4) The bend radius R of the reinforcement used in the corner of the rigid frame is a radius at the center of the reinforcement and 10.5d is used. On that occasion, the arc length is also calculated. In case of arranging bars of different diameters alternately, the larger diameter shall be used.

5) The bend radius of the reinforcement used in the parts except the corner of rigid frame shall be 2.5d or more, as the inside radius.

6) In case that reinforcing bars of different diameters are placed in lap, the lap splice length of the larger diameter shall be used.

7) The maximum length of the reinforcing bar shall be determined taking into account the workability.

8) The joints of the reinforcing bars of different diameters shall be within 2 sizes.

(5) <u>Other structures</u>

5.1) Ventilation

For the ventilation of CAB, natural ventilation method shall be employed as a rule.

(<u>Comment</u>)

1) The various kinds of cables such as electric cables, telephone cables, cables for communication and road administration are installed in the CAB. The ventilating openings shall be provided taking into account the type of cable, number of cables, influence of the temperature of the outside air, etc. Usually, the natural ventilation method shall be employed. In those places where the especially great amount of heat generation is expected, a forced ventilating opening may be necessary.

2) The ventilating openings shall be provided at the planting strip or near the boundary of side walk and road way. The ventilating openings will serve also as openings for lead-in cables to the distribution panel of power cables, transformer, etc.

3) In order to facilitate the ventilation, grating lids shall be used as a rule. The grating lid shall have the structure that prevents unauthorized entry.

5.2) Drainage

Drain pits shall be provided, at the cable connecting sections or starting and terminal sections as a rule.

(Comment)

1) There are following methods to drain water in the cab: 1) natural permeation, 2) to drain water into the public sewer and 3) pump drainage.

2) As for the CABs that are installed above the ground water level, natural permeation method is most widely used to drain infiltrated water such as rain water.

3) As for the CABs that are installed below the ground water level, it is necessary to determine whether water should be drained from the drain pit using pumps or drained to the drain.

5.3) Waterproofing

The structures that are installed below the ground water level must be waterproofed as a rule.

(Comment)

As for the CABs that are installed below the ground water level, waterproofed structure must be the standard in order to prevent the infiltration of ground water, to prevent deterioration of CAB and cables, to reduce the water drainage cost, etc. The waterproofing due to joint sealing is sufficient as shown in Figure 3.32.

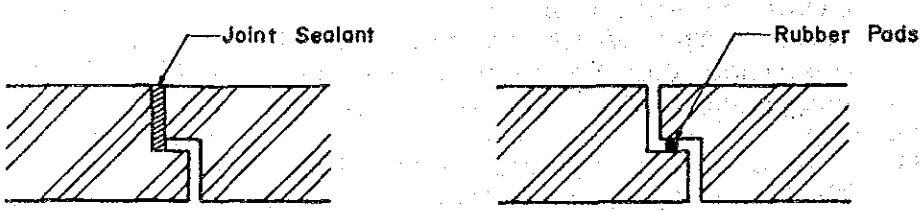


Figure 3.32 Types of Joint Sealing

However, in case certain amount of ground water infiltration does not interfere with the maintenance of utilities in the CAB, waterproofing may not be required. At time of flood, water may flow into the private houses through the lead-in pipe for cable. Therefore, it is necessary to consider the waterproofing of the entrance of lead-in pipe.

5.4) Joint structure

The CAB shall have the joint structure that prevents the difference in level at the joints. In the places where the characteristic of the ground changes abruptly, it is recommended to provide the connecting metal fittings in order to prevent the excess dislocation of joints.

(Comment)

In case the CAB is built the factory-produced concrete products, the half lap joint such as preventing the difference in level at the adjacent segments must be used as shown in Figure 3.33. The length of the half lap joint is, generally, approximately 20mm.

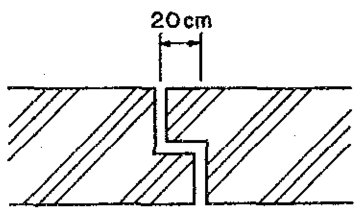


Figure 3.33 Structure of Half Lap Joint

In the places where the ground changes abruptly, where the ground is relatively soft and on which different types of structures are jointed, it is necessary to make the size of half lap joint larger (approx. 30mm) and to mount the connecting metal fittings to joint the segments. It is recommended that the connecting metal fittings, as a rule, installed at four positions so as to prevent settlement, upheaval, snaking, etc. at the joints of the segments as shown in Figure 3.34. The diameter of bolts should be approximately 9 mm, and a certain margin (approximately 20 mm) must be provided to the connecting metal fittings.

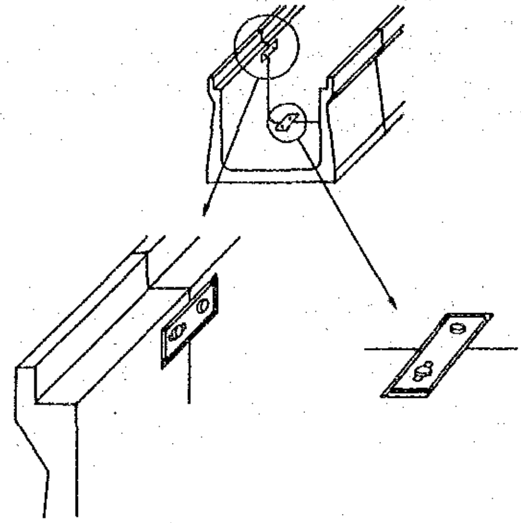


Figure 3.34
Connecting Metal Fittings of Segments

5.6) Structure of the hole for lead-in cables at standard section

The entrance of lead-in cables at the standard section shall be of post-punching type, as a rule. The interval of holes shall be determined taking into account of the interval of the brackets and locations where lead-in cable entrance will be required in the future.

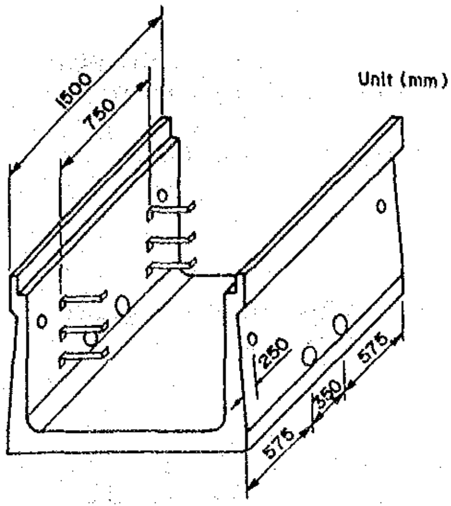
(Comment)

The lead-in cable entrance at the standard section shall be the plain concrete structure and shall be such structure that can be punched.

The interval shall be determined taking into account of the interval of bracket and the locations where lead-in cable hole will be required in the future.

Holes openings are the weak points of the structure so that it is necessary to arrange the additional bars around the holes.

The following Figure 3.35 and 3.36 are the example of position of holes for lead-in cable and arrangement of additional reinforcements , when the one-segment length is 1.5m and the bracket interval is 75cm.



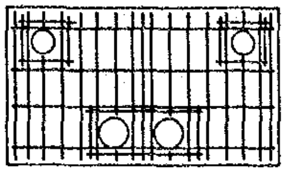


Figure 3.36 Arrangement of Additional Reinforcements

Figure 3.35 Position of Holes for Lead-In Cables

5.7) Accessory hardware

> There is following accessory hardware.
>
> 1) Cable receiving bracket supporting cable 2) Lid for ventilating opening 3) Lid for manhole 4) Ladder

(Comment)

1) Cable receiving bracket

The bracket must satisfy the following conditions.

a) The corrosion resistant material or the material that rust prevention coating is applied shall be used for the bracket. For the materials that have corrosion resistance, there are the weathering steel, stainless steel, etc. and for the rust prevention coating, there are gelvanization, etc.

b) The bracket must have a strength that can bear the cable load and other loads applied during works. Also, the bracket must have a sufficient rigidity.

c) The cast-in-screw anchor used to attach the cable supporting bracket shall be made of corrosion resistant material and shall have a structure so that the anchor will not come off due to the cable load and other loads applied during works.

2) Lid for ventilating opening

The steel grating lid with a large effective ventilating capacity shall be provided at the ventilation opening.

The design load for the grating shall be as follows:

vehicle load : H-15
impact coefficient: i=0.1

In case the opening is provided in the planting strip, sidewalk live loads (415 kg/m^2) may be applied.

3) Manhole lid and frame

Except for lids for openings in the planting strip, the lid must have a structure withstanding the vehicle load. The material of manhole shall be forged steel or cast iron that withstands the repeated vehicle loads.

4) Ladder

Ladder shall be provided for the cable connecting sections, as a rule. The ladder must be removable.

4

PRODUCTION OF MATERIALS NECESSARY FOR PROPOSING REGULATION OR LAW

4. PRODUCTION OF MATERIALS NECESSARY FOR PROPOSING REGULATION OR LAW

4.1 General

To promote and facilitate the introduction of a common utility duct system, some legislative arrangements are required mainly due to the following facts.

1) Although a common utility duct is sure to bring about a benefit to both owners of public utilities and a road administrator in the long run, a higher initial cost in its construction discourages them to join a common utility duct project.

2) A ban on individual excavations in particular roads by each enterprise is a way to promote a common utility duct system.

3) A common utility duct system is useful and effective only when it is planned and constructed with full coordination among the concerned parties.

4) The way of cost sharing among concerned parties is one of the most fundamental issues in deciding the construction of a common utility duct.

In recognition that these issues could be overcome and/or secured by the power of legislative means, the study produces materials with which BMA can draft a necessary legislative bill or regulation that is aimed at promoting construction of common utility ducts. An expected law or regulation needs to cover but not necessary limited to the following items.

1) Designation of "common-utility-duct road" where no individual public utility is allowed other than in a common utility duct.

2) Restriction on excavations in the designated common-utility duct road.

3) Development plans for common utility ducts' construction.

4) Cost allocation among concerned parties, both for construction and operation.

The materials regarding the above items are proposed by referring to the current Japanese practice.

Hence, the following contents are described in this Chapter:

1) Background of Enactment of Common Utility Duct Law in Japan,

2) Outline of Japanese Common Utility Duct Law.

4.2 Background of Enactment of Common Utility Duct Law in Japan

In 1925, first common utility duct of 270 m. in length in Japan was constructed at Kudanzaka, Tokyo as part of the reconstruction projects in the wake of the Great Kanto Earthquake of 1923. Similar ducts were also built at four other locations in Tokyo, including the Hamacho Park neighborhood and Yaesu Street in the central part of Tokyo.

Despite this post-earthquake tendency toward the construction of common utility ducts in Tokyo, no more were built in this country for nearly 30 years that followed. This was primarily attributable to the following factors:

(1) It was not easy to reconcile diverse interests of the various companies concerned with regard to the sharing of construction, operation and maintenance costs.

(2) There was no legislative means which enabled the government and road administrators to share the costs of construction and maintenance actively.

(3) Repeated excavation of road surfaces did not produce so serious effects on road traffic as it would today.

(4) Trends toward urbanization were not conspicuous and the expansion of urban facilities was progressing at a relatively slow tempo.

In 1955, however, the necessity of construction of common utility duct systems in major cities came to be recognized as a means of preventing repeated digging of road surface, as part of measures against increasingly serious vehicular traffic congestion in urban areas, which resulted from a noticeable progress of the nation's motorization and rapid development of nation-wide road networks.

In 1958, permanent vice-ministers of the ministries concerned agreed at a meeting to study the possibility of road occupation by common utility ducts, as a means of preventing repeated digging of road surfaces. In consequence, common utility ducts were constructed in Tokyo's Yodobashi area and along Hanshin National Highway No. 2 in Amagasaki City, Hyogo Prefecture in 1960.

