CHAPTER 5

ALTERNATIVE PLANS

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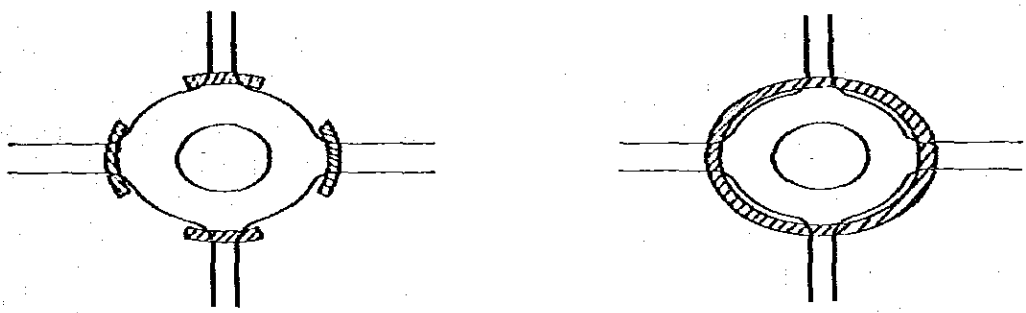
A. General

61. The objective of the Study is to find and propose adequate measures to separate street-crossing pedestrians from vehicles on the roundabout of the Victory Monument. On the premise that vehicle traffic is kept at ground, there are two ways to segregate crossing pedestrians from running vehicles, i.e., to provide pedestrians with crossing facility over or under the streets at the four junctions of the roundabout.

62. Under this Study, a study both on a facility over the streets (hereinafter referred to merely as "overpass") and facility under the streets (referred to as underpass) has been conducted. The Team, as described in its inception report for the Study, has developed two alternative plans for overpass and three for underpass.

63. The two alternative plans in type of overpass are separate overpass and continuous overpass. The "separate overpass" is a plan to construct four pedestrian bridges over the four streets independently, while the "continuous overpass" is a plan to construct a continuous pedestrian bridge around the roundabout, thus connecting all four junctions.

64. The schematic configurations of the two alternative plans are shown in Figure–3.



Separate Overpass　　Continuous Overpass

Figure–3 Schematic Configuration of Overpass

65. The underpass plans include the following alternatives;

1) Separate Underpass;
2) Continuous Underpass; and
3) Underpass with commercial space.

The concept of separate and continuous underpass is the same as that of overpass plans.

66. The underpass with commercial space is an alternative to build footpath combined

with commercial space alongside the footpath. This underpass with commercial space has been proposed for study by BMA with an intention to economize public investment and seek for possibility of multiple land use as well as to attract pedestrians and to enhance their security.

B. Alternatives

67. Based upon the preceding findings and information as well as design conditions, the Team has prepared five alternatives. The followings describe details of each alternative, including structural characteristics, cost estimation, construction method and environment assessment.

68. The cost estimations for all alternatives have been made at 1983 price with prevailing construction unit costs in Bangkok. It should be noticed that the estimated costs are to accuracy of pre-feasibility study.

1. Separate Overpass (Alternative 1)

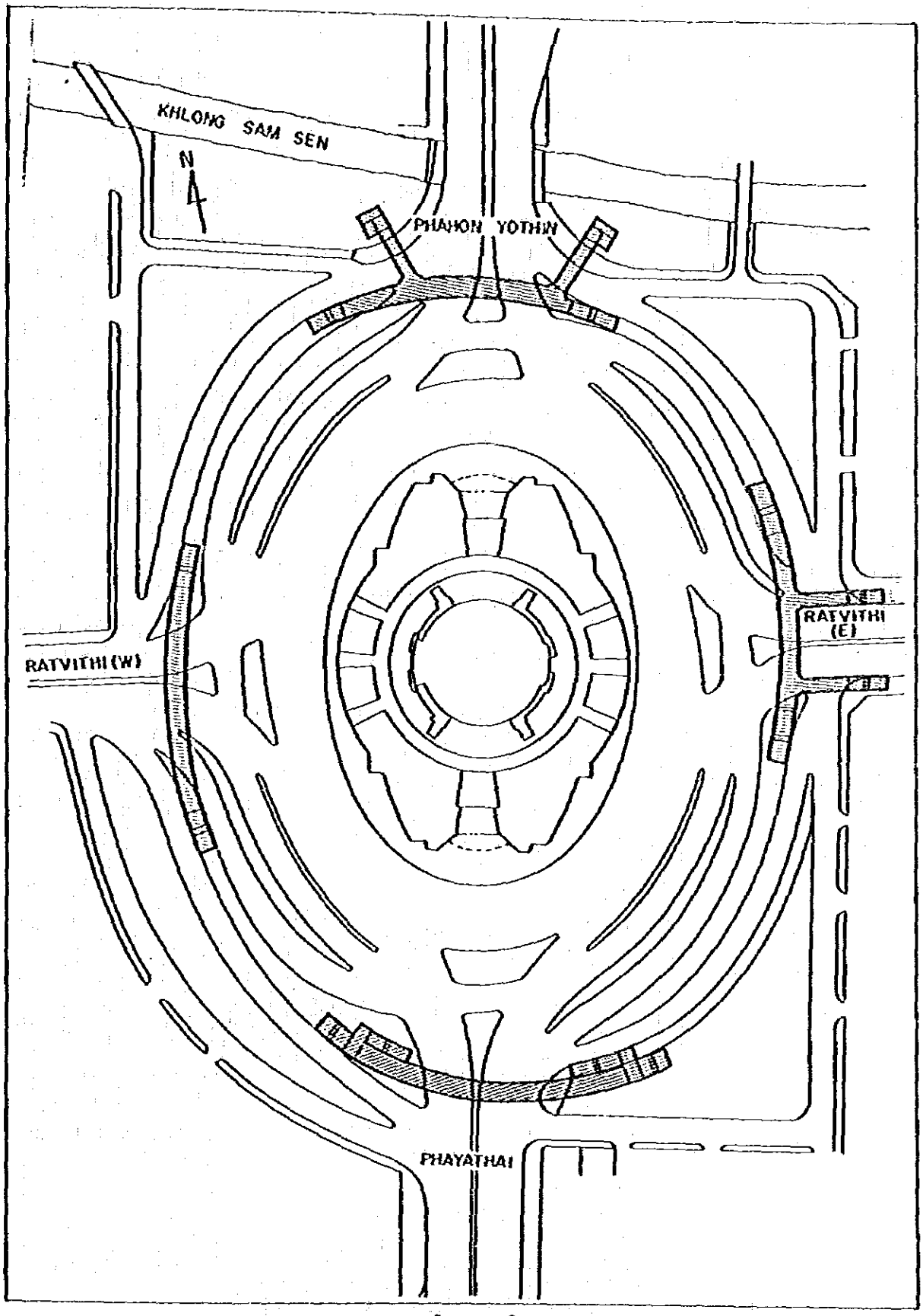
a) Layout of overpass

69. The concept of configuration of these overpasses is to connect middle bus-islands in each quadrant providing bridges over streets at junctions (See Figure–4). This arrangement has been made with expectation that middle bus-islands accommodate more buses than others. Location of piers are laid out enough away from underground utilities to minimize interruption on them.

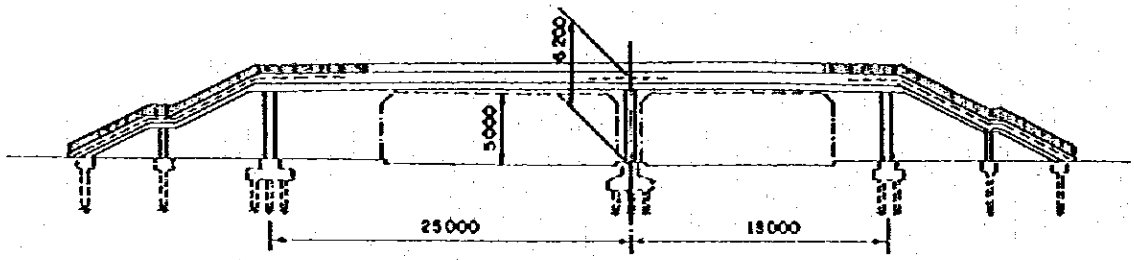
b) Structural characteristics

70. Continuous prestressed concrete hollow slab type has been adopted for superstructure of the bridge. Figure–5 shows typical cross section of the superstructure. This slender section has been selected so as to reduce impact on sight obstruction against the Victory Monument.

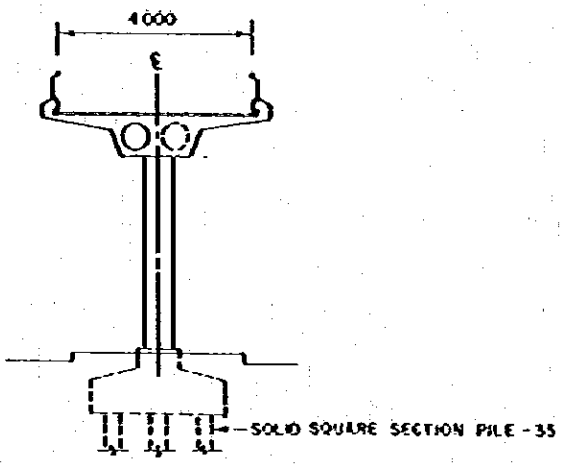
71. The piers to support the bridge's superstructure will be erected at tips of bus-islands and median strips of the streets. The prestressed concrete piles have been applied for foundation. P.C., solid square section pile-35 with 18 meters of length, are assumed to be sufficient.



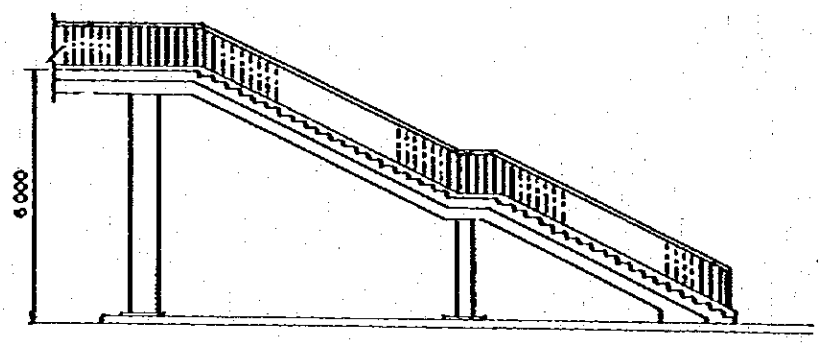
Figure–4 Separate Overpass



PROFILE OF OVERPASS



TYPICAL CROSS SECTION



STAIRWAY

NOTE ; ALL DIMENSIONS ARE IN MILLIMETER.

Figure–5 General View and Cross Section

c) Environment

72. Due considerations for conservation of existing trees/green around the Victory Monument roundabout has been given in the course of study and planning. However, some of trees are obliged to be replanted somewhere nearby.

73. Sight obstruction against the Victory Monument from each street is unavoidable as long as overpass is constructed. The impact of sight obstruction may be reduced by adoption of slender bridge girders.

74. This alternative is inferior to continuous overpass alternative where many pedestrians cross two streets. This disadvantage seems to be not determinate, taking into account the fact that the pedestrians who make two street-crossings, count for only 20% among all pedestrians at the roundabout.

d) . Construction method

75. The superstructure of continuous prestressed concrete hollow slab will be built, molding concrete in situ. During construction, the superstructure shall be supported by erection girders.

76. The vertical clearance of the roads will be reduced by about one (1) meter throughout construction works of superstructure. This reduction of clearance would be tolerable, since the remaining clearance is still about 4 m. During construction of foundations, the outer and middle bus lanes will be reduced by 2.0 or 3.0 meters.

77. The superstructure of four bridges will be constructed in two stages on account of reduction of impact on traffic. This construction approach further will contribute to save the construction cost by means of multiuse of construction equipment.

e) Cost estimation

78. The construction cost for four structures is estimated at 15 million Baht as shown in Table–7.

Table–7 Estimated Construction Cost
(in Million Baht)

Item	Estimated Cost
Superstructure	10
Substructure	5
Total	15

f) Quantity of materials

79. The quantities of main structural materials are roughly estimated as shown in Table–8.

Table–8 Quantity of materials

Superstructure	Substructure	
Concrete Volume	Concrete Volume	No. of Piles
700 m^3	260 m^3	200

g) Maintenance cost

80. The main structure of overpass is in principle maintenance free.

2. Continuous Overpass (Alternative 2)

a) Layout of configuration

81. The continuous overpass has been planned behind of existing trees to preserve them. Pedestrian decks with the width of 10 to 13 meters at each quadrant have the role of not only pedestrian's footpath but also roof to prevent pedestrians on the ground from hard sunshine and rain. The wide decks also could be utilized as public open space where people can take rest (See Figure–6).

b) Structural characteristics

82. The overpass is in the shape of ellipse with major axis of about 210 meters in the direction of north-south and about 170 meters at right angle.

83. The superstructure in the roundabout is composed of reinforced concrete slab. For portions over four streets, continuous prestressed concrete hollow slab type has been adopted to reduce impact on sight obstruction against the Victory Monument. Figure–7 shows typical cross section of the overpass.

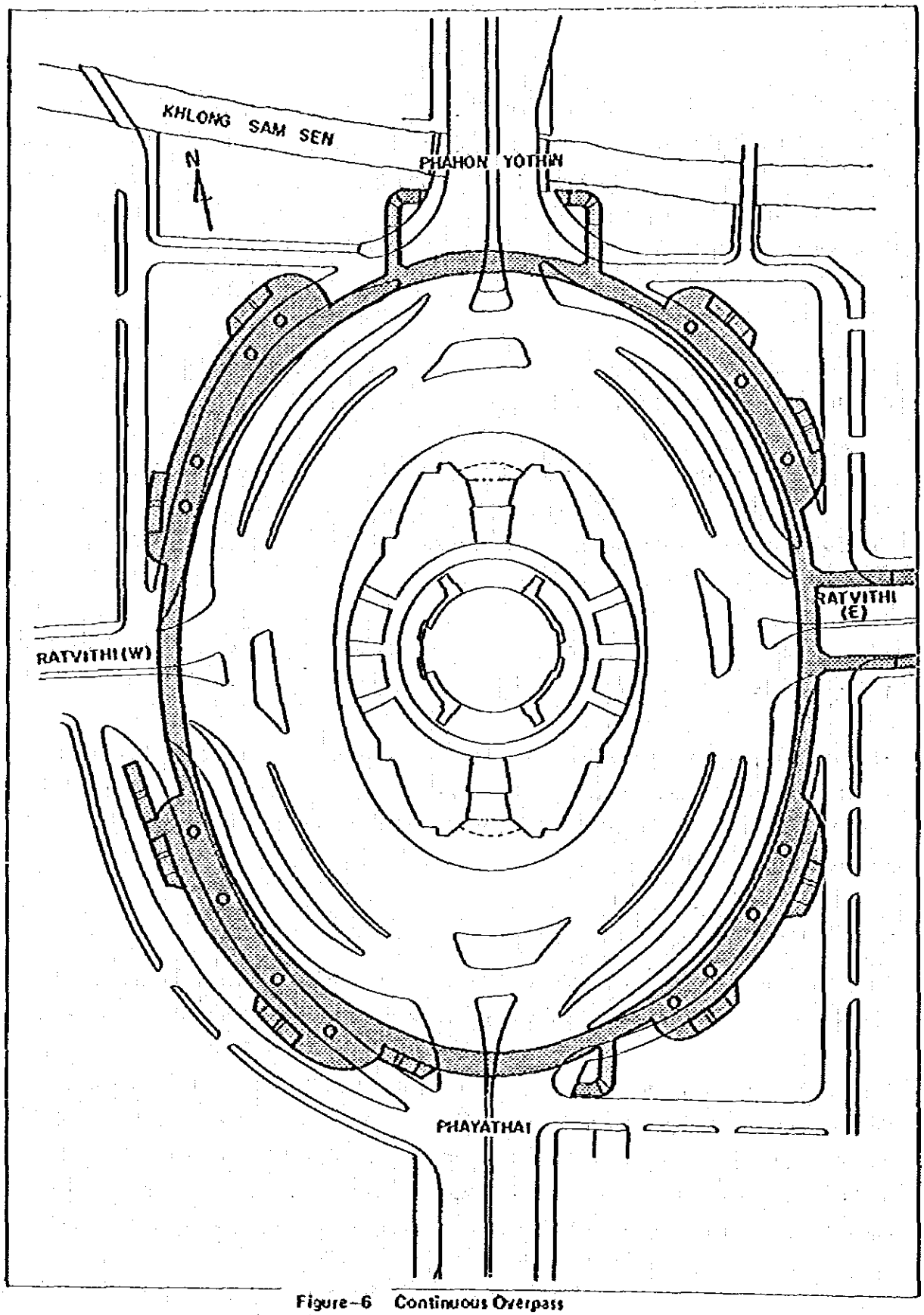
84. Reinforced concrete column pier and pile foundation of P.C. solid square section pile-35 with 18 m of length, are adopted for substructure.

85. It is required for construction of foundations to relocate underground utilities, i.e., a part of drainage at south-eastern quadrant, and a part of water mains and telephone line at south-western and north-western quadrants. A minor modification (shift of alignment by 1 m. to 1.5 m.) on middle bus-islands will be required.

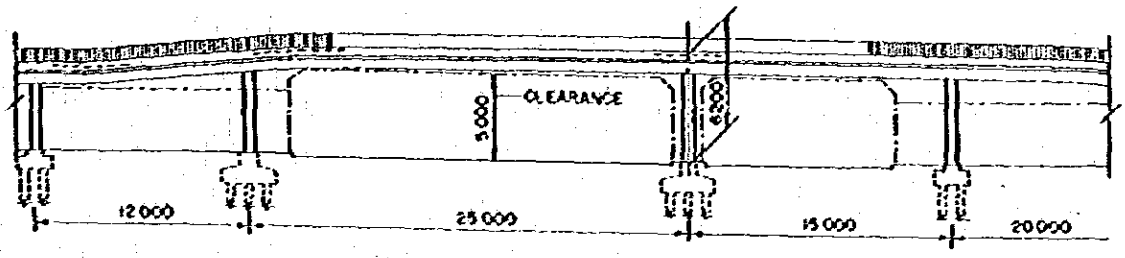
c) Environment

86. Due considerations for preservation of trees in the roundabout have been given. However, because of its size and complexity of structure, some trees are expected to be replanted.

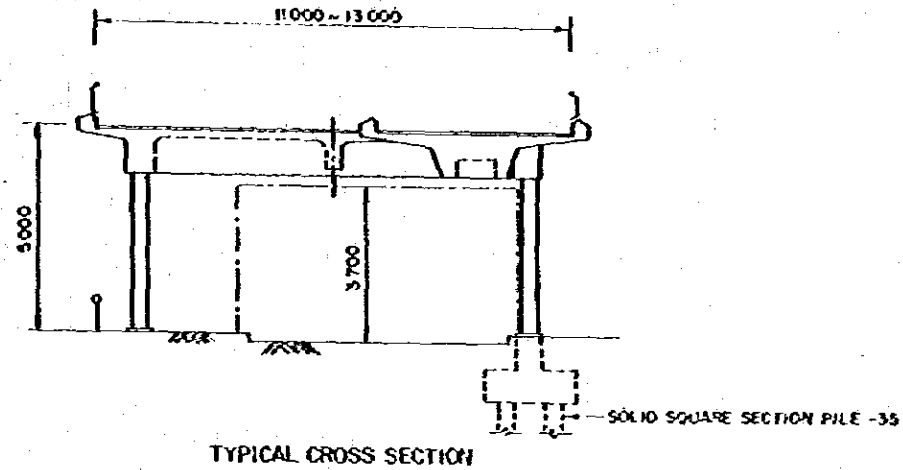
87. Although sight obstruction to the Victory Monument from each street is unavoidable, the adoption of slender and stream-lined girders is expected to reduce the impact of visual intrusion. In urban areas, a structure designed adequately to fit in with its surroundings, could contribute to improve landscape in a way. Under this alternative plan, a new view of the Victory Monument from the bridge could be enjoyed by the public. This may lead this overpass to a new attractive place in the area.



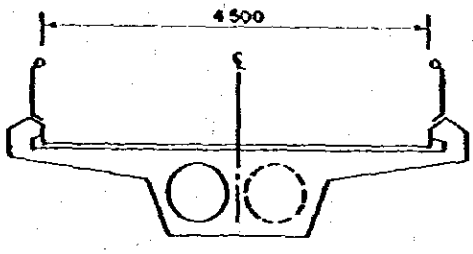
Figure–6 Continuous Overpass



PROFILE OF PEDESTRIAN BRIDGE



TYPICAL CROSS SECTION
OF
PEDESTRIAN DECK



TYPICAL CROSS SECTION
OF
PEDESTRIAN BRIDGE

NOTE ; ALL DIVENSION ARE IN MILLIVETER.

Figure–7 General View and Cross Section

88. This continuous overpass is superior to the scheme of Alternative 1 where a number of pedestrians cross two streets. The plan also has an advantage to provide shelters for waiting passengers at bus stops.

d) Construction method

89. The construction method for the bridges over four streets is the same as that of Alternative 1. For the remaining parts of the bridge, staging construction method could be applicable, at the expense of closure of one outer bus lane.

90. The continuous structure shall be divided into several sections in terms of construction sequence. This construction approach will contribute to save construction cost by multiuse of construction equipment, concrete forms and scaffoldings. The expected construction period will be about 15 months inclusive of relocation works for underground utilities.

e) Cost estimation

91. The construction cost is estimated at 60 million Baht as shown in Table–9.

Table–9 Estimated Construction Cost

(in Million Baht)

Item	Estimated Cost
Superstructure	35
Substructure	15
Relocation of underground utilities	10
Total	60

f) Quantity of Materials

92. The quantity of main structural materials are roughly estimated as shown in Table–10.

Table–10 Quantity of Materials

Superstructure	Substructure	
Concrete Volume	Concrete Volume	No. of Piles
2,670 m^3	620 m^3	530

g) Maintenance cost

93. The main structure of this plan is in principle maintenance free.

3. Separate Underpass (Alternative 3)

a) Structural characteristics

94. The layout of this separate underpass is shown in Figure-8. The concept for layout is to connect middle bus-islands and to minimize the initial construction cost. This plan consists of four independent tunnels. The plan posesses remodeling potential to Alternative 4 or Alternative 5 by extension works without duplication of investment in the future.

95. The shape of tunnel section is rectangular to make an excess room minimum, and the structure is made of reinforced concrete. The thickness of wall and slab was decided to proof stress and buoyancy (See Figure-9).

