopped delay	Average 5 min. (south bound, morning peak)
6) Cycle length	169 sec.(Morning, regular phasing) 306 sec.(Evening, irregular phasing)

(6) Planning of improvement alternatives

1) Points of planning

- Congestion of this intersection is considered to result from the excessive traffic demand in Phahon Yothin Road.
- According to the signal time analysis, the signal timing is reasonable and the improvement cannot be expected.

The restriction of the right-turns from both Pradhipat and Suthisan Vinichai Roads during the peak hours is also studied but the improvement effects cannot be expected.

- Considering the excessive traffic demand in the north-south direction, the improvement plan should aim to increase the intersection capacity. It means that the increase of number of lanes by at-grade or by grade-separation is required.

## 2) Planning of improvement alternatives

Based on the site investigations and traffic analyses mentioned herein before, the following 3-alternative improvement plans are made for comparison:

Alternative 1 : Widening of Phahon Yothin Road to increase the number of through lanes

Alternative 2 : Construction of a two-way 2-lane flyover in north-south direction

Alternative 3 : Construction of a two-way 3-lane flyover (1-lane reversible)

## 3) Description of Alternative 1. (Road Widening)

- Alternative 1 is planned to increase the capacity of Phahon Yothin Road by widening, which carries the most congested north-south flow of the intersection. The number of through lanes is to be increased from 3 to 4. Total number is increased from existing 7 to 9 lanes as shown in Figure 5.5.3.

- The widening involves land acquisition of 4 meter wide and approximately 330 meter long on each side of Phahon Yothin Road. Due to existing permanent buildings around the site, the land acquisition will take longer time than other alternatives 2 and 3.

- Alternative 1 has an advantage of not disturbing the roadside residents view in the commercial area.

In the following Alternatives 2 and 3, the big structure of a flyover is a visual obstruction to the roadside residents and the shoppers.

- Road widening should be considered with surrounding redevelopment plans because considerable houses and shops have to be demolished.

## 4) Description of Alternatives 2 (2-lane Flyover) (Figure 5.5.4)

- Alternative 2 is planned to increase the capacity by constructing a flyover on Phahon Yothin Road approaches instead of the widening plan of Alternative 1. This alternative aims to relieve the traffic congestion without delay, so that it can be constructed within the

**NOTES:**

- a) Widening of Phahon Yothin Rd. approaches.
- b) Existing pedestrian bridges are to be removed and re-constructed.
- c) Land acquisition is necessary.

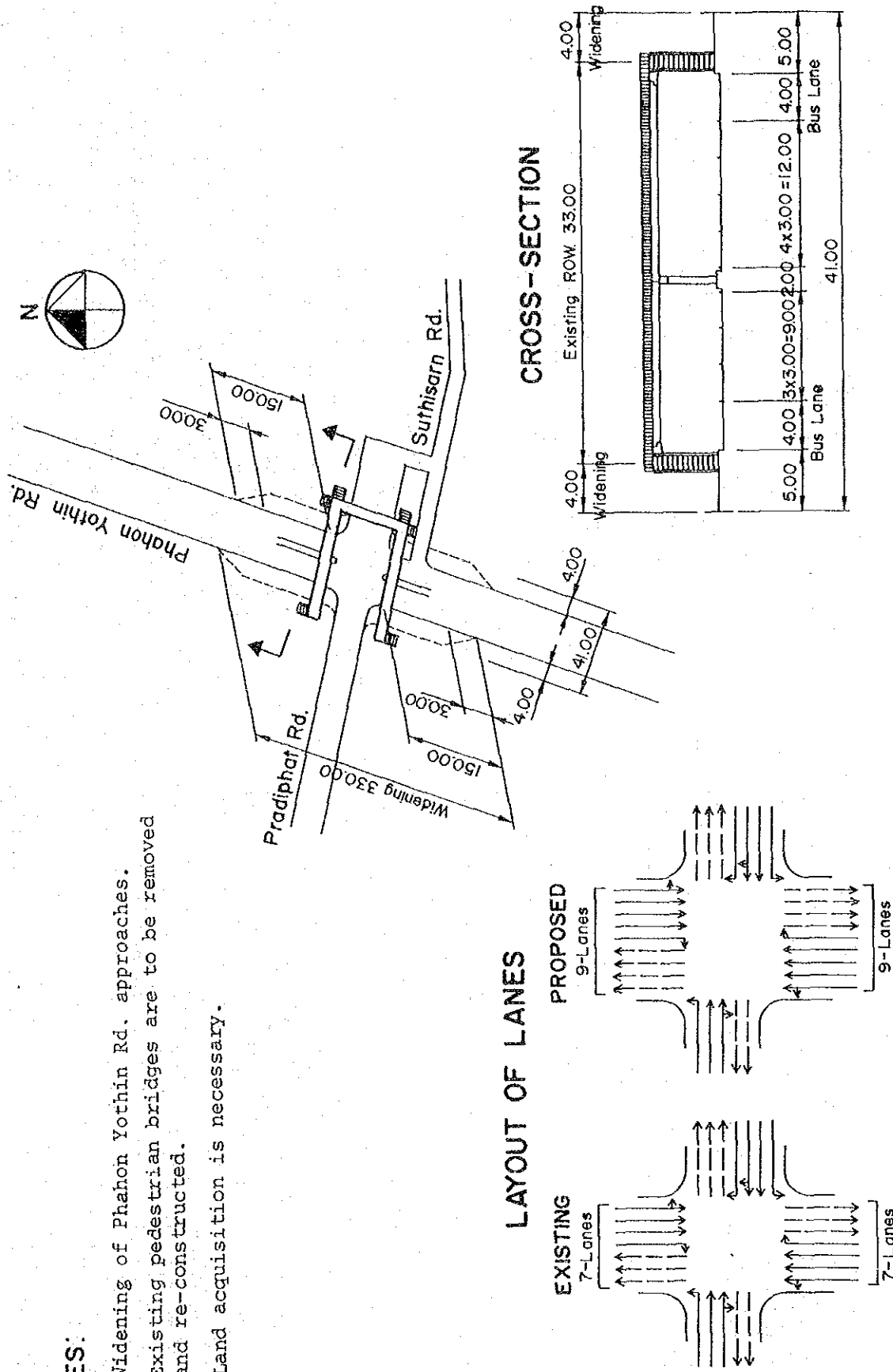
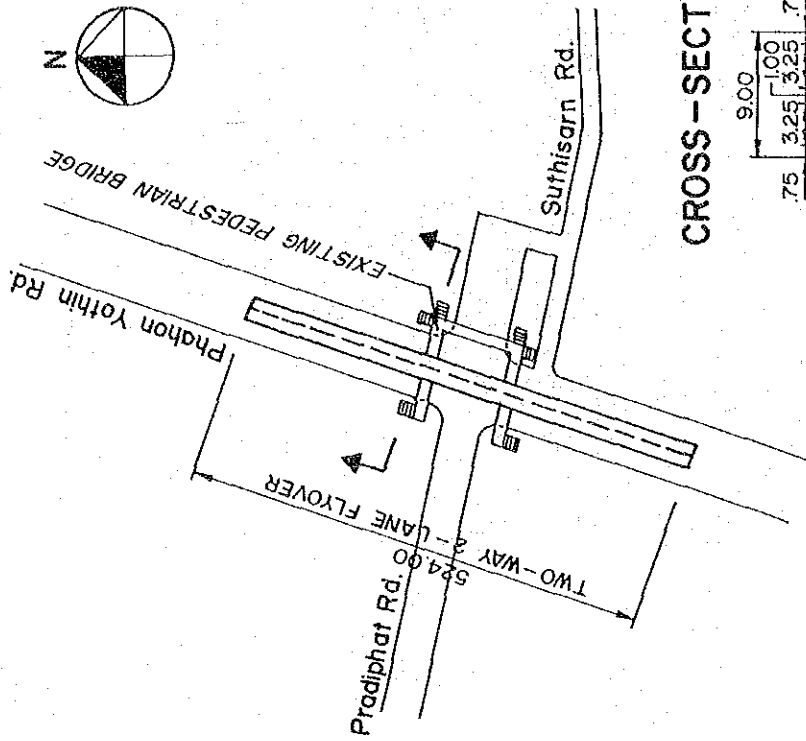


Figure 5.5.3 Pradiphat/Phahon Yothin Rd. Intersection Alternative 1

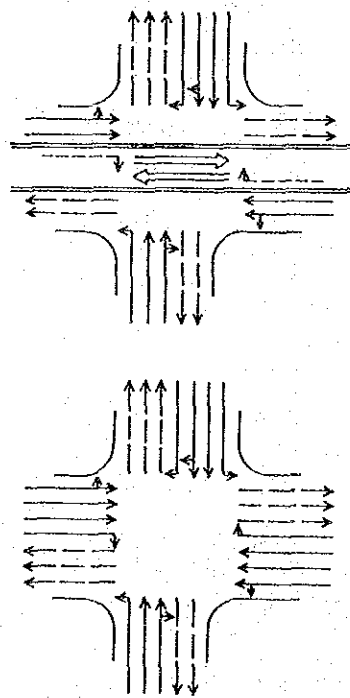
**NOTES:**

- a) Construction of a 2-lane flyover on Phahon Yothin Rd. approaches.
- b) Existing pedestrian bridges are to be preserved.
- c) No land acquisition is necessary.



**LAYOUT OF LANES**

**EXISTING**                      **PROPOSED**



**CROSS-SECTION**

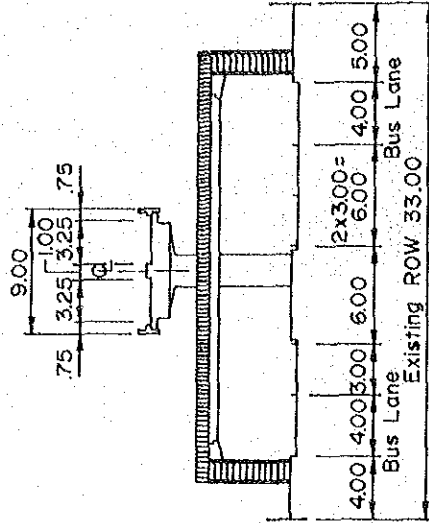


Figure 5.5.4 Pradiphat/Phahon Yothin Rd. Intersection Alternative 2

existing right-of-way. No additional land acquisition is required.

- As for the existing pedestrian bridges, they should be preserved because of the high pedestrian activities in the site. Therefore, the flyover is required to pass over the pedestrian bridges.
- On planning the flyover, two ground-level lanes beside the flyover and an existing 4 to 5 meters sidewalk are considered to be a minimum requirement. The reasons are high demand of bus operation in north-south direction and the high pedestrian activity in the site.
- The flyover of Alternative 2 is planned to serve for the two-way 2-lanes through traffic in most congested north-south direction as shown in Figure 5.5.4.

The small size vehicles are expected to transfer to the flyover while the heavy vehicles still use the ground-level road. The existing traffic volume of the small size vehicle is 1,645 PCU/hr. The capacity of the flyover per lane is estimated as 1,500 PCU/hr. Therefore, the 2-lane flyover can accommodate the existing traffic volume but has no allowances for the future traffic growth and future traffic generation which will occur after the completion of the flyover.

- A 4-lane flyover can be another alternative and would provide a longer term traffic solution. However, the constraints of the site show that it would be costly and require a longer implementation period because land acquisition is involved. The existing right-of-way of Phahon Yothin Road has not sufficient width for providing a 4-lane flyover together with 2-ground-level lanes and full sidewalk at each side. Furthermore, even if this intersection is improved by the 4-lane flyover, the north and south intersections in Phahon Yothin Rd. is still congested. Balanced improvement should be considered. A 4-lane flyover is therefore not proposed as an alternative plan.

#### 5) Description of Alternative 3 (3-lane Flyover)

- The flyover of Alternative 3 is shown in Figure 5.5.5. It is proposed to provide a two-way 3-lanes (with one reversible lane) in the same direction as Alternative 2. This alternative provides a sufficient capacity for the future traffic demand.

The reversible operation should be referred to Dindaeng intersection in 5.4.(6), 4).

It is planned not to require any land acquisition, so that it can be implemented soon.

However, there is not enough space for carriageway of the ground-level lanes. The reduction of a lane width to 2.75 m is required for ensuring 2 lanes at each side adjacent to the flyover.

(7) Effects of improvement (Figure 5.5.6)

1) Traffic flow

When a flyover is completed, the heavy vehicles (mainly buses) is expected to use the down road because of their convenient access to the customers.

Therefore, it is expected that most of the small vehicles will be transferred to the flyover and that heavy vehicles remain to use down road.

Thus, transfer ratio is estimated to be about 70% in terms of PCU as shown in Table 5.5.2.

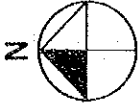
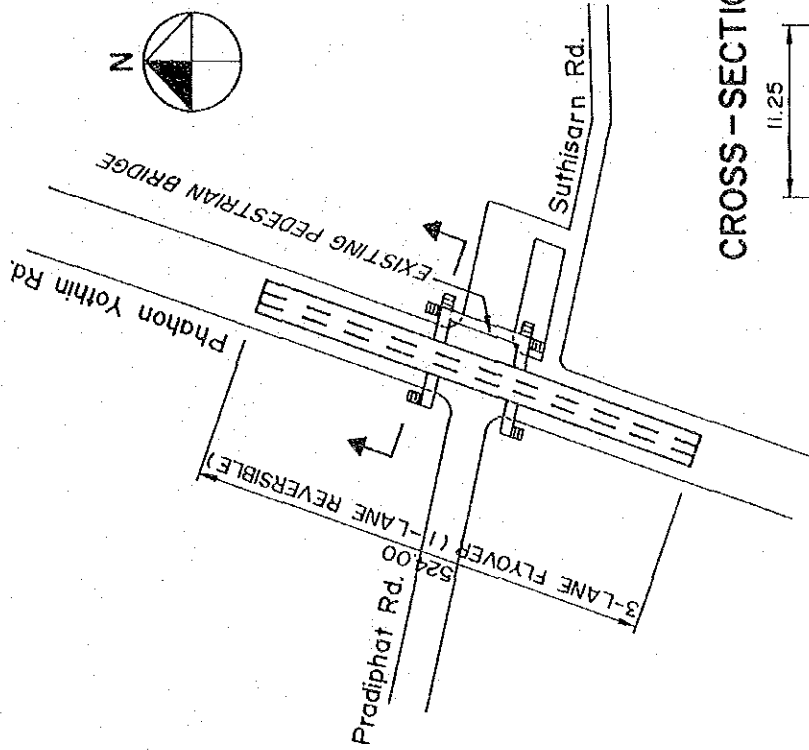
Table 5.5.2 Transfer Ratio of Traffic

	Existing Volume (PCU/hr)	Transfer	Ratio
a) Morning (SB)			
Small vehicles	1,645	To flyover	70%
Heavy vehicles	702	Remain in down road	30%
b) Evening (NB)			
Small vehicles	1,386	To flyover	71%
Heavy vehicles	572	Remain in	29%

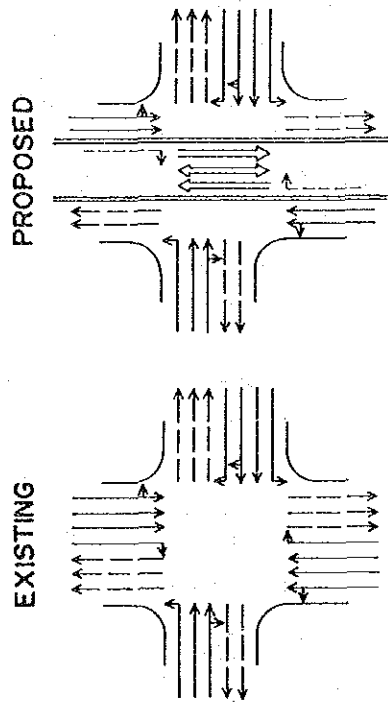
As mentioned in (6) 4),5), both the Alt-2 and Alt-3 flyover have to accomodate the existing traffic volume, therefore the both congestion degrees are considered to be same.

**NOTES:**

- a) Construction of a 3-lane flyover on Phahon Yothin Rd. approaches.
- b) Existing pedestrian bridges are to be preserved.
- c) No land acquisition is necessary.



**LAYOUT OF LANES**



**CROSS-SECTION**

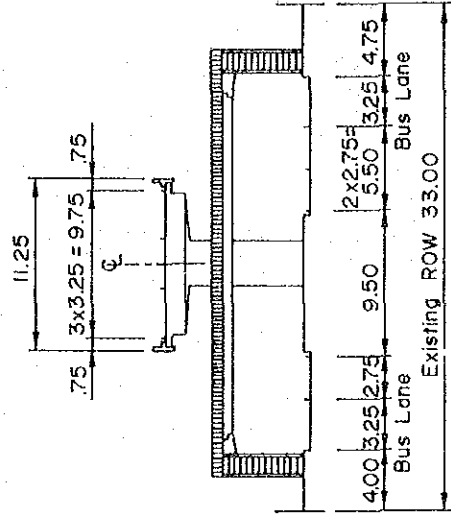


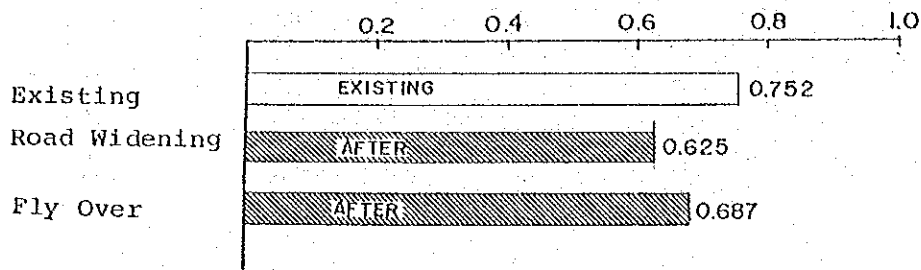
Figure 5.5.5 Pradiphat/Phahon Yothin Rd. Intersection Alternative 3



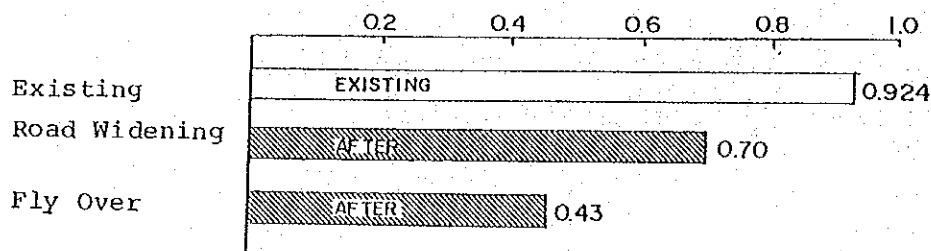
**Figure 5.5.6 Improvement Effects**

Intersection : No. 511 Pradiphat/Phahon Yothin Rd. (Morning Peak)

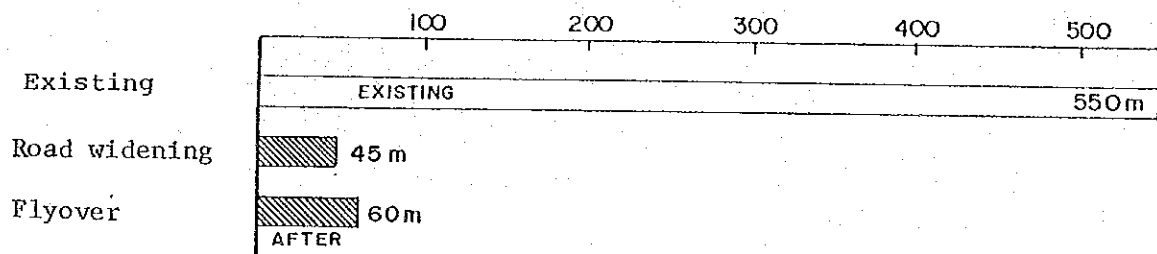
1. Saturation Degree of Intersection



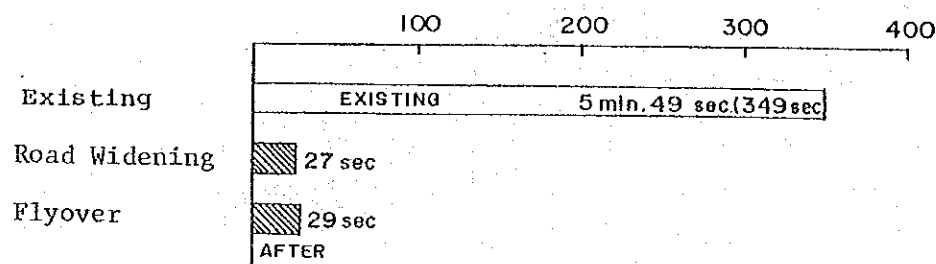
2. Saturation Degree of South Bound



3. Queue Length (m) - Average of South Bound



4. Stopped Delay (second/vehicle) - Average of South Bound



2) Saturation degree of the intersection

Saturation degree will decrease from existing 0.752 to 0.625 by road widening and to 0.687 by construction of a flyover, respectively.