These ducts were constructed by the request of the road administrator to public utilities enterprises and there was no unified system for sharing construction costs and for maintaining the ducts after completion. For these reasons, the construction of common utility ducts still made a slow progress.

In 1962, an emergency measure concerning the control of road surface excavation caused by underground facility works was decided on as a cabinet understanding. The measure promoted the construction of common utility ducts at the same time with major road reconstruction and subway construction, on the basis of studies of the methods of funding.

In 1963, the Common Utility Duct Law was promulgated, thereby the basis for the construction and management of the common utility ducts in Japan was settled. Since then the construction of common utility ducts have been made rapidly in major cities. Nearly 100 km. of these ducts have been completed in Tokyo.

4.3 Outline of Japanese Common Utility Duct Law

The special measures law concerning construction of common utility ducts (hereinafter referred to as Common Utility Duct Law) was enacted and promulgated (as Law No. 81) in 1963 with the objectives of maintaining the structural safety of the road and ensuring smooth traffic through the construction of common utility ducts, in order to cope with repeated digging of road surfaces in public utilities projects, which aggravated serious road traffic congestion in urban areas, as a result of a sharp increase in vehicular traffic throughout the country.

Under the Common Utility Duct Law, common utility ducts are defined as road accessories (Sub-paragraph 7, Paragraph 2, Article 2) and must be constructed at the cost of the road administrator.

Road occupancy of common utility ducts is of the specially permitted use. The road administrator may forbid the occupancy for ordinal facility if necessary (Article 37 of Road Law). In consequence, utilities to be accommodated in common utility ducts must be of great public benefit, be closely related to the people's daily life and be of such nature that it is normal to lay the utility under roads. To be more specific, the property capable of being laid in common utility ducts is limited to electric cables, telephone cables, gas pipes, water pipes and sewage pipes which are laid by the following providers (Paragraph 3, Article 2 of the Common Utility Law):

- Nippon Telegraph and Telephone Corporation;
- Electricity enterprises as defined in the Electricity Enterprise Law;
- Gas enterprises as defined in the Gas Enterprise Law;
- Water supply authority and related suppliers as defined in the Water Supply Law;
- Industrial water suppliers as defined in the Industrial Water Supply Law;
- Public sewerage administrator and urban sewerage administrator as defined in the Sewerage Law.

Common utility ducts should be constructed on roads where traffic is heavily congested or expected to be heavily congested and which are designated by the Minister of Construction as "roads requiring the construction of common utility ducts". In view of the possibility that works relative to occupancy of roads will cause a great deal of interference with road traffic

(Article 3 of the Common Utility Duct Law). Works relative to occupancy of road on designated roads are, in principle, prohibited (Article 4 of the Law). Such prohibition is a measure aimed at being recognized the justification for constructing common utility ducts.

Once a road is designated as requiring the construction of common utility ducts, the road administrator shall refer to the public utility providers, announce its intention to construct a common utility duct (Article 5 of the Law), prepare the construction plan (Article 6 of the Law), finalize it after receiving the written views of the public utilities companies with regard thereto and finally set about the construction (Article 7 of the Law). The duct construction plan must provide the following information:

1) Location and title of work;

2) Structural;

3) Scheduled user of the common utility duct;

4) Allocation of the common utility duct for each scheduled user and a summary of utility construction place for each scheduled users;

5) Cost for the construction of the common utility duct and plan showing how the cost is borne;

6) Scheduled start and completion of the work.

Common utility ducts are road accessories and in this sense they should be constructed by the road administrator at his own cost. In fact, however, the ducts are not ordinary road accessories and the public utility provider are entitled to make the exclusive use of their respective portions of the ducts.

Thus from the standpoint of the principle of equity, it is considered appropriate for the public utility provider to share the construction cost in consideration of the benefits derived by them from the use of common utility ducts.

Public utility providers sharing a common utility duct are required to bear their respective shares the construction cost calculated taking account of the estimated cost of investment determined on the basis of the benefits derivable from the duct construction (Article 20 of the

Common Utility Duct Law). This cost sharing is said to consist of the beneficiary's share and the price for the right of occupancy.

In this connection, Japan Development Bank loans are available to public utilities providers to help them bear their respective shares in the construction costs of common utility ducts.

For the maintenance of common utility ducts, common utility duct maintenance regulations must be laid down by road administrators to keep them in good conditions (Article 11 of the Law).

Figure 4.1 shows the procedure flow of the common utility duct construction based on The Common Utility Duct Law.

Appendix A lists those articles of the Common Utility Duct Law governing the designation of roads requiring the construction of common utility ducts, their construction and management, and the allocation of the costs of construction and maintenance.

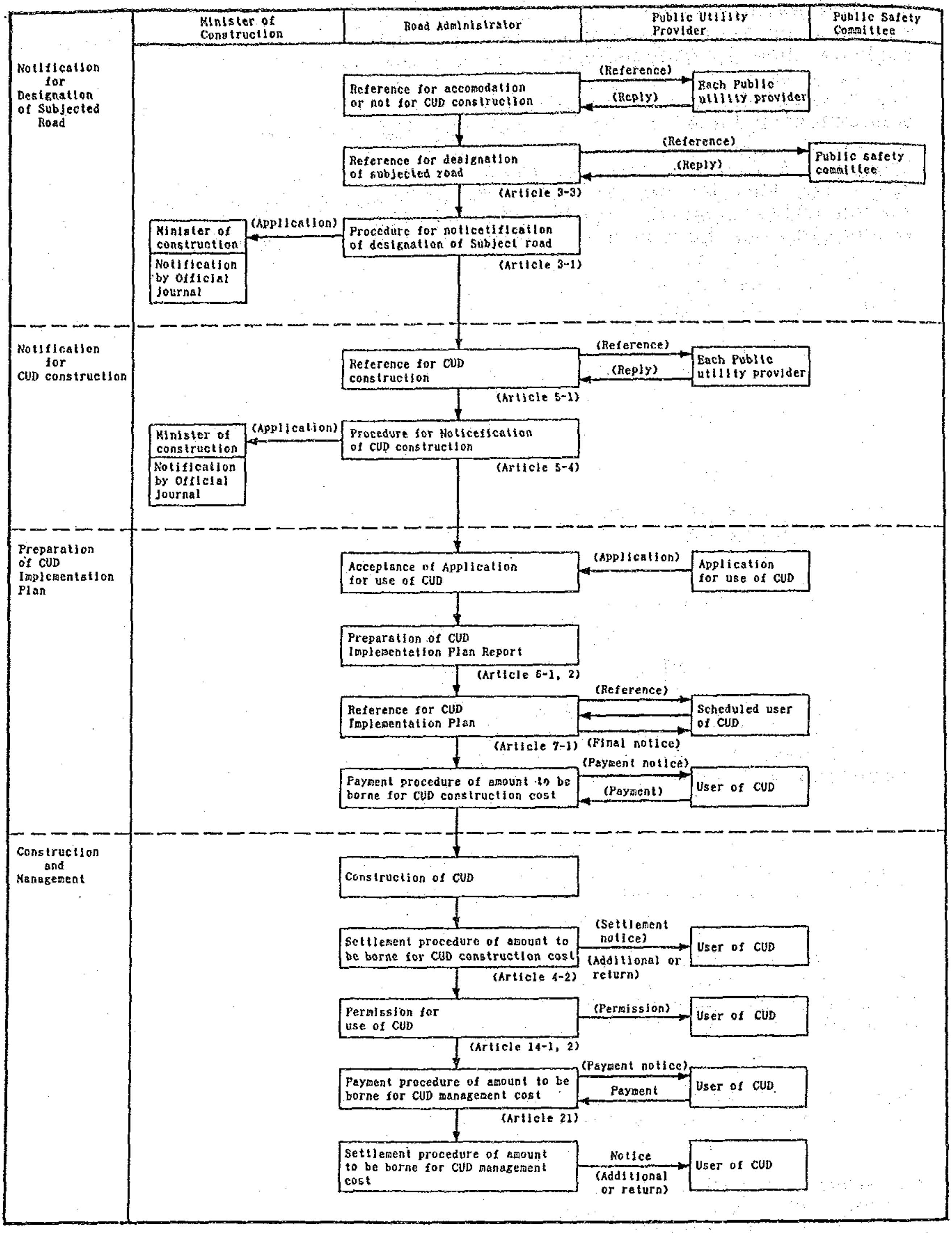


Figure 4.1 Procedure Flow of Common Utility Duct Construction

5

CASE STUDY

5. CASE STUDY

5.1 Objective and Method

Survey results indicate that demand for public utilities is forecast to rise sharply over the next 10 years. Despite this expectation, utility enterprises have not established any coordinated set of long-term plans for the future. Under the current situation, each enterprise carries out expansion projects on an independent basis as the need arises. This procedure serves to aggravate traffic conditions in the city of Bangkok.

In view of the above situation, the need for a common utility duct (CUD) to accommodate all the necessary public utilities was mentioned in the Interim Report (I). Under this Case Study, a sample plan for such a duct was formulated and evaluated for a given section of road in the Bangkok area with the objective of providing a reference point for the establishment of CUD projects in the future.

Although it is possible to forecast the future volume of public utilities demand in Bangkok as a whole, the lack of a coordinated set of detailed plans means that it is not possible to determine the type and capacity of utilities to be accommodated by a CUD. In this Case Study, therefore, these factors were estimated on the basis of the current and future demand for public utilities in the city. The Study proceeded as shown in the flow chart given in Figure 5.1.

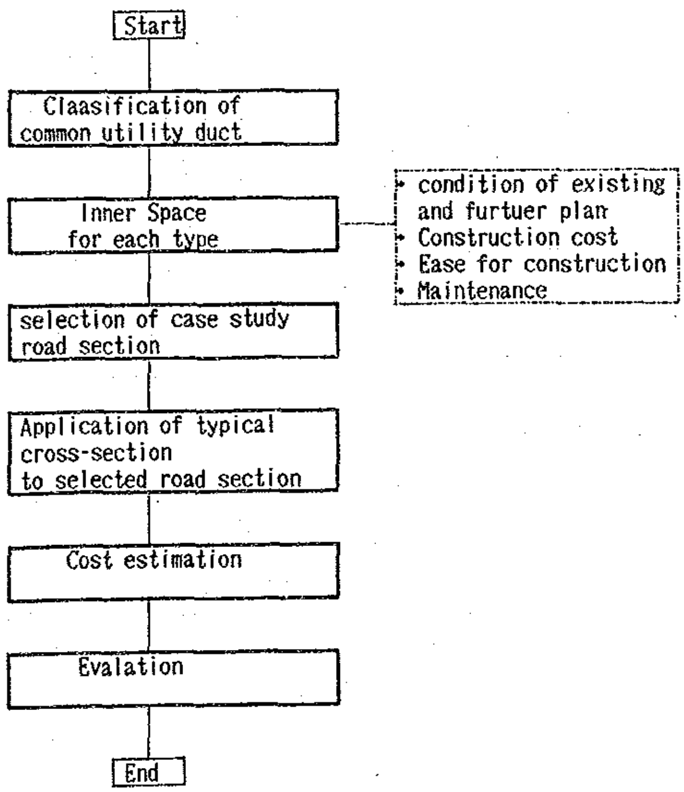


Figure 5.1 Flow Charts

5.2 Trunk-Line CUD

5.2.1 Subject Road

Roads below which the trunk-line CUD is to be planned must fulfill the following conditions:

- Population densities in areas along the road are high.
- Demand for public utilities is forecast to increase along with the further development of the roadside areas.
- Construction works to be necessitated by such increases in demand are certain to obstruct the flow of vehicular traffic on the road.

It would also be desirable that the subject road is already included in a utilities trunk-line project.