96. The pile foundation will not be required against uplift force but for possible uneven settlement.

97. To maintain the inside of tunnel comfortable, the minimum ventilation system is required.

b) Environment

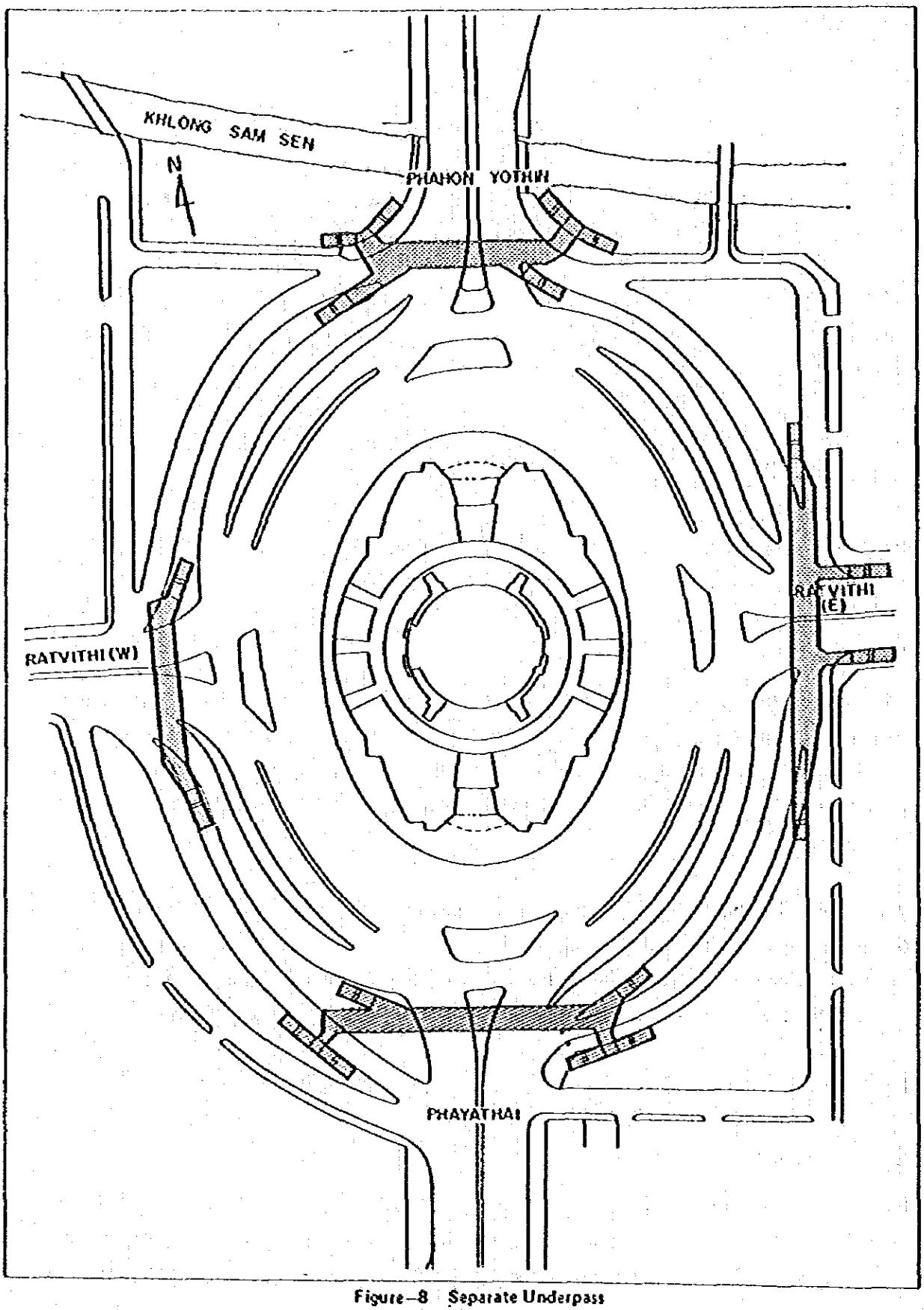
98. In this case, pedestrians who cross two streets are forced to walk down and up twice to reach their destination. Therefore, the amenity and usability are inferior to Alternatives 4 and 5. This disadvantage seems to be not determinate, taking into account the fact that the pedestrians who make two street-crossings, count for only 20% among all pedestrians at the roundabout.

99. From the standpoint of conservation of existing trees, Alternative 3 is the best among the three underpass alternatives because the trees which are forced to cut or replanted are the least. It can be said that the aesthetic impact to the Victory Monument is negligible, because the structure to be built on the ground is only the roofs over the stairways.

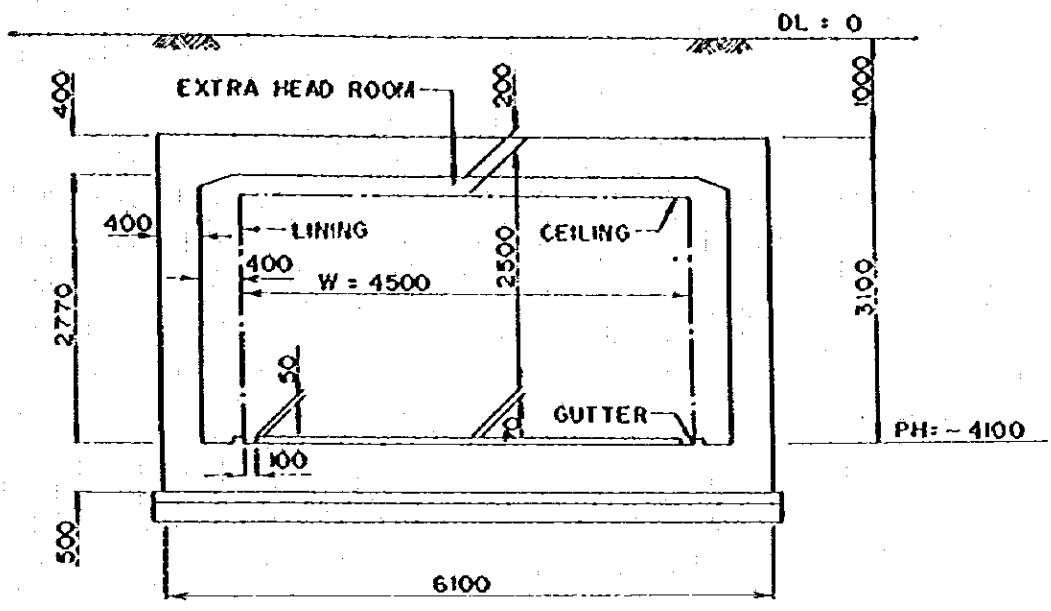
100. To ensure security in the tunnels, adequate arrangement like lighting should be made.

c) Construction method

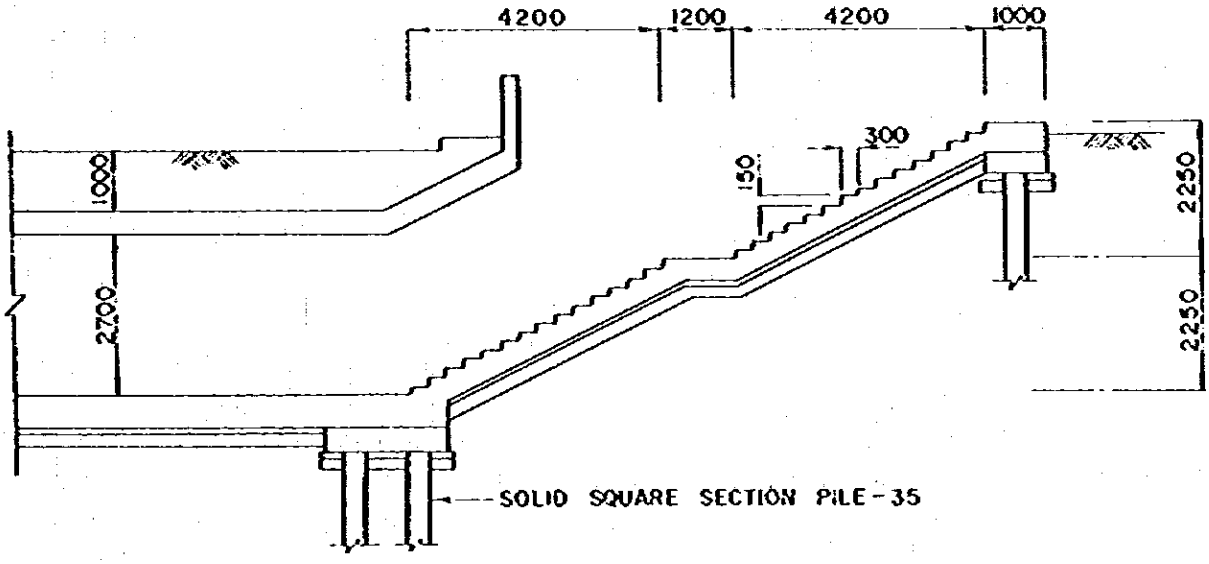
101. The construction works shall be executed in two stages. To economize investment of construction, two stage construction approach, i.e., to construct two separate underpasses after first two underpasses completion, has been employed. This approach enables effective



Figure–8 Separate Underpass



TYPICAL CROSS SECTION



PROFILE OF STAIR

NOTE: ALL DIMENSIONS ARE IN MILLIMETER.

Figure-9 Cross Section

usage of false works' materials as well as construction equipment. Because of relatively thin earth coverage on top of proposed tunnels and shallow earth excavation, Cut and Cover method can be applicable. A schematic construction process of Cut and Cover method is illustrated in Figure–10.

102. With employment of Cut and Cover method, disturbance and regulation on traffic flow could be minimized. The roads can be kept open to the traffic during day time with provision of steel covering plates over the excavated trench and with some traffic control during night time when some of covering steel plates shall be removed for construction works.

103. Due considerations have been given to minimize relocation of utilities accuring from construction. However, a bulk of water supply which is lying all over the roundabout and a part of high tension electric cables are forced to be relocated.

104. The construction period is expected to be approximately 18 months.

d) Cost estimation

105. The construction cost is estimated at 100 million Baht as shown in Table–11.

Table–11 Estimated Construction Cost

(in Million Baht)

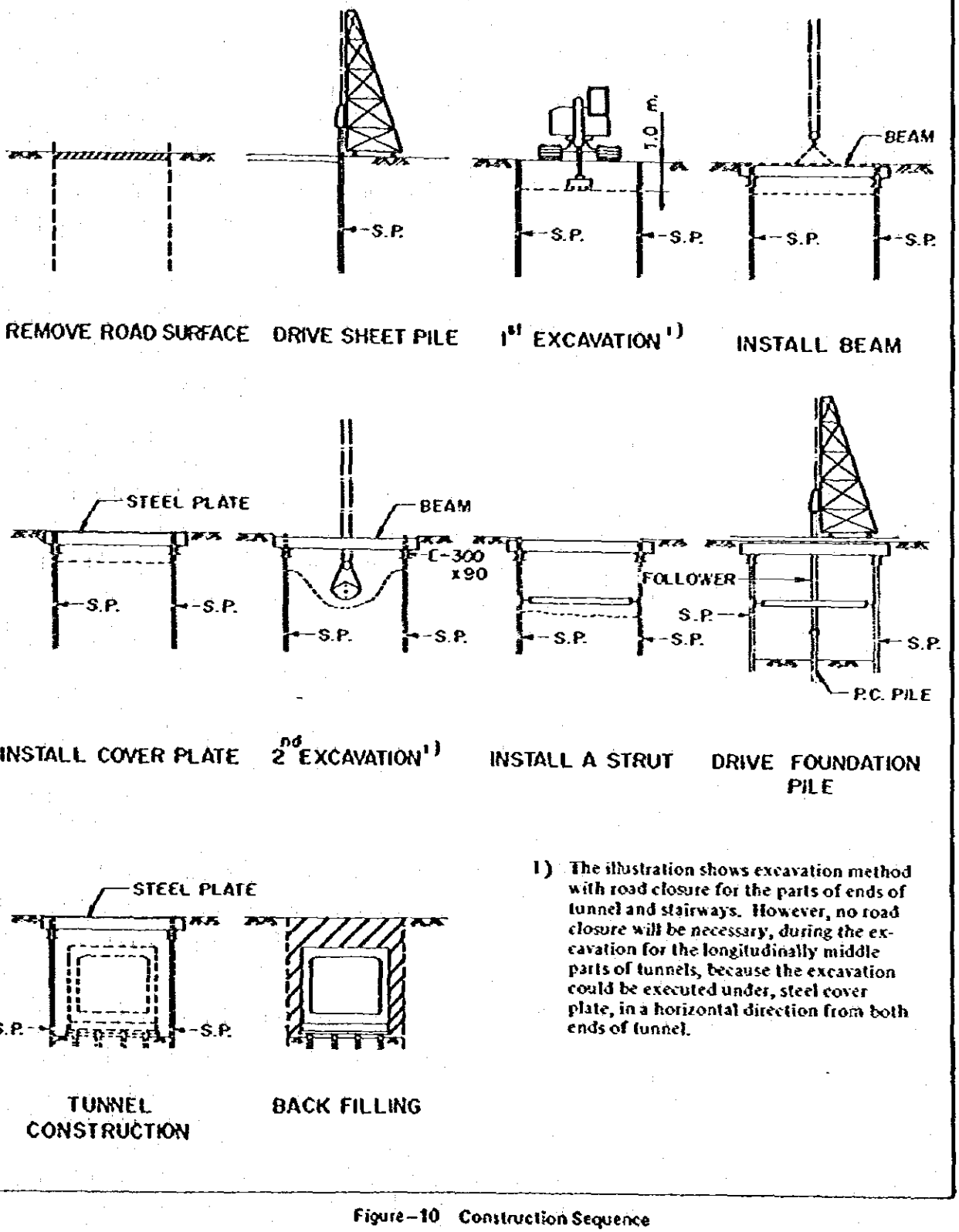
Item	Estimated Cost
Structure	62
Lighting and other associated facilities	3
Relocation of underground utilities	35
Total	100

e) Quantity of materials

106. The quantity of main materials are shown in Table–12.

Table–12 Main Materials

Item	Quantity
Excavation	15,300 m^3
Concrete	2,850 m^3
No. of Piles	260



1) The illustration shows excavation method with road closure for the parts of ends of tunnel and stairways. However, no road closure will be necessary, during the excavation for the longitudinally middle parts of tunnels, because the excavation could be executed under, steel cover plate, in a horizontal direction from both ends of tunnel.

Figure–10 Construction Sequence

f) Running and maintenance cost

107. The running cost for the lighting and pumping, and routine maintenance cost are roughly estimated at 0.2 million Baht per year.

4. Continuous Underpass (Alternative 4)

a) Structural characteristics

108. The layout of this continuous underpass shown in Figure–11 has been prepared with particular attention toward the conservation of existing trees and to minimize disturbance to traffic flow during construction works. The structural characteristics of this alternative is in principle the same as those of Alternative 3. This continuous underpass, however, requires ventilation system, because the tunnel is long enough for pedestrians to feel unpleasant with smell, humidity, stuffiness and so on. Ventilation by only air supply will be sufficient to blow off contaminated air through stairways.

b) Environment

109. The usability and amenity for pedestrians are superior to the separate underpass where the number of pedestrians who cross two streets will be high.

110. The horizontal alignment of underpass is planned so as to avoid the existing trees as much as possible. However, some trees are forced to be replanted.

111. For security reasons, adequate arrangements like lighting and alarm system should be made.

c) Construction method

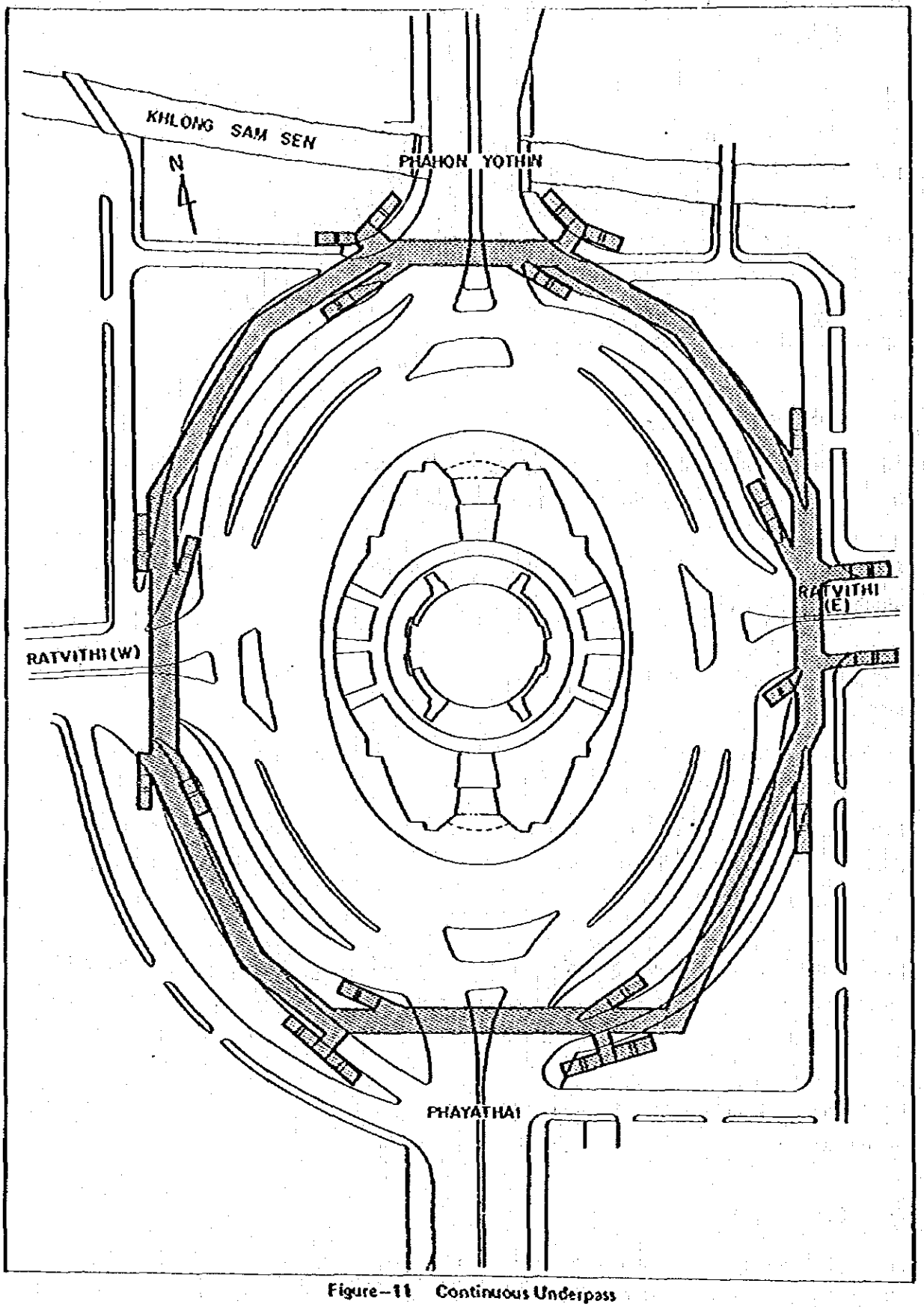
112. This continuous underpass will be constructed in two stages for the same reasons in the case of Alternative 3. This plan can be also completed remodeling the structure of Alternative 3.

113. Most of water supply pipes and drainage pipes, and some of high tension electric cables should be relocated. The drainage pipe lying at the east side of the roundabout shall be lowered to six meters from the road surface so as to go through under the tunnel.

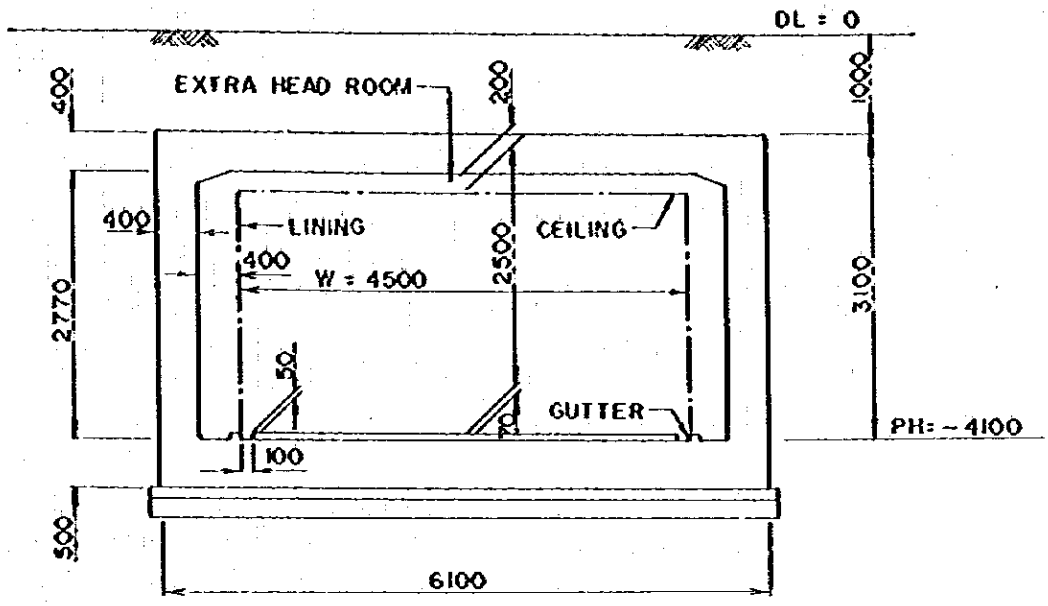
114. The construction period is expected to be about 27 months on the assumption that the construction would be divided into two stages like Alternative 3.

d) Cost estimation

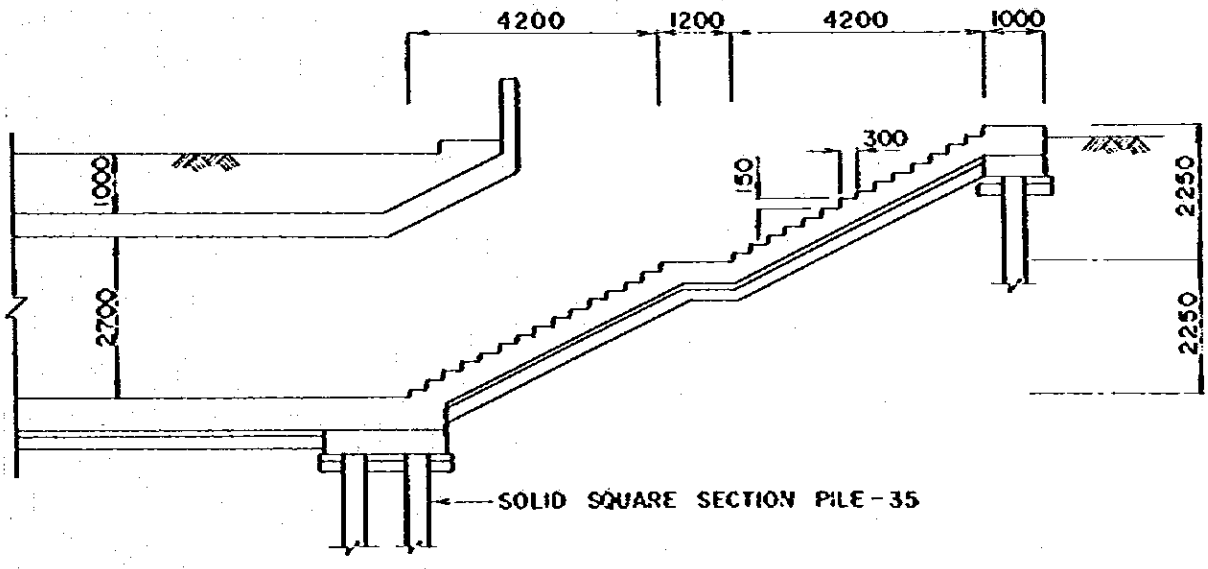
115. The construction cost is estimated at 200 million Baht as shown in Table–13. The premise for the cost estimation is in principle the same as those of Alternative 3.