3) Saturation degree of the critical approach

Saturation degree will decrease from 0.924 to 0.70 by road widening and to 0.43 by the construction of a flyover.

4) Queue length

The existing queue length of max. 550 m in the morning peak hour will decrease to average 60 m by construction of a flyover.

5) Stopped delay

Actual stopped delay was surveyed at the intersection by using a car. The average stopped delay of ten times survey in the morning peak was 5 min. The stopped delay was also calculated by data of queue length. The result was 5 min. 49 sec., almost the same as the actual surveyed time. After construction of a flyover, the stopped delay will decrease to average 29 sec. in south bound.

(8) Selection of an Alternative

Comparison of three alternatives is shown in Table 5.5.3.

Alt-1 costs too much and needs longer time for land acquisition. Alt-2 has no allowance for future traffic increase. Therefore, Alt-3 (two-way, 3-lane flyover) is selected for economic analysis.

(9) Economic Analysis

The results of economic analysis about Alt-3 are shown in Table 5.5.4.

Table 5.5.3 Comparison of Alternative Plans

Intersection : Pradiphat/Phahon Yothin Rd. (No. 511)

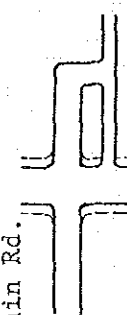
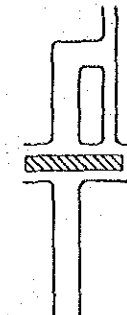
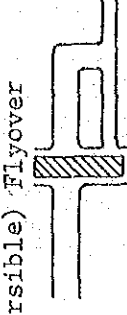
Alternatives		1	2	3 (Recommended)
Improvement Plan	Road widening of Phahon Yothin Rd.			
	Construction Cost	25.6	61.5	76.7
Project Cost (Million Baht)	Land Acq. Cost	161.5	-	-
	Total	187.1	61.5	76.7
	Maintenance Cost per annum	1.0	1.0	1.1
Construction Period		5 months (Land acquisition period unknown)	1.5 years	1.5 years
Improvement Effect (Morning peak)	Saturation degree	0.752 → 0.625	0.752 → 0.687	0.752 → 0.687
	Queue length	550 m → 45 m	550 m → 60 m	550 m → 60 m
Major Constraints	Stopped delay	5 min. 50 sec. → 27 sec.	5 min. 50 sec. → 29 sec.	5 min. 50 sec. → 29 sec.
	Large land acquisition is required.	Flyover shall be above existing pedestrian bridges.	Flyover shall be above existing pedestrian bridges.	Flyover shall be above existing pedestrian bridges.
Advantage/Disadvantage	Construction cost is low but land acquisition takes long time.	No land acquisition. Flyover has no allowance for future traffic increase.	No land acquisition. Flyover has no allowance for future traffic increase.	No land acquisition. Allowance for future traffic increase. Reversible operation.

Table 5.5.4 Economic Analysis (in 10 years)

Item	Result
Initial Cost	76 Mil.B.
Cost in Present Value (C)	82 Mil.B.
Benefit in Present Value (B)	232 Mil.B.
Net Benefit (B-C)	151 Mil.B.
B/C	2.85
IRR	0.255

The net benefit is reasonable, the B/C is more than 2.0 and the IRR is 0.255 in 10 years. Alt-3 is recommended for future execution.

## 5.6 Petburi/Rama VI Rd., No.212

### (1) General description

This intersection is located to the east of a flyover in Petburi Rd. It is a four-leg intersection of which 3 legs are used as a one-way road except each bus priority lane. Petburi Rd. in the west side has 7 lanes while that in the east has 6 lanes. North Rama VI road has 8 lanes but one lane is always occupied by parking vehicles. South Rama VI Rd. has 4 lanes, which is less than other three.

### (2) Traffic flow

Major traffic flow is in west-east direction both in the morning and the evening.

### (3) Constraints

As mentioned in the General description, south Rama VI Rd. has only 4 lanes. Along the road, 1-4 story shop houses are lined up and the sidewalk width is 3 m.

For the road widening or construction of a flyover in the road, land clearance is required.

### (4) Degree of congestion (existing)

Existing conditions are summarized in Table 5.6.1.

The morning saturation degree is 0.991 and the queue length exceeds 400 m from 8:00-9:00 a.m. Therefore, the improvement of the intersection is required.

### (5) Cycle time analysis

- 1) Green time is properly arranged to each direction.
- 2) Cycle length is 210-230 seconds, a little long but acceptable.

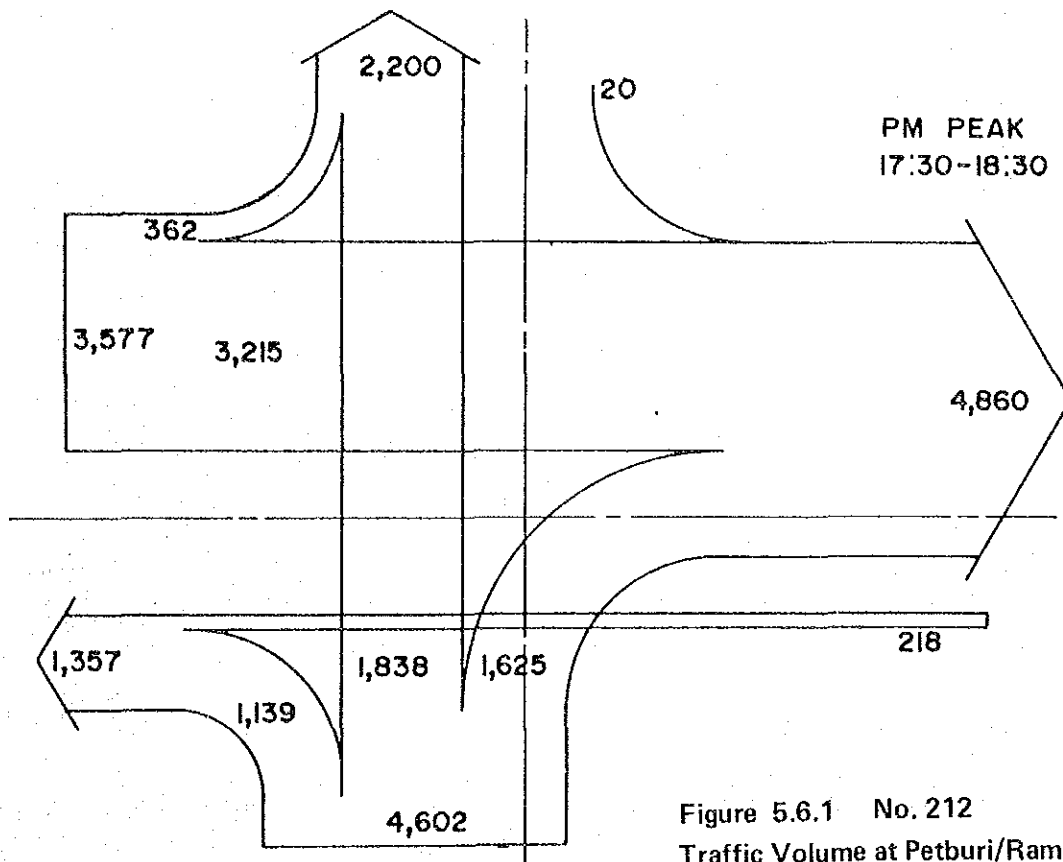
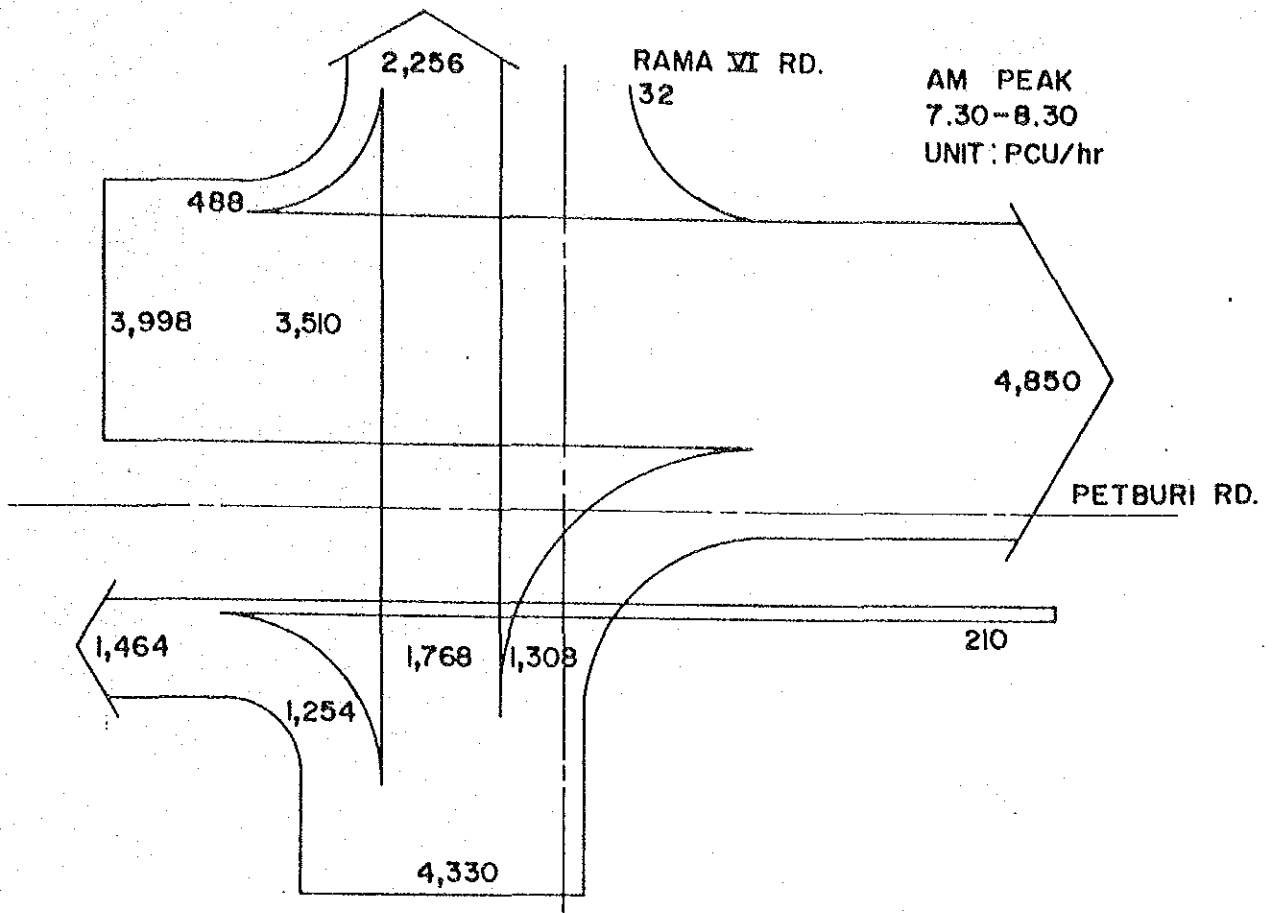


Figure 5.6.1 No. 212  
Traffic Volume at Petburi/Rama VI Road

Table 5.6.1 Existing Condition of Intersection

Item	Characteristics
1) Morning peak hour max. traffic	7:30 - 8:30 3,510 PCU/hr in east bound
2) Evening peak hour max. traffic	17:30 - 18:30 3,215 PCU/hr in east bound
3) Saturation degree Intersection Approach	0.991 (Morning) 1.008 (Morning, north bound) 0.968 (Morning, east bound)
4) Queue length	400-500 m from 8:00 to 9:00 a.m. in north bound 500-600 m from 16:00 to 18:30 pm. in north bound
5) Stopped delay	4 min. in north bound
6) Cycle length	231 sec. (Morning) 213 sec. (Evening)

(6) Planning of improvement alternatives

1) Points of planning

Second stage expressway

It is in the process of detail design in 1986. The main line is north - south and just above Rama VI Rd. An interchange is planned at this intersection. The on/off ramps are also located along east - west Petburi Rd.

For the construction of the elevated expressway main line (6-line), Rama VI Rd. is planned to be widened because of not enough right of way.

Elevated Railway

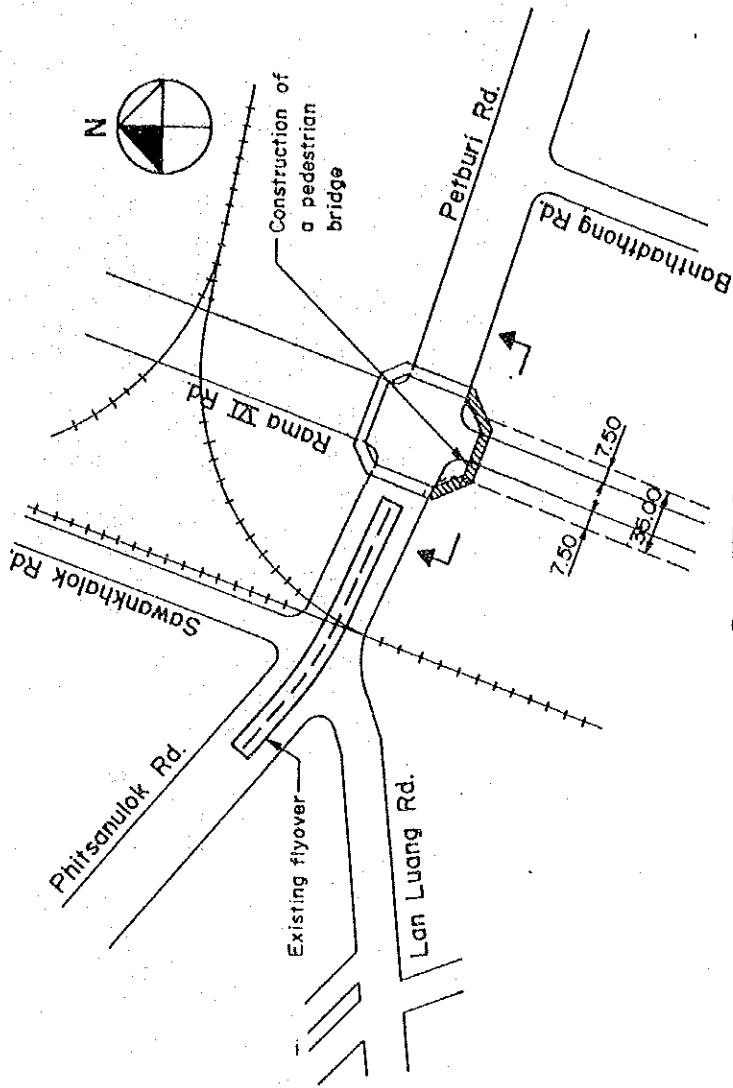
The railway beside Swankhalok Rd. is planned to be elevated in future. It will affect the structure of the existing flyover and the planning of the improvement.

2) Planning of improvement alternatives

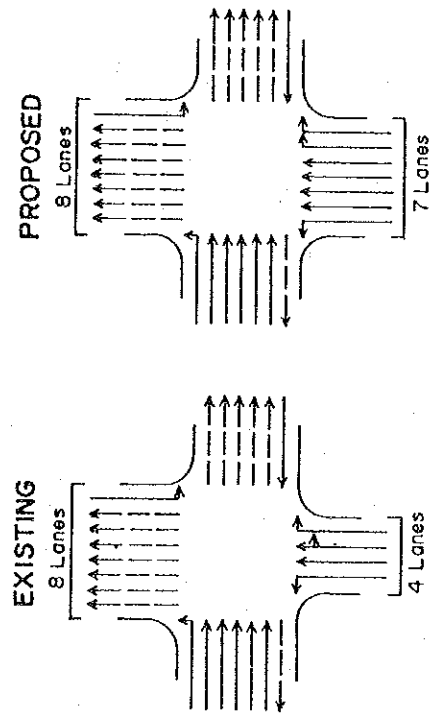
Considering both the above mentioned second stage expressway and the existing flyover to the west, following two alternatives are made and

Notes:

- a) Widening of south Rama VI Rd.
- b) A pedestrian bridge is to be constructed at the mouth of south Rama VI Rd.
- c) Land acquisition is necessary



LAYOUT OF LANES



Rama VI Rd.  
widening 20m → 35m

CROSS-SECTION

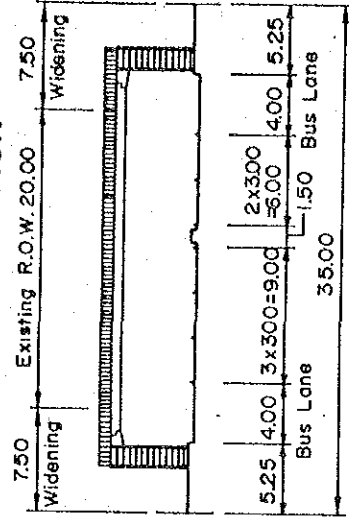
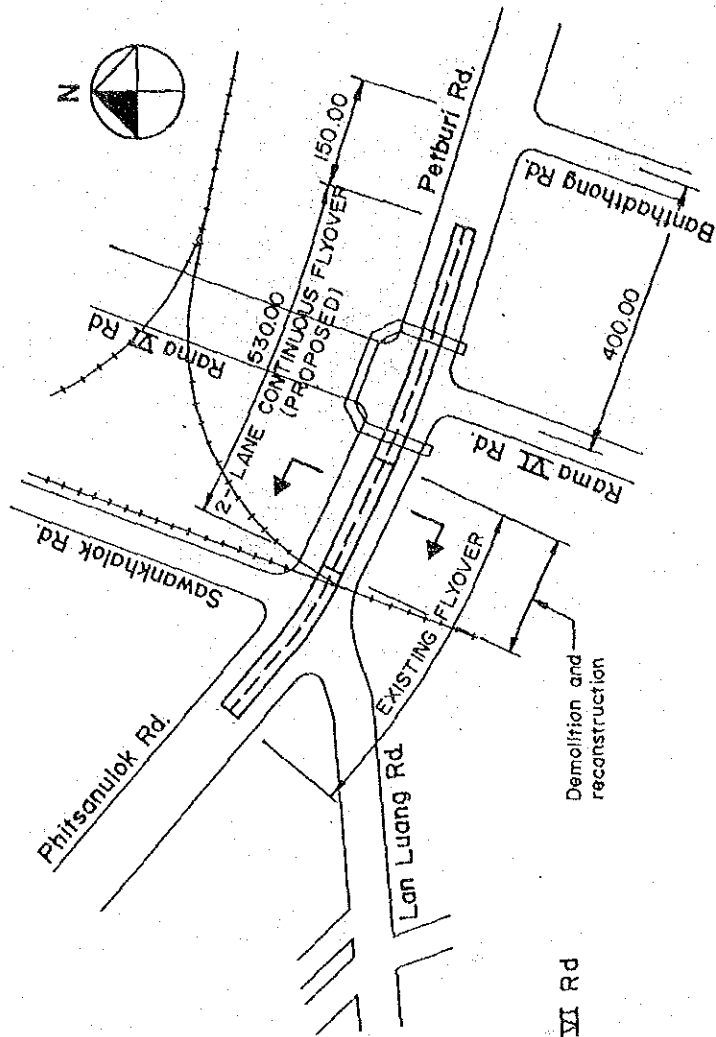


Figure 5.6.2 Petburi/Rama VI Rd. Intersection Alternative 1



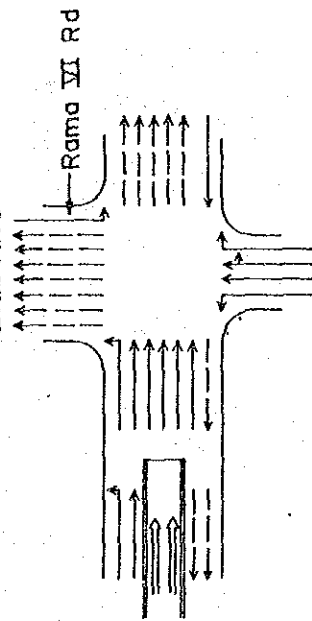
Notes:

- a) Construction of a 2-lane flyover on Petburi Rd. by extending existing one.
- b) Existing pedestrian bridges are to be preserved.
- c) No land acquisition is necessary.