Taking into consideration the above conditions, Phahon Yothin Road was selected for the trunk-line CUD in this Case Study from among the arterial roads located inside the Middle Ring Road and the 14 routes in the two districts (Pathumwan and Bangrak) chosen for the survey area. The road section for the trunk-line CUD is shown in Figure 5.2. This selection was based primarily on the following reasons:

- The road is a major north-south arterial as well as with Rama I and Rama IV.
- Average daily traffic is currently high at 65,000 vehicles.
- The road currently has power transmission cables overhead and trunk-line telephone cables and main water pipes underground.
- The road has sufficient width plus a median.
- None of the related organizations have projects that use up road space either currently or in the future. In addition, there is sufficient space beneath the carriageway.

1) Road Cross Section

As shown in Figure 5.2, the standard cross section of Phahon Yothin Road currently consists of three lanes in each direction, sidewalks on both sides with a width of 4.0 meters and a median with a width of 3.5 meters. The median narrows to 0.75 meters at divergence points. In addition, the median and sidewalks are planted with greenery.

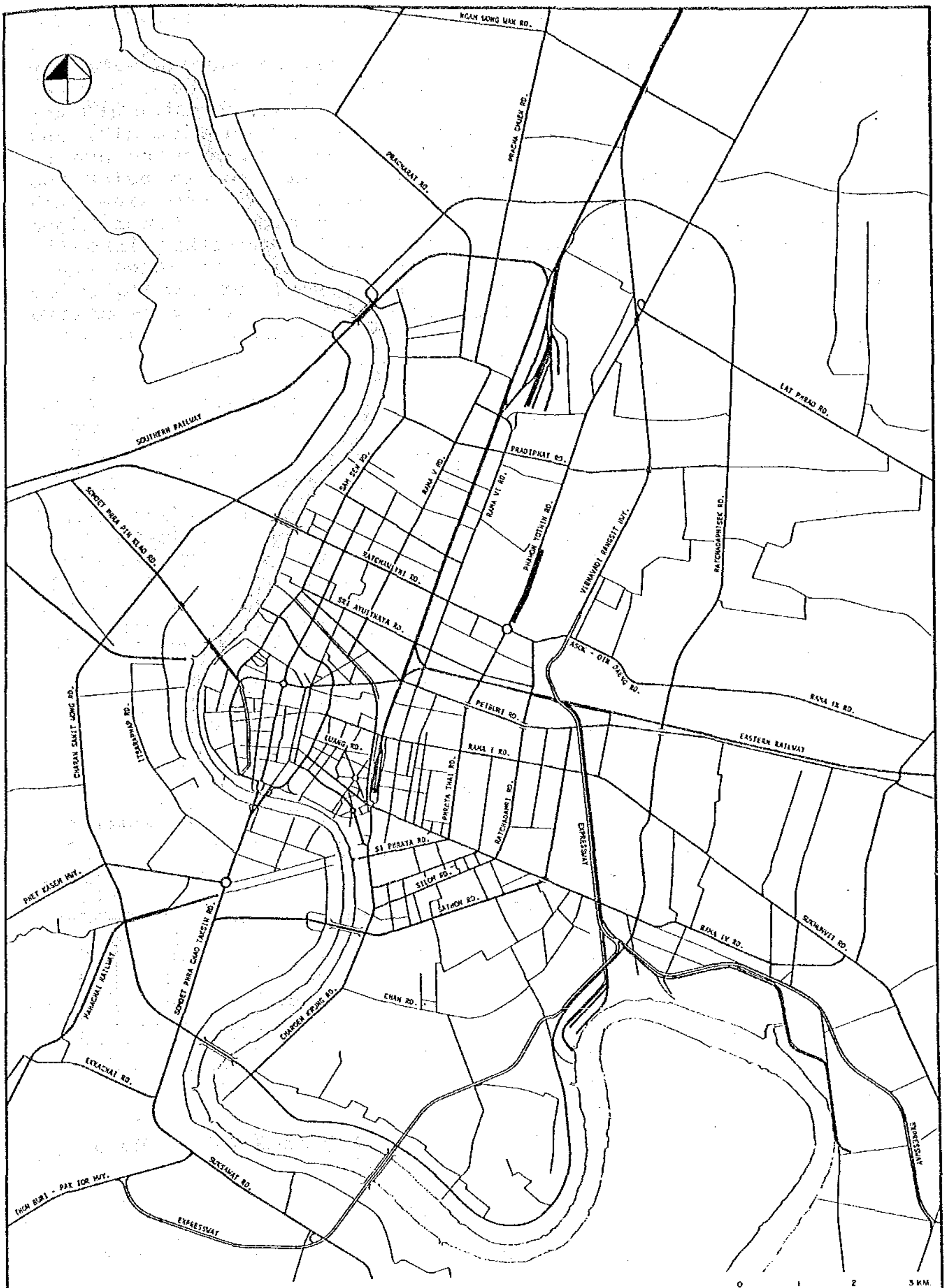
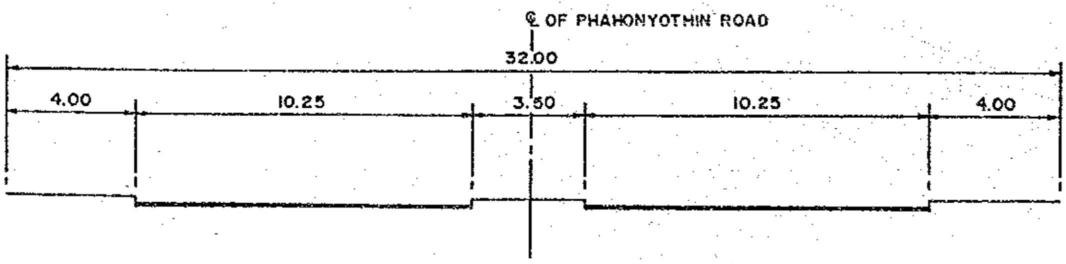


Figure 5.2 Road Section for Trunk-Line CUD

2) Existing Underground Installations

Figure 5.3 shows the current composition of public utility installations found below ground on Phahon Yothin Road. Power cables are found overhead and consist of six high-tension (69 kv) cables. There are 15 telephone lines below each sidewalk, and six below the carriageway along the sidewalk side; there are no aerial telephone lines. Water pipes are also located below the sidewalks: steel trunk pipes (900 mm diameter) on one side only and supply pipes (300 mm diameter) on both sides. Sewer pipes (1,200 mm diameter) are found beneath both sidewalks along the carriageway side, and take up a large proportion of space under the sidewalk. Thus, a large number of public utility installations are found under sidewalks, so any new coming installations will have to go under the carriageway.



Existing Road Cross Section of Phahon Yothin Road

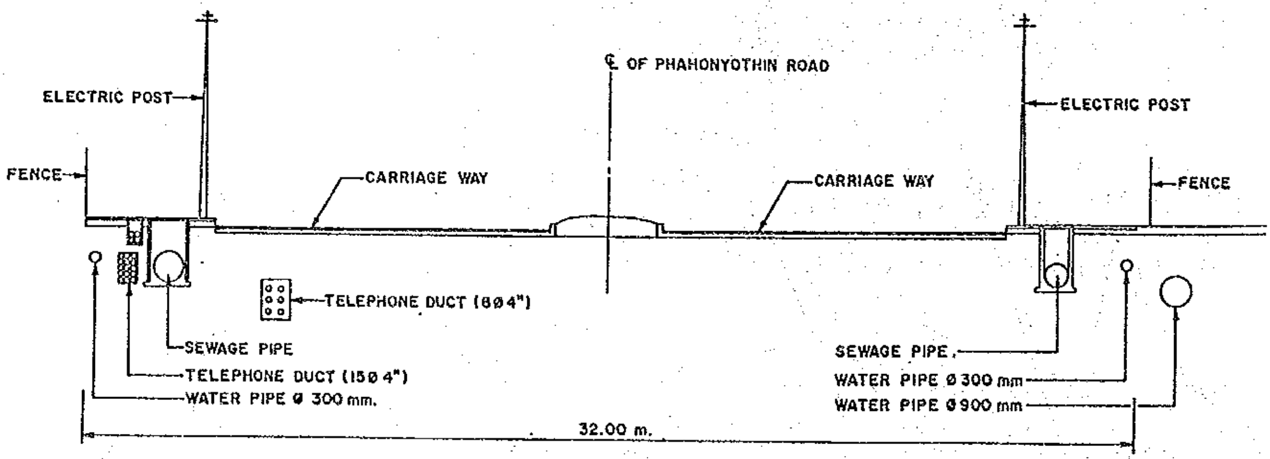


Figure 5.3 Existing Public Utility of Phahon Yothin Road

5.2.2 Utilities to be Accommodated and Standard Cross Section

A common utility duct houses the following public utilities:

- o Telephone
- o Electricity
- o Water
- o Sewerage
- o Gas

Plans for common utility ducts are generally formulated by the organization responsible for road and highway management, on the basis of a coordinated set of plans set forth by utility companies in line with present and future demands, and by taking into account the opinions of utility enterprises. However, as there are no detailed plans available at present, inner-space cross sections in this Case Study were determined on the basis of an overall evaluation of the present capacity of public utilities surveyed and the future volume of demand expected.

1) Telephone

Demand for telephones has increased rapidly in recent years and is forecast to rise 2.5 times over the next 10 years. According to survey results, the number of trunk cables in a given section of road will eventually reach 10-50. Accordingly, two types of inner-space cross section for telephone lines were considered in this Case Study (Figure 5.4).

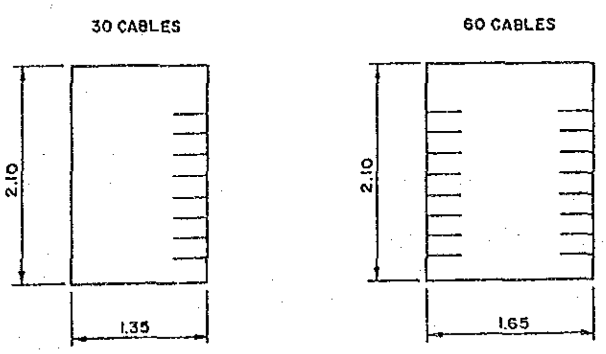


Figure 5.4 Inner Space for Telephone Cables

2) Electricity

Power consumption is expected to increase 1.7 times over the next decade. At present, electricity is transmitted from the EGAT to MEA terminal stations, and from there to distribution substations via underground or overhead high-tension (66 kv) trunk cables. According to survey results, the number of trunk cables in a given section of road ranges between six and 15. Taking this as well as estimated future demand into account, the following two types of inner-space cross section for power cables were selected in this Case Study (Figure 5.5).

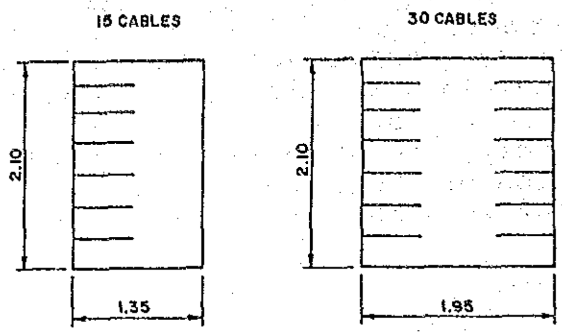


Figure 5.5 Inner Space for Electric Cables

3) Water

Trunk-line water pipes with diameters ranging between 400 mm and 1,200 mm are found along all routes. Nearly all pipes are made of steel or cast iron. The following (Figure 5.6) inner-space cross section for water pipes was selected in this Case Study based on the diameter of existing pipes (900 mm).

4) Gas

According to the PTT Master Plan, natural gas will be supplied to Bangkok in the future, using pipes with 4-10 inch diameters for the trunk line and 1-6 inch diameters for the supply line. Gas pipes to be accommodated by the trunk-line CUD will be high-pressure or medium-pressure pipes that lead from gas tanks to gas burners. According to the PTT Plan, these pipes will have a diameter of 10 inches. Since gas is a volatile element, it is necessary to contain the gas pipes in an isolated room in order to reduce fire hazards. The inner-space cross section selected for gas pipes in this Case Study is shown in Figure 5.7.