Figure–11 Continuous Underpass



TYPICAL CROSS SECTION



PROFILE OF STAIR

NOTE: ALL DIMENSIONS ARE IN MILLIMETER.

Figure – 12 Cross Section

Table--13 Estimated Construction Cost

(in Million Baht)

Item	Estimated Cost
Structure	142
Ventilation, lighting, and other associated facilities	6
Relocation of underground utilities	52
Total	200

e) Quantity of materials

116. The quantity of main materials are shown in Table–14.

Table–14 Main Materials

Item	Quantity
Excavation	23,700 m^3
Concrete	5,700 m^3
No. of Piles	500

f) Running and maintenance cost

117. The running cost for the ventilation, lighting and pumping and routine maintenance cost are roughly estimated at 0.5 million Baht per year.

5. Underpass with Commercial Space (Alternative 5)

a) Structural characteristics

118. The layout of this alternative plan has been prepared in such way so as to ensure sufficient and pleasant commercial space with a simplified configuration and preserve trees. Proposed depth of pedestrian footpath is 4.75 m from the road surface. This is deeper than footpath of Alternative 3 and 4, because of higher vertical clearance for commercial space and thicker upper slab of tunnel (See Figure–14). Other structural characteristics of this alternative is in principle the same as those of Alternative 3 and 4 except for the access alleys to the Victory Monument.

119. This underpass includes commercial space about 7,000 m² in area. The ventilation and air conditioning system is needed to maintain the underground space comfortable. Air supply and blowing off of the contaminated air should be executed by electric fans.

b) Environment

120. The usability and amenity for pedestrians are improved from other two underpass alternatives because the trip length is shorten by changing the horizontal alignment from a polygon to a lozenge. But, as the stairway length becomes longer by lowering the elevation of footpath by 0.65 m, the usability is deteriorated by that much. The shops arranged along the footpath will attract the pedestrians.

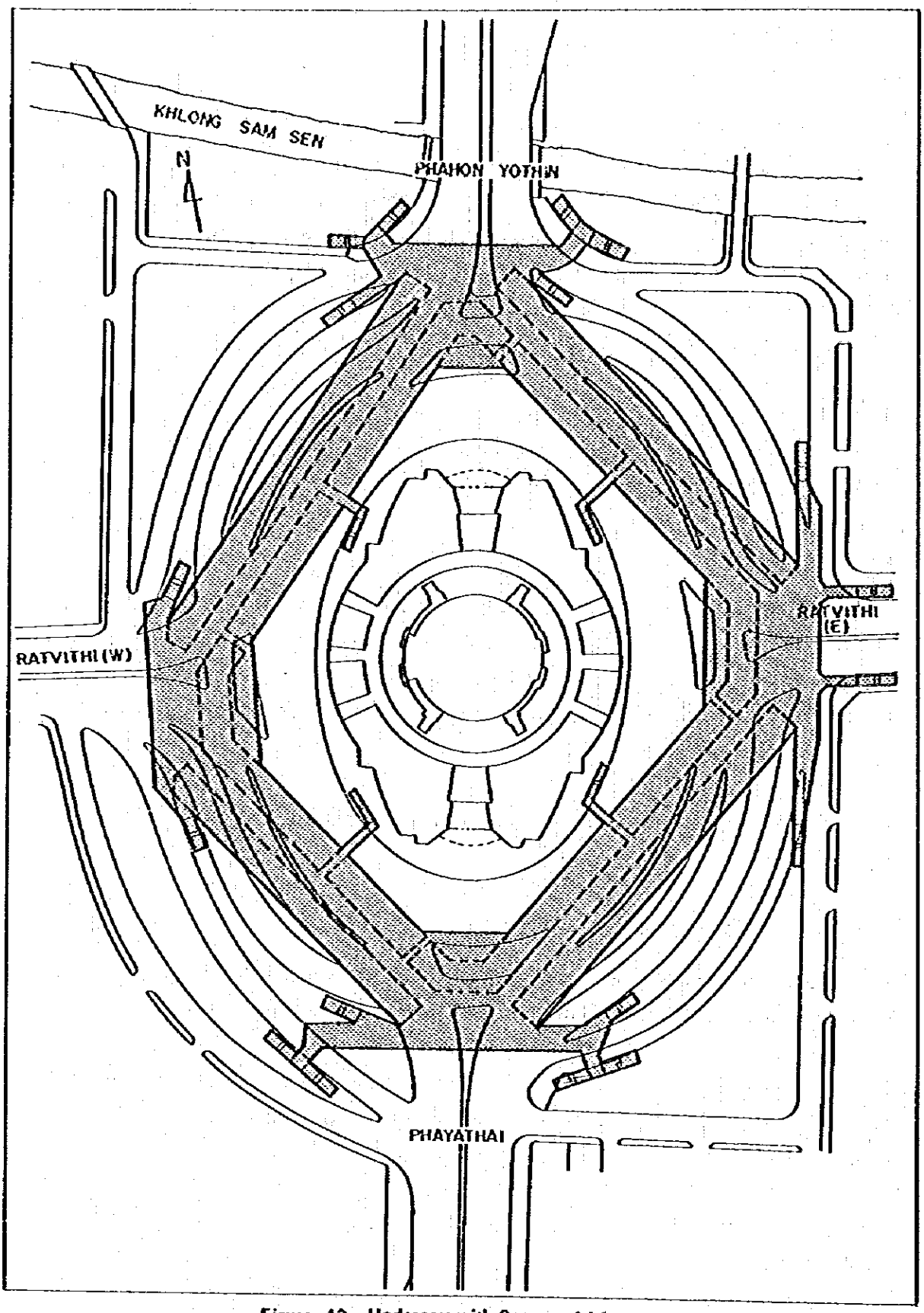
121. For security reasons, adequate arrangements mentioned in Alternative 4, should be made.

c) Construction method

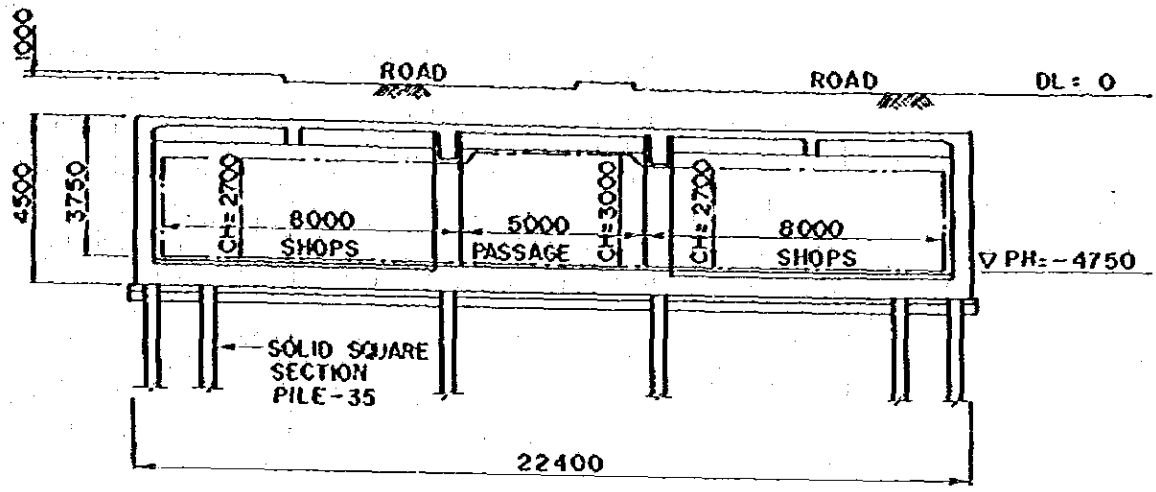
122. Construction method is almost same as Alternative 3 and 4 in principle. The scope of relocation and relocation method of utilities are almost same as Alternative 4.

123. The construction impact to traffic will be considerable because the most part of the carriageway would be affected by construction works even with careful attention to construction method, sequence, working time and others.

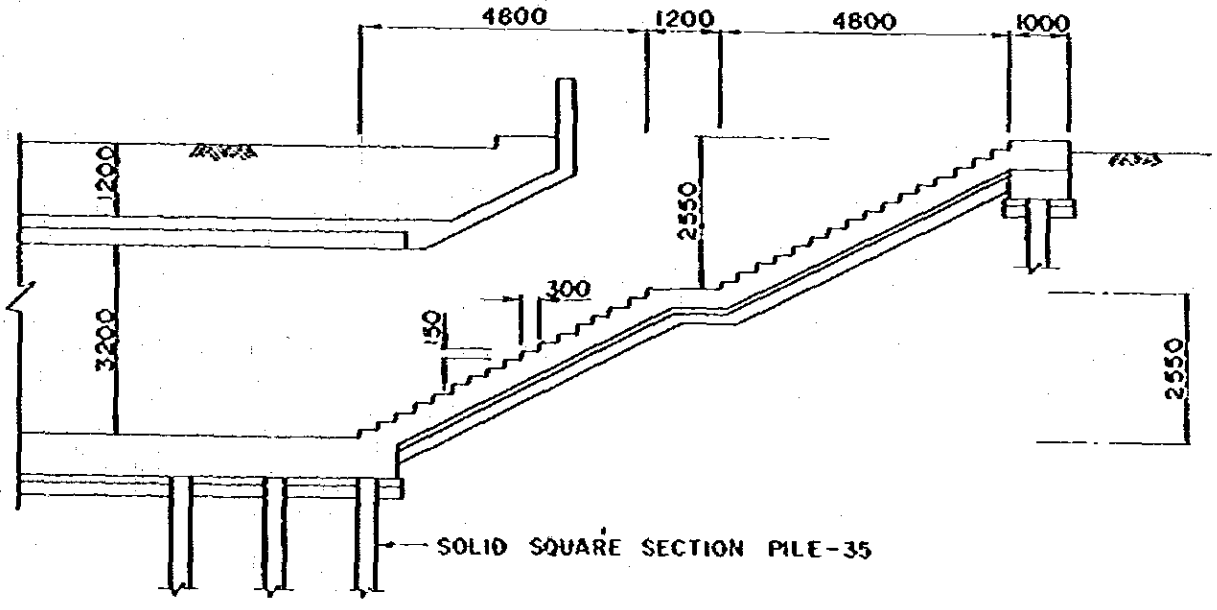
124. Assuming that the construction is divided into two stages, the construction will last for about 36 months.



Figure–13 Underpass with Commercial Space



TYPICAL CROSS SECTION



PROFILE OF STAIR

NOTE: ALL DIMENSION ARE IN MILLIMETER.

Figure-14 Cross Section

d) Cost estimation

125. The construction cost is estimated at 450 million Baht as shown in Table–15. The premise for the cost estimation is in principle the same as those of Alternative 3.

Table–15 Estimated Construction Cost

(in Million Baht)

Item	Estimated Cost
Structure	377 [1]
Ventilation, Lighting and other associated facilities	23
Relocation of underground utilities	50
Total	450

1) Inclusive of cost for internal decoration and safety facilities

e) Quantity of materials

126. The quantity of main materials are shown in Table–16.

Table–16 Main Materials

Item	Quantity
Excavation	67,200 m^3
Concrete	17,400 m^3
No. of Piles	2,300

f) Running and maintenance cost

127. The runnng cost for the ventilation, lighting and pumping and routine maintenance cost are roughly estimated at 2 million Baht per year.

6. Summary of Alternative Plans

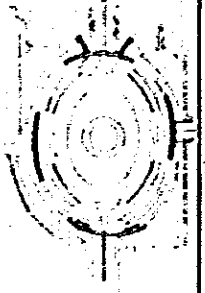
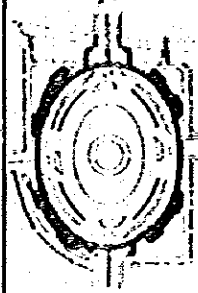
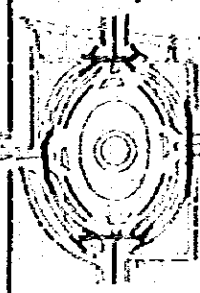
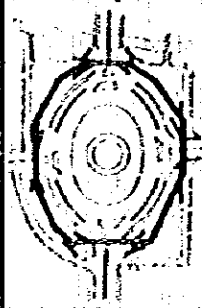
128. The summary of the five alternative plans is shown in Table--17. Although all alternative plans can meet the primary objective to segregate the pedestrians from vehicle traffic at the four junctions of the Victory Monument, they have their advantages and disadvantages in various aspects.

129. The features of each alternative plan are summarized by following items with subdivisions of ;

a) structure ;
b) utilities to be relocated ;
c) Environment ;
d) construction , and
e) maintenance.

130. It should be noted that some items could be evaluated quantitatively while others had to be assessed qualitatively.

Table-17 Summary of Alternative

Item		Alternative 1 Separate Overpass	Alternative 2 Continuous Overpass	Alternative 3 Separate Underpass	Alternative 4 Continuous Underpass	Alternative 5 Underpass with Commercial Space
						
Structure	Type of Structure	P.C. Hollow Slab	P.C. Hollow Slab and R.C. Slab	R.C. Box Culvert	R.C. Box Culvert	R.C. Box Culvert
	Height of Stairway	6.0 m	6.0 m	4.1 m	4.1 m	4.75 m
	Total Length	255 m	630 m	290 m	650 m	850 m
Utilities to be relocated	Drainage Pipe	None	240 m	120 m	480 m	230 m
	Water Pipe ϕ 800		30 m	580 m	580 m	580 m
	ϕ 300		90 m	390 m	390 m	270 m
	Electric Cable		None	300 m	300 m	300 m
	Telephone Cable		110 m	60 m	60 m	60 m
Environment	Sight of Monument	Impaired	Impaired	Not impairment	Not impairment	Not impairment
	Creation of New Landscape	Some	Considerable	None	None	None
	Existing Trees to be Replanted	A few	Some	A few	Some	Some
	Security Measures	Not necessary	Not necessary	Necessary	Necessary	Necessary after close of shops
	Amenity for two-Streets crossing pedestrians (about 20% of all pedestrian)	Poor	Good	Poor	Good	Good
Construction	Obstruction to Traffic Flow	Minor	Some to bus lane	Some	Considerable to bus lane	Considerable to all traffic
	Construction Period (month)	10	15	18	27	36
	Cost (Million Baht)	15	60	100	200	450
Maintenance	Ventilation	Not necessary	Not necessary	Necessary	Necessary	Necessary
	Air Conditioning	Not necessary	Not necessary	Not necessary	Not necessary	Necessary
	Maintenance/Running Cost (Million Baht/year)	Negligible	Negligible	0.2	0.5	2.0

C. Screening of Alternative Plans

131. Through the screening procedure, out of the five alternatives, two alternatives; Alternative 2 and Alternative 3 were selected for further study. The selection of two alternatives instead of one alternative has been made so as to provide the concerned parties with more detailed information for their final decision on the type of pedestrian facility at the Victory Monument which requires a wide range of aspects to be considered in planning any structures to be built in its adjacent area.

132. The screening works have been carried out by the Team and BMA in conjunction with the Committee for Victory Monument Project consisted of 11 agencies [1] chaired by Admiral Tiam Makarananda, the Governor of BMA. The National Environment Board also was consulted in preparing and screening the alternatives. In the course of the screening, comprehensive assessments inclusive of construction cost, maintenance cost, construction method, amenity and convenience of pedestrians and aesthetic aspects inhered in each alternative plan, have been conducted.

133. For overpass bridge, Alternative 2 (Continuous Overpass) has been selected. Alternative 2 costs four times more than Alternative 1 but this construction cost could be easily compensated with the creation of a new artificial sight view and convenience being enjoyed by pedestrians.

134. For underpass tunnel, Alternative 3 (Separate Underpass) has been selected. The other two alternatives are of advantage to Alternative 3 in terms of convenience for pedestrians who have to cross two streets in order to reach their destinations. However, the mere 20% of the pedestrians who negotiate two streets would not necessarily warrant to give high priority to the Alternative 4 and 5 which require substantially high investment cost.

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1) Department of Public Works, Ministry of Interior. (PWD-MOI)
Department of Town and Country Planning, Ministry of Interior. (TCP)
Police Department, Ministry of Interior. (Pol D)
Office of the Committee for the Management of Road Traffic, Ministry of Interior. (OCMRT)
Office of Policy and Planning, Ministry of Interior. (OPP)
The Supreme Command Headquarters, Ministry of Defence. (SCH)
Department of Public Works, Bangkok Metropolitan Administration. (PWD-BMA)
Expressway and Rapid Transit Authority of Thailand. (ETA)
Metropolitan Water Works Authority. (MWWA)
Metropolitan Electricity Authority. (MEA)
Telephone Organization of Thailand. (TOT)

135. Alternative 3 has got otherwise many advantages to other two alternatives. They are mainly the followings ;

1) construction and maintenance costs are low ;
2) structural extension, if necessary in the future to other alternatives can be made;
3) obstruction to the traffic flow during construction works will be less than other two underpass alternatives ; and
4) security problem will be less than others.

136. After the thorough and overall reviews on the alternatives, Alternative 2 and 3 were recommended at the meeting of the Committee for Victory Monument Project. The Team and BMA, based on the Committee's recommendation, exchanged their views and have finally selected Alternative 2 and 3 for the preliminary engineering design.

CHAPTER 6

PRELIMINARY DESIGN

CHAPTER 6 PRELIMINARY DESIGN

A. General

137. The preliminary design for Alternative 2 and Alternative 3 which were selected through the screening procedure has been carried out. Prior to the preliminary design, BMA and the Study Team reviewed the selected alternatives in detail referring to the comments of the Committee for the Victory Monument Project.

138. BMA proposed to alter the stairways' width of Alternative 3 from the original 2.5 meters to 3.5 meters wide, inclusive of space for handrail and lighting. This alternation was made with a view to encourage pedestrians to use the tunnels providing spacious approaches.

139. Consequently, the location of the tunnel at Ratvithi (E) street has been shifted inwards from the outer island to the middle islands to ensure 3.5 meters wide stairways.[1] This change of location has resulted in shortening the tunnel's length by about 30 meters in all at the expense of relocation of about 150 meters of the drainage pipes which happens to lie on the new alignment of the tunnel.

140. A minor change also has been made as to the width of the tunnels of the Alternative 3. The original width between walls was 5.3 meters with composition of effective width of 4.5 meters and 0.8 meters extra room for various accessories. After discussion, the extra room has been widened to 1.0 meter.

141. As for Alternative 2, also some revisions have been made as to layout of stairway at the Phayathai junction and the stairways connected with pedestrian decks. The width was widened from original 2.25 m. to 3.0 m. for the same reason in the case of Alternative 3.

142. The preliminary design for the selected alternatives has been carried out according to the geometrical and structural design conditions which had been confirmed by BMA and the Study Team (see paragraph 57 and Appendix 11 and 12). The design conditions are in principle quoted from the prevailing design standards in Thailand.

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1) The width of the stairways on the sidewalk of Ratvithi (E) Street is 2.25 m. because the sidewalk is not wide enough to accommodate 3.5 m. wide stairway.

143. The layouts and elevation levels of the structures have been decided and calculated based on the detailed designs for the road improvement project which had been prepared by OCMRT and BMA. As this pedestrians' crossing facility project and the road improvement project are closely interrelated, the coordination between the two projects should be made.

144. The pile foundation both for Alternative 2 (Continuous Overpass) and Alternative 3 (Separate Underpass) has been designed utilizing some data available in the area adjacent to the Victory Monument. Although this approach seems reasonable for the design to the level of feasibility study, detailed geotechnical survey should be carried out prior to the detailed design.

145. The cost estimations have been made with quantities obtained from the preliminary design and the prevailing construction unit costs in Bangkok at 1983 price.[1] The estimated costs include overhead and allowance for price escalation during the assumed construction periods, and approximate consulting service fee for detailed engineering design and construction supervision.

1) The relocation costs and time estimation of drainage pipe, water supply pipe, electric cable and telephone cables have been made through cooperation of BMA, MEA, MWWA and TOT.

B. Continuous Overpass (Alternative 2)

1. General

146. Since the Victory Monument is a place where a number of people gather, visual amenity is one of aspects which require due considerations in planning and designing structures of pedestrian crossing facility in the study area.

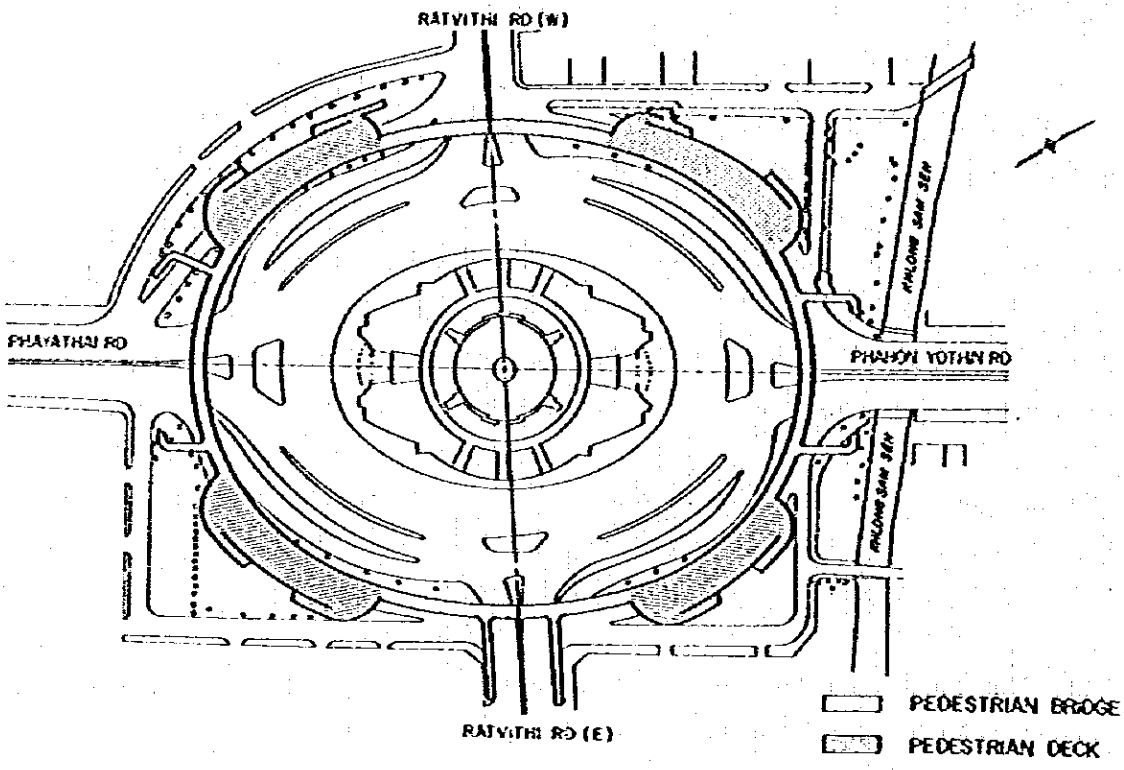
147. There are two approaches to designing structures. One approach is to design structures in a way that they may add to visual value and create a new spectacle together with the monument. another is to design structures being inconspicuous so that they will be harmonized with existing view without a major visual impact.