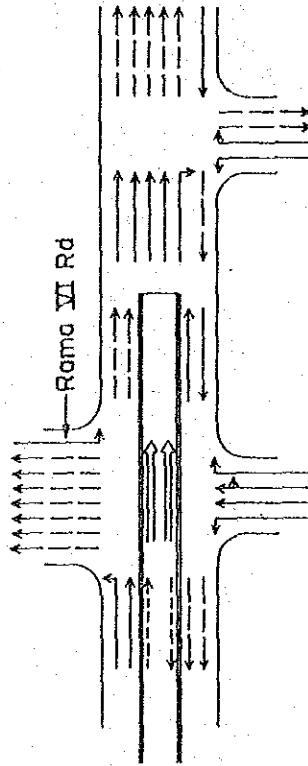


LAYOUT OF LANES

EXISTING



PROPOSED



CROSS-SECTION AT DEMOLITION PART

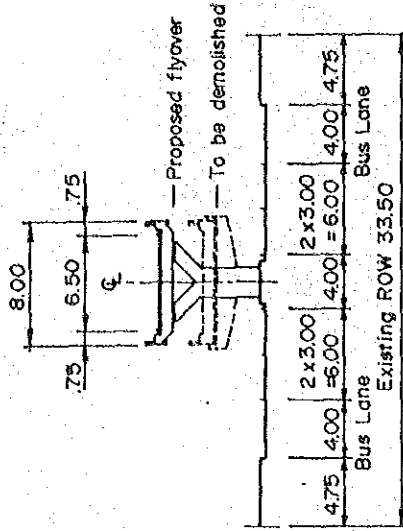


Figure 5.6.3 Petburi/Rama VI Rd. Intersection, Alternative 2

compared.

Alternative 1 : Road widening of Rama VI Rd.

Alternative 2 : Construction of a one-way 2-lane flyover in east-west direction by extending the existing one.

### 3) Description of Alt-1 (At-grade)

#### Road Widening

This alternative is to widen South Rama VI Rd. from existing 4-lane to 7-lane to provide the same capacity as north Rama IV Rd. (Figure 5.6.2) A road widening is included in the second expressway design but the detail is not finalized yet. Therefore, the widening of South Rama VI road has to be included in the design.

For the widening, large land acquisition is required for both sides, each 7.5 m in width. But if it is purchased as a part of the expressway project, it will not be a big problem.

### 4) Description of Alt-2 (flyover)

#### Flyover

This alternative is to construct a 2-lane flyover continuing from the existing one (Figure 5.6.3). It will need about 200 m demolition of the existing flyover and its reconstruction. The vertical alignment between the two intersections is kept almost same level to avoid ups and downs.

#### Pedestrian bridges

The existing pedestrian bridges which are recently constructed by BMA should be preserved. The minimum clearance above it is 2.5 m. The proposed flyover is designed to cross over it.

#### Second stage expressway and elevated railway

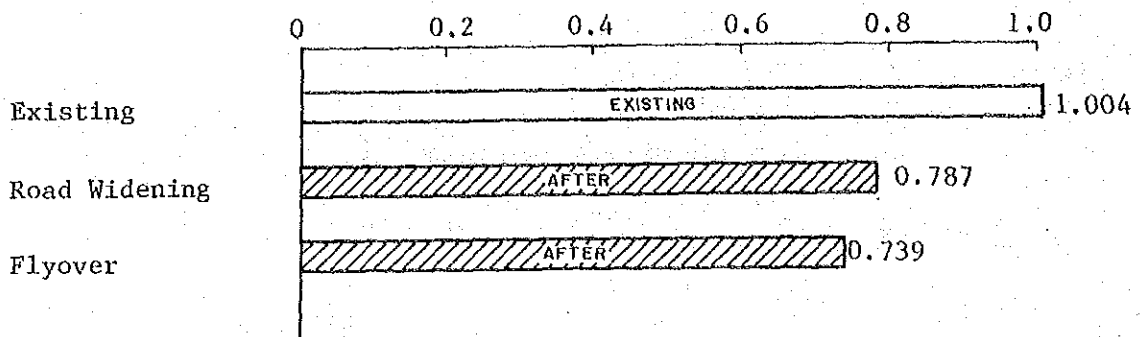
In the second stage expressway design, there are on/off ramps at this intersection. Therefore the flyover design should be coordinated with that of the expressway and the railway.

When the expressway is completed, north-south traffic of this intersection will decrease but the major east-west traffic will not be changed. That means the necessity of the flyover will be still existing.

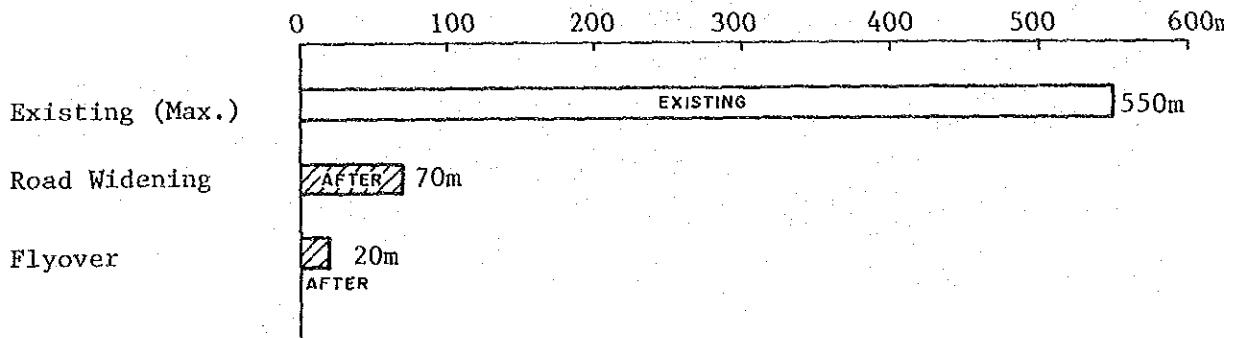
#### East intersection

Distance between Rama VI Rd. and east Banthadthong Rd. is 400 m. (Figure

1. Saturation Degree of Intersection



2. Queue Length (m) - NB



3. Stopped delay(second/vehicle) - NB

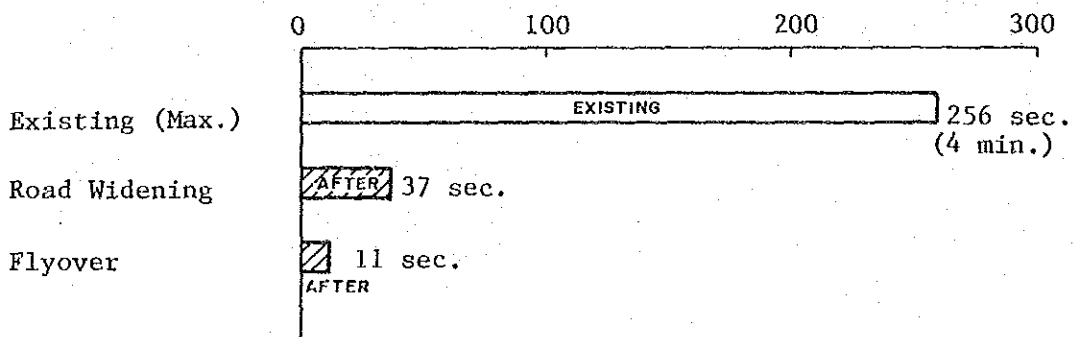


Figure 5.6.4 Improvement Effects Intersection : Petburi/Rama VI Rd.  
(No.212) (A.M. peak)

5.6.3) If the flyover crosses over including east intersection (it is physically possible), it will produce more benefit but the construction cost will also increase. The increase of the construction cost is estimated 50%, but that of the benefit is around 20%. The reasons of the smaller benefit are as follows.

- 1) The east intersection is not so congested because it is a 3-leg, not a 4-leg.  
(It is not a bottleneck at present).
- 2) The traffic volume from/to Banthadthong Rd. is not large.
- 3) Major traffic flow on Petburi Rd. does not stop for a long time at the east intersection.

Therefore, the flyover crosses over only Rama VI Rd. and the east intersection is expected not to be congested even if the flyover is completed.

#### (7) Effects of improvement (Figure 5.6.4)

##### 1) Traffic flow

When a flyover is completed, 2,858 PCU/hr (only small size vehicle) out of 3,510 PCU/hr will transfer to the flyover (transfer ratio 81%) in the morning peak hour. In the evening peak hour, 2,544 PCU/hr out of 3,215 PUC/hr will transfer to the flyover (transfer ratio 79%).

##### 2) Saturation degree of the intersection (Morning)

The existing saturation degree of 1.004 will decrease to 0.787 by the widening of Uruphong Rd. In the case of the flyover construction in Petburi Rd., it will also decrease to 0.739.

##### 3) Queue length

Max. queue length will decrease from existing 500 - 600 m to 70 m by road widening and to 20 m by a flyover, respectively.

##### 4) Stopped delay

Existing max. stopped delay is about 4 minutes. It will reduce to 37 seconds by road widening and to 11 seconds by construction of a flyover.

#### (8) Selection of An Alternative

Comparison of two alternatives are summarized in Table 5.6.2.

Their project costs and the improvement effects are almost the same between the two. Therefore, two are proceeded to next Economic analysis.

(9) Economic analysis

The results of economic analysis are shown in Table 5.6.3.

Table 5.6.3 Economic Analysis (in 10 years)

Item	Alt-1 (Widening)	Alt-2 (Flyover)
Initial Cost	58 Mil.B.	45 Mil.B.
Cost in Present Value (C)	64 Mil.B.	52 Mil.B.
Benefit in Present Value (B)	101 Mil.B.	240 Mil.B.
Net Benefit (B-C)	36 Mil.B.	188 Mil.B.
B/C	1.57	4.64
IRR	0.139	0.397

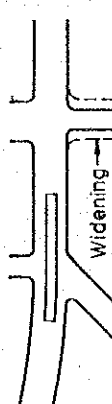
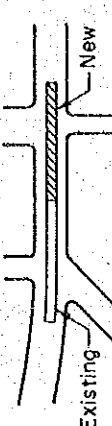
The two alternatives are compared and evaluated as follows.

- 1) Initial cost of Alt-2 is lower than Alt-1.
- 2) Net benefit, B/C and IRR of Alt-2 is much better than Alt-1.
- 3) Alt-1 needs land acquisition which will take long time usually.

From the above reasons, Alt-2 (flyover) is recommended.

Table 5.6.2 Comparison of Alternative Plans

Intersection : Petburi/Rama VI Rd. (No. 212)

Alternatives		1	2 (Recommended)
Improvement Plan		Road widening of Rama VI Rd. 	One-way, 2-lane flyover in addition to existing one. 
	Construction Cost	6.2	45.6
Project Cost (Million Baht)	Land Acq. Cost	52.0	-
	Total	58.2	45.6
	Maintenance Cost per annum	0.9	1.2
Construction Period	6 months (Land acquisition period unknown)		2 years
Evaluation	Improvement Effect (Morning peak)	Saturation degree 1.004 → 0.787 Queue length (NB) 550 m → 70 m Stopped delay (NB) 4 min. → 37 sec.	Saturation degree 1.004 → 0.739 Queue length (NB) 550 m → 20 m Stopped delay (NB) 4 min. → 11 sec.
	Major Constraints	Large land acquisition required. Pedestrian bridges to be reconstructed.	Existing pedestrian bridges to be preserved.
	Advantage/Disadvantage	Widening is planned in 2nd stage expressway. Land acquisition takes time	No land acquisition. 2nd stage expressway ramp may disturb construction.

## 5.7 Pracharat/Pracha Chuen Rd., No.360

### (1) General description (Figure 5.7.1)

This intersection consists of Pracha Chuen Rd. which runs in north-south direction along a Khlong and Pracharat II Rd. which runs east-west direction.

The intersection is located beside the Khlong. At both sides of the Khlong bridge, traffic signals have been installed.

Pracha Rat II road leads to a 3-leg flyover in the east area called Bang Sue.

The intersection is a 4-leg one but the south leg has a dead end. Therefore, it is almost like a 3-leg.

### (2) Traffic flow

The major traffic flow is a north-east and a west-east directions in the morning peak hour (Figure 5.7.2). That means it serves for an inbound traffic from northern area of Bangkok in the morning.

### (3) Constraints

- The 2-lane road in the south has a dead end near Techawanit Rd. (near a pumping station).
- The south road has a right of way of 6-10 m. If a new road is to be constructed, land acquisition is required.
- The south road has to cross an existing khlong at Techawanit Rd. A bridge is required for it. At the place, the water level is controlled by the nearby pump station, then a flat bridge is suitable for the construction instead of a high elevation one.

### (4) Degree of congestion (existing)

Existing conditions are summarized in Table 5.7.1.

The saturation degree is 1.062 and the saturation ratios of two approaches exceed 1.0. Therefore, the improvement of the intersection is required.

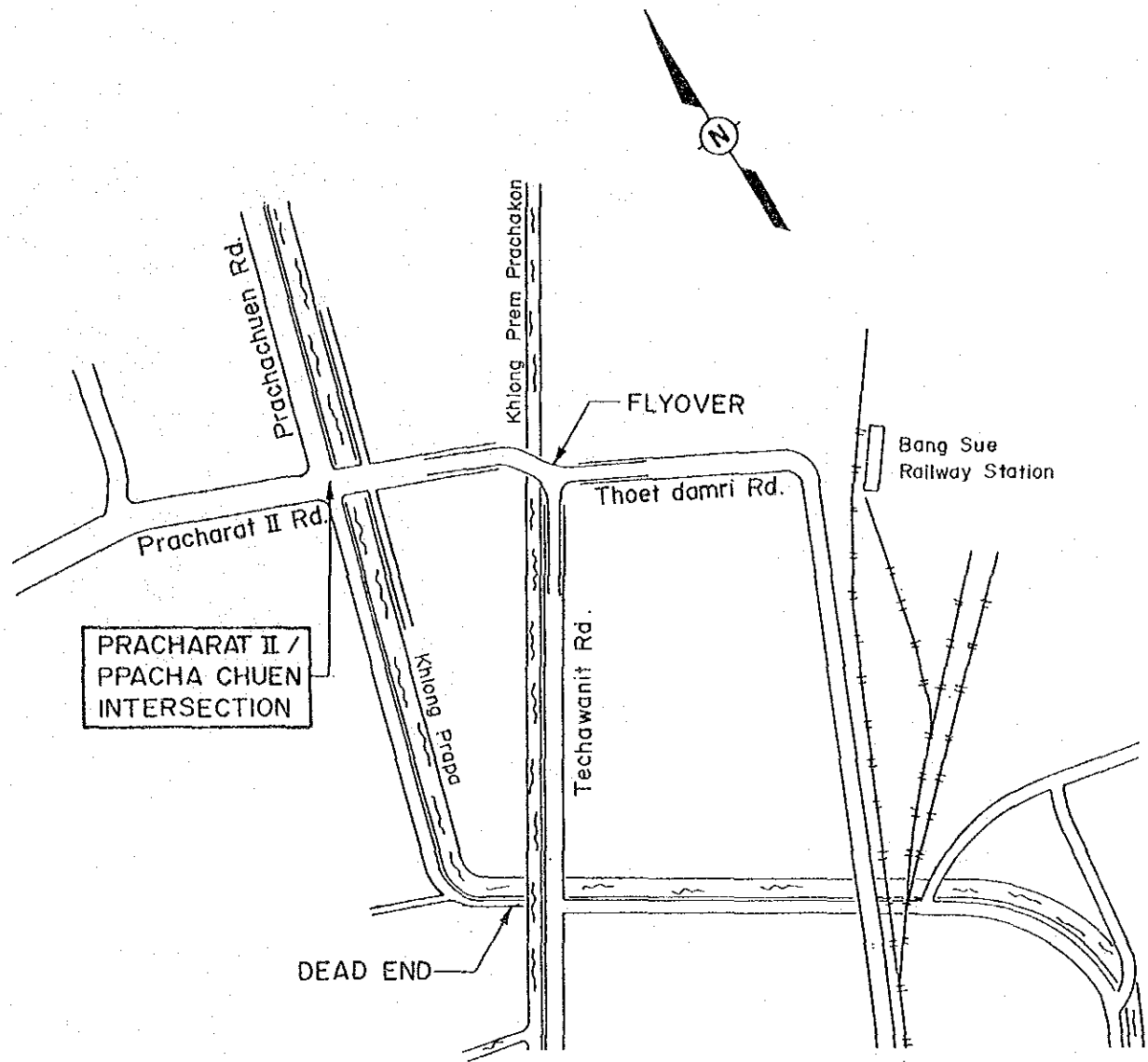
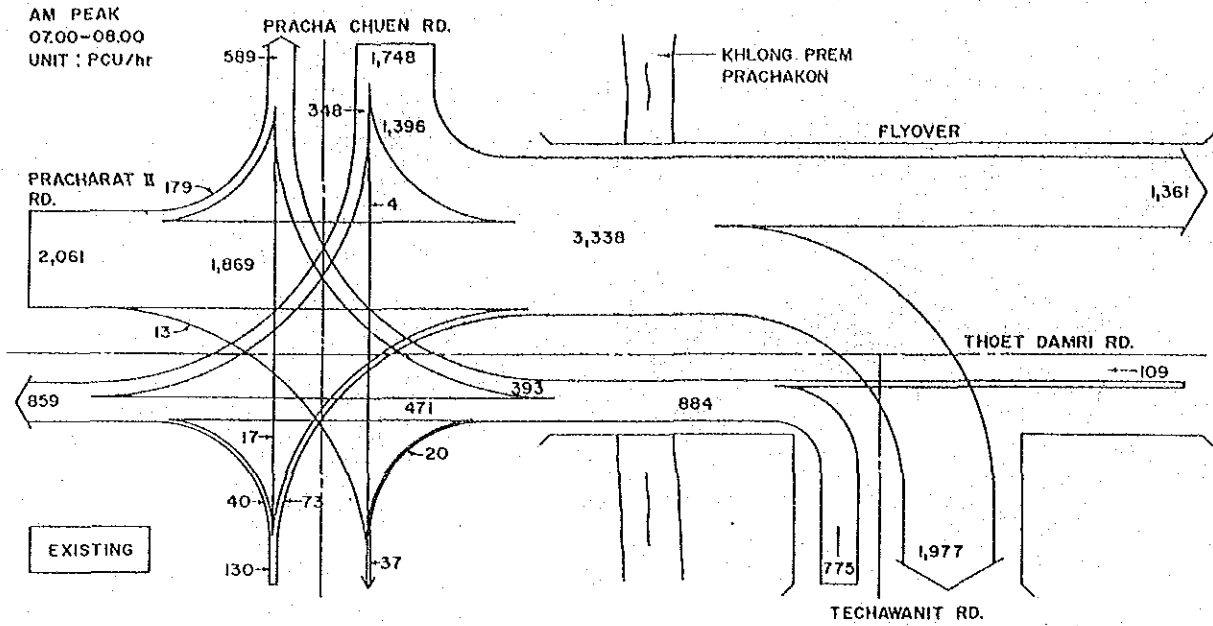


Figure 5.7.1 Existing Condition



Figure 5.7.2 No. 360  
Traffic Volume at Pracharat II/Pracha Chuen Rd.



No. 360  
Pracharat II/Pracha Chuen Rd.

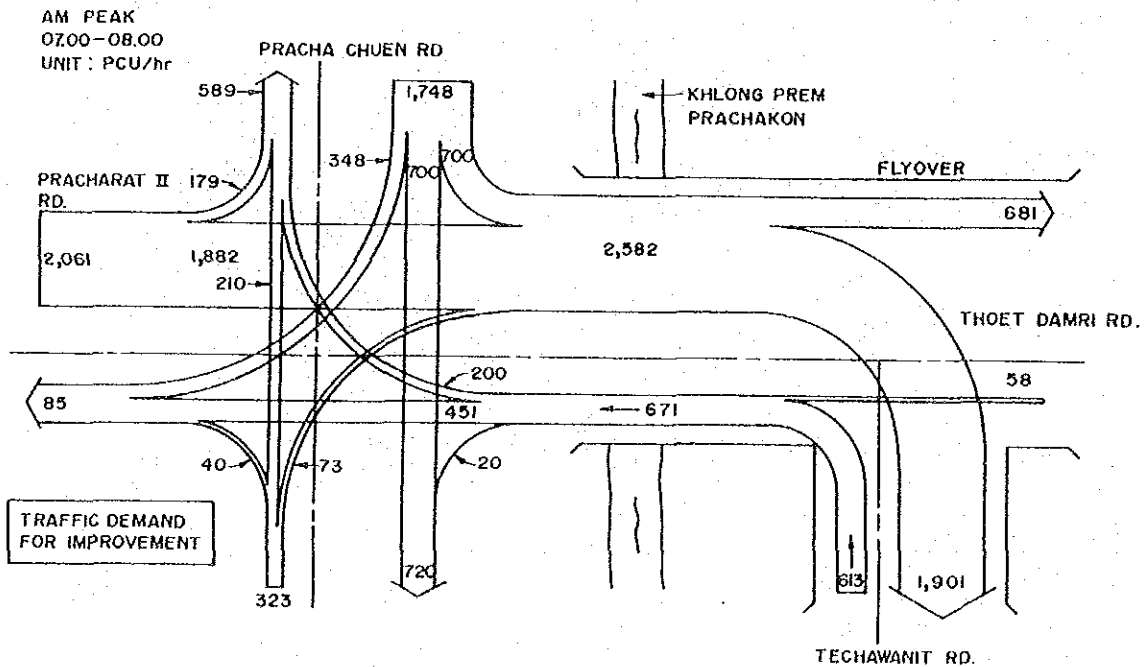


Table 5.7.1 Existing Condition of Intersection

Item	Characteristics
1) Morning peak hour Max. Traffic	7:00 - 8:00 1,869 PCU/hr, east bound 1,396 PCU/hr, north-east bound
2) Saturation degree Intersection Approach	1.062 (Morning) 1.099 (Morning, east bound) 1.005 (Morning, north-east bound)
3) Queue length	120 m, from 7:00 to 8:00, north-east bound
4) Stopped delay	2 min. 30 sec. (North-East bound)
5) Cycle length	132 sec. (Morning)

(5) Cycle time analysis

- Green time is properly arranged to each direction.
- Cycle length is 132 second : reasonable.