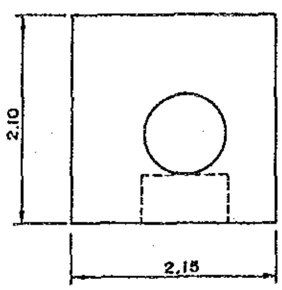


Figure 5.6

Inner Space for Water Pipe

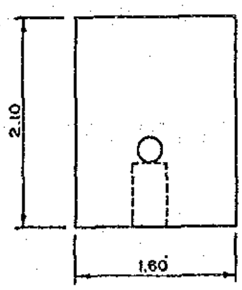


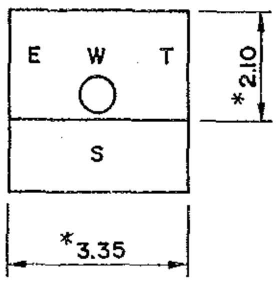
Figure 5.7

Inner Space for Gas Pipe

5) Sewerage

In a sewer system, sewage is collected by branch pipes, passed through trunk pipes, and brought to a treatment plant, where the waste water is purified and released. Of these facilities, a trunk-line CUD mainly houses the trunk pipes. While Bangkok's sewage system is a combined system that uses the natural flow method, pipes that can be considered trunk pipes are found only under Rama IV Road, since the downstream treatment plant has not been completed as yet. When the treatment plant is completed, trunk pipes will be housed in the CUD.

As a sewerage channel in CUD, either one of rooms of CUD or a sewerage pipe installed in CUD can be used. In this case the former type was adopted. Figure 5.8 shows the section of the CUD with a sewerage channel.



* THESE VALUES ARE NOT INCLUDED WALL AND SLAB THICKNESS

Figure 5.8 Inner Space for Sewerage

6) Standard Cross Section

Six types of standard cross section for the subject CUD were established (Table 5.1) by combining the inner-space cross-sections discussed above. The most appropriate cross sections were then selected from among these six in accordance with the accommodation plan for the subject route.

Table 5.1 Standard Sections for Trunk Line Common Utility Duct

		TYPE A	TYPE B	TYPE C	TYPE D	TYPE E	TYPE F
Typical section		5.75 2.1 | E | W ○ | T |	4.45 2.1 | E | W ○ T |	3.85 2.1 | E T | W ○ |	3.35 2.1 | E W ○ T |	6.05 2.1 | E | W ○ T | G ○ |	3.35 2.1 | E W ○ T | | S |
Capa-city	No. of Telephone	60	30	30	30	30	30
	No. of Electricity (69kv)	30	30	15	15	30	15
	Water pipe	φ900	φ900	φ900	φ900	φ900	φ900
	Gas Pipe	------	------	------	------	φ250	------
	Sewerage	------	------	------	------	------	Considered

5.2.3 Preliminary Design

1) Preconditions

The preliminary design for the subject CUD is based on the following preconditions:

a) The subject route is the section between Klong Sam Sen and Soi Ari 7 on Phahon Yothin Road. The planned extension is 1,200 meters.

b) Foundation Structure

In case of bridges or buildings in such area as Bangkok, where the soft alluvial layer has a depth of more than 10 meters, deep foundations such as piles are commonly used, to transmit the load to a more reliable underground.

But in case of underground structures, such as CUD or subway tunnels, it is not necessary to adopt deep foundations generally, for the structure does not cause any additional loading to the under-ground.

In the area, where the settlement of the ground is observed, care must be taken to avoid inconveniences due to unequal settlement. In such area the use of a pile type foundation in CUD will keep the road above the CUD from sinking, but other parts of the road may sink. This will make it difficult to keep the pavement in good condition. Therefore, pile-type foundations were not considered in this Case Study.

c) Concerning temporary system for excavation, the cut-and-cover method, which has been used many times in the past for undergrounworks, will be adopted wherever earthcover is shallow.

d) Non-standard Sections

A trunk-line CUD must include openings for entrance/exit to allow periodic inspection and maintenance of the CUD itself as well as the utility installations. It also needs ventilation ports to let in fresh air from the outside. Since power and telephone cables are of limited lengths, space for joints is required. Gas pipes, moreover, must be housed in a separate room in order to absorb changes in temperature and stress, owing to the volatile nature of gas. In addition, sections where pipes and cables branch off must be larger than standard sections so as to secure enough space for turning.

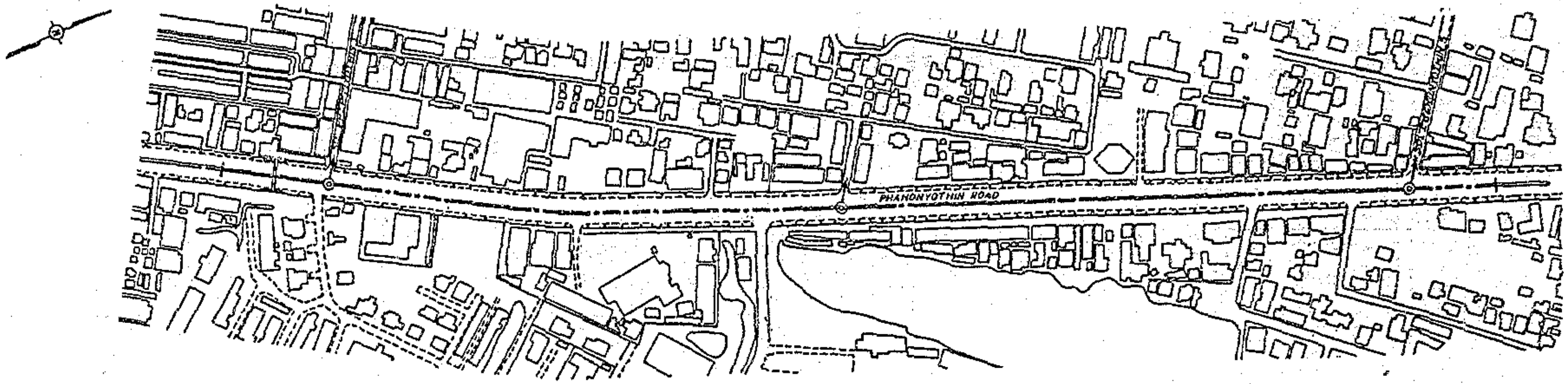
All the above constitute non-standard sections of a CUD. It is obviously desirable from the standpoint of economy to minimize the number of non-standard sections. This can be done by organizing and combining the non-standard sections of each utility whenever possible. Accordingly, the following plan was established for the subject CUD:

- o Cable joint sections for power and telephone cables are provided every 220 meters or so.
- o One loop room is provided for gas pipes.
- o Assuming that cables and pipes will branch off at the intersections of the subject road, branching sections are established at three points.
- o Ventilators are provided every 200 meters or so, with alternating forced and natural ventilation.
- o One opening for entrance/exit is provided, at a location that coincides with a natural ventilation port.

2) Accommodation Plan

An accommodation plan for the subject CUD was formulated so as to accommodate all the public utilities required, along with the necessary non-standard sections. A preliminary design was then drawn up on the basis of this accommodation plan. Based on the consideration that a standard cross section should be designed so as to house the utility installations with a minimum waste of space, six types of standard cross sections were selected. The accommodation plan is shown in Figure 5.9, and the six standard cross sections are shown in Figure 5.10.

Three Types were prepared for the 100-meters section from the starting point. Type F is applied when sewer system is included in the accommodation plan, and Type C or D is applied when they are not included. Type C has the same capacity as Type D but a higher safety factor, as water pipes are housed in a separate chamber and are protected from fires involving power or telephone cables.



P L A N
SCALE 1:4000

TOTAL DISTANCE (m)	1200 m			
SUB DISTANCE (m)	100 m	480 m	540 m	80 m
TELEPHONE	30 CABLES			60 CABLES
ELECTRICITY	15 CABLES	30 CABLES		
WATER PIPE	ø 900 mm			
GAS PIPE	NOT CONSIDERED		ø 250 mm	NOT CONSIDERED
SEWERAGE	NOT CONSIDERED			
TYPICAL SECTION	F	B	E	A

Figure 5.9 Accommodation Plan of Trunk Line CUD

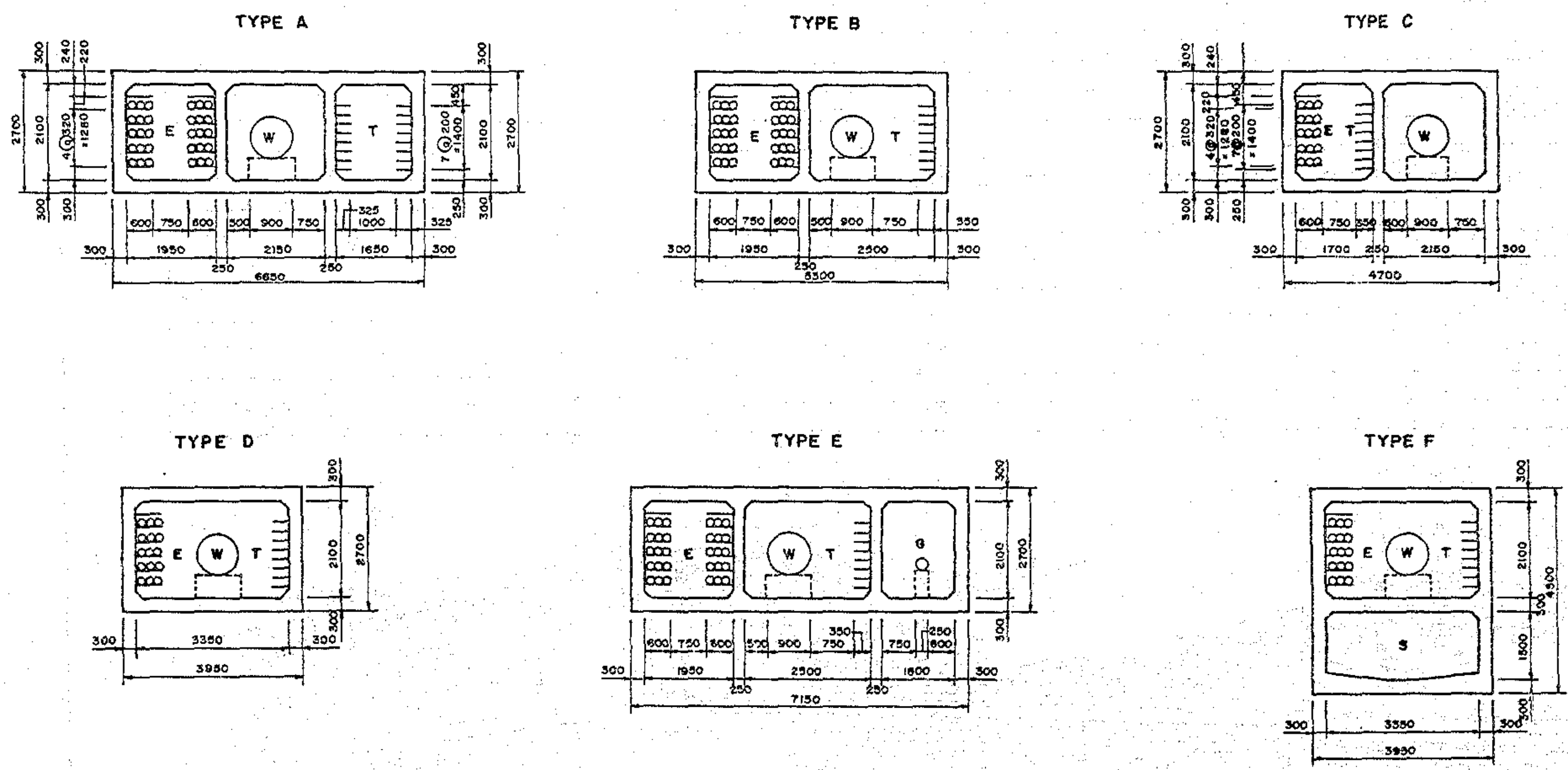


Figure 5.10 Selected Standard Cross-Sections

3) Non-standard Sections

Non-standard sections in the subject CUD include three branching sections, a gas loop room for absorbing the expansion/contraction of gas pipes, and a cable joint section. The cross sections of these non-standard areas are necessarily larger and more complicated than that of the standard area. The length and cross-section size of a non-standard area depend on such factors as the size of the joint structure, the necessary intervals and construction space. Normally these factors are decided by the utility enterprises, but in this Case Study they were established as follows:

- o The required length of the cable joint section is 5 meters.
- o The length of the gas loop room is 5 meters.
- o Water and gas pipes are each provided with one opening for installing cables and pipes.