148. As the overpass structures of Alternative 2 are relatively large in size as compared to the monument, it is rather desirable to design them in a way that their visual impact turns to be possitive leading to a new creation of landscape in the area.

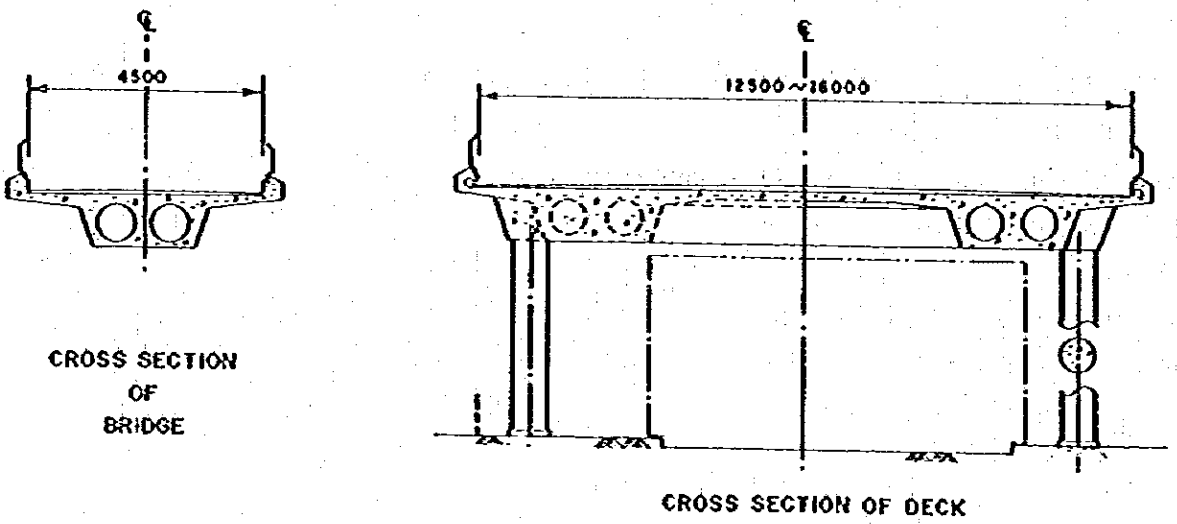
149. The slender and streamlined pedestrian bridges and spacious pedestrian decks, with assistance of moderate accessories like well designed handrail and colorful pavement of footpath, are expected to enhance the view in the area and please pedestrians' eyes.

150. The slender and streamlined bridges also contribute to reduce visual intrusion on the sight of the Victory Monument from the approaching streets.

151. The preliminary engineering design for the overpass of Alternative 2 has been carried out on the following geometric plan which was prepared with the aforementioned concept in mind (See Figure 15 and 16). The overpass can divide into two types by structural and functional characteristics, i.e., one is pedestrian bridges for the portion over streets and another is pedestrian decks for the portion over the planned bus lanes in the quadrants of the roundabout. The total length of the bridges and decks is about 333 m. and 282 m., respectively, while stairways have 277 m. length in all. The detailed drawings of Alternative 2 are contained in Volume II.



Figure–15 Configuration of Overpass



Note: Dimension is in millimeter

Figure–16 Typical Cross Section

2. Geometric Plan

152. Alternative 2 consists of four pedestrian bridges and four pedestrian decks which are all connected to form a continuous pedestrian footpath in a circle. The width and length of the pedestrian bridges and decks are shown in Table-18 and Table-19.

Table-18 Pedestrian Bridge

	Width[1]	Length
Ratvithi (W)	4.5 (m)	76.9 (m)
Phayathai	4.5	78.3
Phahonyothin	4.5	88.3
Ratvithi (E)	4.5	89.2

Table-19 Pedestrian Deck

	Average Width [1]	Length
North-East Quadrant	13.8 (m)	62.2 (m)
North-West Quadrant	13.5	77.3
South-East Quadrant	13.8	71.9
South-West Quadrant	15.0	71.0

1) The width of stairways for pedestrian decks are 3.0 m. wide while that of stairway for pedestrian bridges is 2.25 m. where pedestrians are expected to be less.

153. The alignment of the overpass structures as seen in Drawing No. B-1 in Volume II has been planned with a series of compound circular curves so as to conform with the plans of traffic channelization islands (See paragraph 26). Thus all piers are to be built on the traffic islands.

154. The span length of the pedestrian decks has been determined taking into account structural requirement, construction cost and beauty aspect as well as utilities' location. The construction cost of pedestrian decks being of reinforced concrete slab will not substantially change with span length within a range of 10s meters, while longer span decks appears more suitable in the study area from an aesthetic point of view. For the above reason, the span length has been decided at around 16.0 meters (for details, see Drawing No. B-6 to Drawing No. B-9 in Volume II).

155. For the span length of pedestrian bridges, little choice is available because of physical constraints of roadways and locations of medians only on which piers can be erected.

156. To ensure 5-meter vertical clearance on roadways, the minimum height of footpath of pedestrian bridge becomes 6 meters high above roadway surfaces. The height of pedestrian decks, meanwhile, is 5 meters over bus lanes which require only 3.7-meters vertical clearance which has been confirmed by BMA.

3. Structural Design

157. Although a steel bridge has an advantage of a shorter construction period and less obstruction on a traffic flow on busy street during construction works, a concrete type bridge has been adopted with a view to make use of local materials as much as possible and maintenance free.

158. The pedestrian bridge for which a long span length is required due to physical constraints of road structures, is of prestressed concrete hollow slab. Owing to adoption of prestressed concrete hollow slab, the height of beam can be made as low as 1.0 meter, resulting in less visual intrusion against the view of the Victory Monument. For the pedestrian deck, prestressed concrete hollow slab is theoretically applicable but due to its relatively complexed geometric design, reinforced concrete slab has been adopted.

159. The structures both for pedestrian bridge and deck have been designed in accordance with the structural design conditions in Appendix 12.

4. Lighting

160. For overpass, lighting is necessary only at night. According to the aforementioned road improvement project, a lighting system for the whole area of the Victory Monument roundabout is planned to be installed. Although the planned lighting system appears to be sufficient to illuminate the footpath, supplementary lighting system to secure pedestrian's safety, security and amenity has been planned at stairways and on pedestrian decks.

161. For the bus stop spaces under the pedestrian decks, the provision of skylights on the decks will be of a great use during daytime. As to illumination at night, lighting of fluorescent tubes installed on the undersides of decks is considered a reasonable approach.

5. Relocation of Underground Utilities

162. Except for about 180 m. of drainage pipes in the south-east and south-west quadrants, no underground utilities are required to be relocated. However, as the substructures are planned close to the existing underground utilities which are difficult to be pinpointed, due attentions should be paid in the course of detailed design.

6. Construction Quantity

163. The estimated construction quantities are shown in Table-20. The details with breakdown of the quantities are contained in Appendix 13.

Table-20 Construction Quantity

Item	Unit	Quantity	Remark
1. Preparatory Works			
Removal of Pavement	m^2	1,350	
Removal of Islands	m^2	178	
Relocation of Drainage	m	180	ϕ 1,200 mm
2. Substructure			
Excavation			
Steel sheet piles	t	439.1	
Excavation	m^3	1,310	
Piling			
P.C Piles	No.	456	solid square section-35
Footing			
Concrete A	m^3	388	σck = 210 kg/cm^2
Form	m^2	609	
Reinforcing Bar	t	19.5	SD 30
Lean Concrete	m^3	94	
Pier			
Concrete B	m^3	133	σck = 240 kg/cm^2
Form	m^2	720	
Reinforcing Bar	t	29.7	SD 30
Finishing	m^2	641	Splay painting
Scaffold	m^3	562	Steel scaffold
3. Superstructure			
Main Structure			
Concrete B	m^3	2,148	σck = 240 kg/cm^2
Concrete C (P.C)	m^3	665	σck = 350 kg/cm^2
Form	m^2	9,801	
Reinforcing Bar	t	552.9	SD 30
Rolled steel (H)	t	9.9	
P.C Wire	t	20.5	12-ϕ 12.4 mm, and 12-ϕ 7 mm.
Staging	m^3	23,096	
Erection Girder	t	169	
Others	L.S.	1	temporary foundation, fence
Pavement	m^2	6,218	
Finishing	m^2	9,855	
Handrail	m	1,846	
4. Utility Appurtenance			
Lighting	L.S.	1	
Others	L.S.	1	bench, shade, flower bed, protector for pier
5. Reconstruction	m^2	1,531	

7. Cost Estimation

164. Construction cost has been estimated at 1983 price. Table–21 shows the total cost in Baht. The details of the cost of civil works are contained in Appendix 14 with breakdown of labor, materials and equipment. Price escalation has been estimated based on the implementation schedule in Appendix 15.

Table–21 Estimated Cost

Item		in Baht
(A)	Construction cost	
	Civil works	45,870,000
	Overhead for civil works (21%) [1]	9,630,000
	Relocation of utilities [2]	1,660,000
	Contingency (5%)	2,890,000
	Price escalation (15%) [3]	8,950,000
	Sub-Total	69,000,000 [4]
(B)	Consulting Service	
	Detailed design	7,100,000
	Supervision	3,200,000
	Sub-Total	10,300,000
	Total	79,300,000

1) Inclusive of profit (7.5%) and tax (3.4%).
2) Inclusive of overhead.
3) Based on 5% increase per annum.
4) This figure corresponds to the construction cost in interim report. The increase by about 15% as compared to that of the interim report is mainly due to price escalation.

165. Unit costs and list of main equipment for civil works are shown in Appendix 16 and Appendix 17.

8. Construction Method

166. There are, in general, three construction methods of prestressed concrete bridge, i.e. cast-in-situ method, launch erection method applicable to precast bridge and segmental built method applicable to precast blocks. The construction methods for precast bridge and blocks are economical when a project is big enough to warrant an investment for bridge prefabrication and the shape of structure is uniform. They are also effective method to reduce construction period at site.

167. Meanwhile, the possible bridge project in this study is a relatively small in scale and will not warrant adoptation of these methods, because of little merit of mass-production. Furthermore, as the horizontal alignments of the pedestrian bridges are of circular curves with small radii, the above two methods entail complicate field works at site and may involve uncertainty of structural reliability. In view of these facts, the cast-in-situ method seems to be appropriate at present. However, this does not necessarily mean elimination of the precast methods. A final decision should be made at a detailed design taking into account technical and social circumstances.

168. For the pedestrian decks of reinforced concrete, staging construction method is most practical in terms of construction cost and easiness of construction works.

169. The pedestrian bridges and decks are economically constructed in two stages both for the bridges and decks. The construction of the pedestrian decks has to precede that of the pedestrian bridges, as the pedestrian bridges have been designed to be supported by shoes placed on the ends of pedestrian decks.

170. During construction works, the prestressed concete hollow slab will be supported by 20-meter long erection girders spanned over the streets. Although the erection girders reduce the vertical clearance of arterial streets by 1-meter, the remaining clearance could be kept at about 4 meters which are enough for normal traffic. (See Drawing No. B-13 in Volume II)

171. Due to temporary stagings for the construction of pedestrian decks over bus lanes, the outer bus lanes of each quadrant will be closed. Since some portion of bus lanes and bus stops will be affected by construction works, a full coordination among concerned authorities should be made prior to project implementation.

172. A draft implementation schedule, including consulting services for detailed design is shown in Appendix 15. The construction works are expected to be completed in 14 months.

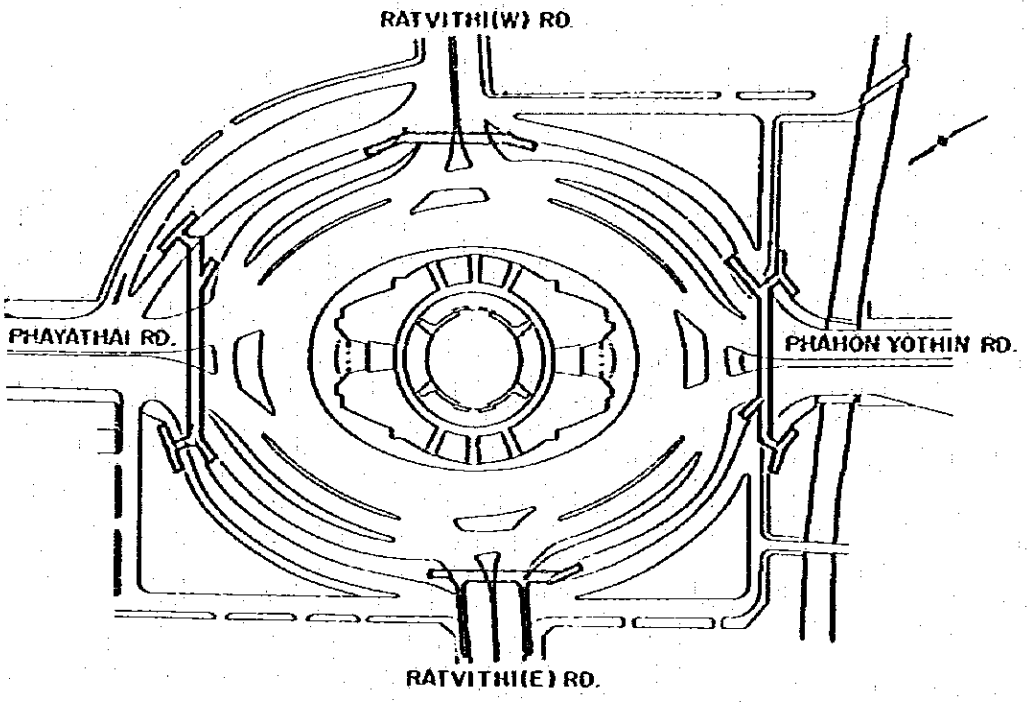
9. Drainage

173. Since the catchment area of the footpath is relatively small, no particular arrangements for rainwater drainage are necessary. The gutters set in on the both sides of footpath, with an adequate longitudinal slope, are sufficient for normally expected rainfall.

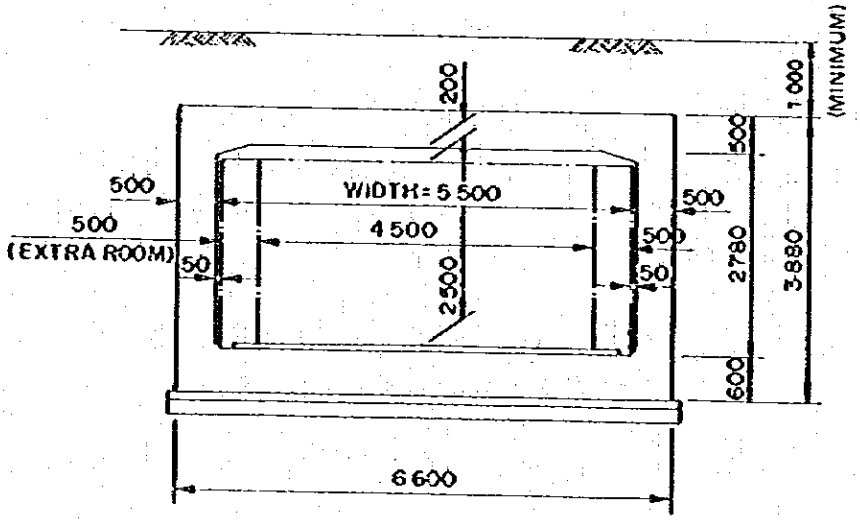
C. Separate Underpass (Alternative 3)

1. General

174. The preliminary engineering design for Alternative 3 has been carried out on the following geometric plan. The tunnels and stairways are of reinforced concrete. The total length of the tunnels is 226 m. while the total length of the stairways is 285 m. The detailed drawings of Alternative 3 are contained in Volume II.



Figure–17 Configuration of Tunnels



Note: Dimension is in millimeter

Figure–18 Typical Cross Section

2. Geometric Plan

175. Alternative 3 consists of four tunnels of which structure is reinforced concrete box culvert. The dimension of the four tunnels under the Ratvithi (W), Phayathai, Phahonyothin, and Ratvithi (E) streets are shown in Table-22.

Table-22 Dimension of Tunnel

	Tunnel		Stairway		
	Width[1]	Length	No.	Width	Length[2]
Ratvithi (W)	5.5 (m)	51.8 (m)	2	3.5 (m)	21.2 (m)
Phayathai	5.5	74.6	6	3.5	85.2
Phahonyothin	5.5	52.2	6	3.5	95.6
Patvithi (E)	5.5	46.9	4	3.5 [3]	83.3

1) Wall to Wall
2) Inclusive of access tunnels
3) The stairways on the sidewalks of Ratvithi (E) street are 2.25 m. wide.

176. The longitudinal profile of the tunnels is planned to slope down from both ends of a tunnel towards its center with 0.2% of grade so as to collect and drain water at one place in the tunnel. This arrangement aims to minimize an earth coverage of tunnel. The crossfall of the footpath in the tunnel is about 1.1% for drainage purpose. The configuration and co-ordinates of the four tennels are shown in Drawing No. U-1 in Volume II while dimensions are shown in Drawing No. U-2, U-5, U-8, and U-11 in Volume II.

3. Structural Design

177. The structures have been designed in accordance with the structural design conditions attached in Appendix 12. To prevent uneven settlement of structures, pile foundation is required. The placement plans of the pile foundation are shown in detail in Drawing No. U-3, U-6, U-9 and U-12 in Volume II.

178. To prevent underground water seepage, water proofing works are necessary. The out-side of tunnels is to be covered with rubber membranes which are protected with mortar from possible impairment in the course of field works.

4. Accessory Facilities

a) Ventilation

179. Although a few ventilation systems (See Appendix 18) are available to these underpass tunnels, a longitudinal ventilation system by booster fan is considered adequate in view of cost and easy maintenance works. The specification and number of fans are as follows;

1) Specification of fan;

power	:	1,500 W;
volume flow	:	0 ∿ 75 m^3/min;
fan pressure	:	83 ∿ 0 mm Aq; and

2) Number of fan;

Ratvithi (W) tunnel	:	4,
Phahonyothin tunnel	:	6,
Ratvithi (E) tunnel	:	6,
Phayathai tunnel	:	6.

The arrangement of the booster fans are shown in Drawing No. U-14 and Drawing No. U-15 in Volume II.

b) Lighting

180. The lighting system has been planned so as to ensure light intensity of 100 lux at the entrance of tunnel and 50 lux inside tunnel. In this plan, fluorescent tube has been chosen as lighting source because of its relatively easiness of maintenance in view of supply and price.

181. The fluorescent tubes should be mounted on the ceiling of tunnel to keep light intensity uniform. This mounting arrangement also makes wiring electric supply easy which can be accommodated right behind ceiling.

c) Drainage

182. To take away water from the footpath pavement, a crossfall and longitudinal slope have been provided. A catch basin (See drawing No. U-15 in Volume II) is placed in the longitudinally middle part of tunnel where profile is lowest so as to collect the water produced by following causes:

cleaning water
seepage
carrying in of the rain water

The water collected in the catch basin is to be drained out automatically by underwater pump when the water depth reaches a certain height. The specification of pump is as follows;

number of pump	:	2 (for each tunnel)
power	:	500 W
capacity	:	0.15 m^3/min
head	:	6.5 m.

183. The steps of stairway at the entrances which will be built on traffic island have been raised by about 10 cm. to prevent water from flowing into the tunnels through stairways.

5. Relocation of Underground Utilities

184. There are numerous telephone cables, electric cables, water and drainage pipes, under the roundabout of the Victory Monument. A certain amount of the utilities come across the planned structures of Alternative 3. The Team consulted with concerned authorities about an extent and method of relocation of the utilities, based on the results of preliminary engineering design. Table–23 shows the length of utilities found to be relocated, while Drawing No. U-18 to Drawing No. U-21 show new alignments of them.

Table–23 Relocation Length of Underground Utilities

Item		Length (m)	Remarks
Telephone cable	6–ϕ4" 12–ϕ4" 4–ϕ4" 24–ϕ4"	30 330 30 370	
Electric cable	69 KV	50 25	
Watermain pipe	ϕ900 m/m ϕ800 m/m ϕ300 m/m ϕ200 m/m	198 396 252 184	
Drainage pipe	ϕ1,200 m/m	167 136	2.1 m deep 6.7 m deep
	ϕ1,000 m/m	40 50	1.9 m deep 6.5 m deep

185. The electric cables are to be removed on the planned tunnels at the present location and some of drainage pipes are to be removed under the structures of tunnel at the Ratvithi (E) Street, while other utilities will be replaced at new location.

6. Cosntruction Quantity

186. The estimated construction quantities are shown in Table-24.

Table-24 Construction Quantity

Item	Unit	Ratvithi (W)	Phayathai	Phahonyothin	Ratvithi (E)	Total	Remarks
1. Preparatory Work							
Removal and disposal of pavement	m^2	682	1,317	1,255	826	4,080	curb, tree, etc.
2. Construction of Tunnel							
Wall protection							
Sheet Pile	t	204	354	339	336	1,233	
Strut, Wale, Beam	t	118	204	195	193	710	
Cover Plate	t	36	127	138	131	429	
Excavation & Disposal	m^3	2,653	5,557	4,567	3,744	16,521	
Foundation							
Pile – 1	No.	8	24	24	14	70	L=22.5 m
Pile – 2	No.	64	158	143	84	449	L=18 m
Footing Concrete	m^3	38	94	88	49	269	210 kg/cm²
Form	m^2	57	118	112	68	355	
Reinforcing Bar	t	2.3	5.6	5.3	2.9	16.1	SD 30
Box Culvert							
Concrete	m^3	515	992	701	631	2,839	210 kg/cm²
Form	m^2	997	2,004	1,453	1,458	5,912	
Reinforcing Bar	t	77.3	148.8	96.0	94.7	417	SD 30
Level Concrete	m^3	34.3	66.4	50.5	45.1	196	
Rubble	m^3	68.6	132.8	101.0	90.3	393	
Lining	m^2	259	478	404	419	1,560	
Ceiling	m^2	269	541	353	332	1,495	
Water Proofing	m^2	1,055	2,022	1,520	1,450	6,047	
Pavement	m^2	254	501	371	318	1,444	
Staging	m^3	768	1,499	1,114	1,012	4,393	
Stair and Entrance-Roof	No.	2	6	6	4	18	
Dewatering	day	–	–	–	–	330	
Back fill	m^3	1,091	2,137	1,787	1,594	6,609	
3. Facilities							
Lighting	No.	63	132	123	86	404	
Ventilation	No.	4	6	6	6	22	booster fan
Drainage system	L.S.	1	1	1	1	4	
4. Reconstruction	L.S.	–	–	–	–	1	Pavement, curb, tree, etc.