(6) Planning of improvement alternatives

1) Points of planning

Traffic volume of this intersection is not so much and its queue length is shorter than others. Therefore, improvement by grade separation is costly and not feasible. BMA has a plan to construct a new road along Khlong Prapa from the intersection to Techawanit Rd. The at-grade improvement is more feasible and practical.

2) Planning of improvement alternatives

As at-grade improvement plans, following two alternatives are made and compared.

- Alt-1 : Two-way, 2-lane new road along Khlong Prapa
- Alt-2 : Two-way, 4-lane new road along Khlong Prapa

### 3) Description of Alt-1

This alternative is to construct a new road with 2-lane along Khlong Prapa. The length is about 730 m. At the Techawanit Rd., it will have a new 4-leg intersection. The connection road in the east has only 2-lane. Therefore, the 2-lane road will be enough and it can accommodate the estimated traffic volume of about 700 PCU/hr per lane.

### 4) Description of Alt-2

This alternative is to construct a new road with 4-lane. It intends to transfer the major traffic flow of Techawanit Rd. into this new road. The existing road width along Khlong Prapa is only 13 m. For the 4-lane new road, large land acquisition is required.

## (7) Improvement Effects (Figure 5.7.3)

### 1) Traffic flow

A half of north-east bound traffics (700 PCV/hr) is expected to shift to the south road after improvement. The other half will still use the east leg. East-north bound traffics (393 PCV/hr) will shift to south-north one. Right turn traffic from Pracharat II is prohibited to ease the intersection congestion. Existing traffic volumes and the one after the improvement are illustrated in Figure 5.7.2.

### 2) Saturation degree of intersection

Saturation degree will reduce from 1.062 to 0.684 by improvement of the south road.

### 3) Saturation degree of critical approach

Saturation degree of south bound will decrease from existing 1.005 to 0.610 and that of east bound will decrease from 1.099 to 0.813 after the improvement, respectively.

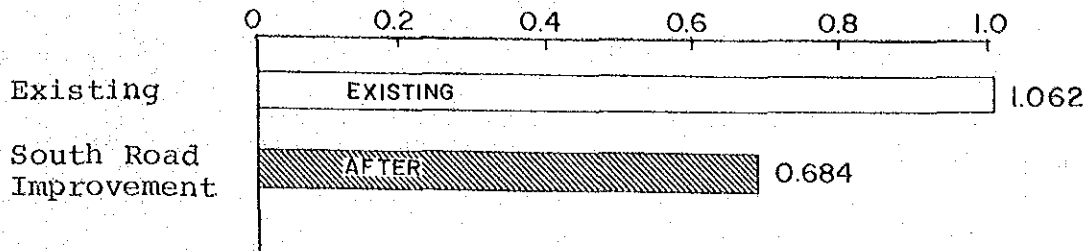
### 4) Queue length

Queue length of south bound will decrease from existing max. 160 m to average 30 m in length.

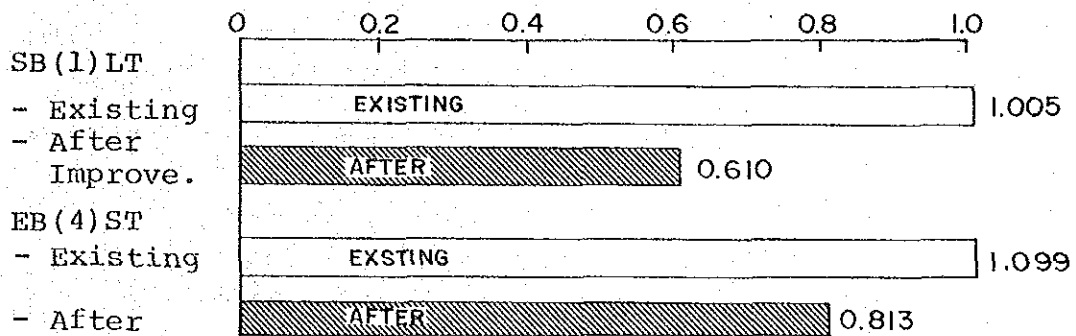
Figure 5.7.3 Improvement Effects

Intersection : No. 360 Pracharat II/Pracha Chuen Rd. (AM. Peak)

1. Saturation Degree of Intersection

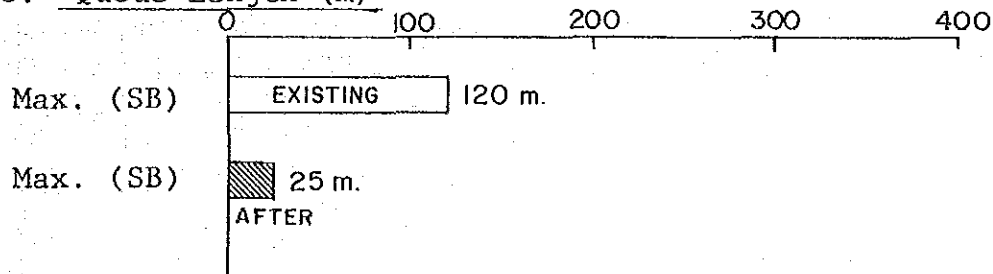


2. Saturation Degree of Critical Approach

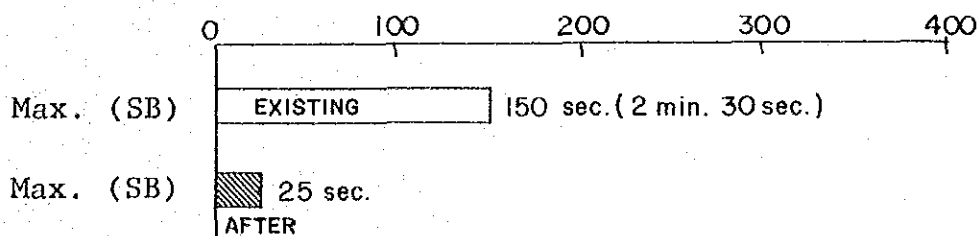


SB: South Bound, EB: East Bound, Lt: Left Turn, ST: Straight, RT: Right Turn

3. Queue Length (m)



4. Stopped delay (second/vehicle)



5) Stopped delay

Existing stopped delay is 2 minutes 30 sec., that is, about one cycle length. It will decrease to max. 25 sec. after improvement.

(8) Selection of an alternative

Comparison of two alternatives is shown in Table 5.7.2. Alt-2 (4-lane) needs larger construction cost and land acquisition cost than Alt-1 (2-lane). As the road capacity is enough by 2-lane, Alt-1 (2-lane) is selected for economic analysis.

(9) Economic analysis

The results of economic analysis (Alt-1) are shown in Table 5.7.3.

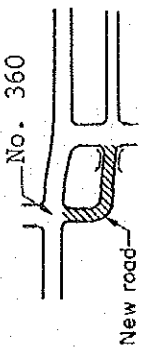
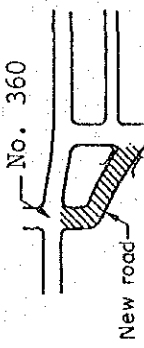
Table 5.7.3 Economic Analysis

Item	10 years
Initial Cost	24 Mil.B.
Cost in Present Value (C)	27 Mil.B.
Benefit in Present Value (B)	37 Mil.B.
Net Benefit (B-C)	9 Mil.B.
B/C	1.35
IRR	0.107

Due to at-grade improvement with a new road construction, the net benefit is relatively small. But in 10 years, the B/C is 1.35 and the IRR is 0.107. Therefore, the Alt-1 is considered to be fair for the future execution.

Table 5.7.2 Comparison of Alternative Plans

Intersection : Pracharat II/Pracha Chuen Rd. (No. 360)

Alternatives		1 (Recommended)	2
Improvement Plan		Two-way, 2-lane new road.  No. 360 New road	Two-way, 4-lane new road  No. 360 New road
	Construction Cost	10.7	23.9
Project Cost (Million Baht)	Land Acq. Cost	13.4	37.1
	Total	24.1	61.0
	Maintenance Cost per annum	0.5	1.1
Construction Period		1 year	1.5 year
Improvement Effect (Morning peak)		Saturation degree 1.062 → 0.684 Max. Queue length (SB) 120 m → 20 m Max. Stopped delay (SB) 2 min. 30 sec. → 25 sec.	Saturation degree 1.062 → 0.767 Max. Queue length (SB) 120 m → 20 m Max. Stopped delay (SB) 2 min. 30 sec. → 25 sec.
	Major Constraints	Existing dead end road is too narrow. A bridge & land acquisition is required.	Large land acquisition and a skew bridge at Khlong is required.
Evaluation		Small land acquisition. New road has only small allowance for traffic increase.	Enough capacity for future traffic increase. Large land acquisition & a skew bridge.

## 5.8 Sukhumvit/Rama IV Rd., No.131

### (1) General description (Figure 5.8.1)

This intersection consists of two three-leg intersections, namely Sukhumvit/Rama IV (No.131) and Sukhumvit/ Soi 71 (No.132). They are 220 m apart from each other.

The intersections are located in the commercial area. All along the Sukhumvit Rd. and Soi 71, shop houses and other commercial buildings are located.

### (2) Traffic flow (Figure 5.8.2)

Existing traffic flow in the morning peak hour is illustrated in Figure 5.8.2. Major flow is east-west direction in Sukhumvit Rd. But traffics from/to Soi 71 are 800 - 900 PCU/hr, not so small. The traffic from Sukhumvit Rd. to Rama IV Rd. shows the biggest turning movement of 1,441 PCU/hr. The longest queue was recorded in Sukhumvit Rd. west bound, namely 650 m from 7:30 to 8:30 (Figure 5.7.3) at the Soi 71 intersection. The queue continued beyond the Phrakanong bridge. The second longest queue was at Soi 71, 500 m from 7:00 to 8:30. The Soi 71 intersection has longer queues than those at the Rama IV intersection.

### (3) Constraints (Figure 5.8.1)

- Distance between the two intersections is only 220 m.
- If the two intersections are to be made into one by constructing a new road, the proposed construction site to the south of Sukhumvit Rd. is already densely built-up. The north side of Sukhumvit Rd. has some open spaces and parking areas, affecting existing buildings less than that in the south.
- Distance from the Soi 71 intersection to the east Prakanong bridge approach is only 240 m. If a flyover is to be constructed, the approach length should be checked.
- There are two pedestrian bridges on Sukhumvit Rd. As there are many pedestrians, they should be preserved.

### (4) Degree of congestion (existing)

The existing conditions are summarized in Table 5.8.1.

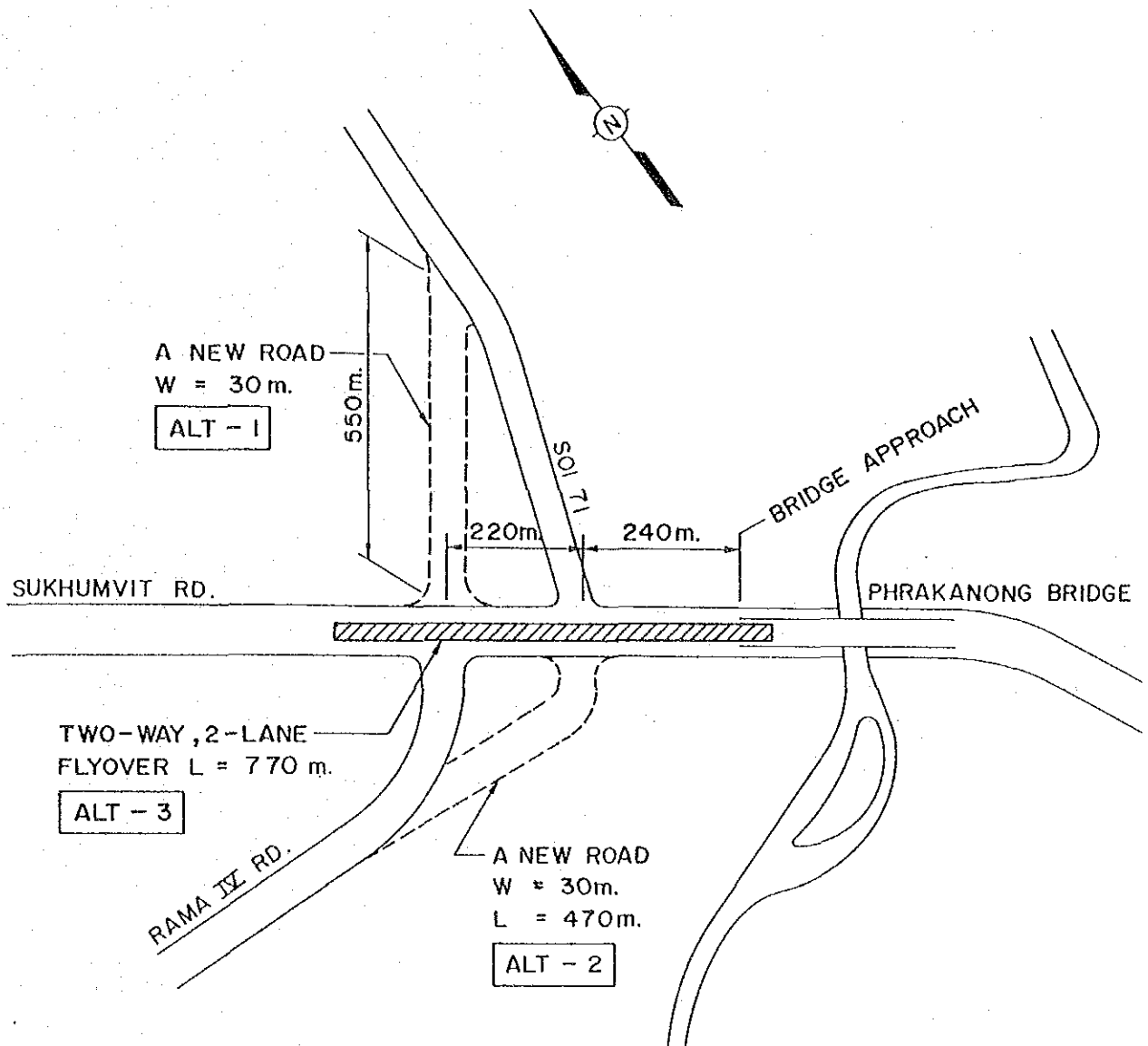


Figure 5.8.1 Improvement Alternatives



Figure 5.8.2 No. 131  
Traffic Volume at Sukhumvit Rd./Rama IV Rd.

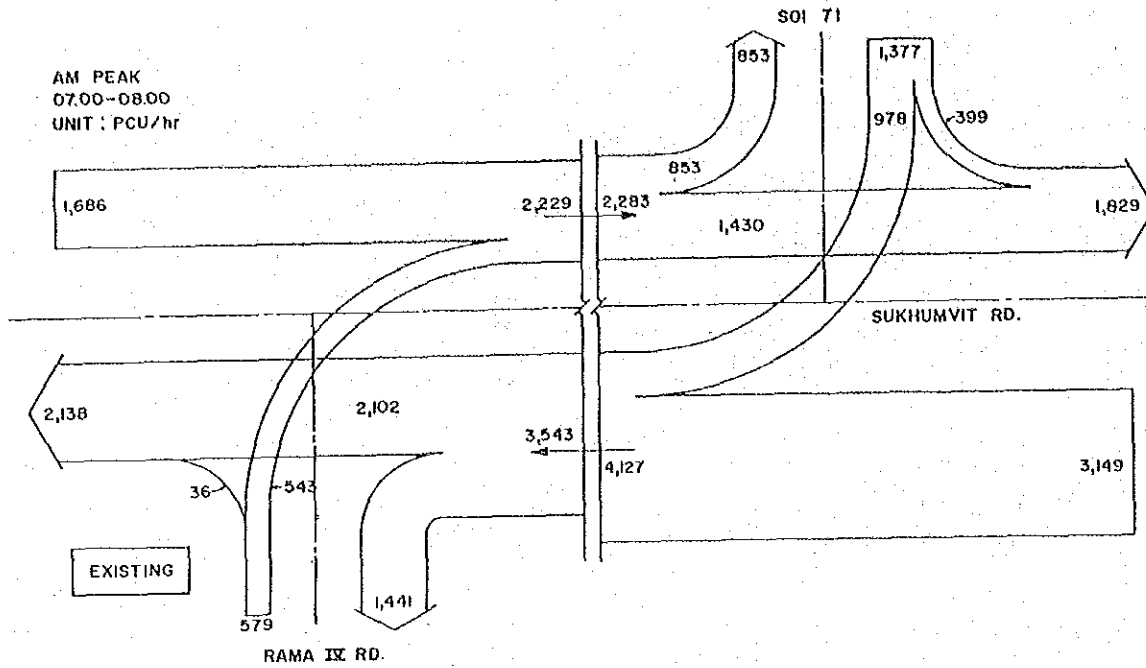


Figure 5.8.3 No. 132  
Sukhumvit/Rama IV Road.  
Queue Length (A.M. Peak)

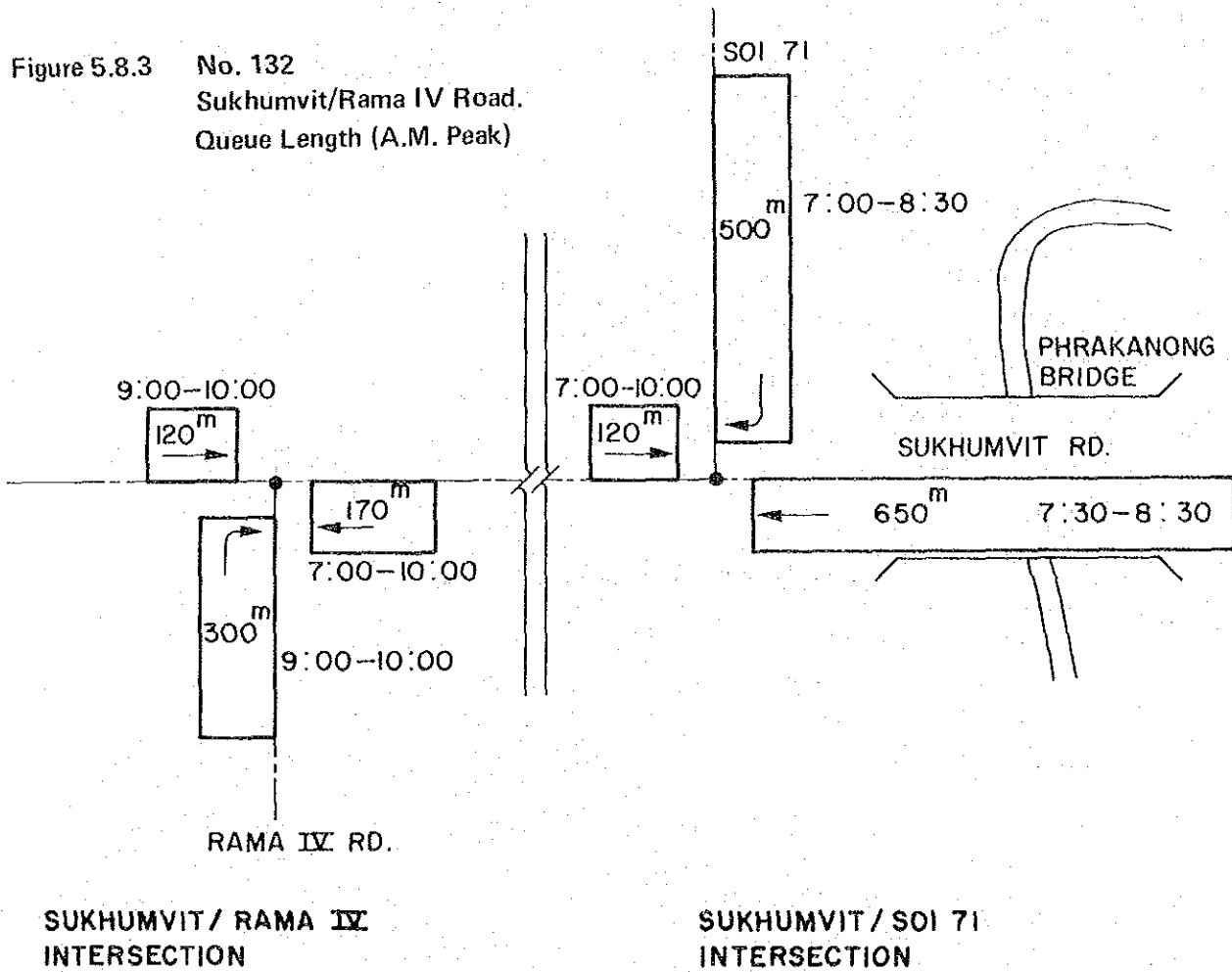


Table 5.8.1 Existing Condition of Intersection

Item	Characteristics (Morning peak only)	
	Sukhumvit/Rama IV	Sukhumvit/Soi 71
1) Morning peak hour	7:30 - 8:30 3,271 PCU/hr in Sukhumvit, west bound	7:00 - 8:00 3,149 PCU/hr in Sukhumvit, west bound
2) Saturation degree of intersection	0.909	1.062
3) Queue length	300 m between 9:00 - 10:00, north bound, right turn	650 m between 7:30 - 8:30, west bound, straight
4) Stopped delay	-	5 min. 40 sec.
5) Cycle length	271 sec. (regular)	188 sec. (regular)

Both the saturation degree and the queue length at the Sukhumvit/Soi 71 intersection is larger than those of Sukhumvit/Rama IV one. The former has the saturation degree of 1.062. It should be improved together with the latter one because the two are 220 m apart only.