As mentioned above, non-standard sections are larger and more complicated than standard sections. For this reason it would be desirable to combine non-standard sections wherever possible for the sake of economy and the efficient use of space. Accordingly, the number of non-standard sections, including ventilation ports, were reduced to the following six points in the subject CUD:

- o Branch 1 -------- Branching of power cables and sewer pipes, and natural ventilation
- o Branch 2 -------- Branching of gas pipes, and natural ventilation
- o Branch 3 -------- Branching of gas pipes and telephone cables, and forced ventilation
- o Ventilation 1 --- Forced ventilation
- o Ventilation 2 --- Forced ventilation
- o Ventilation 3 --- Natural ventilation, gas loop room, cable joint room, and opening for pipe/cable installation

The details are given in Figures 5.12 - 5.16.

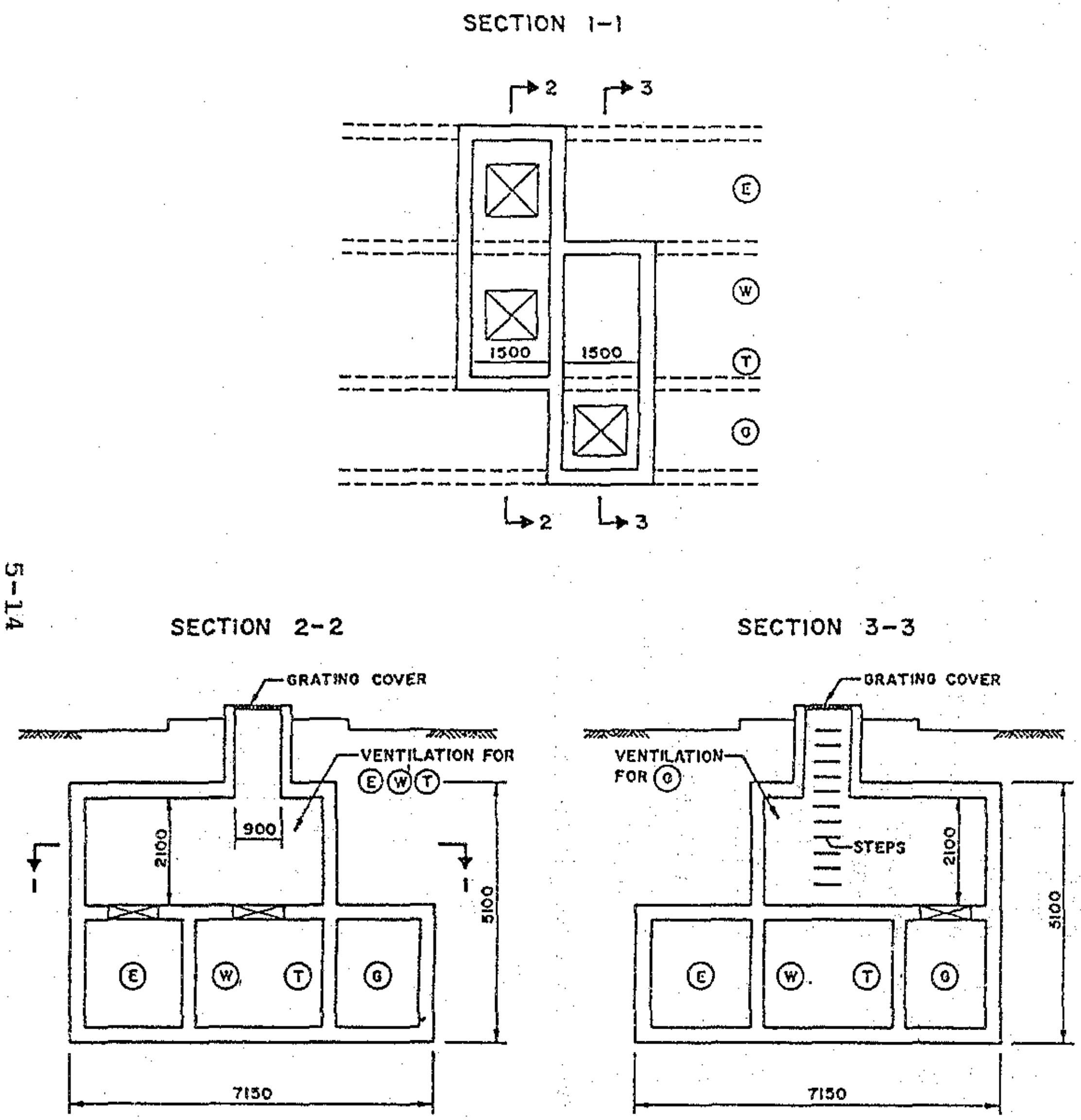


Figure 5.15 Detail of Ventilation No. 1 and No. 2

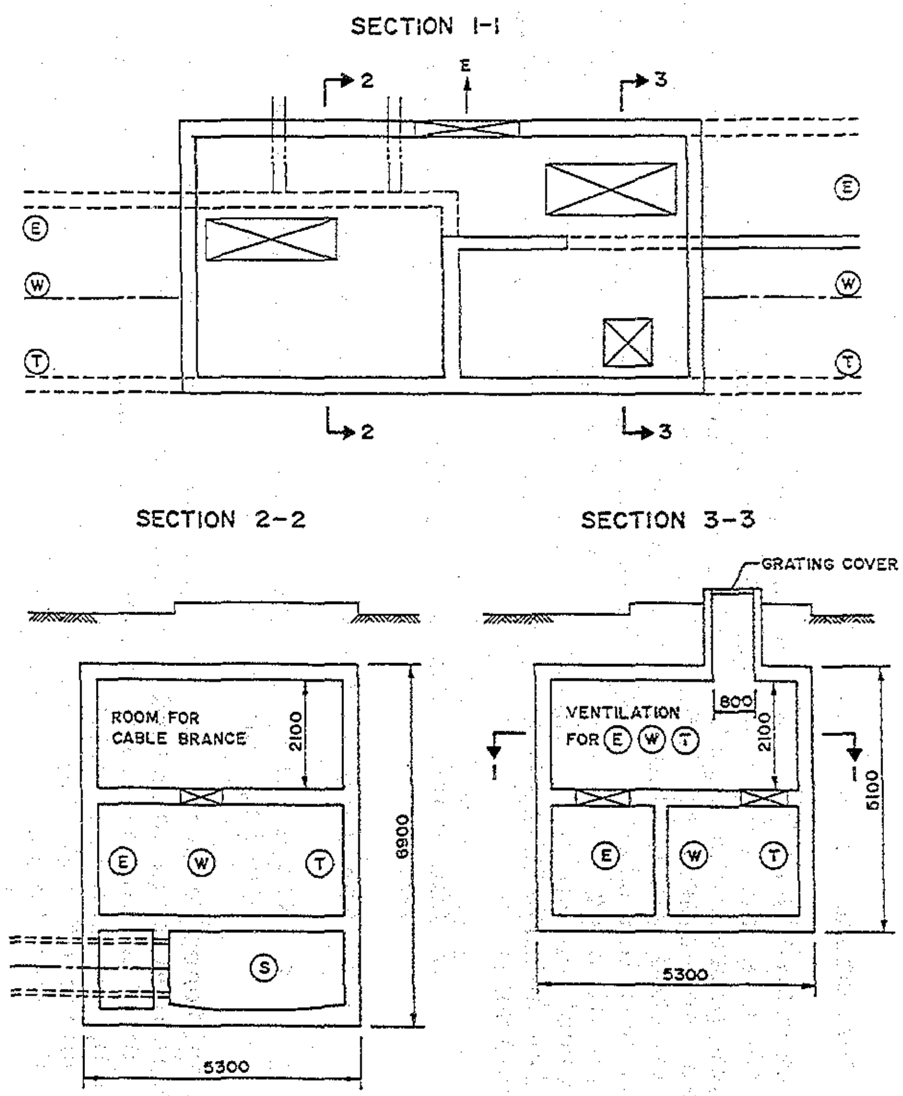


Figure 5.12 Detail of No. 1 Branch Section

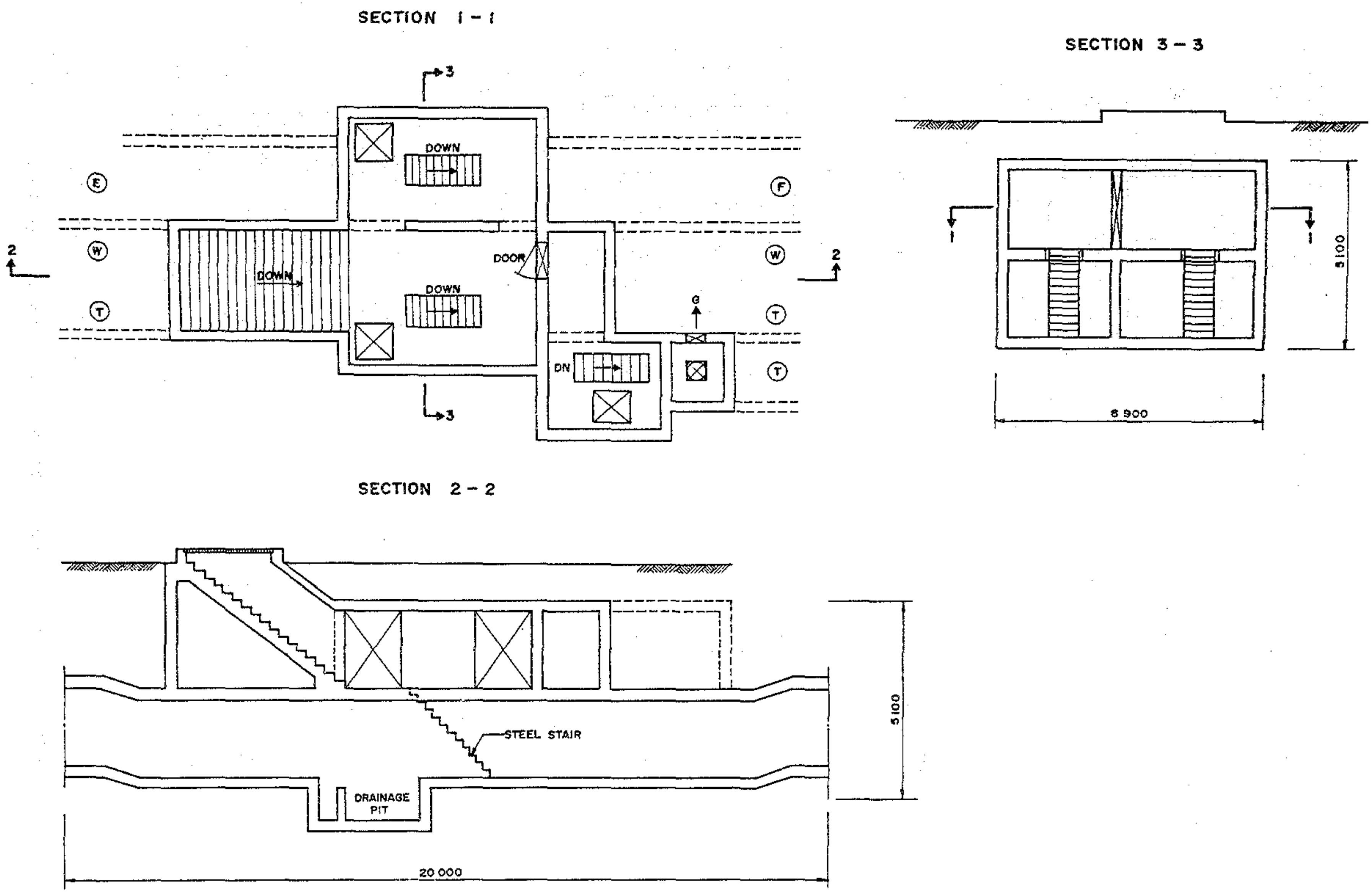


Figure 5.13 Detail of No. 2 Branch Section

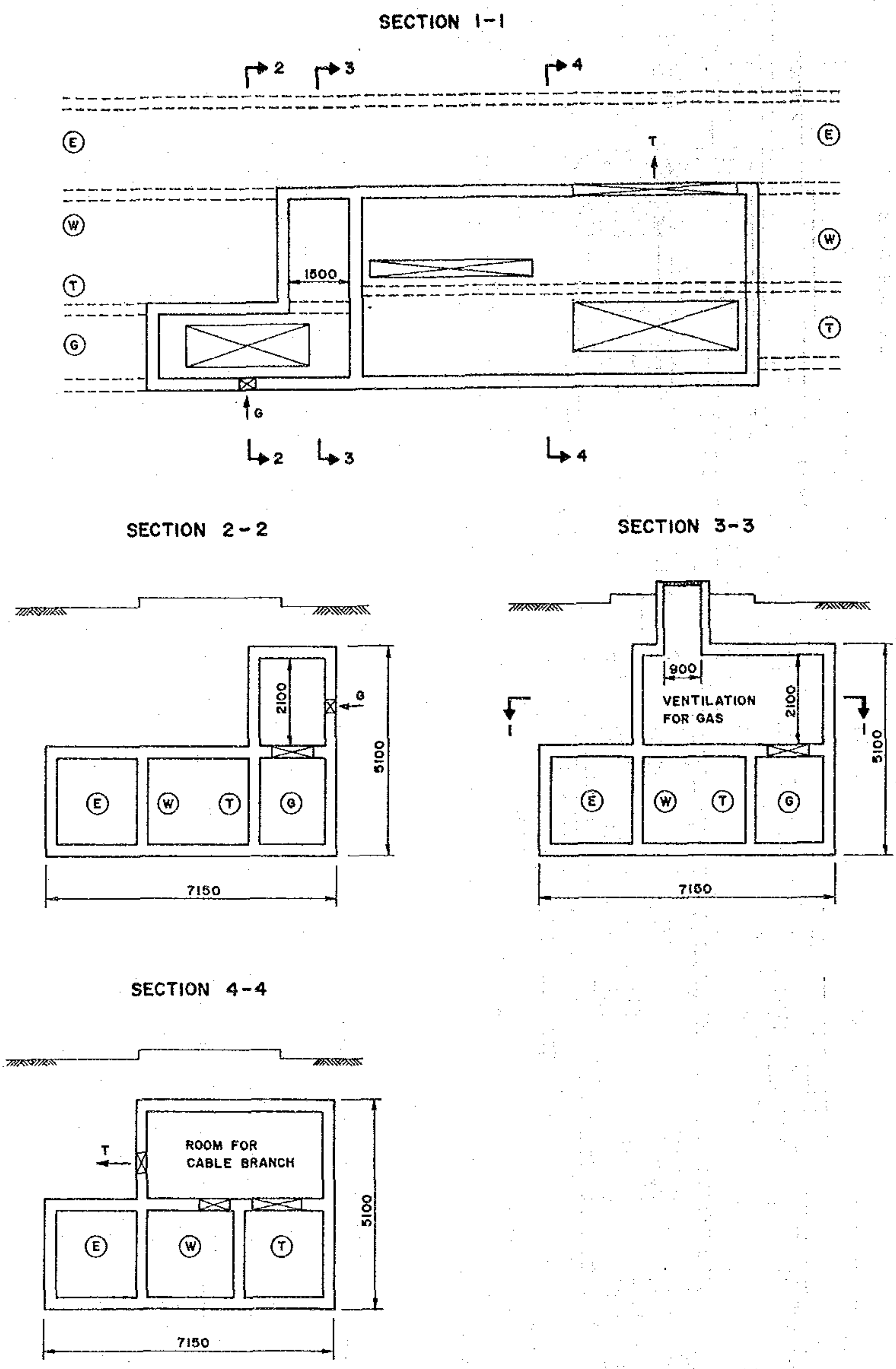


Figure 5.14 Detail of No. 3 Branch Section

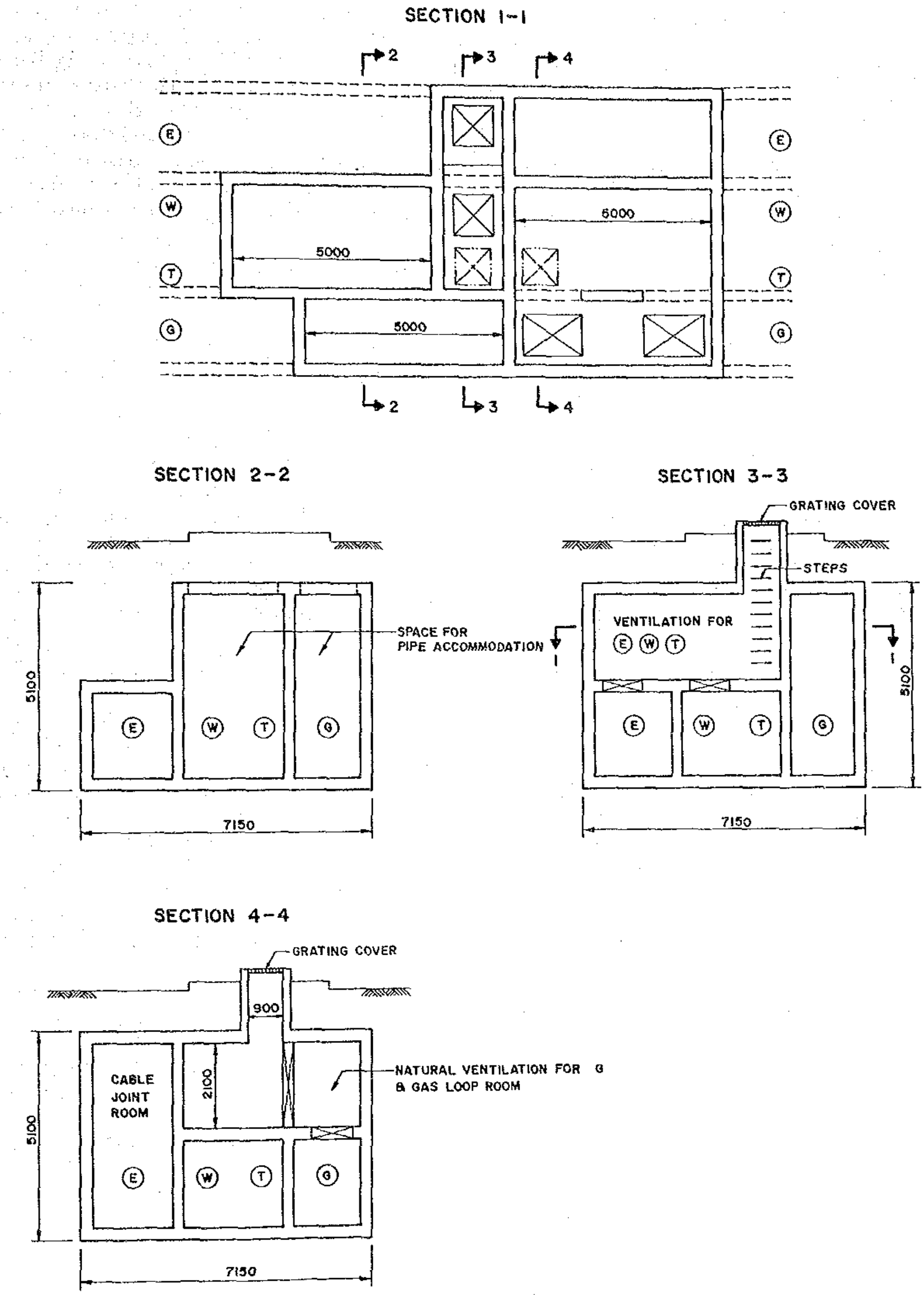


Figure 5.16 Detail of Ventilation No. 3

4) Ventilation Plan

Ventilators are provided every 200 meters or so in the subject CUD, with alternating forced and natural ventilation. Gas pipes, however, are enclosed in a separate room and ventilated separately in order to ensure the safety of other facilities. Natural ventilation ports are also used as entrance/exit openings, with ladders for climbing in and out of the duct. One location will serve as an emergency exit and is provided with stairs. Since the noise of ventilation fans escapes from ventilation ports, ventilation ports are provided on the median, away from roadside residences. The ventilation plan is shown in Figure 5.11.