7. Cost Estimation

187. Cost estimation shown in Table–25 has been made at 1983 price. The details of the cost of civil works are contained in Appendix 19 with breakdown of labor, materials and equipment. Price escalation has been estimated based on the implementation schedule in Appendix 20.

Table–25 Estimated Cost

Item		in Baht
(A)	Construction cost	
	Civil works	60,360,000
	Overhead for civil works (21%) [1]	12,680,000
	Relocation of Utilities [2]	34,160,000
	Contingency (5%)	5,360,000
	Price escalation (15%) [3]	16,890,000
	Sub-Total	129,450,000 [4]
(B)	Consulting Service	
	Detailed design	7,300,000
	Supervision	3,650,000
	Sub-Total	10,950,000
	Total	140,400,000

1) Inclusive of profit (7.5%) and tax (3.4%).
2) Inclusive of overhead.
3) Based on 5% increase per annum.
4) This figure corresponds to the construction cost in the interim report. The increase by about 29% as compared to that of the interim report is mainly due to widening the width of tunnels and stairways and price escalation.

188. Unit costs and list of main equipment for civil works are shown in Appendix 21 and Appendix 22.

8. Construction Method

189. As mentioned in Chapter 5 (See paragraph 101), two stage construction method is desirable from economical point of view. However, as there are a substantially heavy traffic and a large amount of utilities to be relocated, a final construction method, in particular, its sequence should be decided after consultation with concerned authorities.

190. The relocation of electric cables and drainage pipes are to be executed along with construction works of tunnels, because they are supposed to be replaced right on or under the structures of tunnels. Meanwhile, the telephone cables and water pipes shall be relocated prior to construction works of tunnels to make the whole construction period shorter.

191. A draft implementation shedule, including consulting services for detailed design is shown in Appendix 20. They are decided after consultation with BMA. The construction period is expected to be 18 months on condition that the relocation of telephone cable and watermain will be executed prior to the construction.

9. Roof Design

192. The main structures of Alternative 3 have practically no visual impact. The planned roofs over stairways, however, have some effect on visual amenity within the limited areas where they are to be constructed.

193. Since the roofs are relatively small structures, the design approach to minimize their visual impact and accommodate them to the existing surroundings is considered appropriate. Therefore, in principle, simplified structures for roofs have been proposed as shown in Drawing No. U-16 and No. U-17 in Volume II. The exterior of the structures may be decorated with adequate materials like tiles.

194. The roofs for the entrances on the outer islands at the junctions of the streets of Phahonyothin and Phayathai have been designed to be symbolic but in a moderate manner, because they directly face the main traffic flows and constitute a sort of gateways to the monument. They are topped with about 5-meter high towers which concurrently form a rear ended wall and may be utilized as places to mount or place some symbolic objects e.g., clock, sculpture, statue, street name, direction sign (See Drawing No. U-16 in Volume II).

195. In addition to the architectural design, due considerations have been paid to traffic safety. As the roofs are located on the tips of traffic islands where bus travelled ways converge, the sidewall height of the entrance are kept to minimum only high enough to prevent pedestrians from falling down. This arrangement will enable bus drivers to gain a clear sight into another bus travelled ways.

CHAPTER 7
EVALUATION

CHAPTER 7 EVALUATION

1. Basic Approach

196. A general approach to evaluation in a feasibility study is to measure impacts accrued from alternatives for a project and assess them. However, mainly due to complexity and difficult definition of impacts, a traditional approach to project evaluation limits the scope of impacts only to those which are tangible and quantitative in monetary term, and assesses them from an economic viewpoint in comparison with investment.

197. For example, the most popular evaluation approach for highway projects generally measures only the road users' direct and quantitative benefits in terms of savings of operation cost and travelling time on which the main objective of road construction is rested. And the project evaluation is made based on economic analysis in the form of "benefit-cost ratio" or "economic internal rate of return".

198. In case of the Victory Monument project, since its main objective is to ensure pedestrians' safety and orderly traffic movement at the roundabout of which effect can not be easily measured quantitatively, the traditional evaluation method is not directly applicable. What is more, there are following requirements of which evaluation can not be inherently made by the economic analysis;

1) to provide pedestrians with convenience and amenity; and
2) to preserve the dignity of the Victory Monument and its surrounding view.

199. The Victory Monument project, thus, involves various aspects which are mostly subjective matters of which evaluation should be made qualitatively, reviewing various information. This Chapter, therefore, concentrates to present information obtained through the study which helps a decision maker select a final alternative.

2. Engineering Features

200. The project cost, construction period, quantity of utilities to be relocated and maintenance cost are shown in Table–26.

Table–26 Engineering Features

	Alternative 2	Alternative 3
Project Cost (Million Baht)	79.3	140.4
Maintenance Cost (Million Baht)	Almost none	0.2 (Per annum)
Construction period	14 months	18 months
Utilities to be relocated		
Drainage Pipe	180 m.	393 m.
Water Pipe	None	1,030 m.
Electric Cable	None	75 m.
Telephone Cable	None	760 m.
Obstruction on traffic flow	Minor but some for bus lane	Some for all traffic

201. In case of Alternative 2, construction works can be executed in the daytime and will be completed in much shorter period than Alternative 3. During construction, the outer bus lane should be closed. The portion of construction works of Alternative 3 which may otherwise affect the heavy traffic flow shall be carried out mainly at night when traffic volume is less. However, some obstruction on traffic flow during construction work as well as relocation of utilities are unavoidable.

202. Alternative 3 has a potential to be remodeled to other alternatives as shown in Chapter 5 without duplication of investment, if necessary in the future.

3. Amenity

203. As for amenity under this study, major aspects to be assessed are convenience, comfort and security of pedestrians. Table-27 describes preliminary assessment on the above aspects contrasting the two alternatives.

Table-27 Amenity

	Alternative 2	Alternative 3
Convenience	For those who cross two streets; Convenient	For those who cross only one street; Convenient because height of stairway is lower [1] Better accessibility, because of entrance location
Comfort	Brighter Footpath. Open-air atmosphere. To provide passengers at bus stop with shelter.	Free of weather. To require lighting and ventilation.
Security	Safer	To require security arrangement like emergency alarm.

1) The height of stairway of Alternative 2 is about 6.0 m. as compared to 4.2 m. of Alternative 3.

4. Beauty

204. Beauty is entirely subjective matter and not measurable. However, in case of Alternative 2, the view of the Victory Monument from the approaching streets is unavoidably impaired by the bridge girders.

205. Meanwhile, the view from within of the monument may be artificially enhanced by properly designed circular bridge structures of Alternative 2, although the bridges are not salient because they are planned to be built behind the rows of existing high trees.

206. Alternative 3 has no effect as far as visual intrusion on the monument from the approaching streets is concerned. The roofs over stairways of the tunnels may have some impact on the view within the monument. This impact could turn out to be desirable one if the roofs are designed in a manner so that they might fit in with the surrounding sight.

207. For information, the perspectives of the two alternatives are shown in Appendix 23 and 24.

5. Economic Benefit

208. The direct beneficiary of the project is pedestrians and vehicle users at the Victory Monument roundabout. The expected economic benefit for pedestrian is time saving due to elimination of waiting time at the junctions of the roundabout. The benefits of vehicle users are mainly time saving and saving of operating cost due to relief from stopping and starting their vehicles at the junctions during pedestrians' crossing.

209. Where a motor vehicles comes to a stop and then regains speed at intersection, extra fuel and oil are consumed. In the Study, the provision of pedestrian crossing facility at grade separation will relieve some vehicles from stopping and regaining speed at the junctions. The additional operating cost which would be born by those vehicles, should the facility not be implemented, turns to be benefit attributable to the pedestrian crossing facility project.

210. Although the expected time saving by all pedestrians and vehicle users will theoretically reach to a substantial amount, the time saving of each individual is in a range of one minute at most and seems imperceptible so far as each individual pedestrian and passenger is concerned.

211. The economic analysis, therefore, has been made as to only the benefit from the saving of additional operating cost for the time span of 15 years (1986–2000). The number of vehicle which benefits from the Victory Monument project was calculated based on the forecast traffic volumes (see paragraph 52 in Chapter 3) on condition that the traffic signal system designed by the Office of the Committee for Management of Road Traffic (OCMRT) will be introduced.

212. The results of the economic analysis on the project are in Table–28, while the detail of analysis is presented in Appendix 25.

Table–28 Benefit/Cost Ratio

Alternative	Benefit/Cost Ratio
Alternative 2	0.52
Alternative 3	0.29

213. Because both alternatives are same as far as vehicles' movement is concerned and the expected economical benefits from them can be assumed equal, obviously Alternative 2 of which construction cost is cheaper than Alternative 3, will have favorable result of economic analysis under a benefit cost method. The benefit/cost ratios for both alternatives are relatively small as shown in Table-28.

214. However, as the alternatives will bring about to the public other benefits than measurable ones in monetary term, the result of the economic analysis should be interpreted as one of the alternatives' features but not a decisive factor as occasionally experienced in other public transportation facility projects.

215. In particular, it should not be overlooked that the project will bring about invaluable benefit from possible reduction of human suffering and property damage attributable to the project, although no evaluation has been made due to lack of data.

6. Conclusion

216. Table-29 summarizes the foregoing discussions and shows relative comparisons made by the Team between Alternative 2 and Alternative 3. The plus (+) mark in the table indicates that the alternative is assumed to be relatively superior to the other and the minus (-) mark is the other way, while the zero (0) mark means both alternatives are assumed equal. The comparisons in terms of plus and minus have been made to demonstrate one of various approaches to select a final plan among alternatives which involve various none-quantitative factors. The result of the comparisons should be considered as an arbitrary assessment by the Team and does not necessarily mean a decisive judgement.

217. After all, although the two alternatives have got different features inhered in their structural natures, the both are worthy of being implemented under a strong social demand for better traffic conditions. Since this project involves a number of factors, besides those of engineering and economics, like beauty and human aspects which are subjective matters but should be paid due attention to, the final evaluation on the two alternatives should be made through an intensive examination on the findings of this study as well as social requirements.

Table–29 Evaluation of Alternatives

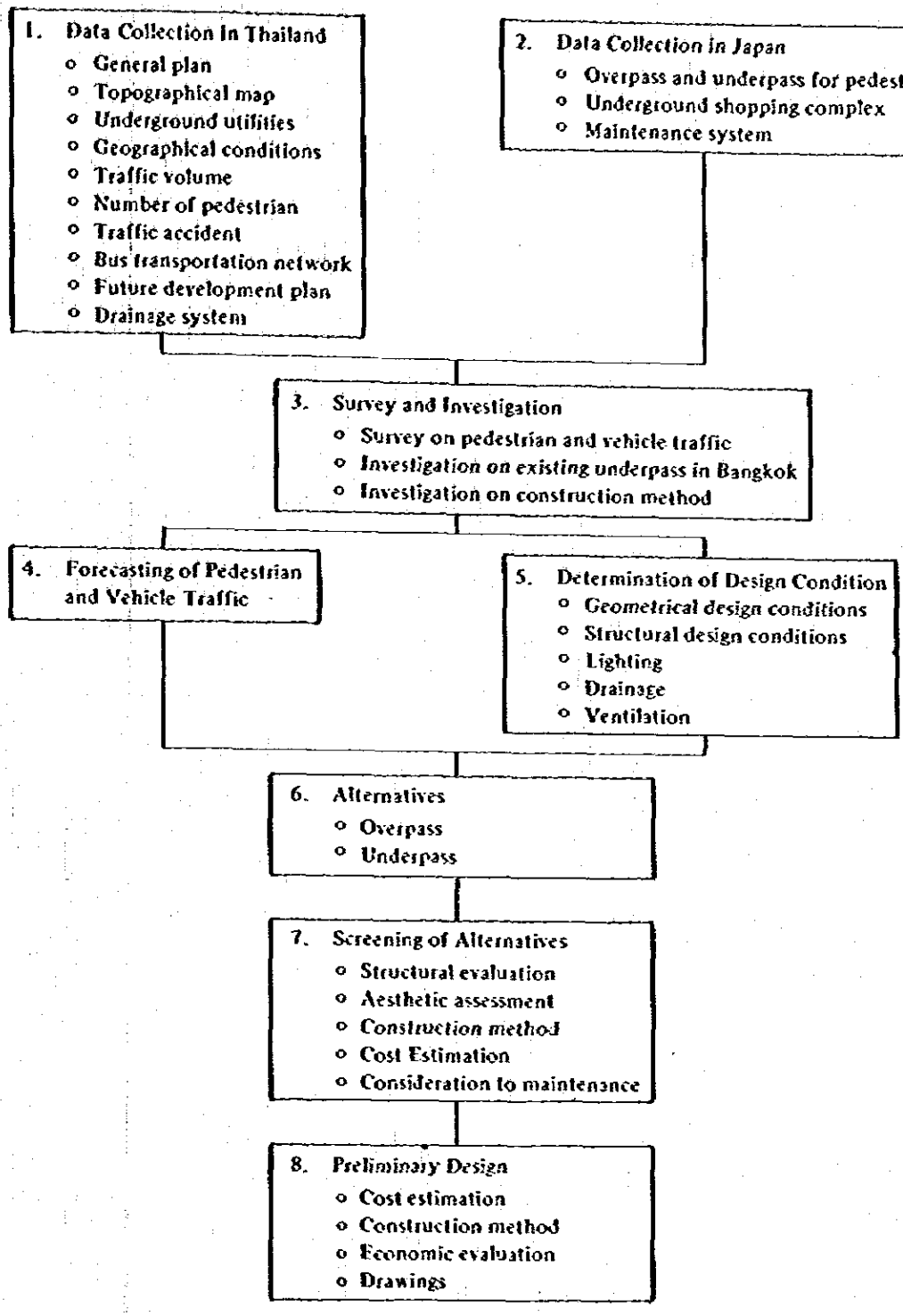
EVALUATION ITEMS		QUALITATIVE COMPARISON	
Classification	Sub Division	Alternative 2	Alternative 3
ENGINEERING FEATURE	1. Project cost	+	–
	2. Potential for structual extention	–	+
	3. Obstruction against traffic flow during construction works	o	o
	4. Maintenance cost	+	–
AMENITY	5. Convenience for pedestrians	o	o
	6. Security of pedestrians	+	–
	7. Surrounding atmosphere on passageway	+	–
	8. Vulnerability to weather at bus stop	+	–
	9. Vulnerability to weather on passageway	–	+
BEAUTY	10 Landscape around Monument	+	–
	11. Preservation of dignity	–	+
	12. Impact on view from approaching road	–	+
	13. Preservation of trees	–	+
BENEFIT	14. Saving of vehicular operation cost	o	o
	15. Saving of waiting time (vehicles)	o	o
SAFETY	16. Traffic safety	o	o

Note: The plus (+) mark in column "QUALITATIVE COMPARISON" indicates the alternative is superior to another.

The minus (–) mark is another way around.

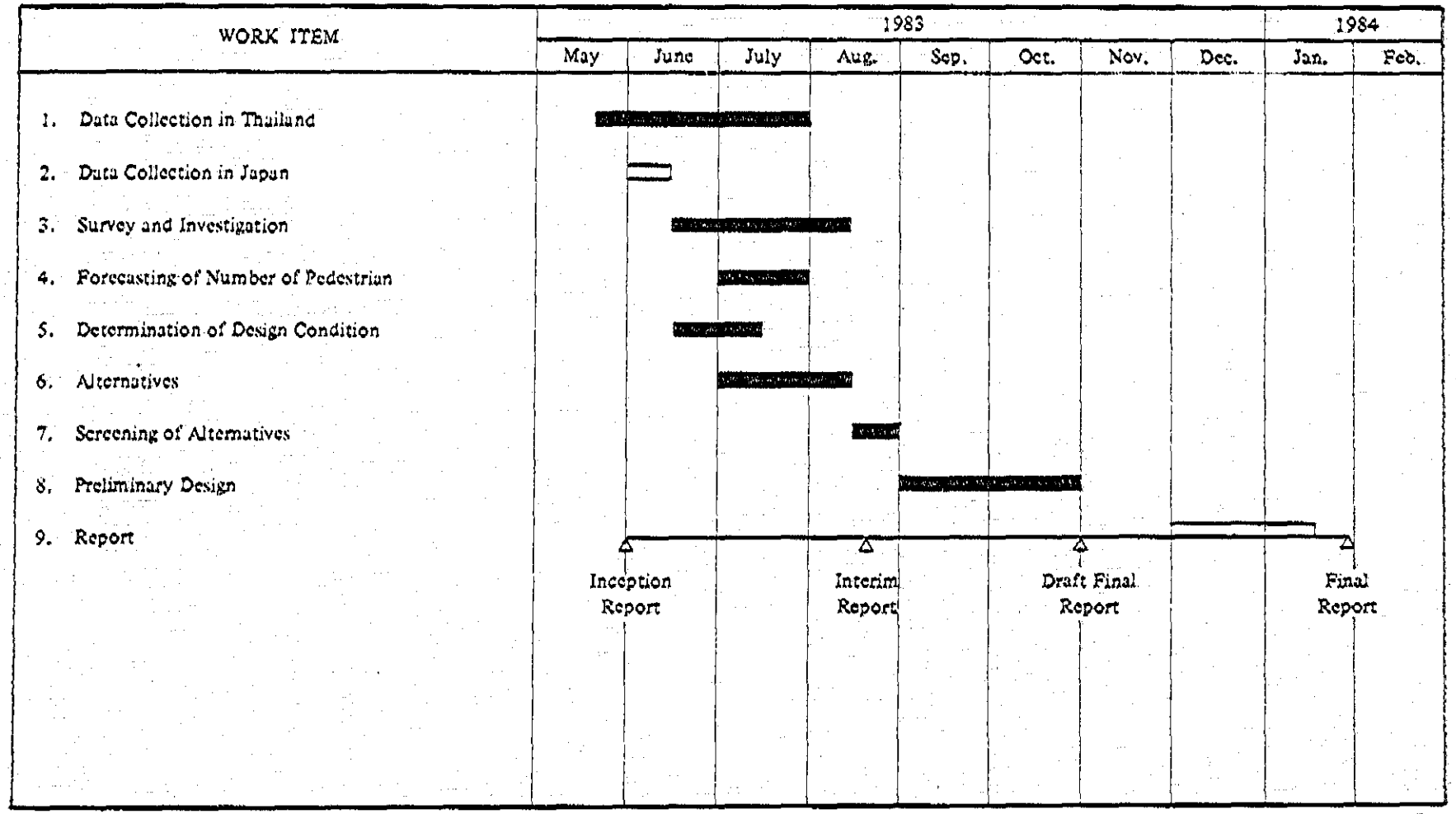
The zero (o) mark means both alternatives are equal.