(5) Cycle time analysis

- Green time allocation at both the intersections is properly arranged.
- Cycle time at the Sukhumvit/Rama IV intersection is relatively long (271 sec.) but acceptable.

(6) Alternative improvement planning

1) Temporary improvement before planning

At this intersection, followings are compared for planning.

- a. New road construction to make the two intersections into one.
- b. A flyover along Sukhumvit Rd.

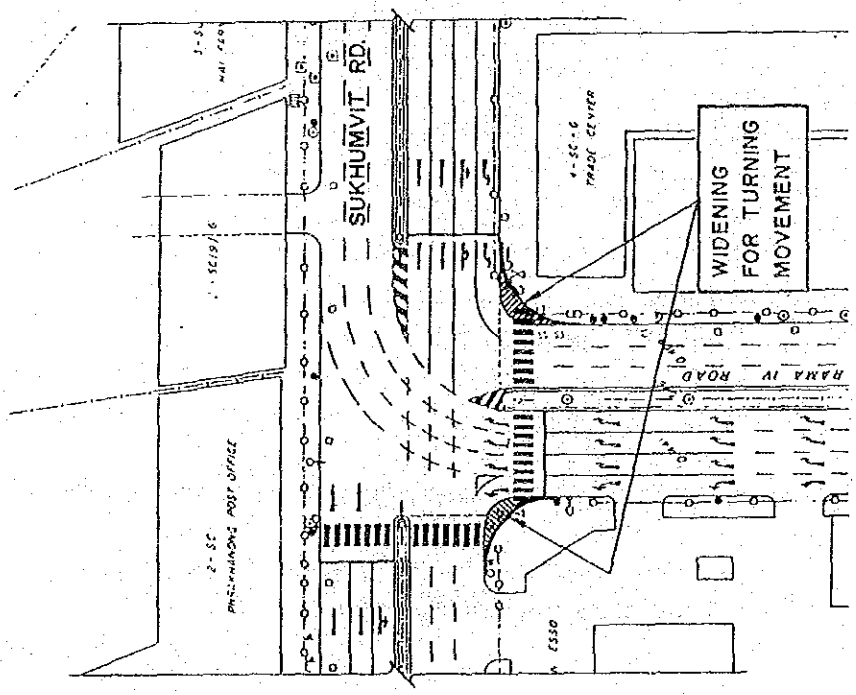
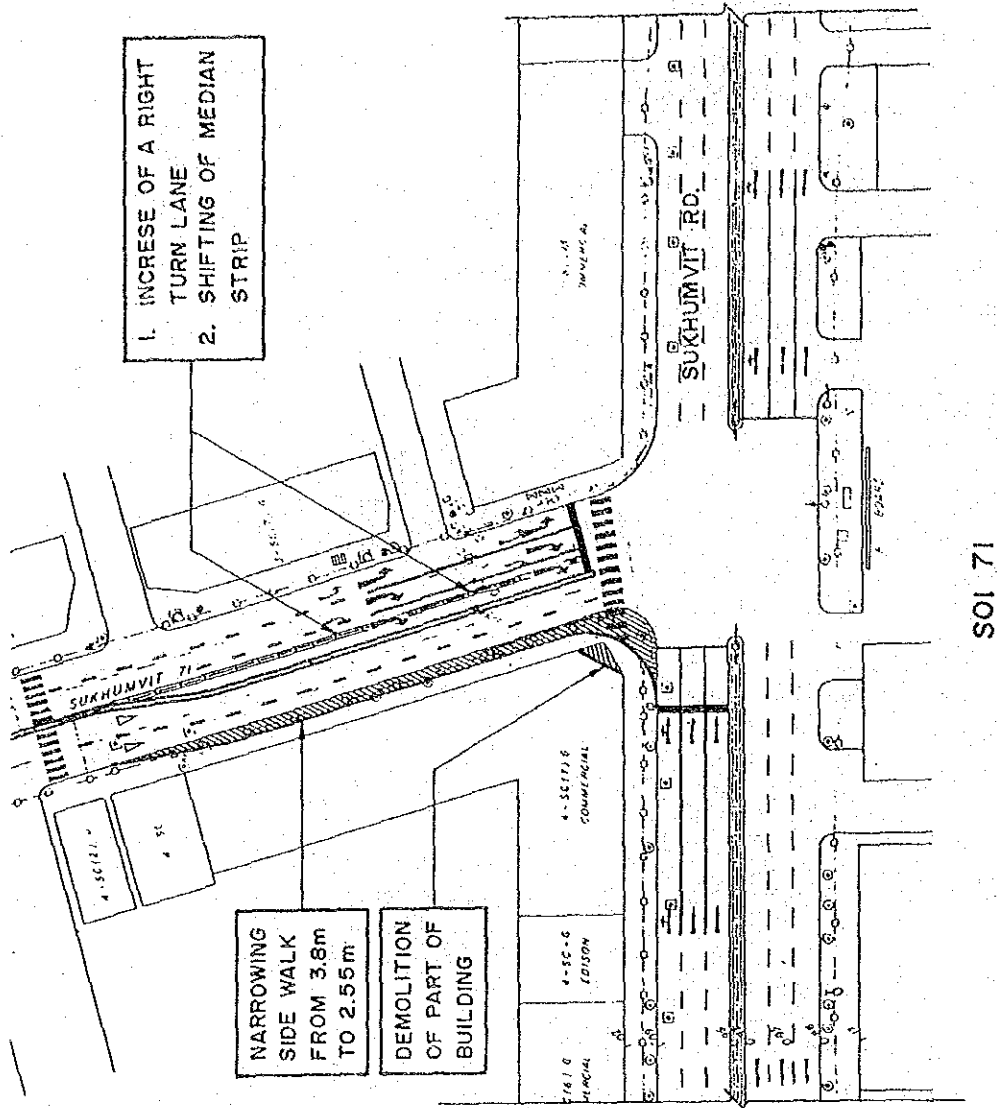


Figure 5.8.4 Temporary Improvement

RAMA IV

But the implementation of the two takes time in terms of land acquisition (in the case of a) and the large construction cost (in the case of b).

To avoid the delay, a fast and least-cost temporary improvement plan was made as follows.

- Temporary improvement at Soi 71 (Figure 5.8.4).  
It is proposed that the existing right turn lane should be increased from one to two lanes for accommodating the large turning movement of 978 PCU/hr. For the increase, the west sidewalk width should be decreased from existing 3.8 m to 2.55 m.
- Temporary improvement at Rama IV (Figure 5.8.4).  
The existing two left turns from Rama IV to Sukhumvit and from Sukhumvit to Rama IV have a turning radius of about 5 m, too small. It is proposed that the radii should be enlarged to 10 m as shown in the figure.

## 2) Alternative improvement planning (Figure 5.8.1)

Following three alternative plans are made for comparison.

Alternative 1 : A new road at Soi 71 side.

Alternative 2 : A new road at Rama IV side.

Alternative 3 : A flyover on Sukhumvit Rd. covering Rama IV and Soi 71 intersections.

## 3) Description of Alternative 1 (A new road)

The Alternative 1 intends to make the two intersections into one. The new road will be constructed to the north of Rama IV Rd. and constitutes a right-angle 4-leg intersection.

The proposed site is less built-up than that of Alternative 2 because there are more open spaces and parking areas. Soi 71 will be left as it is and be used for only left turns.

## 4) Alternative 2 (A new road at Rama IV side)

The Alternative 2 is to construct a new road at Rama IV side as shown in Figure 5.8.1. The proposed road is located behind Thai Daimaru department store and the site is densely built-up. The land acquisition will be much more difficult than Alternative 1.

## 5) Alternative 3 (A flyover)

- If a flyover is to be constructed, it will have to cover the two intersections because the two are 220 m apart only. If a flyover is constructed covering only one intersection, the approach road will come close to the other intersection within 20 m. It is too close to make weaving.
- The proposed flyover is 770 m long and the approach comes into the existing Phrakanong bridge approach.
- There are two pedestrian bridges on Sukhumvit Rd., one is between the two intersections, the other is between Soi 71 and the Phrakanong bridge. The two pedestrian bridges are preserved and the flyover is planned to cross over them with required clearance.

## (7) Effects of improvement (Figure 5.8.5)

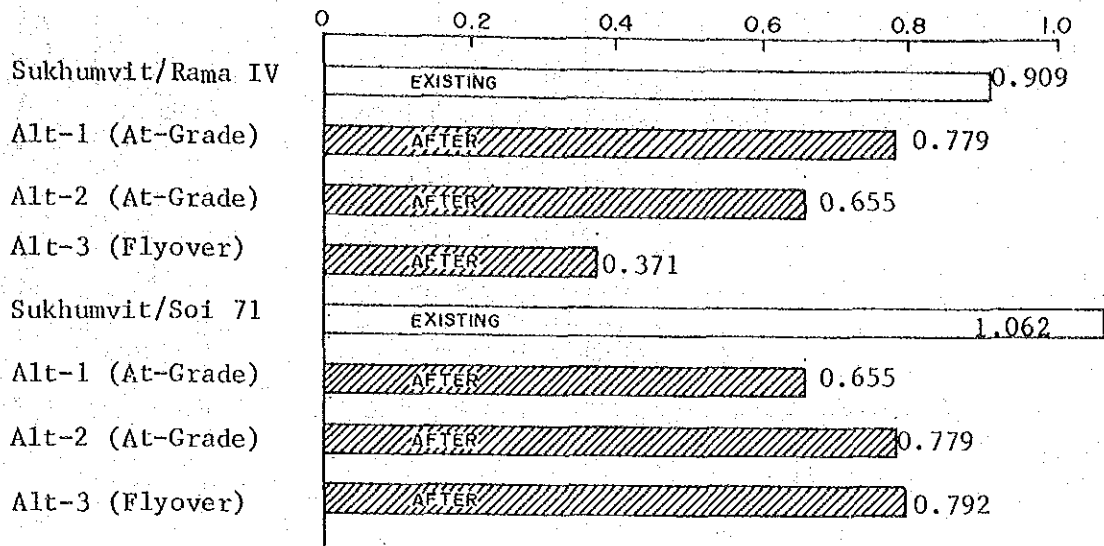
### 1) Traffic flow

- Alt-1 and Alt-2 (At-grade improvement)  
In Alt-1, a new 4-leg intersection will be located at Rama IV intersection, while in Alt-2m at Soi 71, respectively.  
The traffic flow of Alt-1 is shown in Figure 5.8.6 In Alt-1, the traffics from/to Soi 71 will be diverted to the new intersection at Rama IV.
- Alt-3 (flyover)  
If the flyover is constructed, it will have the following traffic volumes (estimated for morning peak hour only).  
East bound : 1,000 PCU/hr  
West bound : 1,600 PCU/hr  
As the flyover has two-way, 2-lane, the existing traffic volume can be accommodated but there is no allowance for future traffic increase.

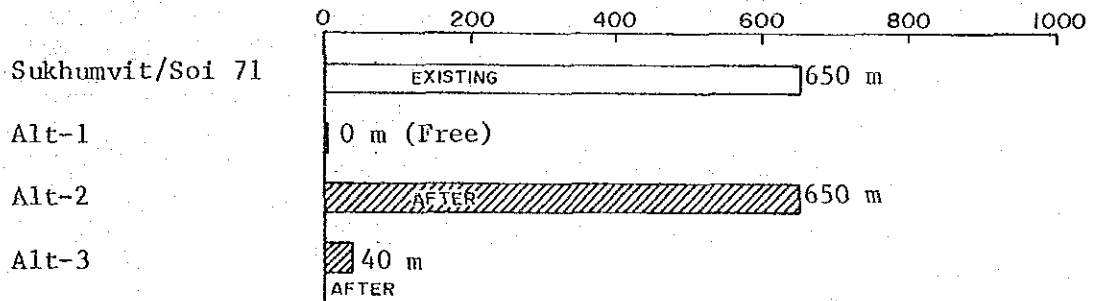
### 2) Saturation degree of intersection

- Alt-1 and Alt-2  
In Alt-1, the saturation degree of the Soi 71 intersection will decrease from the existing 1.062 to 0.655. That of Rama IV intersection will decrease from the existing 0.909 to 0.779. Alt-2 will give almost the same results, but the figures should be

1. Saturation Degree of Intersection



2. Queue Length (m) - West bound of Rama IV at Soi 71



3. Stopped Delay (Second/vehicle) - West bound of Rama IV at Soi 71

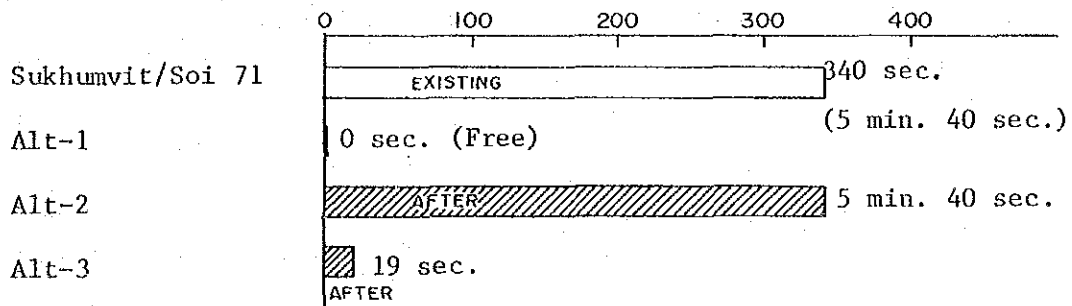


Figure 5.8.5 Improvement Effects  
Intersection: No. 131 Sukhumvit/Rama IV Rd. (Morning Peak)

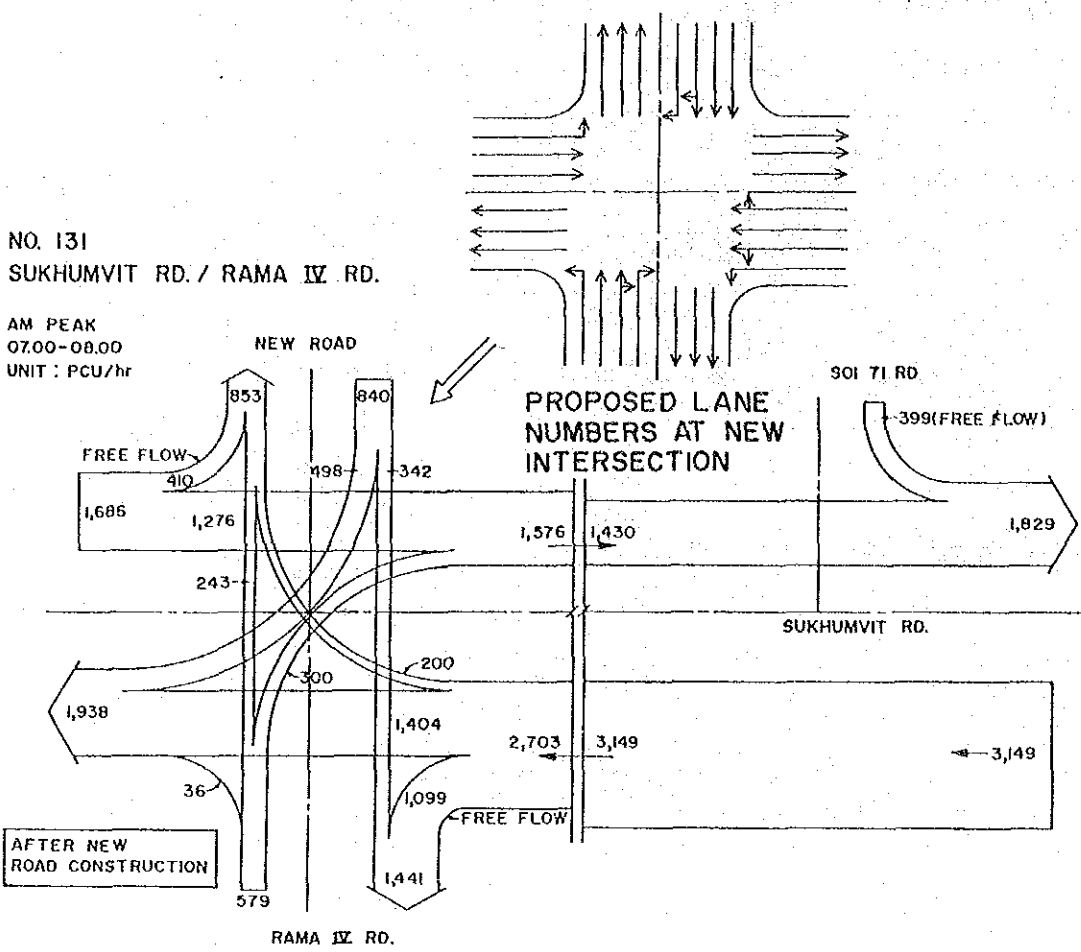

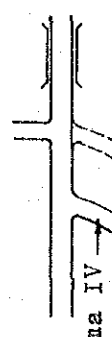
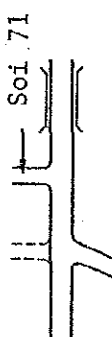


Figure 5.8.6 Estimated Traffic Volume of Alt - 1

Table 5.8.2 Comparison of Alternative Plans

Intersection : Sukhumvit/Rama IV (No. 131)

Alternatives		1	2	3 (Recommended)
Improvement Plan	A new road at Soi 71 side		A new road at Rama IV side	
	A new road at Rama IV side			Two-way, 2-lane flyover above two intersections
Project Cost (Million Baht)	Construction Cost	12.5	11.2	70.4
	Land Acq. Cost	90.1	116.9	-
	Total	102.6	128.1	70.4
	Maintenance Cost per annum	2.1	2.0	1.5
Construction Period	1 year	1 year	1.5 year	
Improvement Effect (Morning peak)	Saturation degree			
	Rama IV : 0.909 → 0.779 Soi 71 : 1.062 → 0.655 Max. Stopped delay Rama IV(NB): 15 min. → 64 sec. Soi 71 (WB): 5 min. 40 sec. → 0 sec.		Saturation degree Rama IV : 0.909 → 0.655 Soi 71 : 1.062 → 0.779 Max. Stopped delay Rama IV(NB): 15 min. → 64 sec. Soi 71 (WB): 5 min. 40 sec. → unchanged.	Saturation degree Rama IV : 0.909 → 0.371 Soi 71 : 1.062 → 0.792 Max. Stopped delay Rama IV(NB): 15 min. → 40 sec. Soi 71 (WB): 5 min. 40 sec. → 19 sec.
Major Constraints	550 m in length of land acquisition is required.	470 m in length of land acquisition is required in dense commercial area.	Flyover enters into bridge. Bridge has only 4-lane. Pedestrian bridges preserved	
Advantage/ Disadvantage	Improvement effect is bigger and land acquisition is easier than Alt-2.	Improvement effect is smaller and land acquisition is larger than Alt-1.	No land acquisition. The smallest total cost. No allowance for traffic increase.	



exchanged between Soi 71 and Rama IV.

- Alt-3

By constructing a flyover, the saturation degree of Soi 71 will decrease to 0.792 and that of Rama IV to 0.371.

3) Queue length

- Alt-1 and Alt-2

The existing max. queue length of 650 m (west bound at Soi 71) will decrease to 0 m (free) in Alt-1 and 650 m (unchanged) in Alt-2.

- Alt-3

If a flyover is constructed, the queue length will decrease to 36 m.

4) Stopped delay

Existing max. stopped delay of west bound at Soi 71 is 5 min. 40 sec. It will decrease to 0 sec. (free) in Alt-1 and 5 min. 40 sec. (unchanged) in Alt-2, and 19 sec. in Alt-3, respectively.

(8) Selection of an Alternative

Comparison of three alternatives is shown in Table 5.8.2.