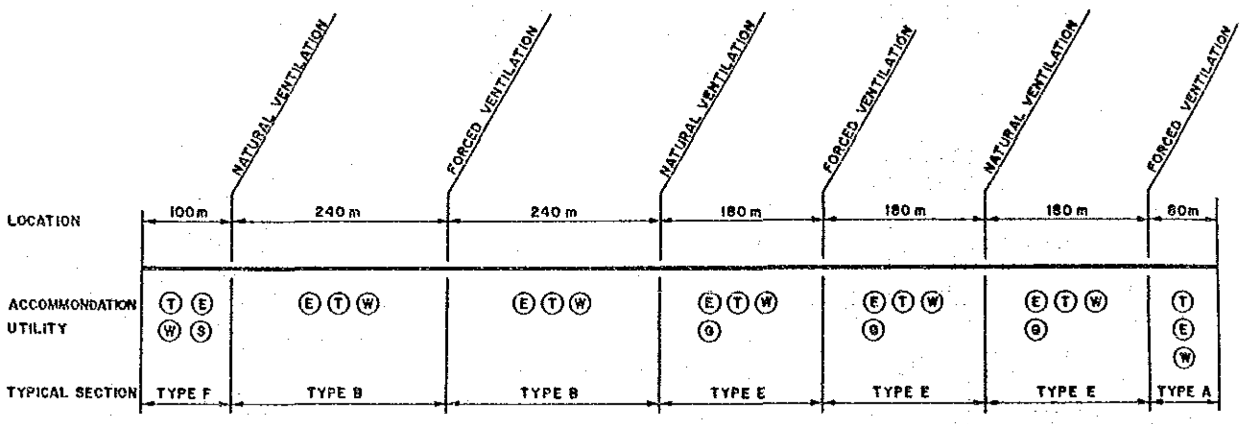


Figure 5.11 Ventilation Plan

5) Alignment Plan

a) Horizontal Alignment

Control points influencing the the horizontal alignment plan of a CUD are as follows:

- o Horizontal alignment of the road
- o Distance from road space boundary
- o Urban planning and other related projects

The Phahon Yothin Road does not have any particularly large objects buried under the carriageway. There are also no relevant projects being planned for the road. Thus, the horizontal alignment of the subject CUD was made to coincide with that of the existing road. Since the median can be used for entrance/exit and ventilation openings, the center line of the subject CUD was made to coincide with the center line of the road.

b) Vertical Alignment

The vertical alignment must be considered simultaneously with the horizontal alignment. In addition to the control points influencing the horizontal alignment, the vertical alignment plan must take into consideration the following factors:

- o Earth cover (distance from road surface to CUD top slab)
- o Gradient

Since there are no large transverse pipes buried under the subject route, the main control point in planning the vertical alignment of the subject CUD is earth cover. Since non-standard areas have larger cross sections than standard areas, the bottom of CUD must be made deeper. This means that the overall CUD will have to be placed further down from the road surface. Since this is undesirable from the standpoints of economy and ease of construction, areas near non-standard sections were made partially deeper and provided with stairs. This allows earth cover in the standard sections to be kept shallow.