APPENDIXES


1. Data Collection in Thailand
o General plan
o Topographical map
o Underground utilities
o Geographical conditions
o Traffic volume
o Number of pedestrian
o Traffic accident
o Bus transportation network
o Future development plan
o Drainage system
2. Data Collection in Japan
o Overpass and underpass for pedestrians
o Underground shopping complex
o Maintenance system
3. Survey and Investigation
o Survey on pedestrian and vehicle traffic
o Investigation on existing underpass in Bangkok
o Investigation on construction method
4. Forecasting of Pedestrian and Vehicle Traffic
5. Determination of Design Condition
o Geometrical design conditions
o Structural design conditions
o Lighting
o Drainage
o Ventilation
6. Alternatives
o Overpass
o Underpass
7. Screening of Alternatives
o Structural evaluation
o Aesthetic assessment
o Construction method
o Cost Estimation
o Consideration to maintenance
8. Preliminary Design
o Cost estimation
o Construction method
o Economic evaluation
o Drawings

Study Flow

Work Schedule



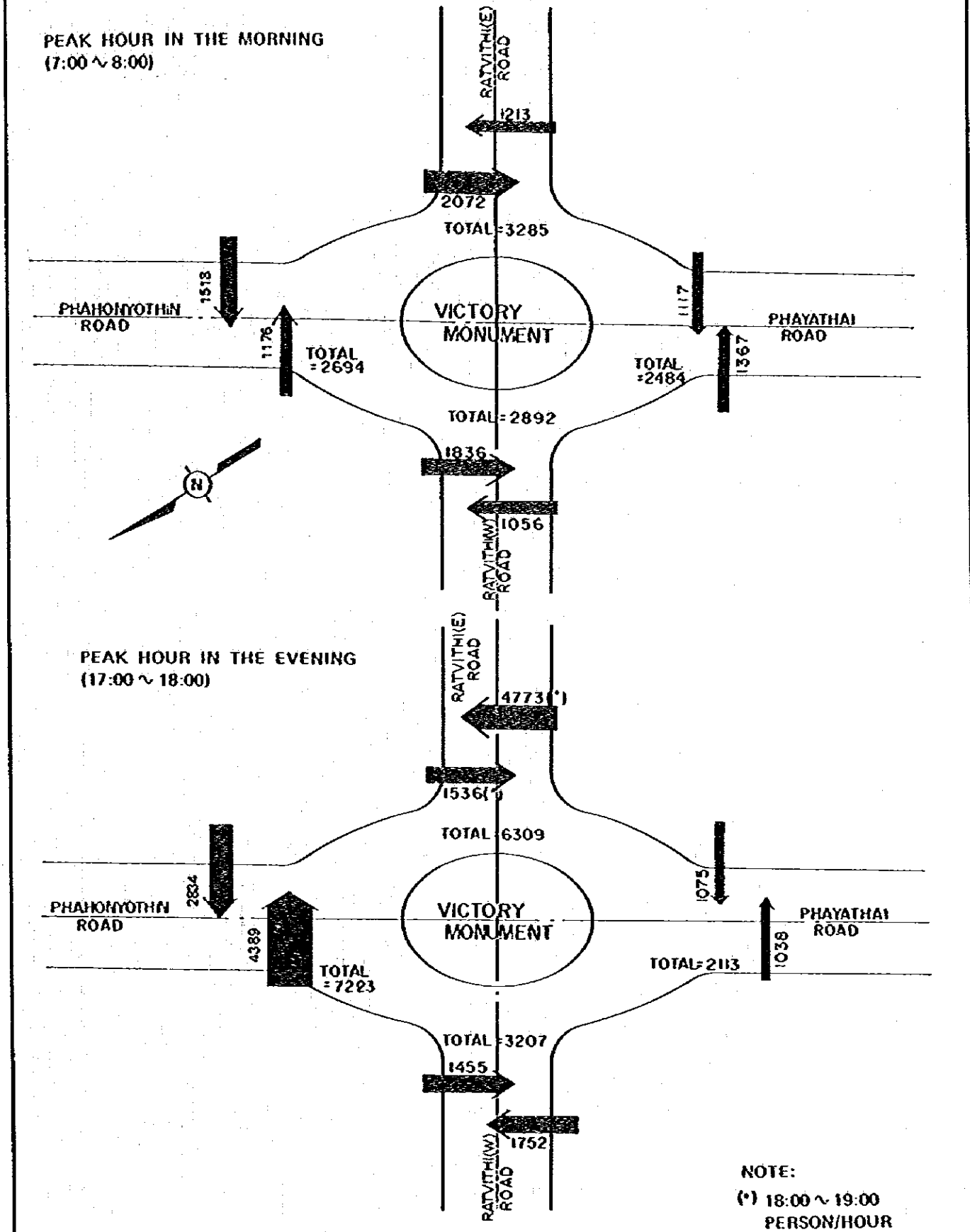
Note: Work in Thailand Work in Japan

Organization for Study

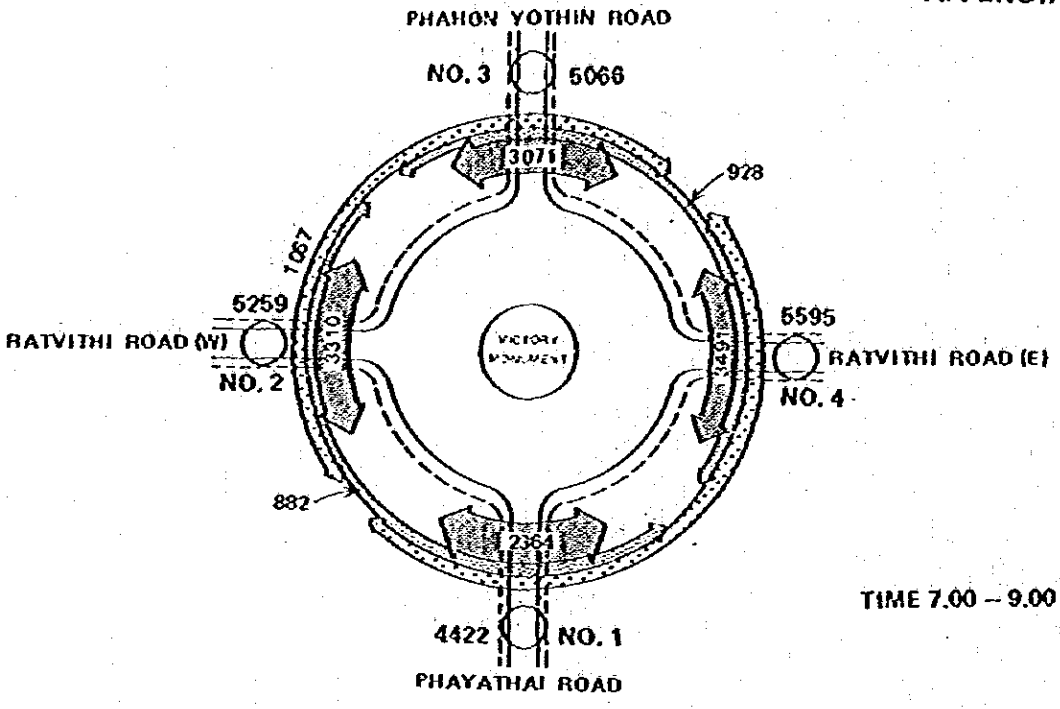
* Former, now is Damri Ratanawang

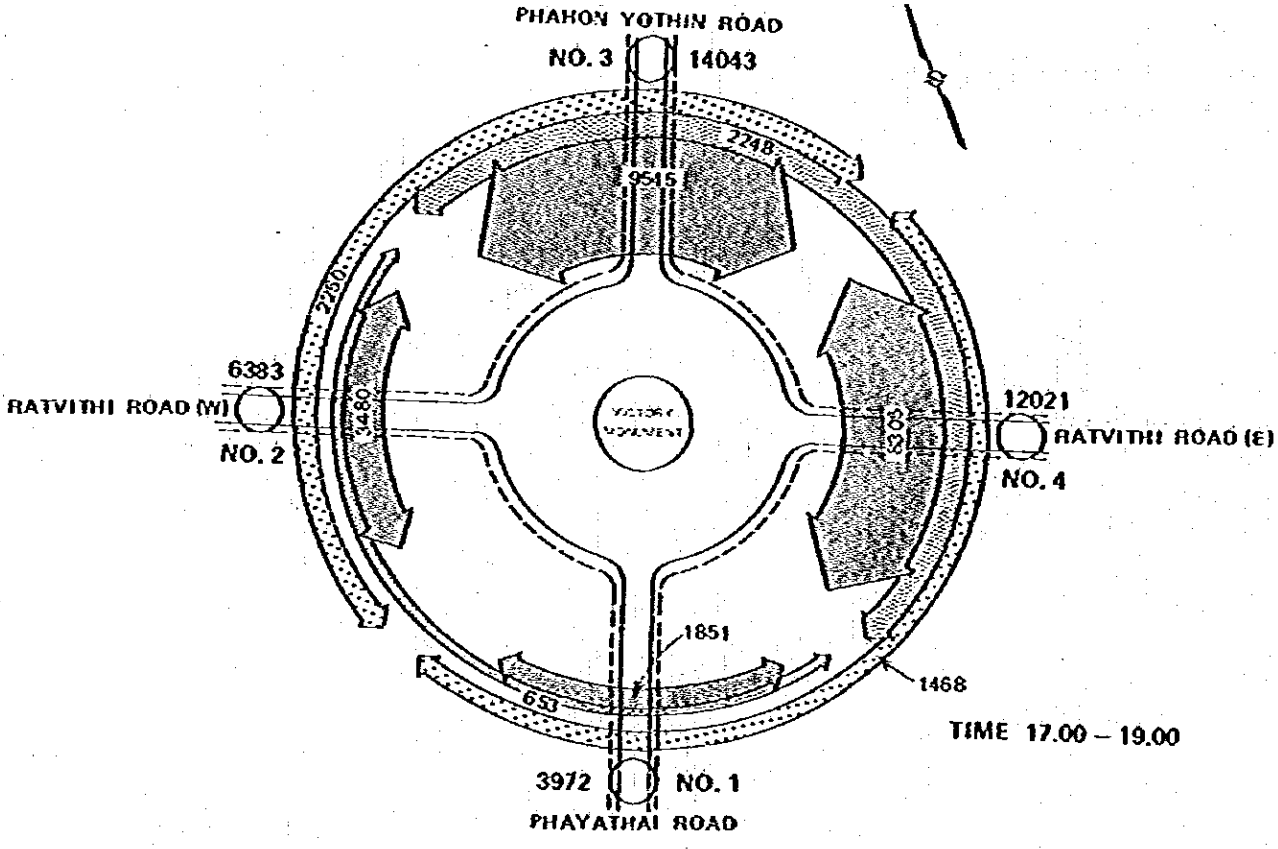
Number of Pedestrians

Time	Crossing Street				Total
	Phahonyothin	Ratvithi (E)	Phayathai	Ratvithi (W)	
07:00 – 08:00	2,694	3,285	2,484	2,892	11,355
08:00 – 09:00	2,372	2,310	1,938	2,367	8,987
09:00 – 10:00	2,907	2,356	1,644	2,470	9,377
10:00 – 11:00	2,613	2,130	1,435	2,332	8,510
11:00 – 12:00	2,968	2,553	1,482	2,361	9,364
12:00 – 13:00	3,840	5,793	2,012	2,150	13,795
13:00 – 14:00	3,747	4,323	1,709	2,139	11,918
14:00 – 15:00	2,950	2,749	1,548	2,220	9,467
15:00 – 16:00	3,715	2,987	1,471	2,087	10,260
16:00 – 17:00	5,639	4,853	1,972	3,105	15,569
17:00 – 18:00	7,223	5,712	2,113	3,207	18,255
18:00 – 19:00	6,820	6,309	1,859	3,176	18,164
Total	47,488	45,360	21,667	30,506	145,021

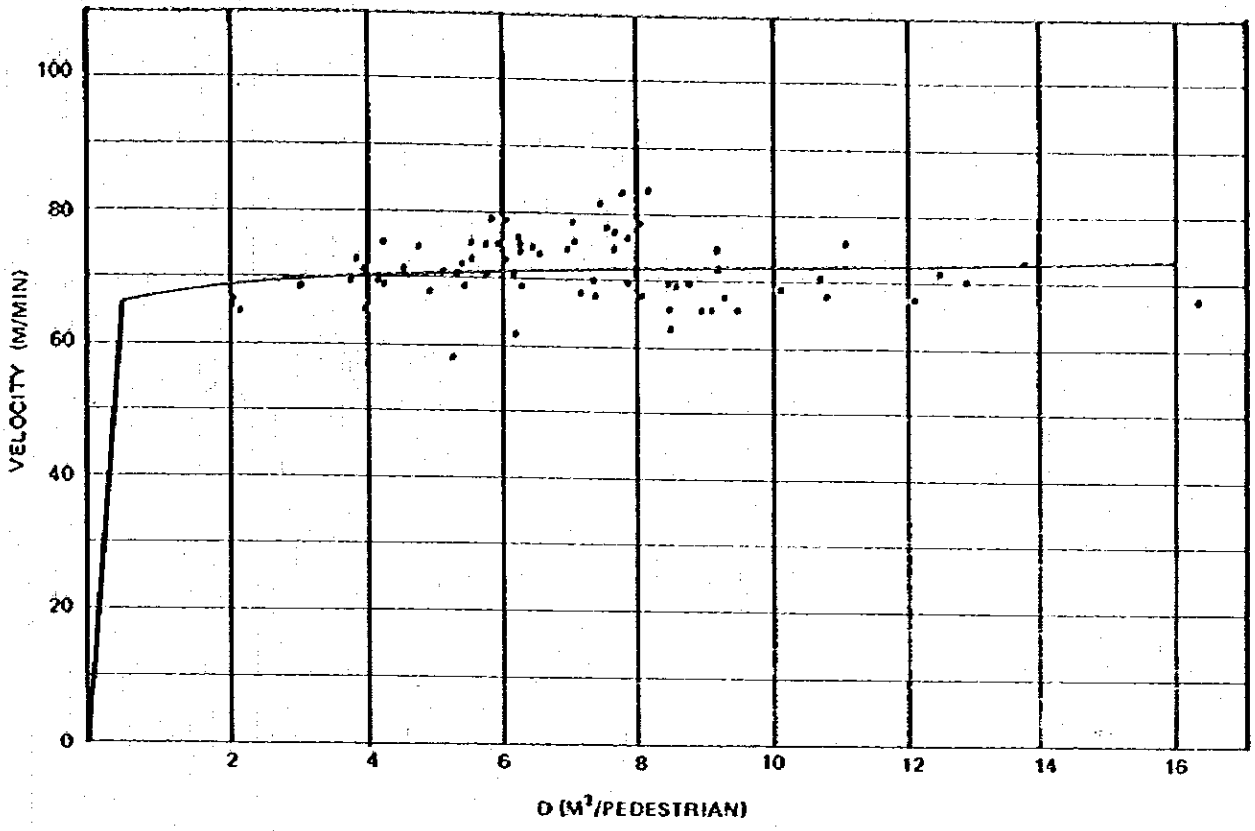


Crossing Pedestrian Volume at Peak Hour

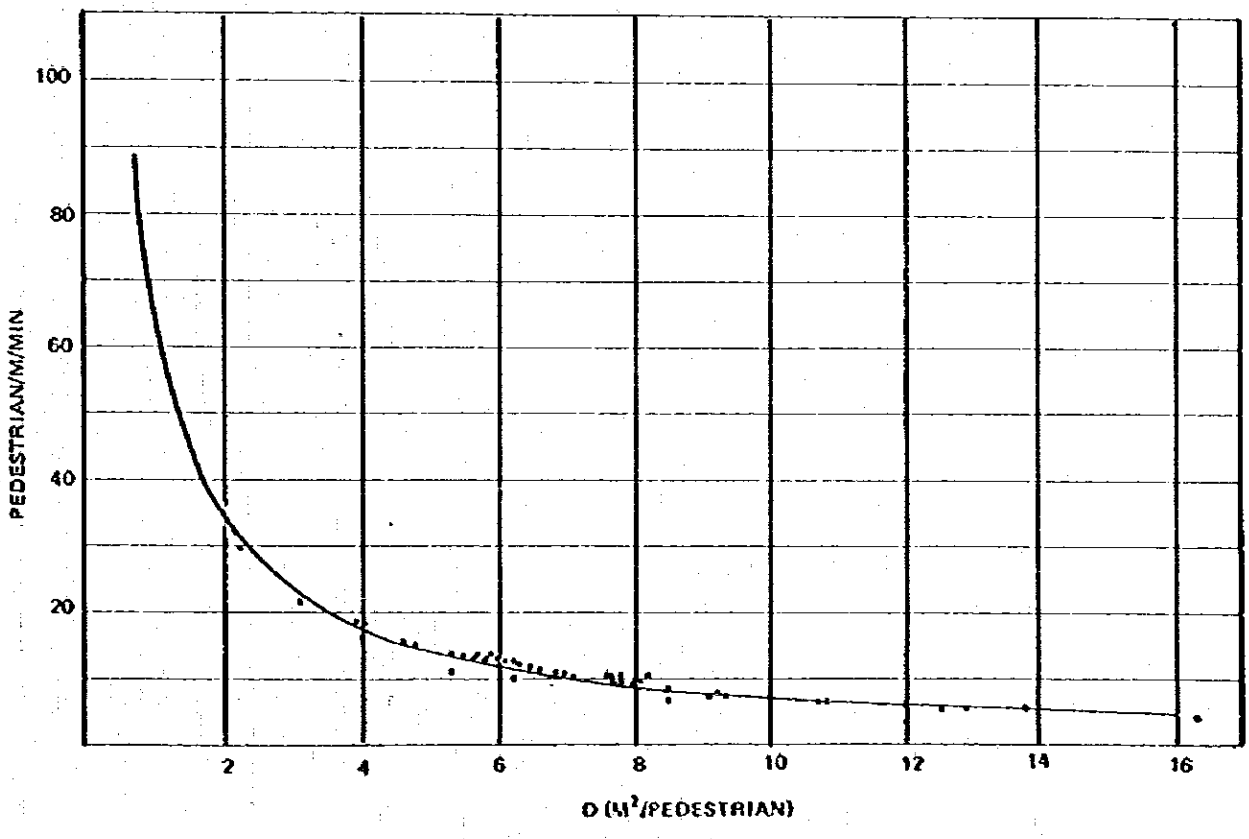




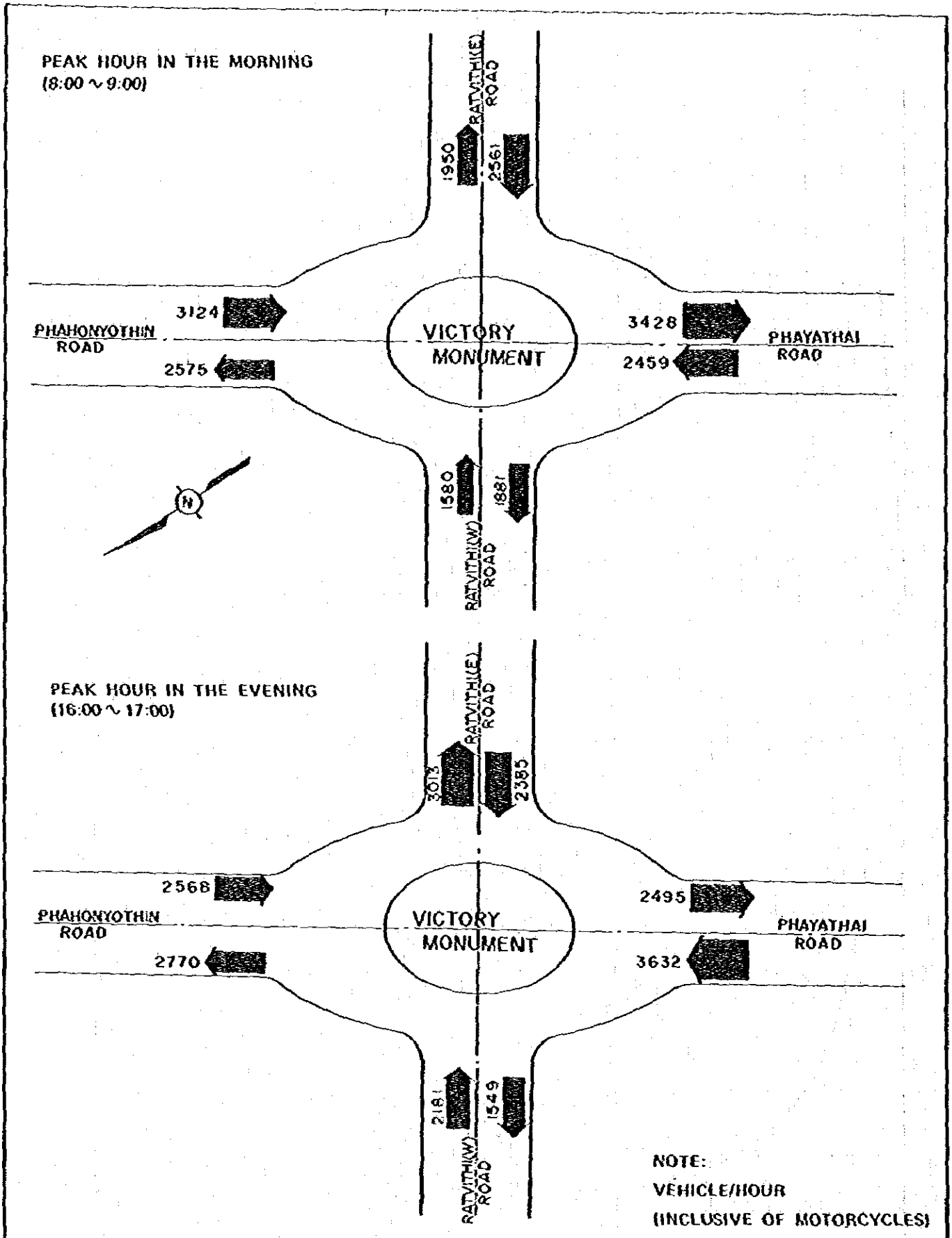
Pedestrian Flow Around Victory Monument



Walking Velocity VS D of all Samples



Pedestrian/m/min VS D of all Samples



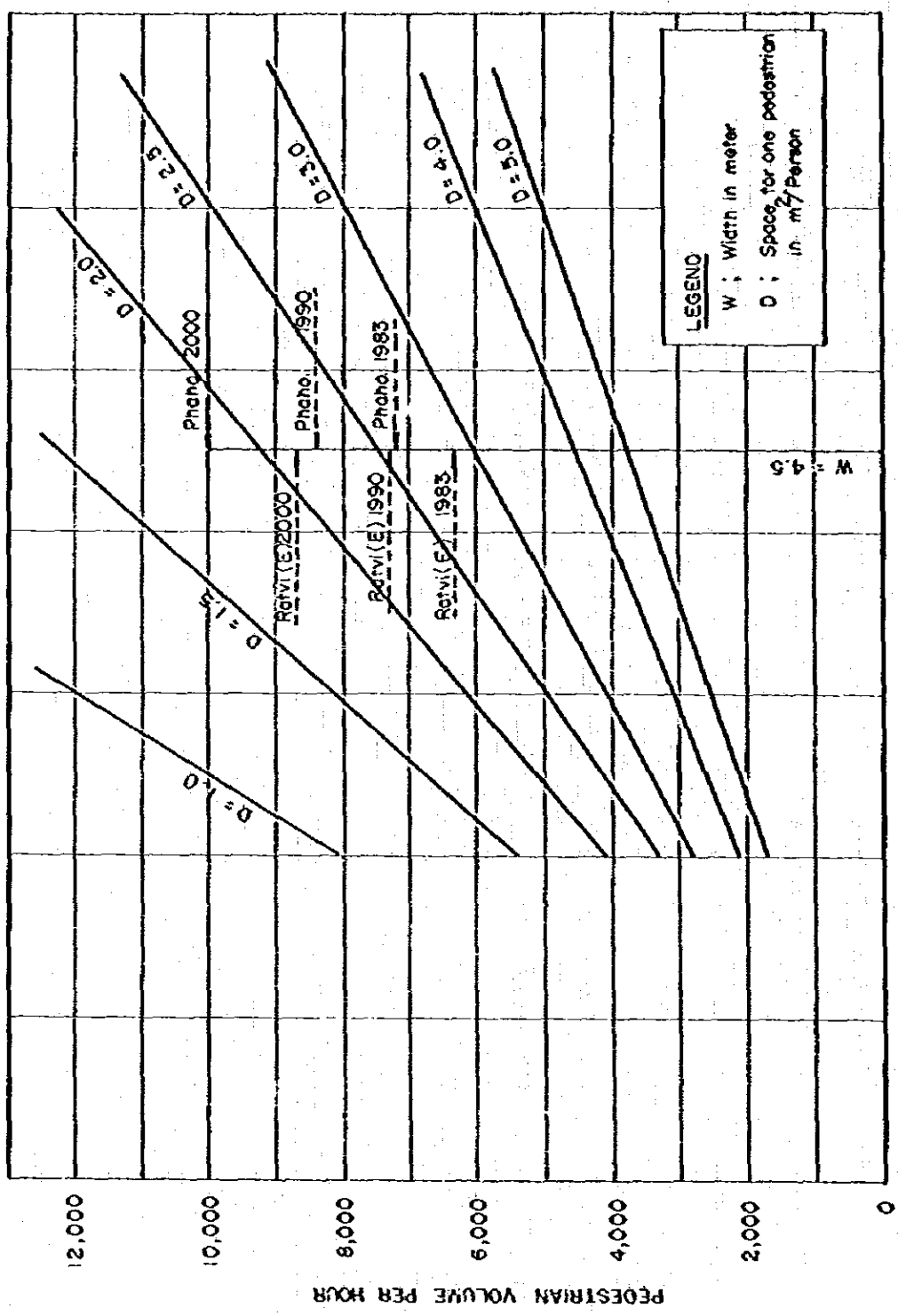
Traffic Volume of all Vehicle Types Around Victory Monument

Vehicle Composition of Traffic

Unit: Vehicles/day

Peak Period	Vehicle Types	Ratvithi (W) Rd.				Phayathai Rd.				Phahonyothin Rd.				Ratvithi (E) Rd.			
		WB	%	EB	%	SB	%	NB	%	NB	%	SB	%	EB	%	WB	%
AM Peak 08:00–09:00	1) Passenger Cars	888	47.2	575	36.4	1,801	52.5	1,070	43.5	1,043	40.5	1,533	48.8	668	34.3	1,185	46.3
	2) Taxis, Samlors	838	20.4	466	29.5	475	13.8	613	24.9	568	22.1	546	17.4	341	17.5	382	14.9
	3) BMTA, Mini Buses	194	10.3	143	9.1	361	10.7	204	8.3	316	12.3	411	13.1	446	22.9	294	11.5
	4) Trucks	99	5.2	67	4.2	25	0.7	31	1.3	97	3.7	135	4.2	24	1.1	148	5.7
	5) Motorcycles	317	16.9	329	20.8	766	22.3	541	22.0	551	21.4	519	16.5	471	24.2	552	21.6
	6) All traffic	1,881	100.0	1,580	100.0	3,428	100.0	2,459	100.0	2,575	100.0	3,144	100.0	1,950	100.0	2,561	100.0
PM Peak 16:00–17:00	1) Passenger Cars	685	44.2	1,220	55.9	1,155	46.3	1,796	49.4	1,415	51.1	930	36.2	1,470	48.8	954	40.0
	2) Taxis, Samlors	297	19.2	330	15.1	511	20.5	824	22.7	444	16.0	597	23.2	431	14.3	403	16.9
	3) BMTA, Mini Buses	192	12.4	157	7.2	303	12.1	315	8.7	273	9.9	307	12.0	382	12.7	322	13.5
	4) Trucks	82	5.3	117	5.4	29	1.2	43	1.2	121	4.3	145	5.7	83	2.7	160	6.7
	5) Motorcycles	293	18.9	357	16.4	497	19.9	654	18.0	517	18.7	589	22.9	647	21.5	546	22.9
	6) All traffic	1,549	100.0	2,181	100.0	2,495	100.0	3,632	100.0	2,770	100.0	2,568	100.0	3,013	100.0	2,385	100.0

Source: Traffic Survey on June 15th 1983.