Project cost of Alt-3 (70 Mil. Baht) is much lower than other Alt-1 (102 Mil. B.) and Alt-2 (128 Mil. B.). The saturation ratio, queue length and stopped delay are also decreased significantly.

Therefore, Alt-3 is selected for economic analysis.

(9) Economic analysis

The results of economic analysis about Alt-3 are shown in Table 5.8.3.

Table 5.8.3 Economic Analysis (in 10 years)

Item	Result
Initial Cost	70 Mil.B.
Cost in Present Value (C)	78 Mil.B.
Benefit in Present Value (B)	176 Mil.B.
Net Benefit (B-C)	98 Mil.B.
B/C	2.26
IRR	0.207

The net benefit is reasonable, the B/C is 2.26 and the IRR is 0.207 in 10 years. Therefore, Alt-3 is considered to be good for future execution.

## 5.9 Petburi/Ramkhamhaeng Rd., No.245

### (1) General description (Figure 5.9.1)

This intersection has four legs and forms skew angles. The shape looks a little irregular. It is one of the most important intersections which accommodate heavy traffics from/to the eastern district of Bangkok, called Bang Kapi and Phrakanong.

### New road projects

In the vicinity of the intersection, BMA and ETA have new road construction projects for two missing links called Samsen Khlong-side road and Ekkamai extension road. The former is under construction by BMA to connect between Middle Ring road and Ramkhamhaeng road in parallel to Petburi road. The latter is being planned by ETA to extend Ekkamai road northward up to Ram Indra road with a crossing at Lat Phrao road. These new roads are designed as dual six-lane standard and expected to reduce the traffic volume coming into the intersection.

### (2) Traffic flow (Figure 5.9.2)

Major traffic flows are a right-turn from Ramkhamhaeng road (1,124 PCU/hr) and a left-turn from Petburi to Ramkhamhaeng road (1,185 PCU/hr) in the morning peak hour of 8:00 - 9:00. Through traffics are smaller than those turning ones.

The queue length is the longest in the west bound, 800 m during 7:00 - 8:30.

### (3) Constraints (Figure 5.9.1)

#### 1) Skewed alignment

The intersection has four legs and forms skewed alignment, that makes the improvement plan of the intersection difficult.

#### 2) Frontage

Frontages are densely built up with rows of shophouses except at the northeast corner of the intersection where open space exists in the premises of a used car dealer.

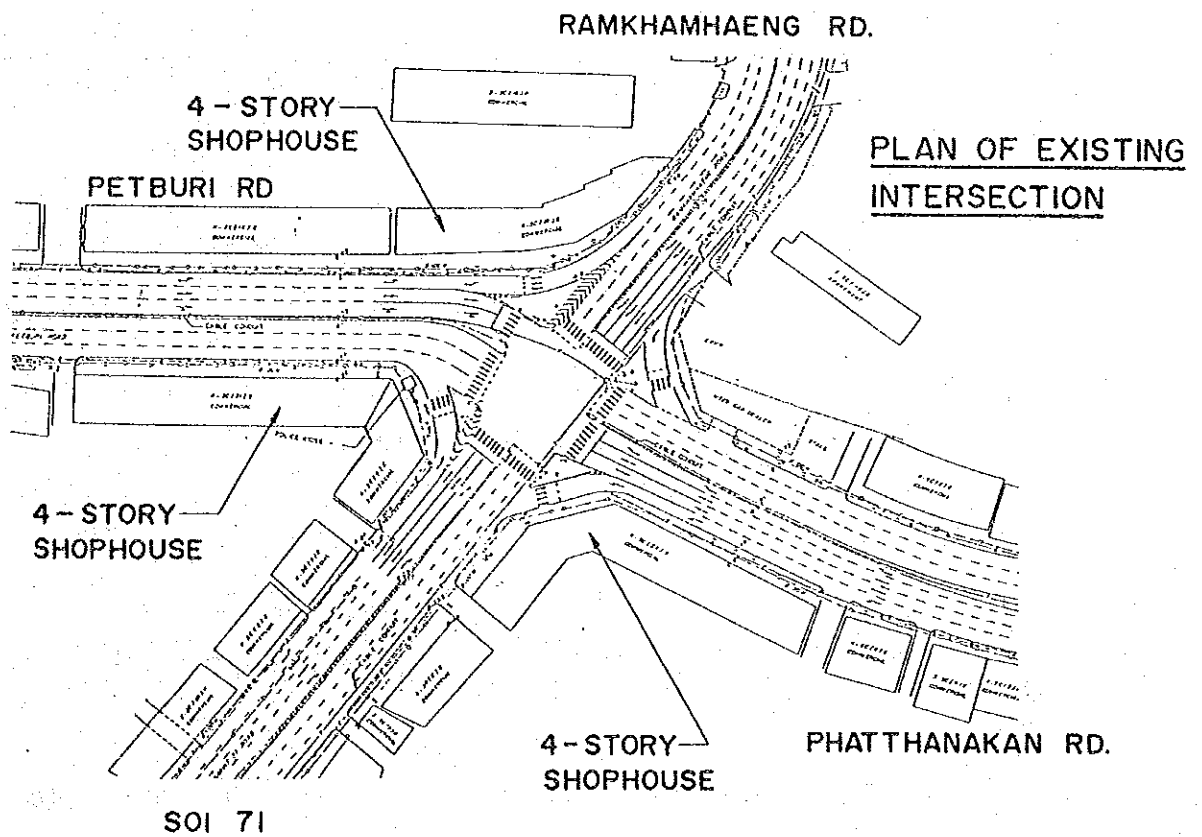
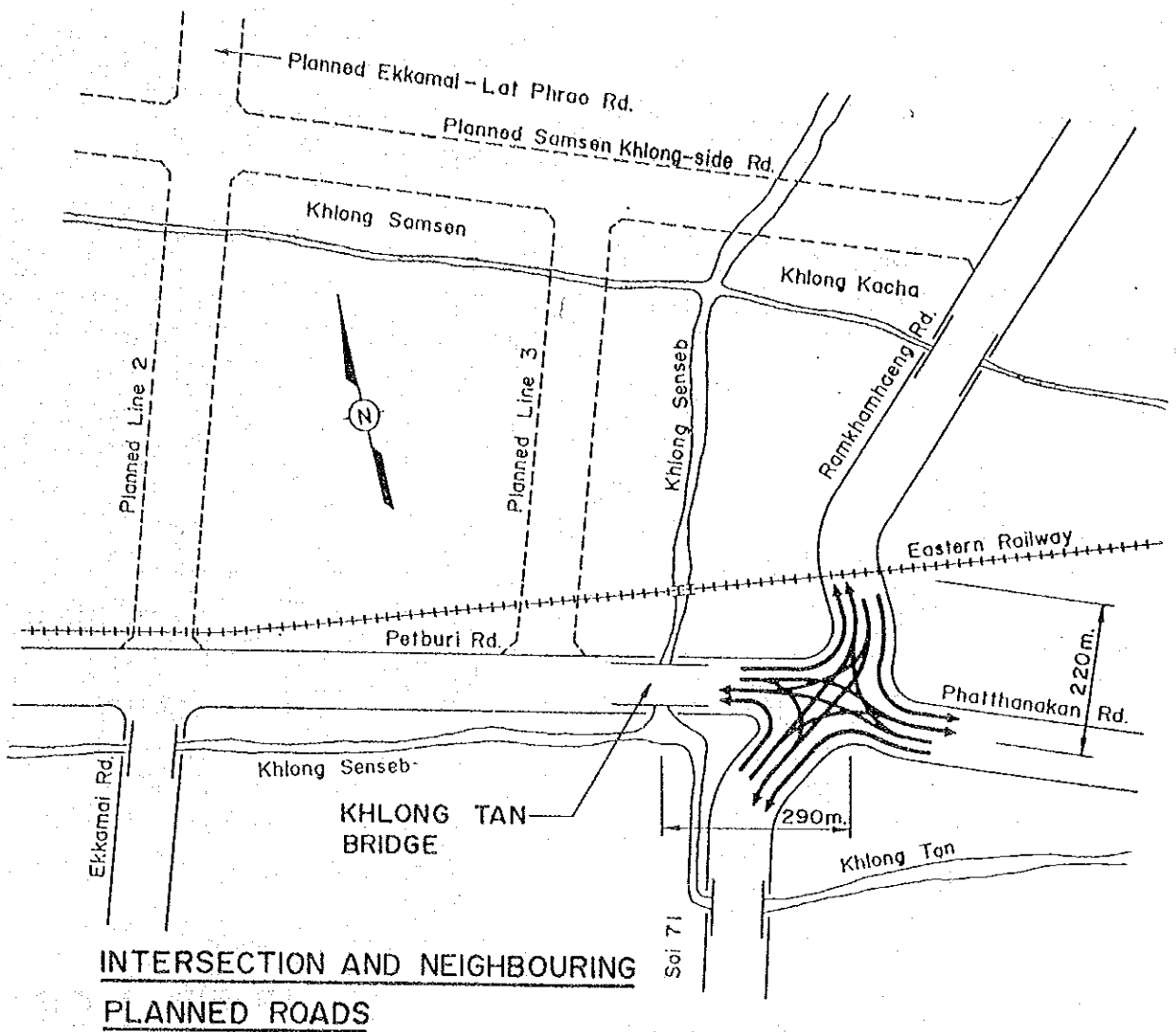
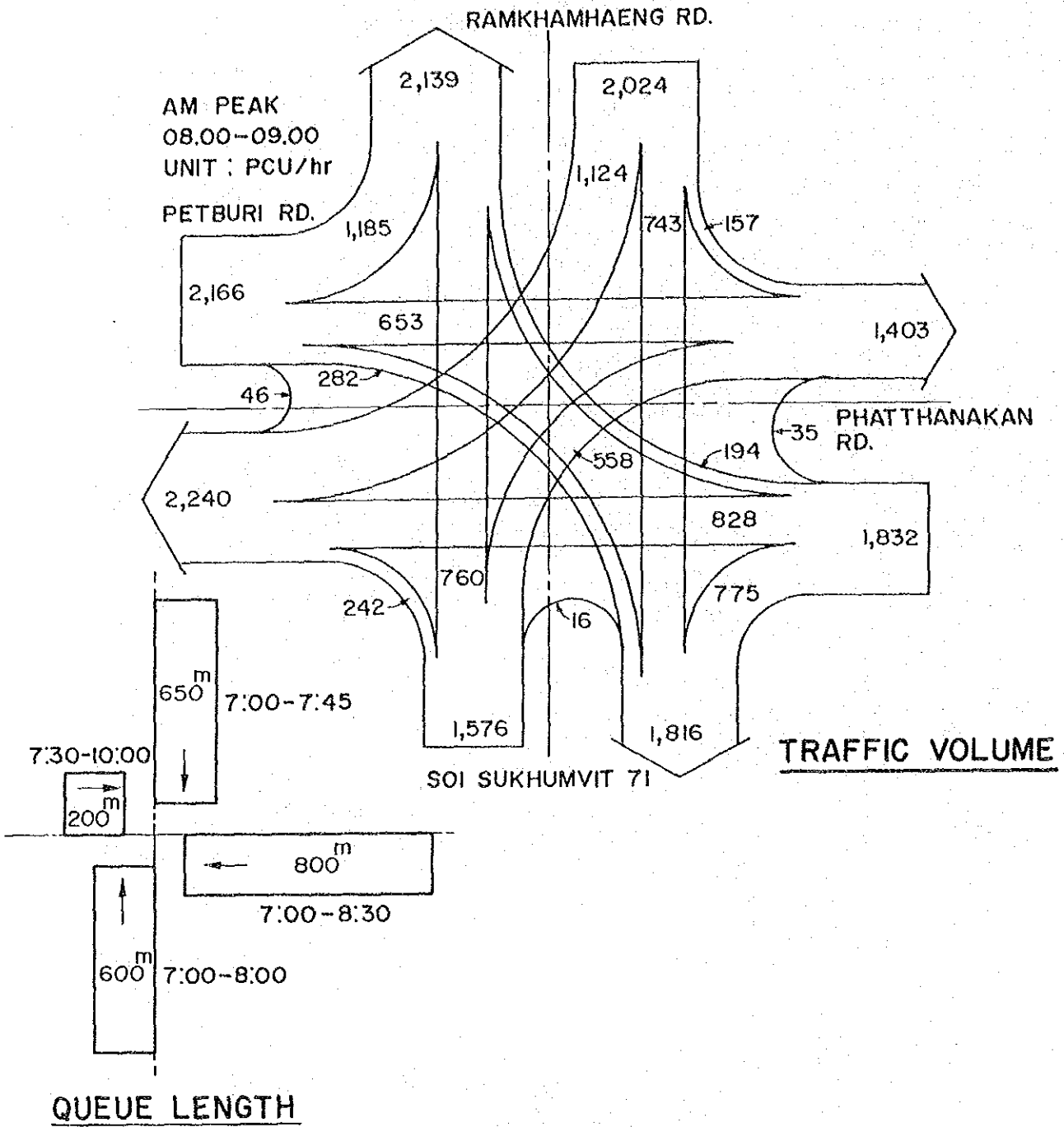


Figure 5.9.1 Petburi/Ramkhamhaeng Rd. Intersection

Traffic Volume at Petburi/Ramkhamhaeng Rd.



EXISTING SIGNAL PHASE

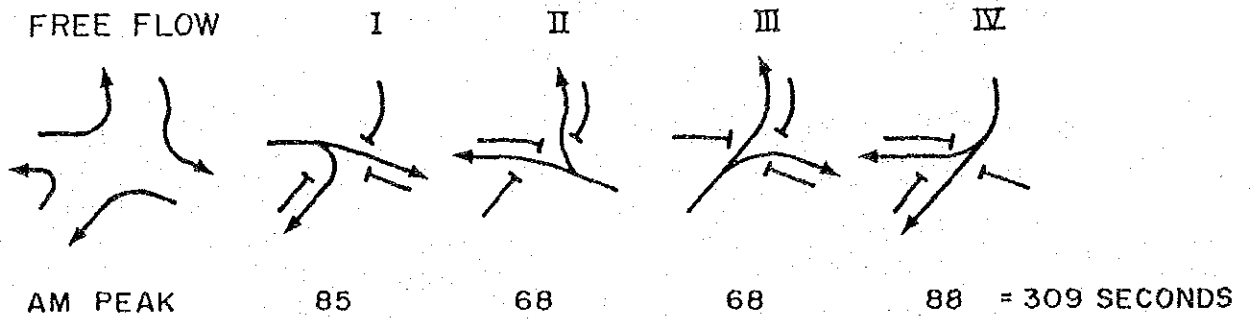


Figure 5.9.2 Petburi/Ramkhamhaeng Rd. Intersection

3) Khlong Tan bridge

The Khong Tan bridge is located over Khlong Saensab on Petburi road 290 m westward from the intersection. The bridge has only four lanes, while Petburi road normally six lanes.

4) Eastern railway

Eastern railway crosses the Ramkhamhaeng Rd. to 200 m north of the intersection.

(4) Degree of Congestion (Existing)

Existing conditions of the intersection are summarized in Table 5.9.1.

Saturation degree of the intersection is 1.198. If Sam Saen Canal-side road is completed, the traffic volume into the intersection will be reduced by about 25%. When the volume is reduced, the saturation degree of the intersection will become 0.924, still too high. Therefore, the improvement of the intersection is required.

Table 5.9.1 Existing Condition of Intersection  
(Morning peak hour only)

Item	Characteristics
1) Morning peak hour Max. Traffic	08:00 - 09:00 1,185 PCU/hr, left-turn from Petburi to Ramkham- haeng Rd.
2) Saturation degree of intersection	1.198
3) Max. Queue length	800m, 07:00 - 08:30, west bound
4) Max. Stopped delay	12 min. 40 sec., west bound
5) Cycle length	306 sec. (regular)

(5) Cycle time analysis

- Green time allocation is unbalanced. East and south bounds are given 85 sec. and 88 sec., respectively. They are too long comparing with their saturation ratios. The reason is maybe both traffics are more than others, then more green times are allocated manually.

- Cycle length is long, 306 sec. If it is shortened, the queue length will become short, too.

## (6) Planning of improvement alternatives

### 1) Points of planning

#### Irregular right turn

The right turn traffic from Ramkhamhaeng Road, which is a major flow in the intersection, has to turn irregularly at the jutting nose of median on Petburi road. It reduces the capacity of the intersection.

#### Uneasy free left turn

Free flows are allowed in all four left turn lanes. However, three free flows, except the flow from Petburi Road to Ramkhamhaeng Road, are interfered by other incoming traffics. It is caused by inadequate channelization of the left turns.

#### Pedestrian crossing

There are many people using pedestrian crossings because of surrounding commercial areas. In particular, the people wishing to cross over the left turn lane at the north-western corner of the intersection are given very few crossing chances due to its heavy traffic volume.

#### Insufficient right turn lanes

There is large traffic volume of right-turns at Ramkhamhaeng and Soi 71. Their numbers of lanes are not enough.

### 2) Planning of improvement alternatives

Taking into account the points mentioned above, the following improvement alternatives are made:

Alternative 1 : At-grade improvement with road widening.

Alternative 2 : A flyover with minimum road widening.

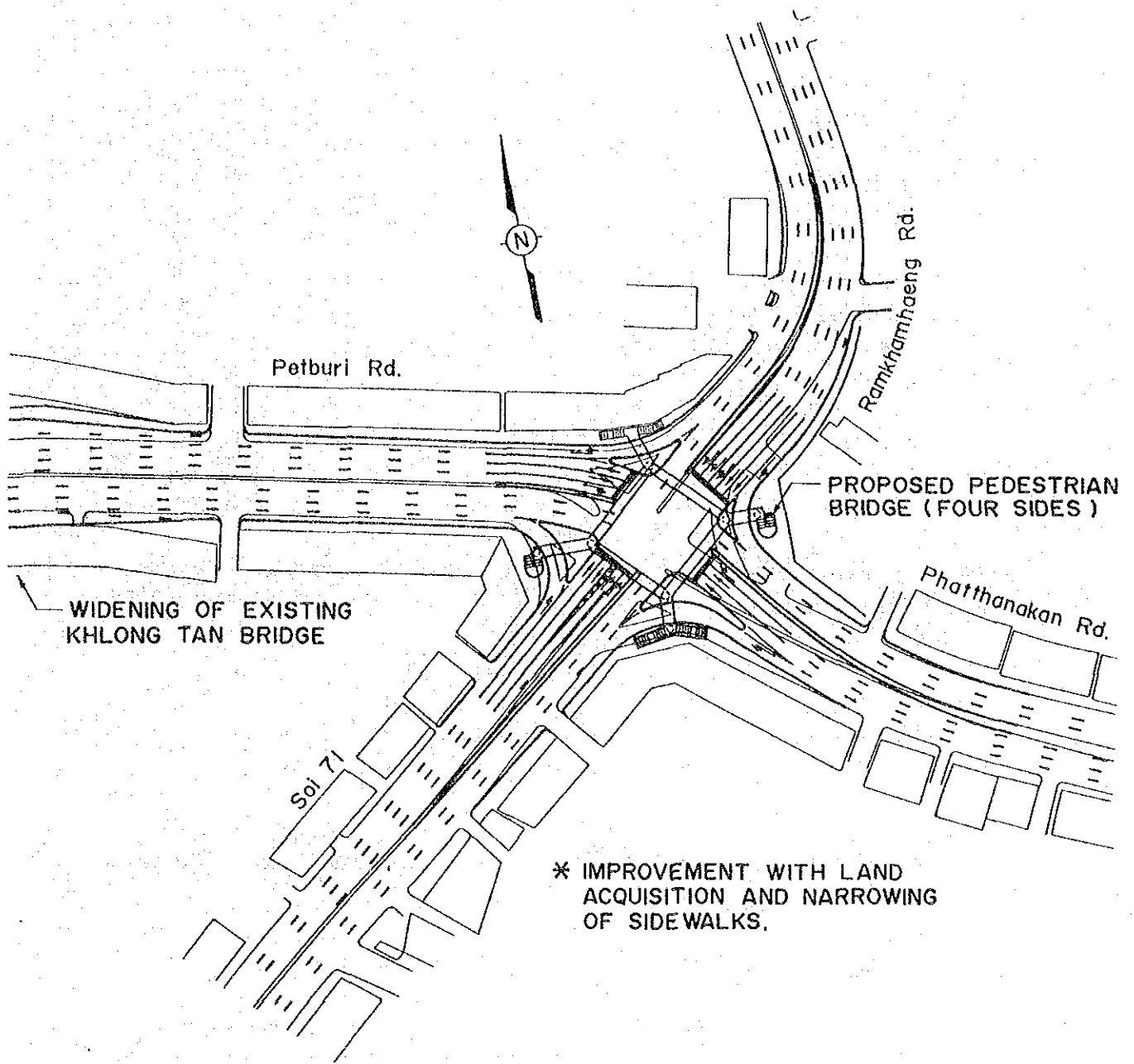
### 3) Description of Alternative 1 (Figure 5.9.3)

This is an at-grade improvement plan to increase the intersection capacity.