In accordance with the guidelines, earth cover of 2.5 meters was secured for standard sections and at least 1.0 meter for non-standard sections. To allow drainage, the subject CUD was designed with a gradient of at least 0.2% in the standard sections.

The alignment plan is shown in Figure 5.17.

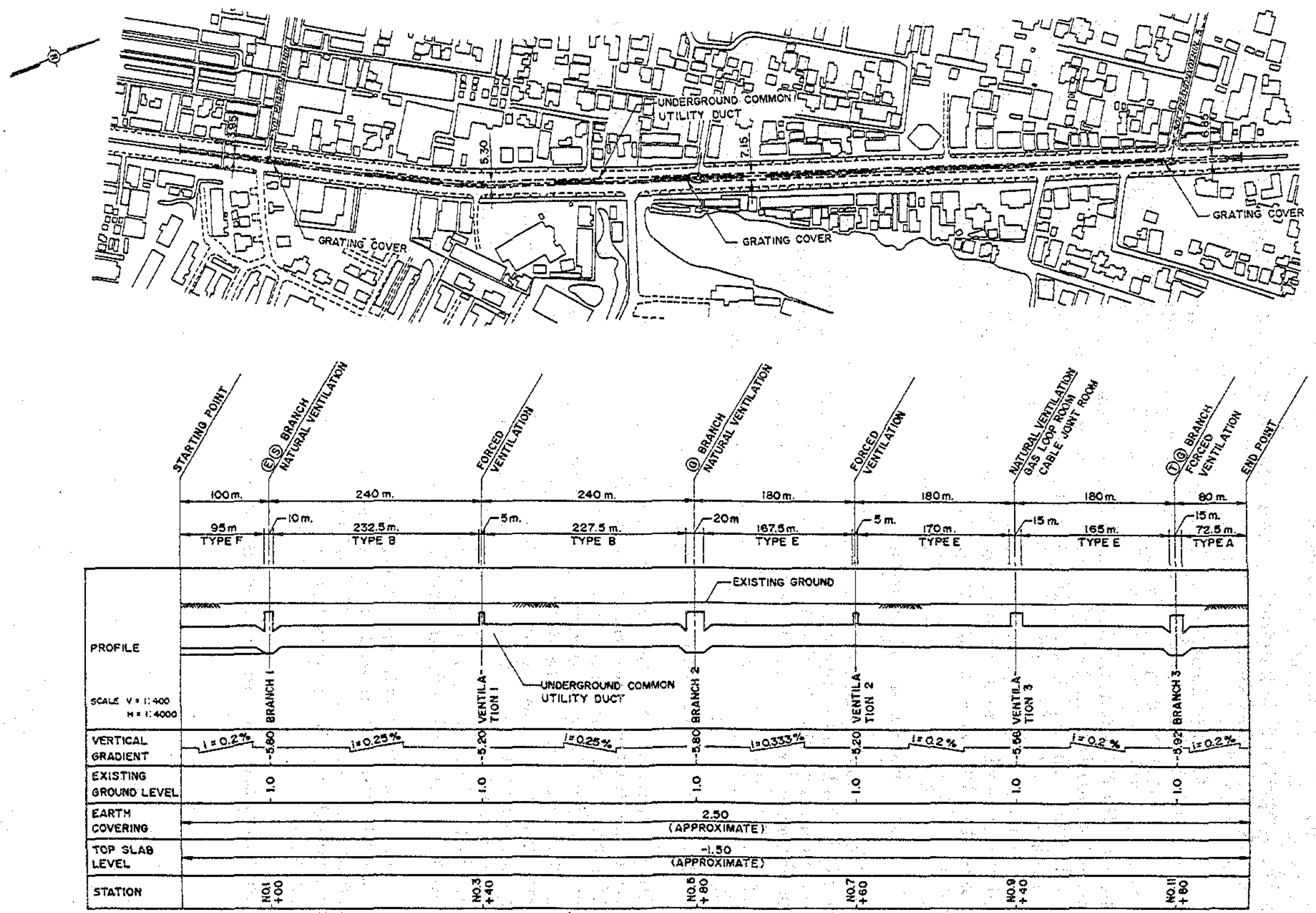


Figure 5.17 Plan and Profile of Trunk Line CUD

5.3 Supply-Line CUD and CAB

5.3.1 Subject Road

Routes to be provided with a supply-line CUD should fulfill the following conditions:

- Roadside usage is already high and is expected to be promoted further in the future.
- There is need for securing the means to expand the capacity of public utilities in an efficient manner.
- The heavy volume of traffic is causing, or is forecast to cause, congestion.
- Sufficient road width has already been secured in accordance with urban planning projects, and there are no plans to widen the road further in the future.
- The road is wide enough to allow the construction of a supply-line CUD.

Taking into account the above conditions, Rama I Road was selected for the supply-line CUD in this Case Study, from the two districts surveyed (Pathumwan and Bangrak). The road is one of the east-west arterials with Rama IV Road and New Petha Buri Road, and its average daily traffic is currently a high 78,000 vehicles. Moreover, there are large durable structures along the road, including a hotel, department store, world trade center and hospital, and pedestrian traffic is quite high. The road section for supply-line CUD is shown in Figure 5.18.

1) Road Cross Section

Figure 5.19 shows the cross section of Rama I Road. The sidewalk width changes as the road crosses the Ratcha Damri intersection. To the west of the intersection (Rama I), the sidewalk width on both sides is over 6.0 meters, and there is a drainage pipe along the road shoulder on the northern side. To the east of the Ratcha Damri intersection (Phloen Chit), the sidewalk width is about 4.0 meters. There is also a pedestrian bridge in front of the department store.

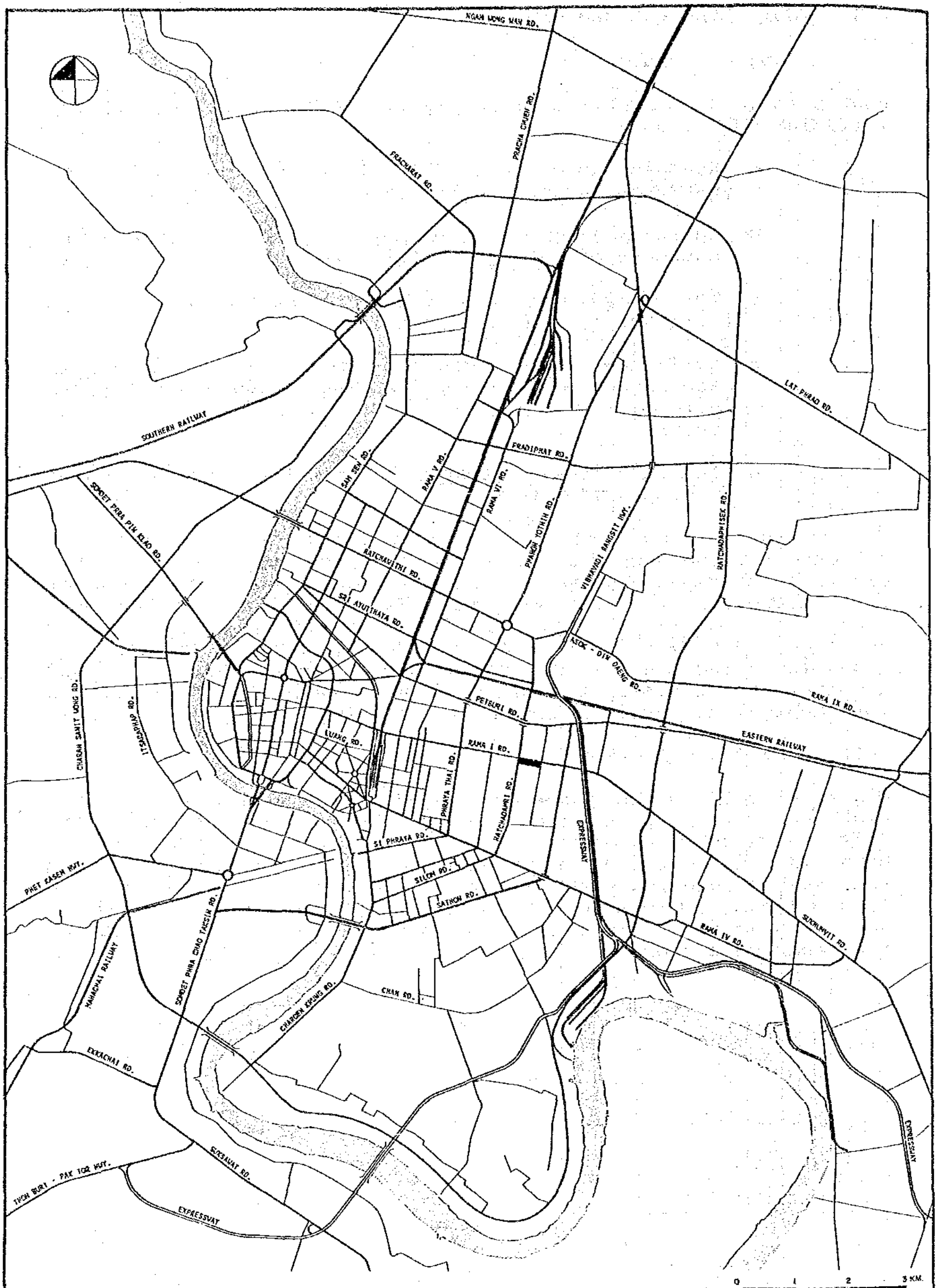


Figure 5.18 Road Section for Supply Line CUD

2) Existing Underground Installations

Figure 5.20 shows the underground installations currently found under the subject section. In addition to aerial cables, 18 high-tension power cables (69 kv) are now in the process of being laid beneath the carriageway. For telephones, there are 38-40 trunk cables installed underground, with those on the northern side below the sidewalk and those on the southern side beneath the carriageway. Water pipes consist of three supply pipes located below the sidewalks and 1 trunk pipe located beneath the carriageway. Sewer pipes on both sides of the road have diameters of 600 mm and are located under the sidewalks along the carriageway side, with the exception of the northern side of the section to the west of Ratcha Damri intersection, where the pipe is found below the road shoulder.