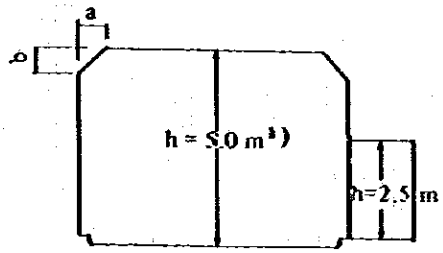
Pedestrian Volume and Width of Footpath

Geometric Design Conditions (1)

1. Clearance

Roadway clearance, pedestrian path clearance and other limits on planning of pedestrian footpath have been developed as shown in the below figures.

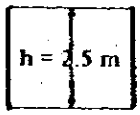
1) For Roadway and Sidewalk



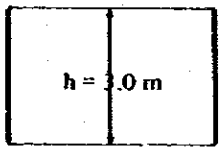
a = b = 0.8 m

[1]) 3.7 m. for bus lane

2) For Pedestrian Bridge and Tunnel



3) For Underground Commercial Sapce.



2. Profile and Crossfall

		Bridge		Tunnel
Profile	i ≥	1.0%	i ≥	0.2%
Crossfall	i ≥	2.0%	i ≥	1.0%

3. Stairways

The gradient of stairway shall be 1:2 as a standard. Landing shall be provided at half way of stairways, in case of the height is more than 3 meters.

The length of landing shall be as follows:

1) For straight stairway : more than 1.2 m
2) For other type of stairway : Width of stairway

4. Earthcoverage for Tunnel

To take advantage of underpass, it is desirable to plan structures as shallow as possible. To achieve this objective, earth coverage of underpass should be kept to minimum requirement. Giving consideration to above mentioned matters and existing underground utilities, 1 m is adopted for planning of the Study.

5. Extra Room

In case of underpass, following extra-rooms are equipped in addition to necessary clearance for footpath.

Overhead : 0.2 m
Lateral : 0.4 m (on each side) - (after screening this has been changed to 0.5 m)

The excess room is mainly for lighting, lining and wiring.

Structural Design Conditions (1)

1. Design Loads

Dead Load Bridge and Tunnel	Pavement 2.4 t/m³, Soil (dry) 1.7 t/m³ Reinforced concrete 2.5 t/m³ Steel 7.85 t/m³
Live Load Bridge	Floor slab/Floor beam 500 kg/m² Main girder 500 kg/m² ($l < 30$ m) l : span length
Tunnel	Vertical load $Pv = \frac{4.60}{H + 0.1}$ t/m² ($H < 3.5$ m) $Pv = 1.0$ t/m² ($H \geq 3.5$ m) H : Depth from ground surface Horizontal load $Ph = 0.5$ t/m² Impact 30% of Live loads Earth pressure Vertical $Pve = \gamma \cdot H$ Horizontal $Phe = K \cdot Pve$ K : Coefficient of earth pressure at rest (K = 0.5) γ : Specific gravity of Soil H : Depth from ground surface Water pressure Vertical $Pvw = h$ t/m² Horizontal $Phw = h$ t/m² h : Depth from water table

2. Allowable Stress

1) Reinforced Concrete

(1) Specified compressive strength : $f'c$ = 210 kg/cm²
240 kg/cm²

(2) Allowable extreme fibre compressive stress : $fc = 0.375\, f'c$

Structural Design Conditions (2)

2) Prestressed Concrete

(1)	Design strength	:	σck =	350 kg/cm²
(2)	Compressive strength at time of initial prestress	:	σci =	280 kg/cm²
(3)	Allowable compressive stress			
	at temporary prestress	:	σcat =	160 kg/cm²
	at service load	:	σca =	125 kg/cm²
(4)	Allowable tensile stress (temporary)	:	σtat =	13.5 kg/cm²
(5)	Allowable shearing stress	:	σsa =	5 kg/cm²
(6)	Allowable tensile stress (service)	:	σta =	9 kg/cm²

3) Reinforcing Bar

Allowable tensile stress			
for round bar	:	σsa =	1,200 kg/cm²
for deformed bar	:	σsa =	1,400 kg/cm² 1,800 kg/cm²

4) Wire for Prestressed Concrete

(1)	Ultimate tensile strength	:	σpu =	175 kg/cm²
(2)	Yield point stress	:	σpy =	150 kg/cm²
(3)	Allowable tensile stress			
	at service load	:	σpa =	105 kg/cm²
	at tensile stress	:	σpat =	123 kg/cm²
	at initial prestress	:	σpai =	135 kg/cm²

Structural Design Conditions (3)

5) Pile Foundation

Soil testing has not been executed at planning site, but some data in the area adjacent to the Victory Monument, which could be applicable for this study, have been obtained. According to the data, the upper strata from ground surface to some 13 m in depth is very soft and as such bridge design requires pile foundation. For tunnel, since the weight of it is lighter than soil, pile is not required from the standpoint of bearing capacity. But, to protect a tunnel from the damage caused by possible uneven settlement, pile foundation is also required. As the planned tunnel weight surpasses estimated uplift force due to buoyancy for uplifting action, no particular measures are necessary. The specification of pile used in this planning is as follows:

Classification	:	P.C. solid square section pile-35 (0.35 x 0.35 m)
Pile length	:	18 m to 23 m
Allowable bearing value:		35 t/each

6) Shape Steel (Sheet pile, Strut, Wale, Cover plate)

(1)	Allowable extreme fibre tensile stress	:	0.6 f_y kg/cm²
(2)	Allowable extreme fibre compressive stress	:	0.6 f_y kg/cm²
(3)	Yield point	f_y = 2,500 kg/cm²	(t ≤ 4 mm)
		f_y = 2,200 kg/cm²	(t > 4 mm)

3. Arrangement of Reinforcing Bar

1) Concrete Cover for Reinforcement

3 inch (or 8 cm)

when the concrete is permanently exposed to earth

2) Spacing Limit

Clear distance between bars shall be of the maximum among the followings;

1.5 times of bar diameter

1.5 times of the maximum size of coarse aggregate

1.5 inch (or 4 cm)

Structural Design Conditions (4)

4. Arrangement of Pile

1) Center to center distance of piles $S_c \geq 3d$
   d : maximum dimension of the pile

2) Edge of footing to center of the extreme outer pile $S_e \geq d/2$
   d : depth of footing

3) Minimum depth of footing F = 0.15 m

5. Safety Factor for Buoyancy

$F \geq 1.1$

Construction Quantities of Overpass (1)

Item	Unit	N-Bridge	S-Bridge	E-Bridge	W-Bridge	Sub-Total
Preparatory Works						
1) Removal of Pavement	m^2	140	140	150	55	485
2) Removal of Island	m^2	22	30	13	14	79
3) Relocation of Drainage	m	–	–	–	–	–
Substructure						
1) Excavation						
Steel sheet piles	t	60.9	60.9	69.0	32.4	223.2
Excavation	m^3	109	109	129	77	422
2) Piling						
P.C. Piles	No.	49	43	49	27	168
3) Footing						
Concrete A	m^3	39	34	39	24	136
Form	m^2	59	51	59	29	198
Reinforcing Bar	t	2.0	2.0	2.0	1.2	7.2
Lean Concrete	m^3	9	9	10	5	33
4) Pier						
Concrete B	m^3	16	15	16	11	58
Form	m^2	86	75	86	48	295
Reinforcing Bar	t	4.7	4.2	4.7	3.1	16.7
Finishing	m^2	78	68	78	43	267
Scaffold	m^3	60	70	60	60	250
Superstructure						
1) Main Structure						
Concrete B	m^3	102	72	91	21	286
Concrete C (P.C)	m^3	175	157	179	154	665
Form	m^2	971	852	987	584	3,394
Reinforcing Bar	t	25.1	22.3	25.6	14.0	87
Rolled steel (H)	t	–	–	–	–	–
P.C. Wire	t	5.6	6.4	5.0	3.5	20.5
Staging	m^3	1,482	1,264	1,556	970	5,272
Erection Girder	t	39	39	59	32	169
Others	L.S	1	1	1	1	4
2) Pavement	m^2	534	455	536	346	1,871
3) Finishing	m^2	950	832	962	569	3,313
4) Handrail	m	247	248	304	154	953
Utility Appurtenance						
1) Lighting	L.S	1	1	1	1	4
2) Others	L.S	1	1	1	1	4
Reconstruction	m^2	162	173	163	69	567

Construction Quantities of Overpass (2)

Item	Unit	N-E Deck	N-W Deck	S-E Deck	S-W Deck	Sub-total	Total
Preparatory Works							
1) Removal of Pavement	m^2	200	240	200	225	865	1,350
2) Removal of Island	m^2	47	30	22	–	99	178
3) Relocation of Drainage	m	–	–	110	70	180	180
Substructure							
1) Excavation							
Steel sheet piles	t	51.7	57.7	51.5	55.0	215.9	439.1
Excavation	m^3	207	259	207	215	888	1,310
2) Piling							
P.C. piles	No.	68	80	68	72	288	456
3) Footing							
Concrete A	m^3	59	72	59	62	252	388
Form	m^2	95	119	95	102	411	609
Reinforcing Bar	t	2.9	3.5	2.9	3.0	12.3	19.5
Lean Concrete	m^3	14	18	14	15	61	94
4) Pier							
Concrete B	m^3	16	27	16	16	75	133
Form	m^2	100	122	100	103	425	720
Reinforcing Bar	t	3.1	3.7	3.1	3.1	13.0	29.7
Finishing	m^2	88	107	88	91	374	641
Scaffold	m^3	100	120	100	100	312	562
Superstructure							
1) Main Structure							
Concrete B	m^3	410	519	447	486	1,862	2,148
Concrete C (P.C)	m^3	–	–	–	–		665
Form	m^2	1,340	1,657	1,600	1,810	6,407	9,801
Reinforcing Bar	t	101.7	128.8	112.1	123.3	465.9	552.9
Rolled Steel (H)	t	2.1	2.5	2.1	3.2	9.9	9.9
P.C. Wire	t	–	–	–	–	–	20.5
Staging	m^3	3,800	4,780	4,352	4,892	17,824	23,096
Erection Girder	t	–	–	–	–	–	169
Others	L.S	–	–	–	–	–	–
2) Pavement	m^2	951	1,195	1,088	1,113	4,347	6,128
3) Finishing	m^2	1,367	1,695	1,634	1,846	6,542	9,855
4) Handrail	m	175	252	223	243	893	1,846
Utility Appurtenance							
1) Lighting	L.S	1	1	1	1	4	8
2) Others	L.S	1	1	1	1	4	8
Reconstruction	m^2	247	270	222	225	964	1,531

Cost of Civil Works (Continuous Overpass)

Unit: 1,000 Baht

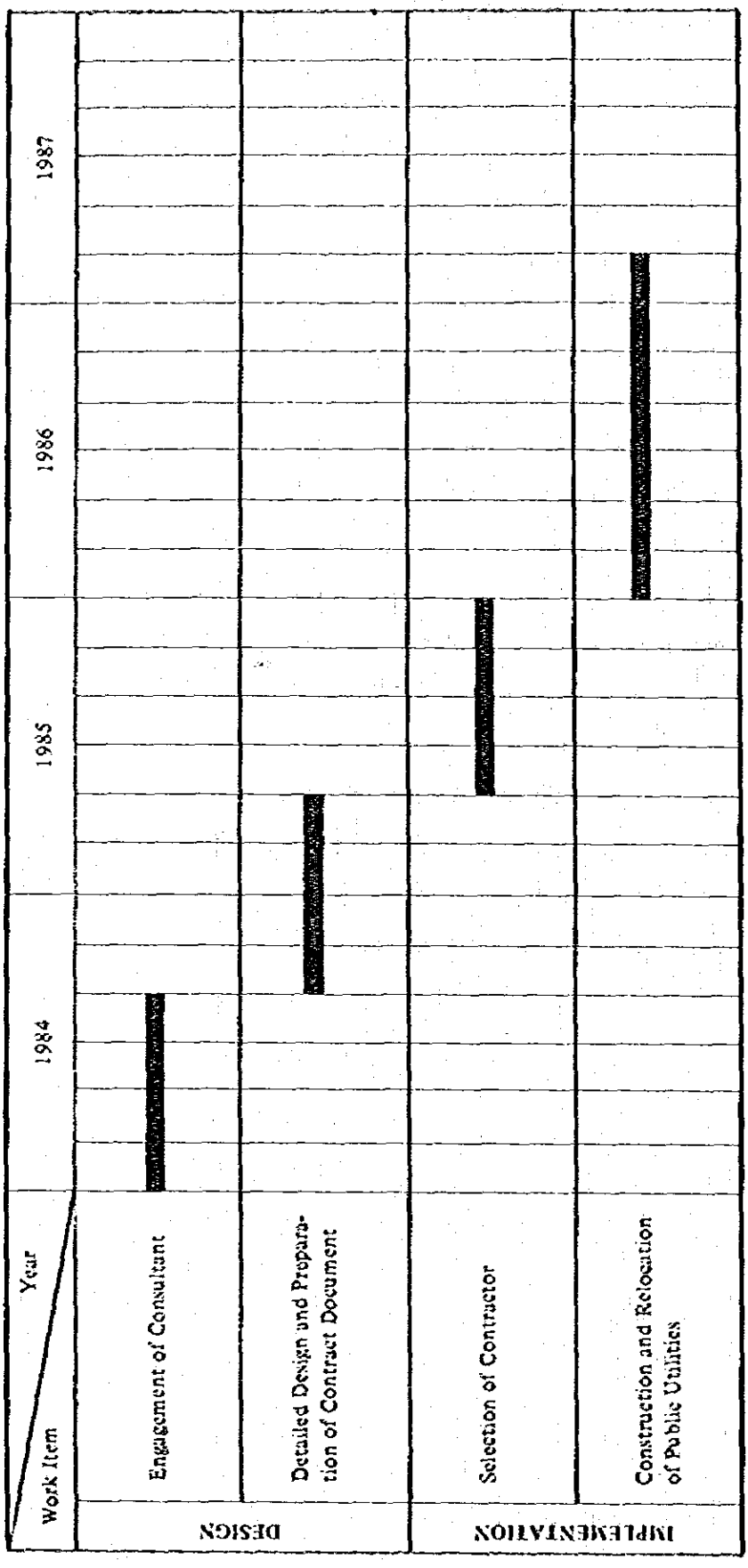
Item	Material	Labor	Equipment	Total
1. Preparatory Work	440	270	1,060	1,770
2. Substructure				10,560
1) Excavation	120	580	1,630	2,330
2) Piling	3,555	550	1,630	5,470
3) Footing	1,135	400	85	1,620
4) Pier	800	285	55	1,140
3. Superstructure				31,370
1) Main Structure	18,340	5,030	1,760	25,130
2) Pavement	2,600	930	200	3,730
3) Finishing	665	45	180	890
4) Handrail	1,295	245	80	1,620
4. Utility	1,090	170	40	1,400
5. Reconstruction of pavement	580	40	150	770
Total	30,720	8,545	6,605	45,870

Relocation of Utilities

Unit: 1,000 Baht

Item	Cost	Remarks
Drainage	1,660	S-E and S-W Quadrant

Draft Implementation Schedule
(For Alternative 2)

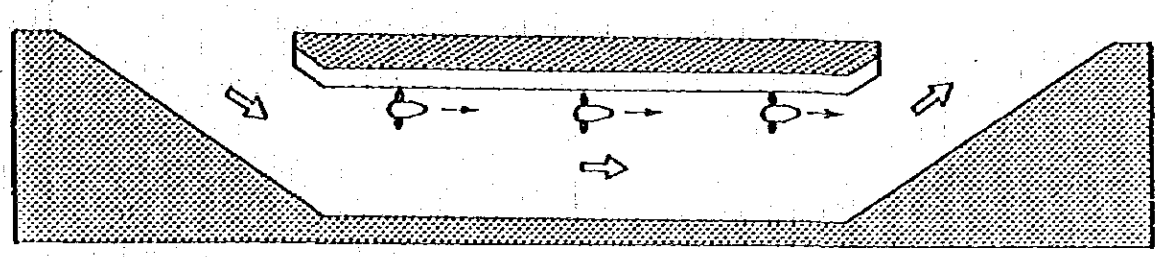


Unit Construction Cost
(Continuous Overpass)

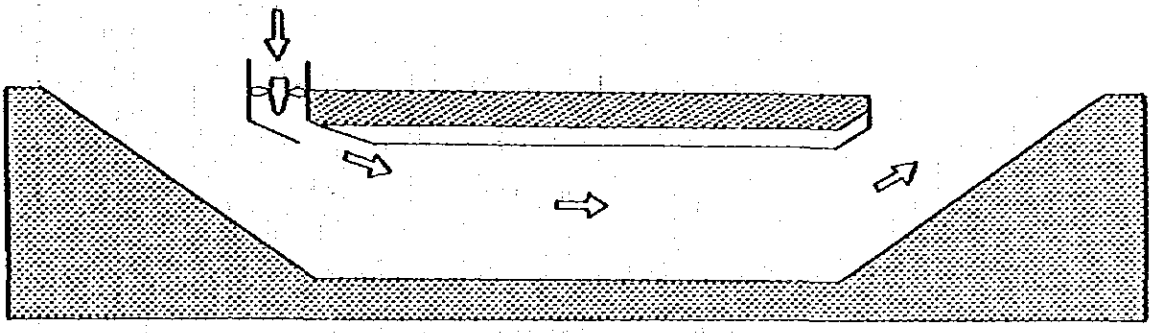
Item	Unit	Unit Cost in Baht
Removal of pavement	m^2	500
Sheet Pile	t	9,400
Earth Work		
1) Excavation	m^3	200
2) Backfill	m^3	250
Substructure		
1) P.C. pile l = 22.5 m	piece	12,000
2) Concrete A (210 kg/cm^2)	m^3	2,000
3) Concrete B (240 kg/cm^2)	m^3	2,150
4) Form (Foundation)	m^2	200
5) Form (Pier)	m^2	300
6) Peinforcement	t	13,750
7) Scaffold	m^3	60
Superstructure		
1) Concrete B (240 kg/cm^2)	m^3	2,150
2) Concrete C (350 kg/cm^2)	m^3	2,500
3) Form	m^2	350
4) Reinforcement	t	14,350
5) P.C. Wire	t	70,000
6) Pavement	m^2	600
7) Finishing	m^2	300
8) Staging	m^3	140

Main Equipments
(Continuous Overpass)

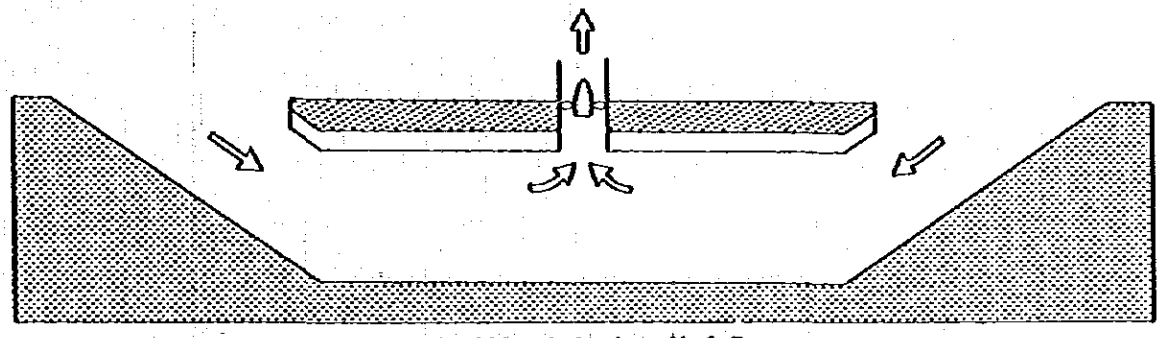
Name	Capacity	Work
Compressor	75 HP	Removal of pavement
Breaker		Removal of pavement
Back Hoe	15 HP	Excavation
Truck Crane	13 t	Unloading
Vibro Hammer	2,000	Driving sheet pile
Drop Hammer	4 t, H = 24 m	Driving pile and sheet pile
Dump Truck	15 t	Soil disposal
Bulldozer	D–3	Backfill
Transformer	50 KVS	All works
Generator	100 KW	All works
Tire Roller	14 t	Pavement
Baby Compressor	5.0 KW	Concrete work
Grout Pump		Grouting
Grout Mixer		Grouting
Freyssinet Jack		Prestressing
Freyssinet Pump		Prestressing