Major improvement items are as follows.

- Phatthanakan Rd.

The approach is shifted to the north to make the smooth traffic flow.



**PROPOSED SIGNAL PHASE**

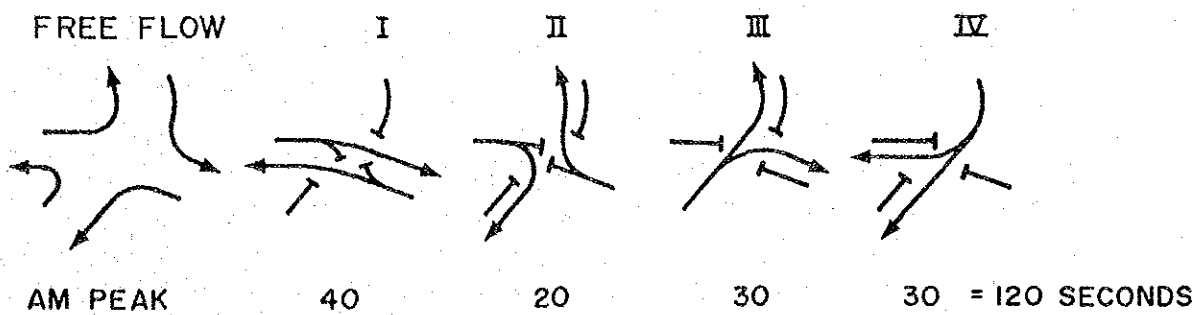


Figure 5.9.3 Petburi/Ramkhamhaeng Rd. Intersection, Improvement Alternative 1 (At-Grade)



- Right-turn lanes  
Number of right-turn lanes are increased for the most congested two locations. Ramkhamhaeng approaches are increased from existing 2-lane to 3-lane.  
Soi 71 is also increased from existing 1-lane to 2-lane.
- East bound on Petburi Rd.  
The number of through lane is increased from existing 1-lane to 2-lane considering evening heavy outbound flow.
- Traffic islands  
The traffic islands are shifted and their shapes are revised to provide smooth free left-turns.
- New pedestrian bridges  
New pedestrian bridges are provided to protect the pedestrians and to enable the intersection at its full capacity. They will surround the intersection by four sides.
- Bridge widening  
The Khlong Tan bridge is widened from existing 4-lane to 6-lane to make the number of lanes the same as the intersection.
- Land acquisition  
Land acquisition and narrowing of sidewalks are required to increase the number of lanes as shown in Figure 5.9.3.

#### 4) Description of Alternative 2 (Figure 5.9.4 and 5.9.5)

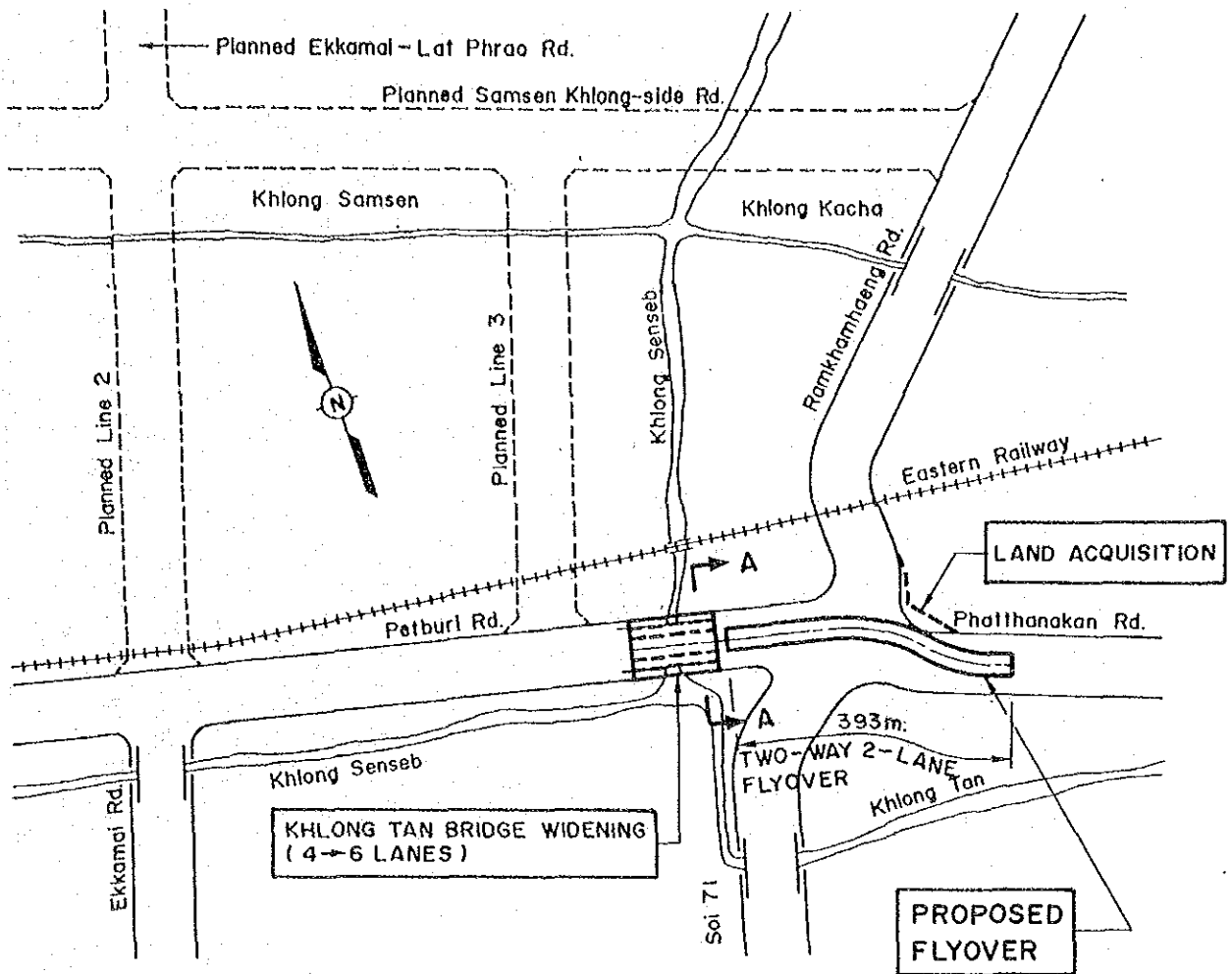
This alternative is a grade separation by constructing a two-way 2 lane flyover in the east-west direction to increase the capacity of the intersection.

##### Direction of flyover

There are three options, considering the direction of the flyover.

- a) East-west, two-way, 2-lane
- b) North-west (largest traffic volume direction)
- c) North-south, two-way, 2-lane

In the case of b), the flyover has to have a horizontal radius of 80 m due to the curved Ramkhamhaeng Rd. It is too small to adopt for the curved flyover structure.



**CROSS SECTION A - A**

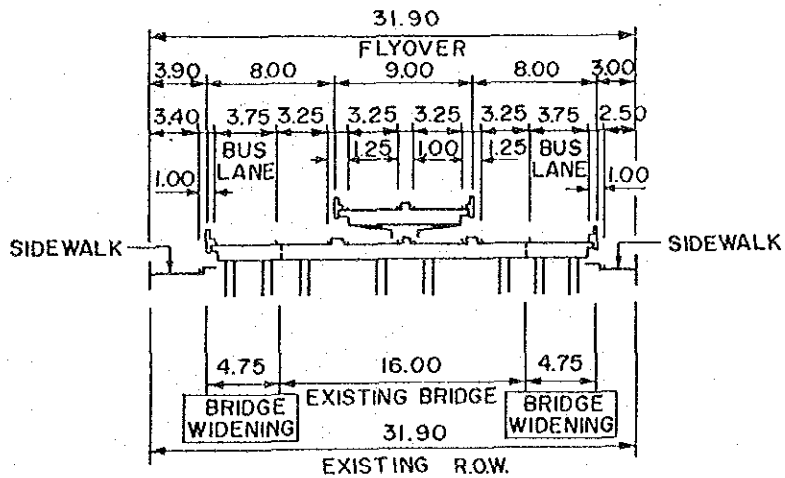


Figure 5.9.4 Petburi/Ramkhumhaeng Rd. Intersection, Alternative 2

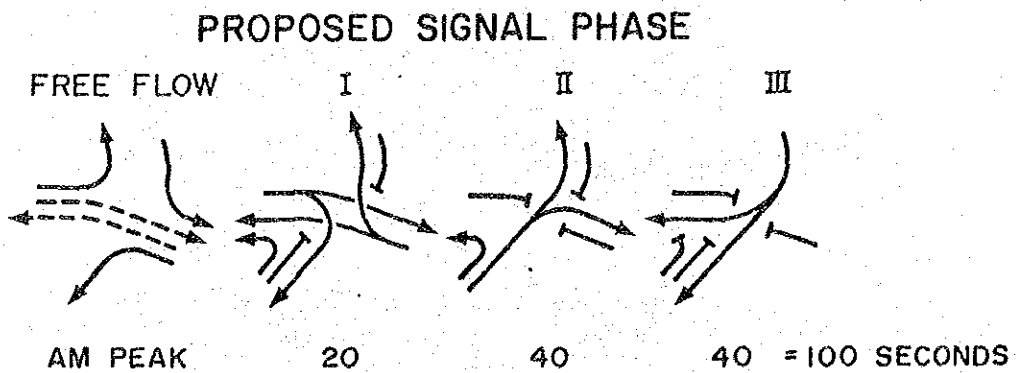
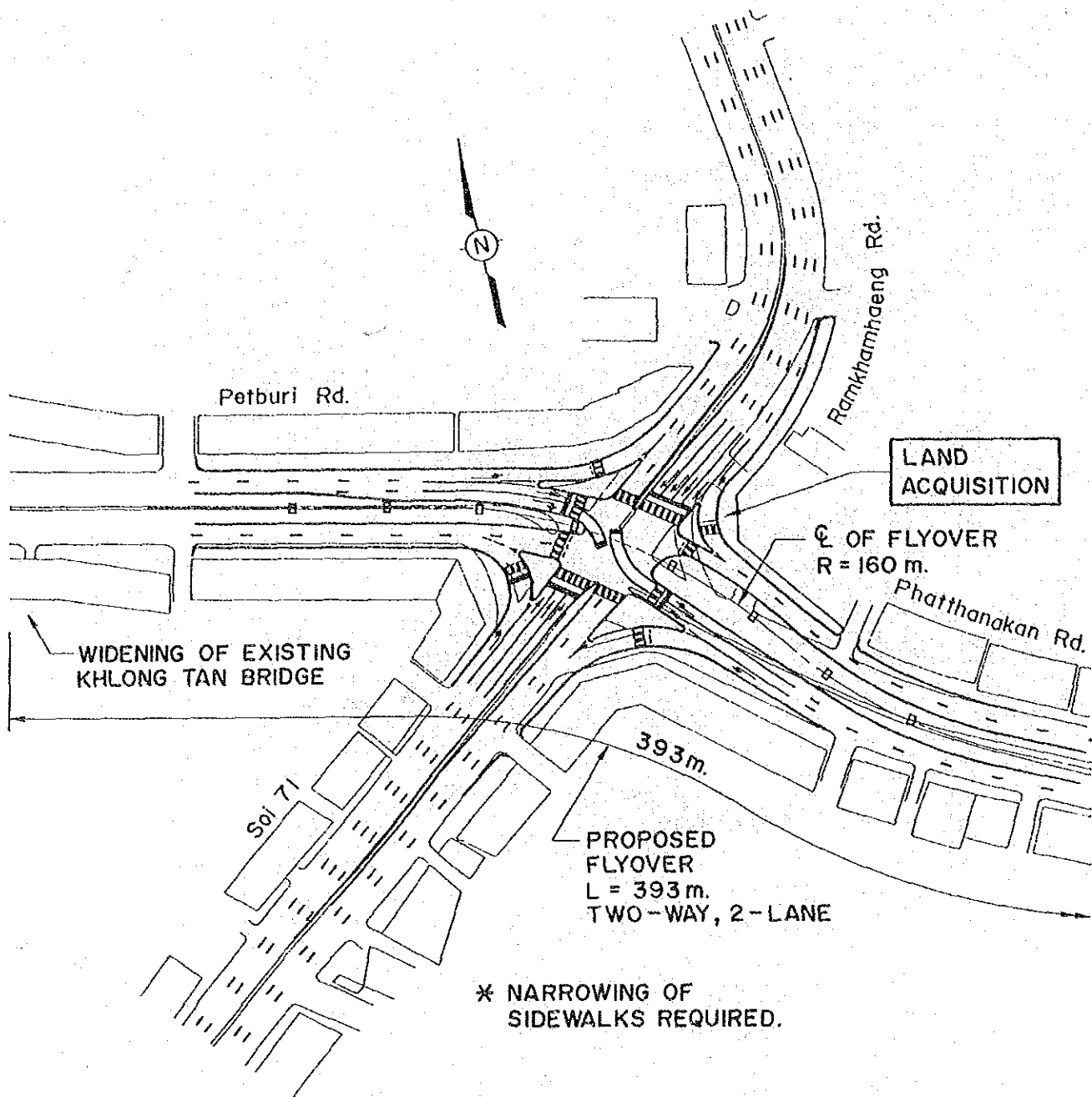


Figure 5.9.5 Petburi/Ramkhamhaeng Rd. Intersection, Alternative 2 (Flyover)

In the case of c), the northern approach on Ramkhamhaeng Rd. needs to cross over the Eastern Railway line because the railway is located only 220 m apart from the intersection. (Figure 5.9.1)

Therefore, the options of b) and c) are discarded. The option a), a flyover in east-west direction, is selected as alternative 2.

#### Curved flyover

As the east-west leg of the intersection forms a skew angle, the flyover has to have a curve. The design speed is 60 km/hr and its minimum radius is 150 m. Therefore, the horizontal curvature of the flyover is set to be 160 m.

#### Khlong Tan bridge widening

The widening of the existing Khlong Tan Bridge from 4-lane to 6-lane is indispensable for this grade separation plan. Because the western end of planned flyover approach comes close to the existing bridge, and there would be not enough space remaining on the ground-level roads adjacent to the the flyover structure. It needs minimum two lanes beside the flyover for catering the major turning traffic flow between Petburi and Ramkhamhaeng roads. The flyover construction without widening of the existing bridge will invite unavoidable traffic congestion into the intersection.

#### Land acquisition

A small scale land acquisition is necessary at the north-west corner of the intersection, where few building exists.

### (7) Effects of improvement

Improvement Effects are summarized in Figure 5.9.6

#### 1) Saturation degree of intersection

The saturation degree will decrease from existing 1.198 to 0.806 (Alt-1) and 0.813 (Alt-2), respectively. In spite of the flyover construction Alt-2 does not reduce the degree so much because the east-west flyover is not on the major traffic flow of north-west direction due to physical constraint mentioned before.

#### 2) Max. queue length and max. stopped delay

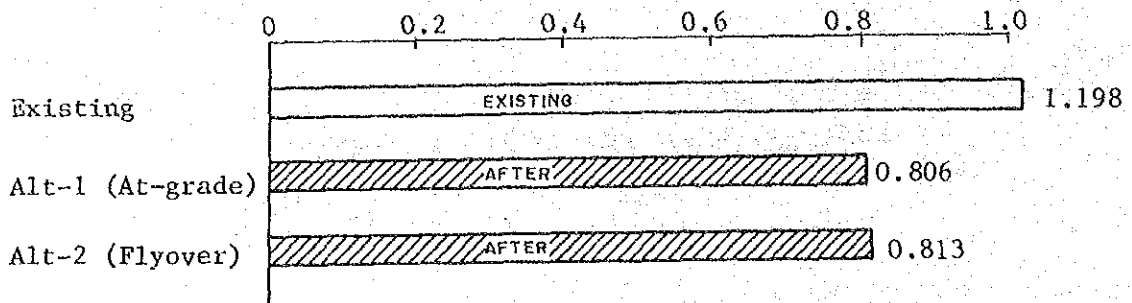
Those will be reduced to about 5% of the existing length in both alternatives. It is partly because the cycle length is reduced to one third of

Figure 5.9.6 Improvement Effects

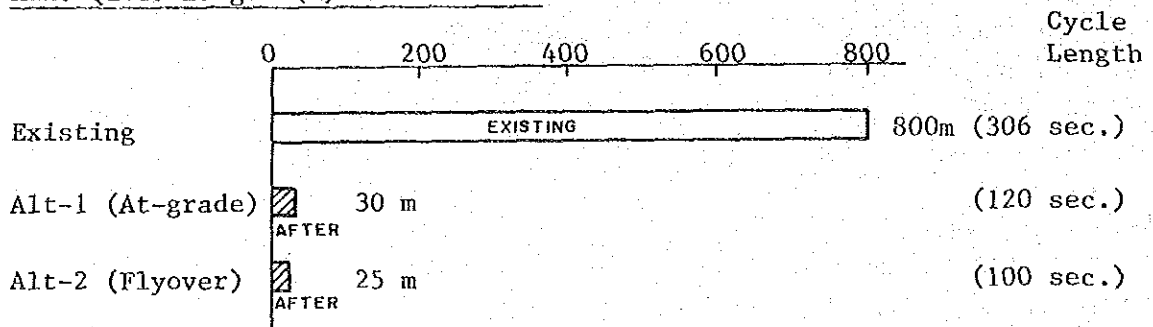
Intersection : Petburi/Ramkhamhaeng Rd. (No. 245)

(A.M. peak only)

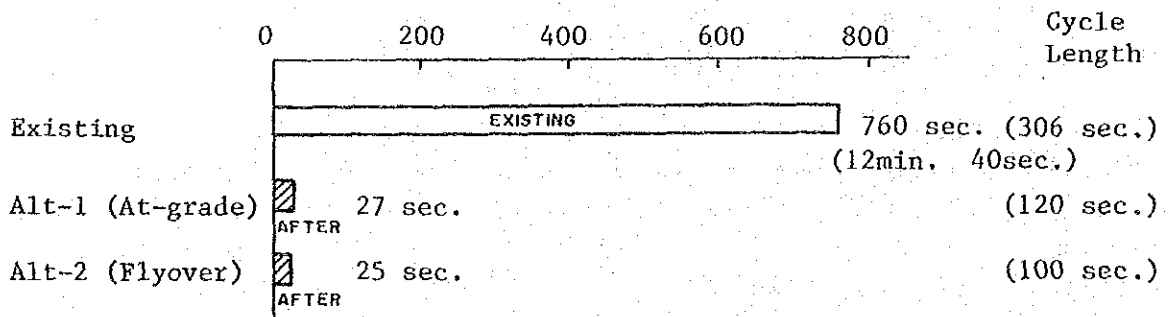
1. Saturation Degree of Intersection



2. Max. Queue Length (m) - west bound



3. Max. Stopped delay (second/vehicle) - west bound



the existing one.

#### (8) Selection of An Alternative

Comparison of the two alternatives are summarized in Table 5.9.2. Alt-1 is selected for the further economic analysis due to the following reasons.

##### Reasons of selection

#### 1) Cost and effect

Alt-1 is road widening but it can be made by narrowing sidewalk width. Therefore, its land acquisition cost is small.

Alt-2 is construction of a flyover. Its construction cost is 1.6 times of Alt-1. About the total cost, Alt-1 is only 63% of Alt-2. Improvement effects are almost the same between the two alternatives.

#### 2) Flexibility

Another important factor is flexibility for future change. As mentioned in (1) General description, three new road projects are going on near the intersection. Especially, one of them (Samsen Khlong-side road) is under construction.

When the road is completed, the traffic volume at the intersection is estimated to be reduced by 25%. The influence of the other two roads is also unknown including the starting time of the construction.

Considering the future possible change of the traffic volume, the improvement plan should be flexible for that, particularly against the decrease of the traffic volume.


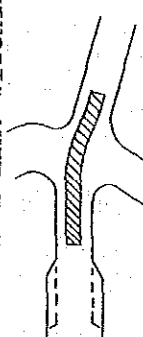
Alt-2 is construction of a flyover, a rigid structure. Furthermore, the flyover direction is not on the major traffic flow due to physical constraints. Therefore Alt-2 is considered not flexible for the future change.

#### 3) Selection

By comparison of the above costs and flexibility, Alt-1 (At-grade improvement) is selected for the economic analysis.