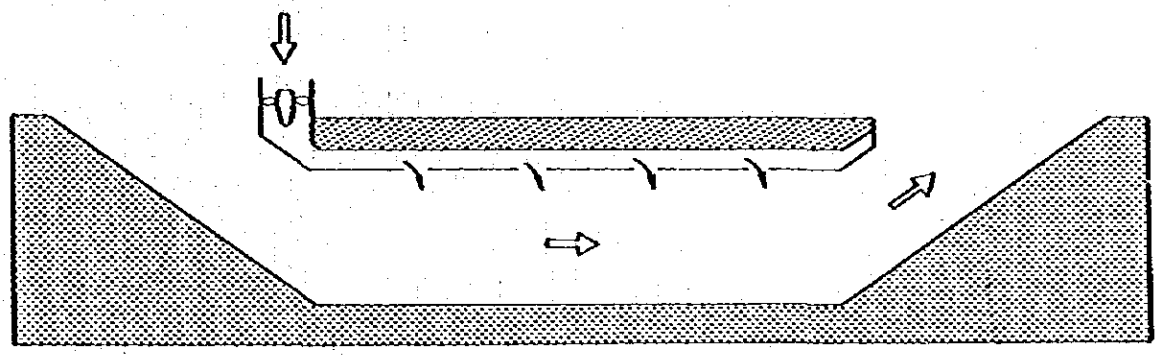
Longitudinal Ventilation by Booster Fans



Longitudinal Ventilation by an Inlet Fan



Longitudinal Ventilation by a Shaft Fan



Semi-Transverse Ventilation

Available Ventilation Methods

Cost of Civil Works
(Separate Underpass)

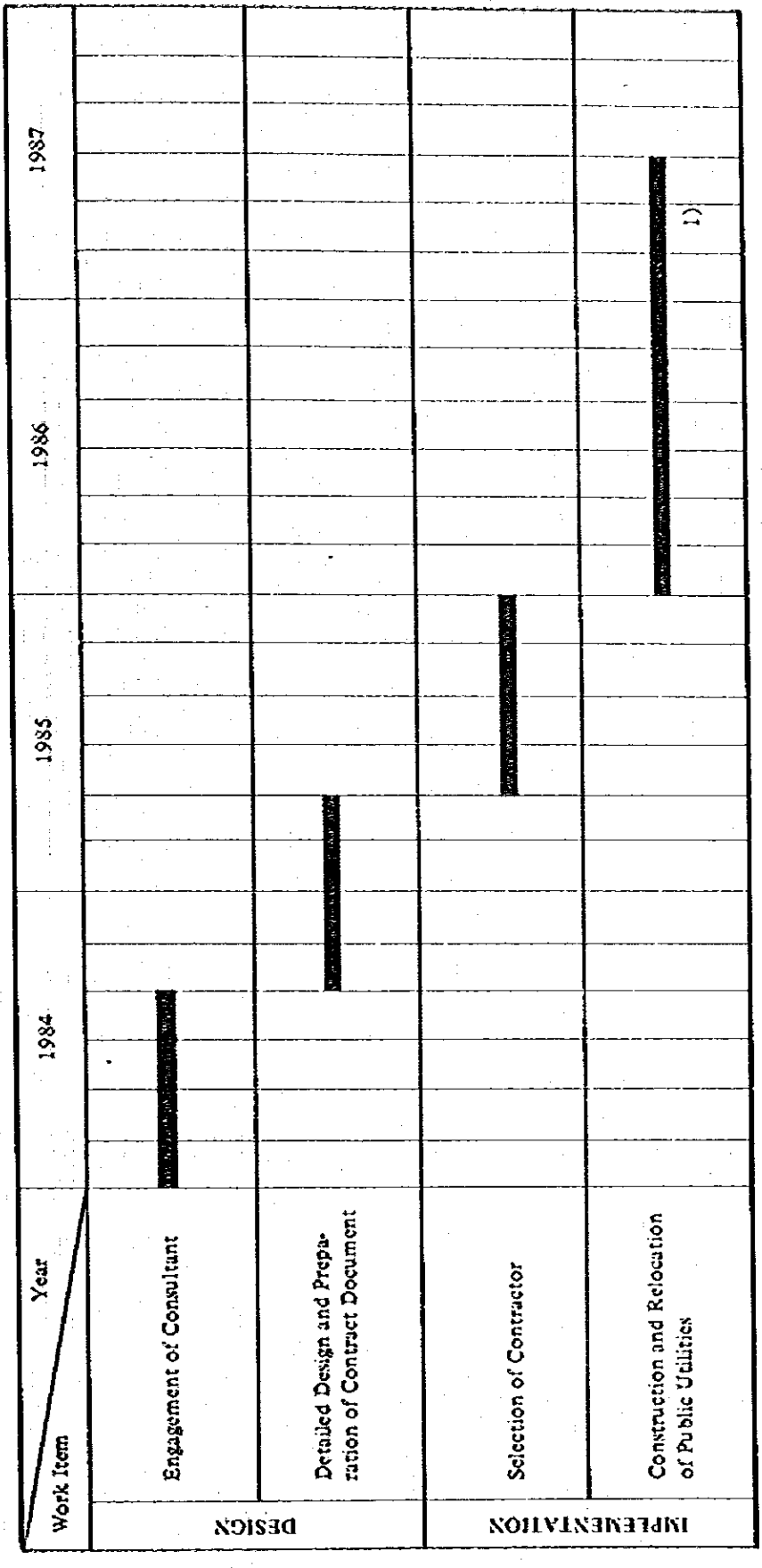
Unit: 1,000 Baht

Item	Material	Labour	Equipment	Total
1. Preparatory Work	535	315	1,250	2,100
2. Construction of underpass				
1) Wall protection	8,366	751	1,603	10,720
2) Earth work	330	1,650	4,630	6,610
3) Foundation	4,243	1,690	247	6,180
4) Box Culvert	14,265	3,980	1,695	19,940
5) Stair & Roof	7,190	2,010	850	10,050
6) Dewatering	198	67	65	330
3. Reconstruction of Pavement	1,830	123	487	2,440
4. Facilities	1,690	300	–	1,990
Total	38,647	10,886	10,827	60,360

Relocation Cost

Item	Cost in Baht
1. Telephone Cable	
Construction work	2,490,000.–
Cable work	13,000,000.–
2. Electric Cable	
Construction work	310,000.–
Cable work	2,260,000.–
Others	170,000.–
3. Watermain	8,670,000.–
4. Drainage	6,140,000.–
Total	33,040,000.–

Draft Implementation Schedule (For Alternative 3)



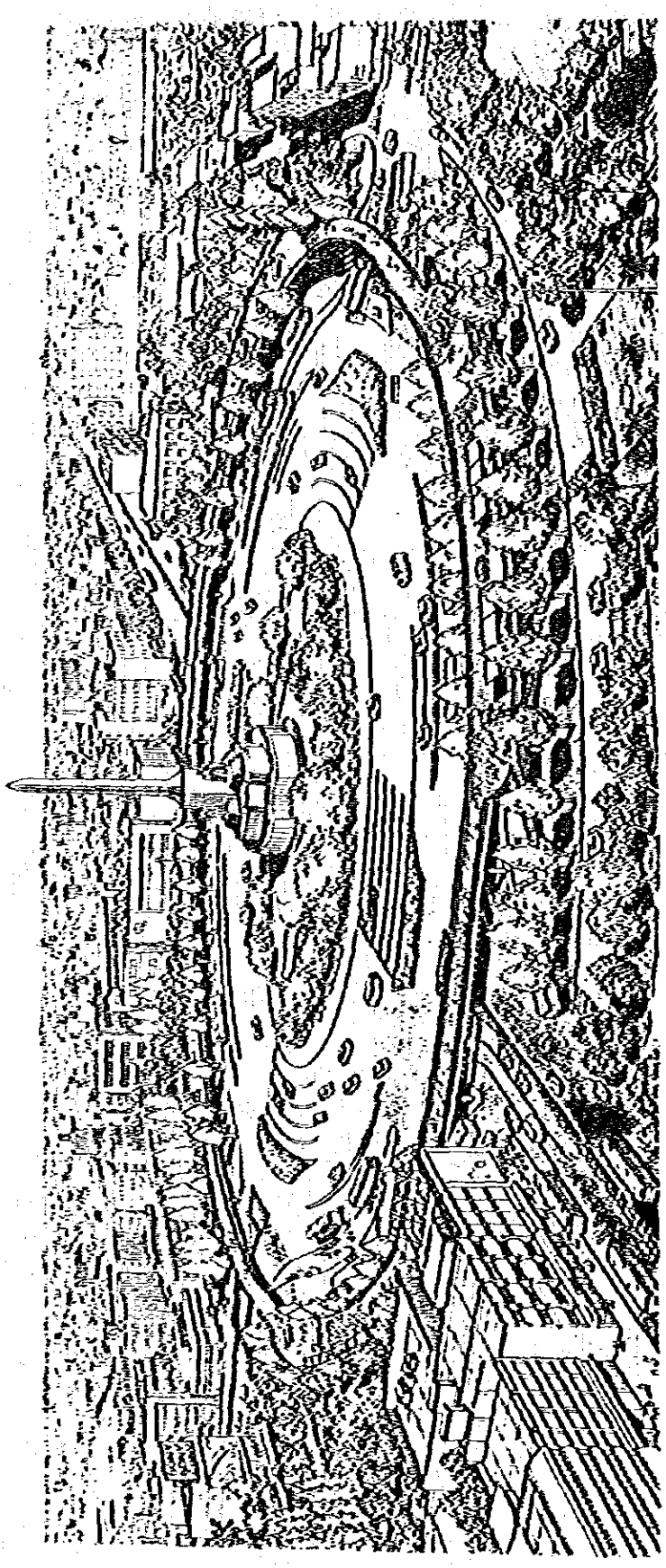
1) On the assumption that relocation of telephone cable and water pipes are completed prior to construction works.

Unit Construction Cost
(Separate Underpass)

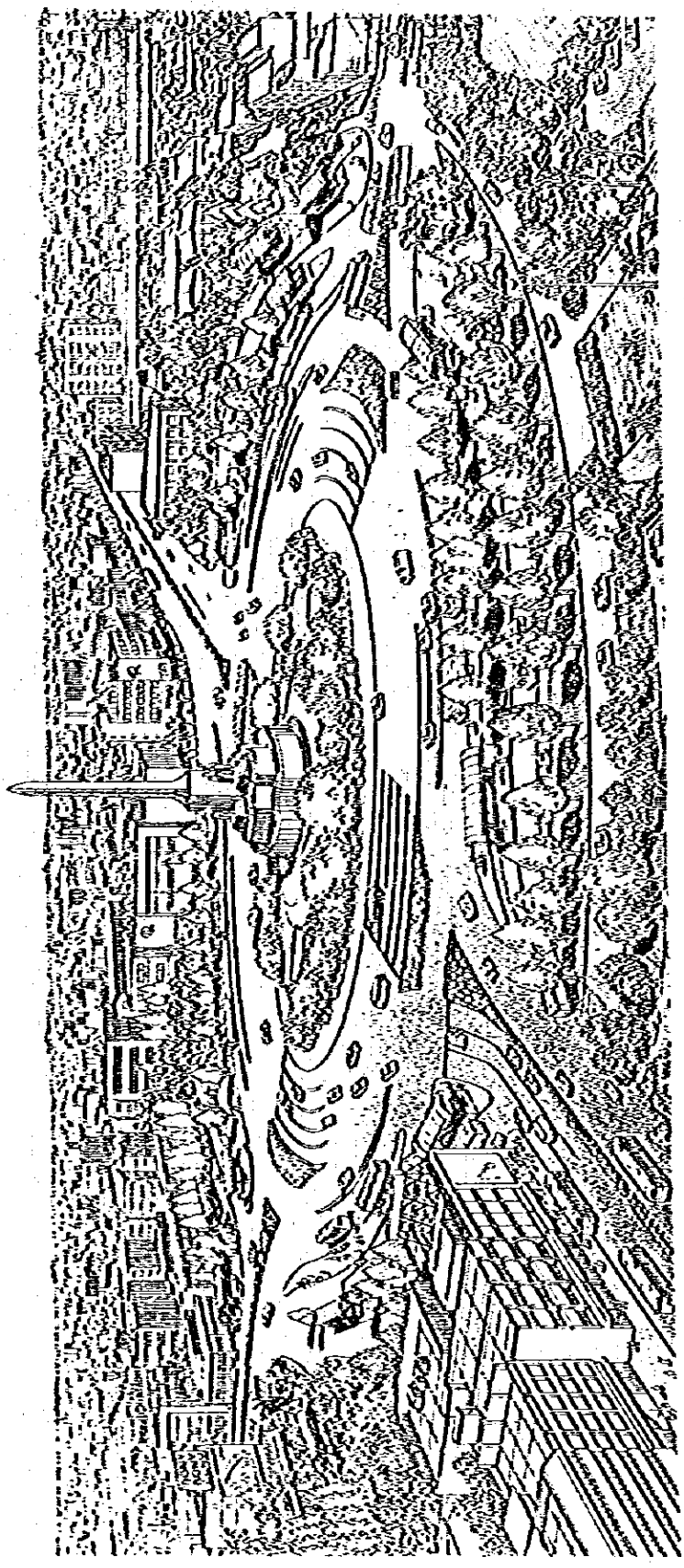
Item	Unit	In Baht
Removal of pavement	m^2	500
Wall protection		
1) Sheet pile	t	9,400
2) Strut, Wale	t	10,000
3) Coverplate	t	5,500
Earth Work		
1) Excavation	m^3	300
2) Backfill	m^3	250
Foundation		
1) P.C. pile l = 22.5 m	piece	12,000
2) P.C. pile l = 18 m	piece	9,600
3) Concrete (210 kg/cm^2)	m^3	2,000
4) Form	m^2	200
5) Reinforcement	t	13,750
Box culvert, Stairways		
1) Concrete	m^3	2,000
2) Form	m^2	280
3) Reinforcement	t	13,750
4) Lining	m^2	500
5) Ceiling	m^2	720
6) Pavement	m^2	500
7) Water proofing	m^2	600
8) Staging	m^3	30
Dewatering	day	1,000

Main Equipments
(Separate Underpass)

Name	Capacity	Work
Portable Compressor	6 m^3	Removal of pavement
Giant Breaker		Removal of pavement
Concrete Breaker		Removal of pavement
Back Hoe	0.45 m^3	Excavation
Truck Crane	15 t	Unloading
Crawler Crane	22 t	Unloading
Vibro Hammer	2,000	Driving sheet pile
Drop Hammer	4 t, H = 24 m	Driving pile
Bulldozer	D-3	Exc. Backfill
Bulldozer	D-4	Soil disposal
Clamshell	0.6 m^3	Excavation
Submersible pump	ϕ 4"	Dewatering
Submersible pump	ϕ 2"	Dewatering
Transformer	50 KVS	All works
Tire Roller	14 t	Pavement
Grader	W = 3,100	Pavement



Perspective – Alternative 2



Perspective – Alternative 3

BENEFIT-COST RATIO

1. Cost

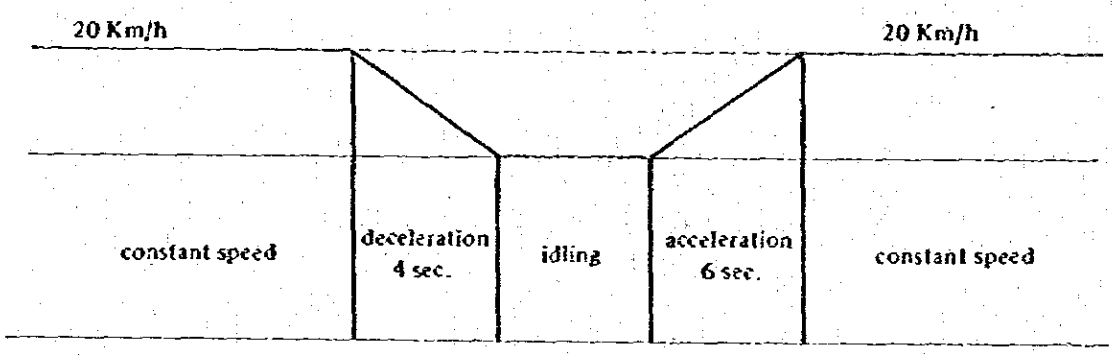
The costs in this economic analysis are construction cost and maintenance cost (in case of Alternative 3). Since the economic analysis is based on 1983 price, the cost for price escalation has been subtracted from the estimated project cost in Table–26 of Chapter 7 (See paragraph 164 and 187 in Chapter 6). The construction cost for Alternative 3 has been assumed to be disbursed equally in 1986 and 1987 when pedestrian project is expected to be implemented, while only in 1986 for Alternative 2.

2. Benefit

The additional operating cost caused by stopping due to pedestrians' crossing on streets at grade is equivalent to benefit when pedestrians' crossing at grade is eliminated with pedestrians' crossing at grade is eliminated with provision of grade-separated pedestrian crossing facility.

The additional operating cost varies with vehicle type and driving conditions, in particular, initial speed from where speed will be reduced to a halt and returned to. The average running speed of vehicles on the streets in the areas adjacent to the Victory Monument is about 20 Km/h.

For the following running mode, additional fuel consumption as compared to that of running at constant speed of 20 Km/h. can be calculated utilizing various studies on this field.



(Running Mode)

Table–1 in this appendix shows fuel consumption for the above mode of running by type of vehicles.

The waiting time and the number of vehicles which are supposed to stop at traffic signals of the junctions, should no pedestrian crossing facility be built, has been calculated based on the traffic signal system developed by OCMRT. (See Table–II and Table–III in this appendix)

Additional operating cost per vehicle and additional operating cost for one day which can be calculated from data in Table–I in this appendix and future traffic volume forecast in Chapter 3 (See paragraph 52) are also shown in Table–II and Table–III in this appendix.

It should be noted that the traffic volumes beyond year 1991 are leveled off without any increase taking into account the limited traffic capacity of the roundabout and its connecting streets.

3. Benefit-Cost Ratio

Table–IV in this appendix presents the cost and benefit stream for 15 years from 1986 to 2000. The cost and benefit are at 1983 price while the present values have been calculated with interest rate of 12% per annum.

Because Alternative 2 and Alternative 3 are same as far as the traffic movements of vehicles on the streets are concerned, the benefits accrued from the two alternatives can be assumed equal.

The benefit-cost ratios for Alternative 2 and Alternative 3 are 0.52 and 0.29, respectively as shown in Table–IV in this appendix.

Table–1 Fuel Consumption by Vehicle Type[1])

(cc/sec)

Running Mode	Passenger Car	Mini Bus	Heavy Bus	Pick-up	Heavy Truck	Required Time
Constant (20 km/h)	0.67	1.50	3.76	0.72	2.89	–
Deceleration from 20 km/h	0.34	0.60	1.50	0.40	1.10	4 seconds
Idling (stop)	0.16	0.60	1.50	0.21	1.10	–
Acceleration to 20 km/h	1.30	3.40	10.04	1.47	9.25	6 seconds

1) 1. Heavy Bus and Heavy Truck : Diesel Engine
2. Mini Bus, Passenger Car and Pick-up : Gasoline Engine

Table–11 Additional Operating Cost per Day in 1987

(Baht)

Vehicle Type		Passenger Car	Mini Bus	Heavy Bus	Pick-up	Heavy Truck	Total
a. Traffic Volume (ADT)		123,900	9,000	15,600	7,000	3,100	158,600
In-bound traffic	b. Rate of vehicle to stop	20%	20%	20%	20%	20%	–
	c. Waiting time per vehicle	12 sec	12 sec	12 sec	12 sec	12 sec	–
	d. Additional operating cost per vehicle	0.098	0.285	0.457	0.118	0.410	–
	e. Number of vehicles to stop	24,780	1,800	3,120	1,400	620	31,720
	f. Additional Operating Cost (d x e)	2,427	513	1,427	165	254	4,786
Out-bound traffic	g. Rate of vehicle to stop	10%	50%	50%	10%	10%	–
	h. Waiting time per vehicle	6 sec	30 sec	30 sec	6 sec	6 sec	–
	i. Additional operating cost per vehicle	0.086	0.422	0.646	0.102	0.364	–
	j. Number of vehicles to stop	12,390	4,500	7,800	700	310	25,700
	k. Additional Operating Cost (i x j)	1,063	1,899	5,040	71	112	8,185
Total		3,490	2,412	6,467	236	366	12,971

Table—III Additional Operating Cost per Day in 1991

(Baht)

Vehicle Type		Passenger Car	Mini Bus	Heavy Bus	Pick-up	Heavy Truck	Total
a. Traffic Volume (ADT)		151,700	11,300	19,600	8,200	3,600	194,400
In-bound traffic	b. Rate of vehicle to stop	20%	20%	20%	20%	20%	–
	c. Waiting time per vehicle	12 sec	12 sec.	12 sec	12 sec	12 sec	–
	d. Additional operating cost per vehicle	0.098	0.285	0.457	0.118	0.410	–
	e. Number of vehicles to stop	30,340	2,260	3,920	1,640	720	38,880
	f. Additional Operating Cost (d x e)	2,971	644	1,793	194	295	5,897
Out-bound traffic	g. Rate of vehicle to stop	10%	50%	50%	10%	10%	–
	h. Waiting time per vehicle	6 sec	30 sec	30 sec	6 sec	6 sec	–
	i. Additional operating cost per vehicle	0.086	0.422	0.646	0.102	0.364	–
	j. Number of vehicles to stop	15,170	5,650	9,800	820	360	31,800
	k. Additional Operating Cost (i x j)	1,301	2,384	6,333	84	131	10,233
Total		4,272	3,028	8,126	278	426	16,130

Table–IV Cost Benefit Streams and Ratios

(Million Baht)

Year	Cost				Benefit	
	Alternative 2		Alternative 3		Alternative 2 and 3	
	Cost	Present value 1)	Cost	Present value 1)	Benefit	Present value 1)
1986	70.35	70.35	61.76	61.76	–	–
1987	–	–	61.85	55.22	4.73 (2.37) 2)	4.22 (2.11) 2)
1988	–	–	0.20	0.16	5.02	4.00
1989	–	–	0.20	0.14	5.31	3.78
1990	–	–	0.20	0.13	5.60	3.56
1991	–	–	0.20	0.11	5.89	3.34
1992	–	–	0.20	0.10	5.89	2.98
1993	–	–	0.20	0.09	5.89	2.66
1994	–	–	0.20	0.08	5.89	2.38
1995	–	–	0.20	0.07	5.89	2.12
1996	–	–	0.20	0.06	5.89	1.90
1997	–	–	0.20	0.06	5.89	1.69
1998	–	–	0.20	0.05	5.89	1.51
1999	–	–	0.20	0.05	5.89	1.35
2000	–	–	0.20	0.04	5.89	1.21
Total	70.35	70.35	126.21	118.12	79.56 (77.20) 2)	36.70 (34.59) 2)

1) Interest rate is 12% per annum.

2) As to Alternative 3, the benefit of year 1987 is a half of the figure in table, because the project is expected to be completed in mid 1987.

	Alternative 2	Alternative 3
Benefit/Cost Ratio	0.52	0.29