Table 5.9.2 Comparison of Alternative Plans

Intersection : Petburi/Ramkhamhaeng Rd. (No. 245)

Alternatives		1 (Recommended)	2
Improvement Plan		At-grade with widening 	Flyover with min. widening 
	Construction Cost	26.4	43.7
Project Cost (Million Baht)	Land Acq. Cost	4.1	4.5
	Total	30.5	48.2
	Maintenance Cost per annum	1.0	1.2
Construction Period		6 months	2 years
Improvement Effect (Morning peak)		Saturation degree 1.198 → 0.806 Max. Queue length (WB) 800m → 30m Max. Stopped delay (WB) 12min. 40sec. → 27sec.	Saturation degree 1.198 → 0.813 Max. Queue length (WB) 800m → 25m Max. Stopped delay (WB) 12min. 40sec. → 25sec.
	Major Constraints	Buildings are already built-up. Khlong Tan bridge has only 4-lane.	Buildings are already built-up. Khlong Tan bridge has only 4-lane.
Evaluation	Advantage/ Disadvantage	Large land acquisition. Pedestrian bridges required Flexible for future change	Small land acquisition. Construction cost is high. Not flexible for future change.

(9) Economic analysis

The results of the economic analysis about Alt-1 are shown in Table 5.9.3.

Table 5.9.3 Economic Analysis (in 10 years)

Item	Result
Initial Cost	30 Mil.B.
Cost in Present Value (C)	38 Mil.B.
Benefit in Present Value (B)	409 Mil.B.
Net Benefit (B-C)	372 Mil.B.
B/C	10.90
IRR	0.951

The net benefit is the second largest next to Rama IV/Si Phraya - Sathon flyover. The B/C and the IRR are the largest of all the 9 intersections.

Therefore, Alt-1 (Road widening) is recommended for future execution.



## 5.10 Rama IV/Kasemrat Rd., No.035

### (1) General description (Figure 5.10.1)

This intersection is located at Rama IV Rd. It consists of two neighboring intersections called Kasemrat Rd. and Soi Ari (or Soi 26). They are only 85 m apart each other. As vehicles often have to stop two times at each intersection, long queues are formed on Rama IV Rd.

### (2) Traffic flow (morning peak only)

Existing traffic volume is shown in Figure 5.10.2. Major flow is east-west direction amounting 1,500 - 3,400 PCU/hr. Traffic from Soi Ari and Kasemrat Rd. is relatively small, 600 - 1,000 PCU/hr.

Queue length of Rama IV Rd. east bound is the longest ranging 400 - 500 m during 8:30 - 9:30. The queue continues all along the west curved portion of Rama IV Rd. (Figure 5.10.3).

There are two other factors which will affect the traffic flow of the intersection.

Firstly, Middle Ring Rd., which is about 1 km to the west of the intersection, is under construction. It will have 6 lanes and connects Sukhumvit Rd. with Rama IV Rd. When it is completed, the traffic volume of this intersection will increase and the congestion will get worse.

Secondly, the intersection is located near Khlong Toey port, about 1.5 km to the north of the port. Most of the heavy vehicles related to the port use the south road called Atnarong Rd. It is partly because the intersection is congested. Therefore, the present proportion of the heavy vehicle is not high here but if the intersection is improved, it will increase.

### (3) Constraints

- Two intersections are only 85 m apart each other.
- The width of Rama IV Rd. is reduced at the west curved portion as follows.
  - East bound : from 4-lane to 3-lane
  - West bound : from 3-lane to 2-lane
- Near the intersection, there are open spaces but also banks and shop houses are located.

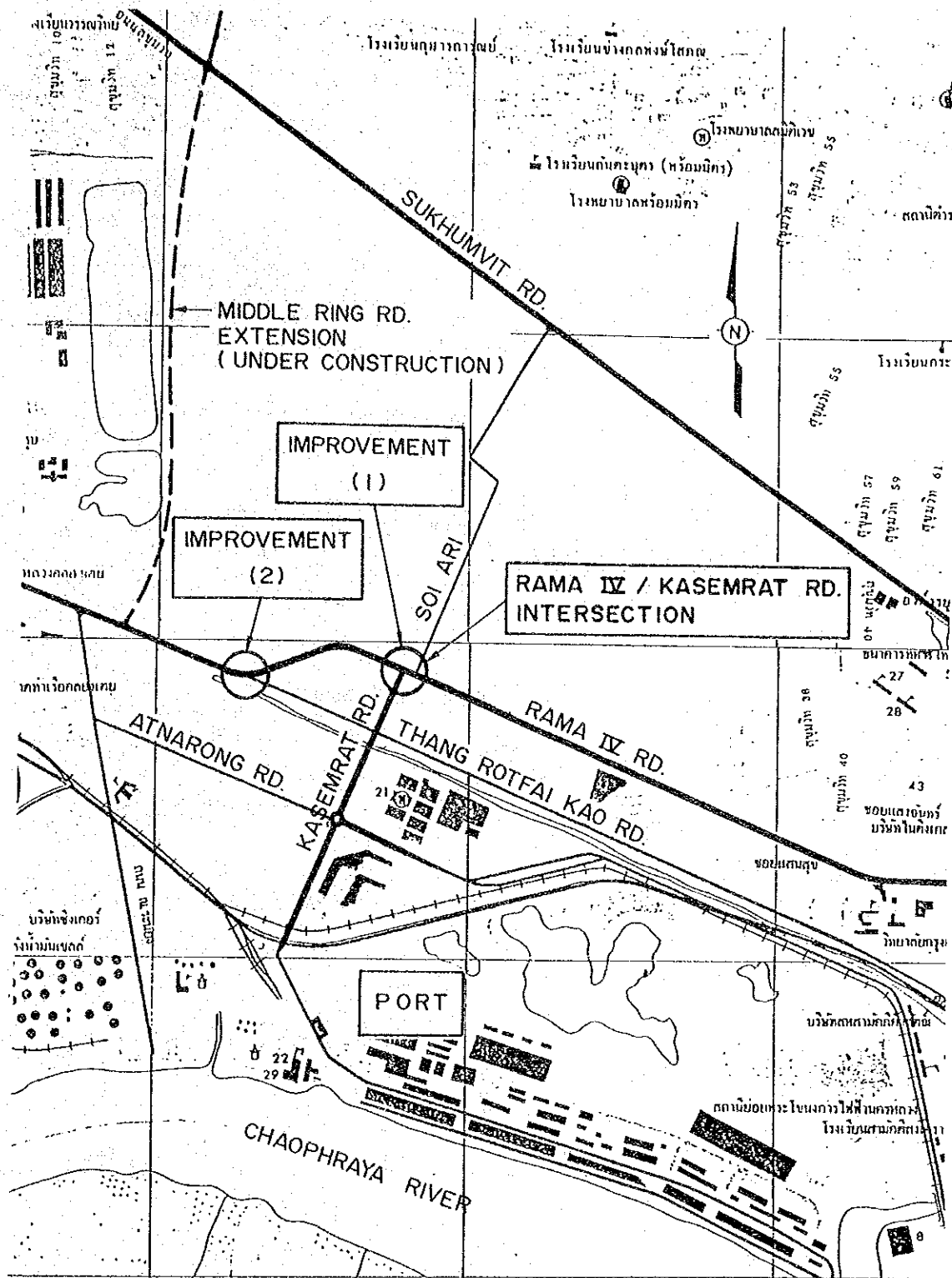


Figure 5.10.1 Kasemrat Intersection

NO. 035

RAMA IV / KASEMRAT RD

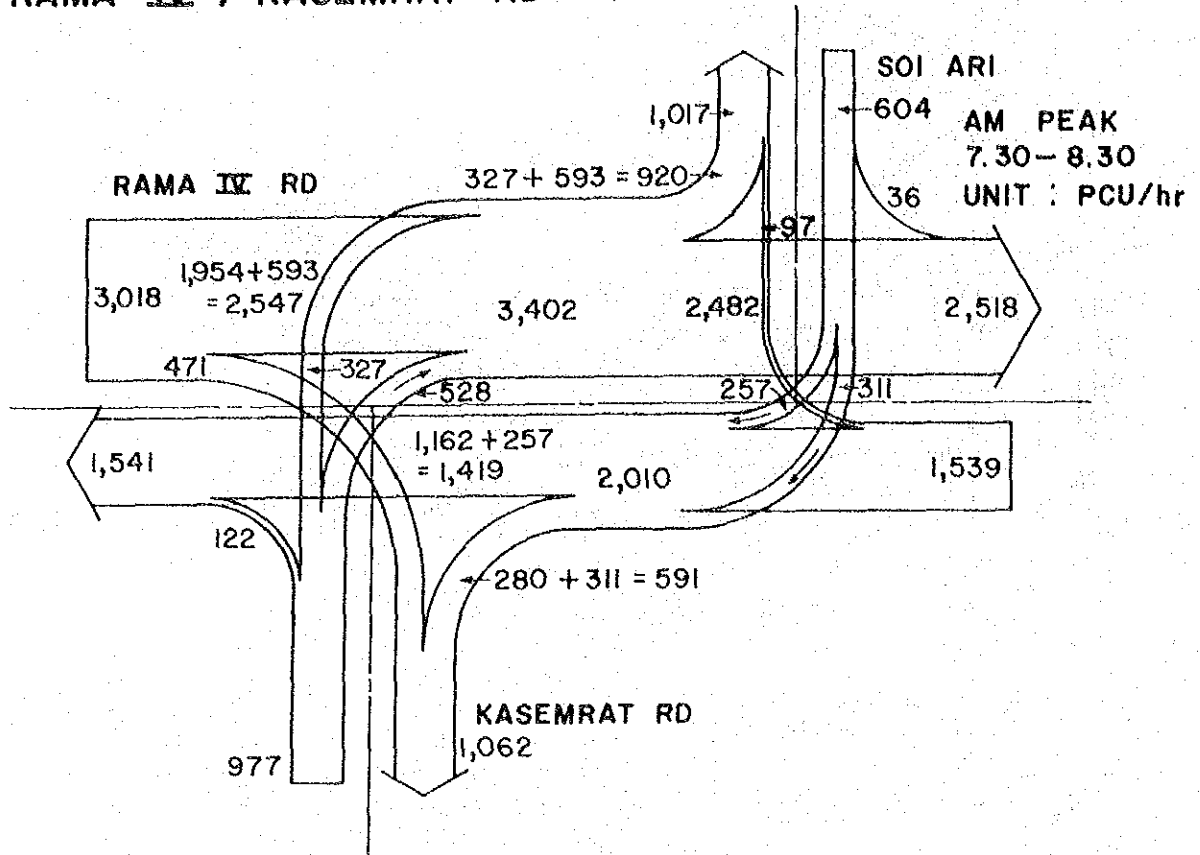


Figure 5.10.2 Traffic Volume at Kasemrat

NO. 035

RAMA IV / KASEMRAT RD.  
QUEUE LENGTH (AM PEAK)

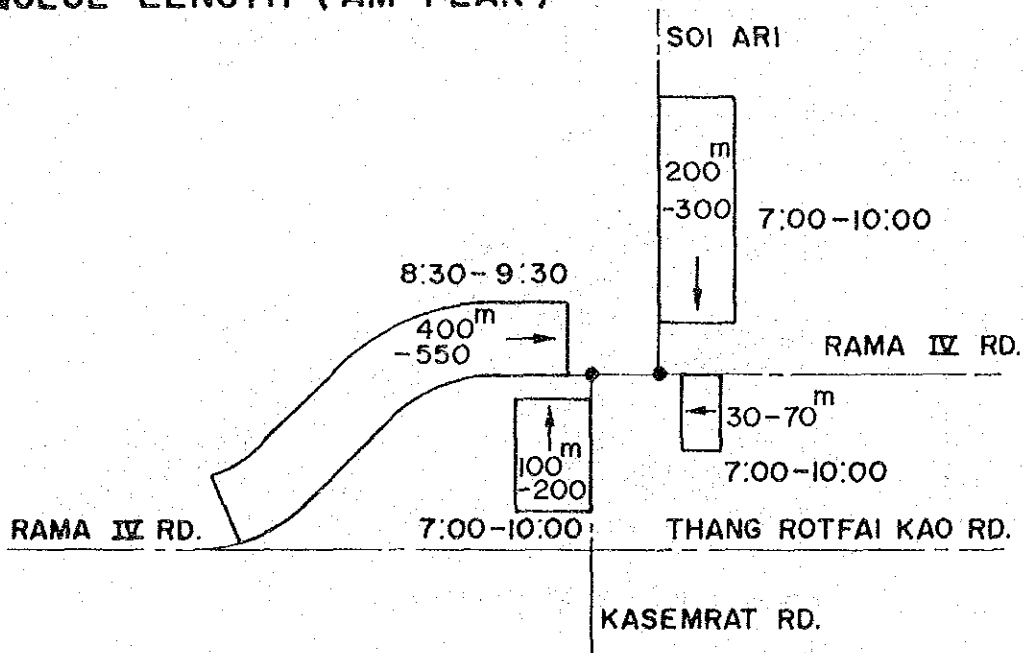


Figure 5.10.3 Queue Length at Kasemrat

(4) Degree of congestion (existing)

The existing conditions are summarized in Table 5.10.1.

Table 5.10.1 Existing Condition of Intersection  
(Morning peak only)

Item	Characteristics
1) Morning peak hour Max. Traffic	07:30 - 08:30 1,954 PCU/hr in Rama IV Rd. east bound
2) Saturation degree	1.036
3) Max. Queue length	400 - 550 m in Rama IV Rd. east bound, 08:30 - 09:30
4) Max. Stopped delay	7min. in Rama IV Rd. east bound
5) Cycle length	242 sec.

Max. queue length is 400 - 550 m and stopped delay is 7 min. This intersection should be improved.

(5) Cycle time analysis

- Due to neighboring two intersections, green time allocation is unbalanced. If those are combined into one, the allocation can be improved.
- Cycle time of 242 sec. is long and manually operated.

(6) Planning of improvement alternatives

1) Points of planning

As mentioned in General description, the biggest problem in this intersection is that the two intersections are located too close, only 85 m. Many vehicles have to stop two times at each intersection. If the two are combined into one, the loss time will be reduced and the queue length will be less.

Planning of a flyover may be one of the solutions, but it will not be feasible because traffic volume from two connection roads, Kasemrat Rd. and

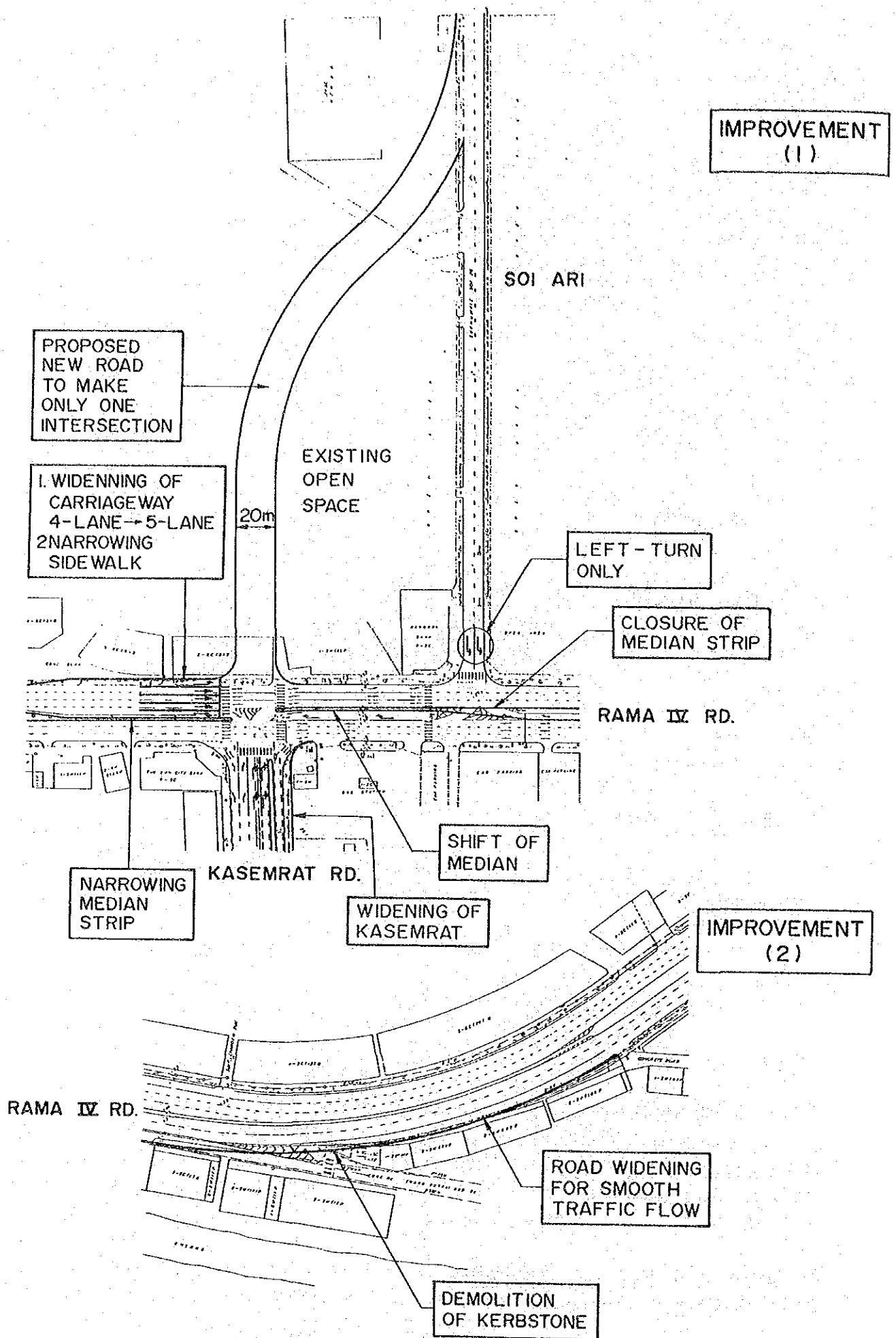


Figure 5.10.4 Proposed Improvement at Kasemrat (No. 035)

Soi Asok, is relatively small comparing with other intersections. Therefore, at-grade improvement is planned hereinunder.

## 2) Improvement planning (Figure 5.10.4)

### A New road

To make two intersections into one, a new road branching from Soi Ari is proposed as shown in Figure 5.10.4. The location of the new road is mainly open spaces. But at the north of Kasemrat intersection, 3-storey shop houses are located in the proposed road area.

At the two intersections, median strips also have to be revised and shifted. At Kasemrat, number of east bound lanes will have to be increased from existing 4-lane to 5-lane. It is because vehicles from/to Soi Ari will shift to the intersection.

### Road widening

Together with the above improvement, Rama IV Rd. west bound should be widened to make the smooth traffic flow at the curved portion as shown in Figure 5.10.4, Improvement (2). The existing 2-lane is widened to 3-lane.

## (7) Effects of improvement (Figure 5.10.5)

By combining two intersections into one, the saturation degree will decrease from existing 1.036 to 0.815.

Max. queue length and max. stopped delay at Rama IV east bound will also decrease to almost one tenth, from 550 m to 50 m and 420 sec. (7 min.) to 40 sec., respectively.

## (8) Selection of an Alternative

As there are no other suitable alternatives of the improvement plan, the only one plan is listed in Table 5.10.2. The plan is proceeded for the further economic analysis.

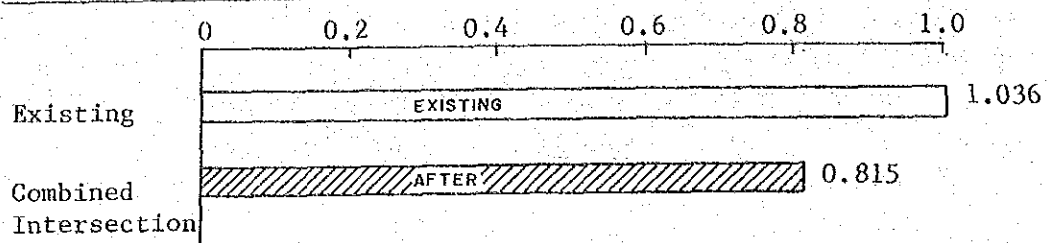
## (9) Economic analysis

The results of the economic analysis about the improvement plan is shown in Table 5.10.3

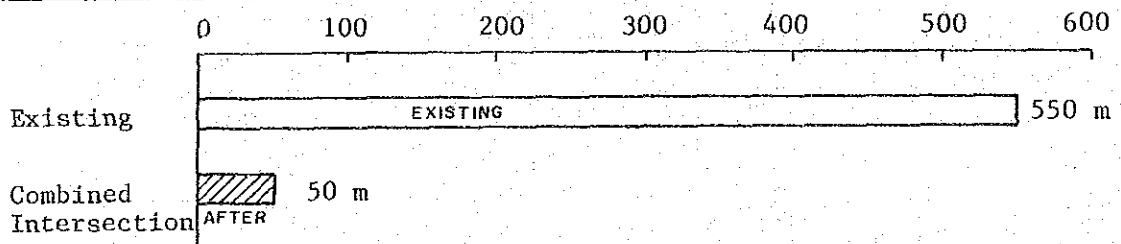
Figure 5.10.5 Improvement Effects

Intersection : Rama IV/Kasemrat Rd. (No.035) (A.M. Peak)

1. Saturation Degree of Intersection



2. Max. Queue Length - Rama IV Rd. east bound



3. Max. Stopped delay (second/vehicle) - Rama IV Rd. east bound