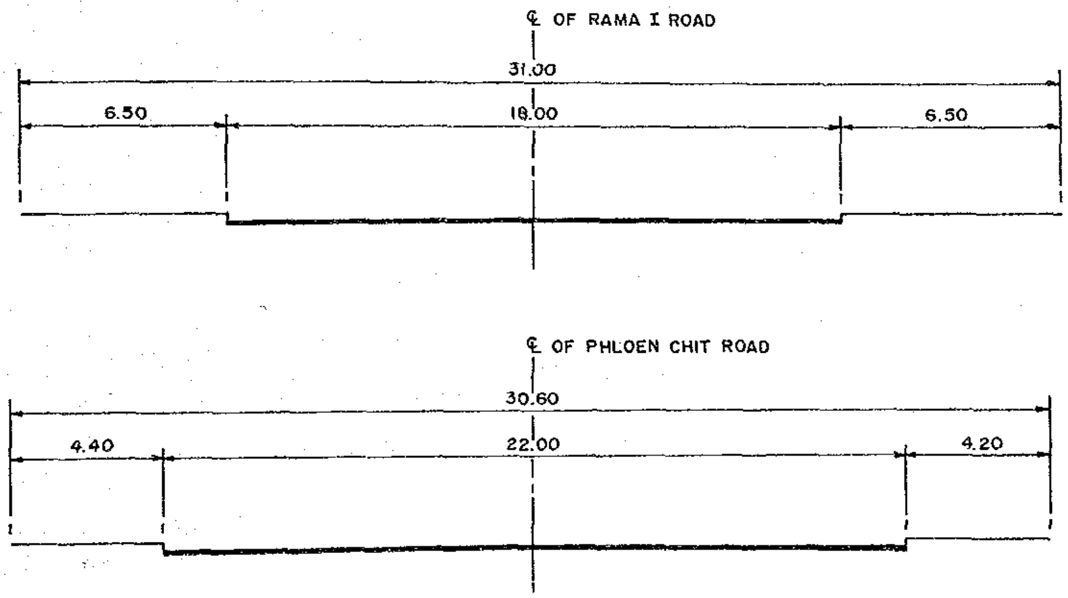
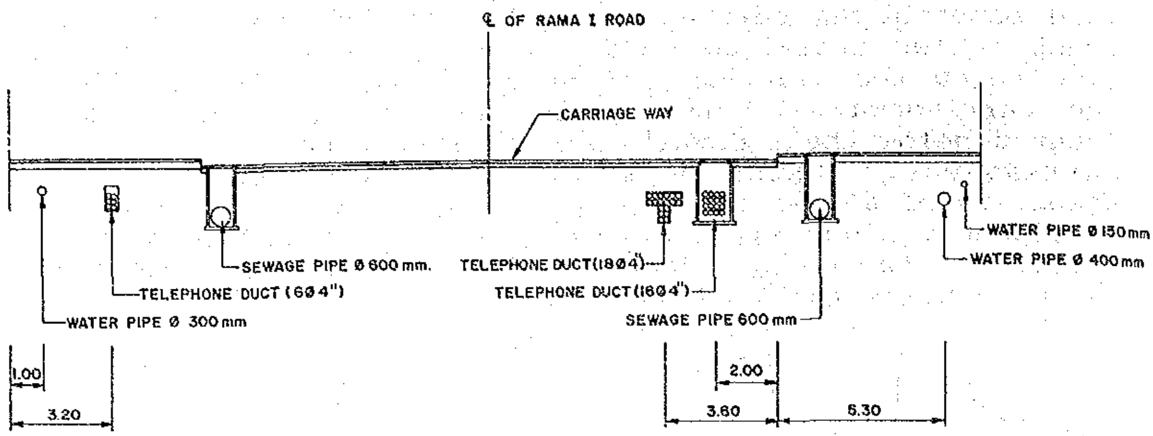


Figure 5.19 Existing Road Cross Section of Rama I Road



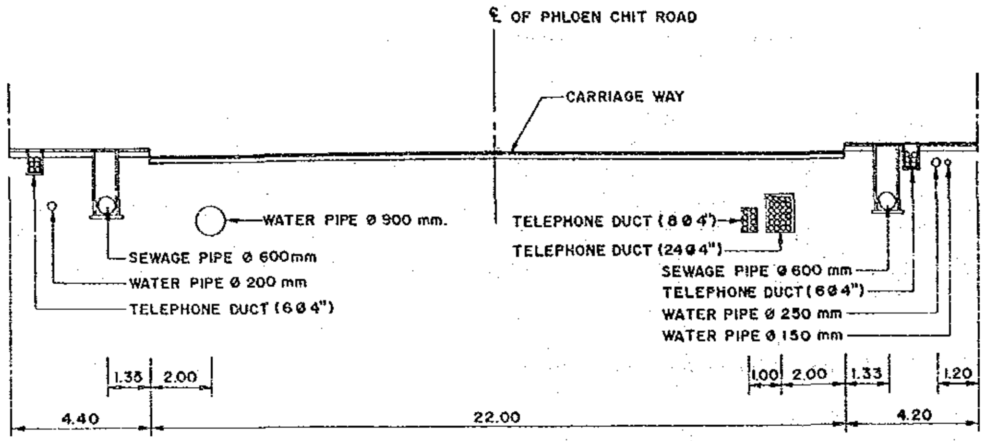


Figure 5.20 Existing Public Utility of Rama I Road

5.3.2 Utilities to be Accommodated and Standard Cross Section

1) Utilities to be Accommodated

Since supply-line CUD's Which are designed to service roadside areas, re usually placed below the sidewalks on both sodes of the road, they should have as small as cross section as possible. Supply-line CUD's accomodate supply cables and pipes and have small capacities; therefore, in general they are not sectioned but are designed to accomodate cables and pipes in a single cross section. The following public utilities may be accomodated by a CUD.

- o Telephone
- o Electricity
- o Water
- o Sewerage
- o Gas

In Bangkok, a supply-line CUD will house medium-tension (12 kv) electric cables, telephone distribution cables, and small-diameter (150-300 mm) water pipes.

Bangkok's sewer system, as mentioned above, is a combined system and has catchments every 10 meters or so as a countermeasure against flooding. At the same positions as the catchments and running along both sides of the road there are sewer pipes with diameters ranging between 600-1,200 mm; these pipes serve simultaneously as trunk and branch lines. If a sewer pipe of this type were to be incorporated into the supply-line CUD, it will be necessary to secure a much larger CUD cross section as well as a steeper gradient to enable natural flow. Since these measures entail substantially greater construction costs, sewer pipes were not included in the supply-line CUD in this Case Study.

Concerning the placement of a gas system in a supply-line CUD, complete safety can not be assured owing to problems stemming from the characteristic property of gas. Should breakage or leakage occur, the damage may be greater than if the system is buried directly in the ground. We believe it is currently difficultly to place a gas system in a sealed environment. If a gas system were to be housed in a sealed environment, an isolated room would have to be prepared like the trunk-line CUD. This would make the cross section of the CUD too large and unneconomical. Therefore, it is better to install the gas system outside the CUD insted of inside the sealed space. Figure 5.21 gives an example of how this is done in Japan. When placing the system outside the duct, it would be easier to locate the pipe and effect maintenance work if it is placed in close proximity to the duct. In this case, the gas system should have an earth cover of about 1.0 meter(36 inches), in conformance with ANSIB31.8. In this Case Study, the gas system is placed either on top of or at the side of the CUD depending on the earth cover of the CUD (Figure 5.22).

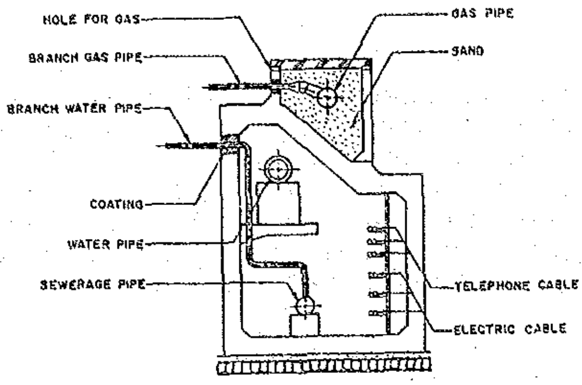


Figure 5.21 Example in Japan

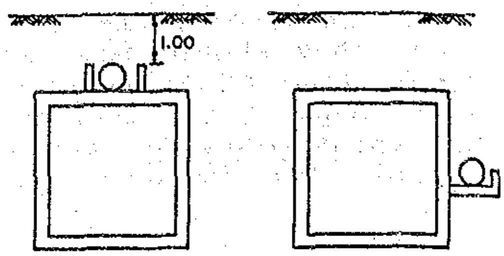


Figure 5.22 Gas Pipe Location

2) Standard Cross Section

The layout shown in Figure 5.23 is oftrn adoped for a supply-line CUD from the standpoint of making effective use of available space, as well as to keep the interminglimg of cables and pipes to a minmum. The separation of telephone and power cables is beleived to be unnecessary; it shoud be sufficient to leave an approproate space (about 300 mm or more) between the two, plus space for maintenance and repair.

Utilities to be accomodated are 8-10 telephone cables, 12 power cables with 12KV tension, and 300-diameter water pipes.

Two types of standard cross sections (Figure 5.24) were considered for the subject CUD.

The advantage of Type 1 is that it allows uniformity in construction and maintenance and reduces the need for digging. Another advantage is that, after completion, it will be possible to conduct maintenance entirely within the duct, which means that it is much safer. On the other hand, its disadvantage is that, like the trunk-line CUD, it requires non-standard sections for branching and incidental facilities (ventilation, illumination, drainage, etc.). This means that its construction cost will be higher than Type 2.

Type 2 is adopted when the sidewalks are not very wide, but its capacity is limited. Since maintenance and repair of cables and pipes must be conducted from above ground, it is necessary to place the duct below a sidewalk with little earth cover.

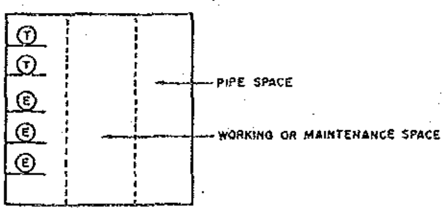


Figure 5.23 Standard Space

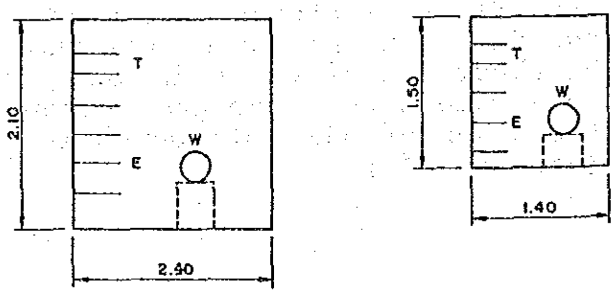


Figure 5.24
Standard Sections for Sypply Line CUD

5.3.3 Preliminary Design

1) Preconditions

A preliminary design was prepared for the 700-meter section extending to the east and west of the Ratcha Damri intersection. The design is based on the following preconditions.

- o Of the existing underground installations, trunk cables and pipes will be relocated to the trunk-line CUD.
- o Since existing water pipes are supply pipes, they will be relocated to the supply-line CUD.

2) Accommodation Plan

There is a large number of underground installations below the sidewalks of the subject road, and it will be difficult to relocate all these pipes and cables. In addition, there are connector pipes leading from roadside housing toward sewer manholes located on the carriageway sides of the sidewalks. These connector pipes run at right angles to the road and are found about 50 cm beneath the sidewalks at 10-20 meter intervals, making it impossible to construct a large structure of continuous length immediately under the sidewalk surface anywhere between the dwellings and sewer trunk pipes in a position parallel to the sidewalks. Therefore, the subject CUD is placed below these connector pipes. This makes its earth cover roughly 1.0 meter.

The subject CUD houses low- and medium-tension power cables, telephone supply cables, and supply pipes (300 mm diameter) for water. Telephone cables include two cables for data communication (telex, etc.) provided by the Communication Authority of Thailand. The standard cross section is shown in Figure 5.25.

3) Branching Plan

The subject CUD is designed to branch off at the Ratcha Damri and Soi Lang Suan intersections. The cross section of a branching section is larger than standard, and is determined by the turning radius of the cable or pipe involved. Figure 5.26 shows the cross-section of a branching section in the subject CUD.

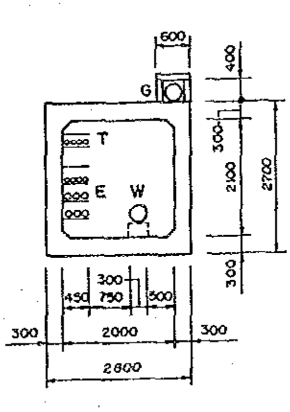


Figure 5.25
Section for Supply Line CUD

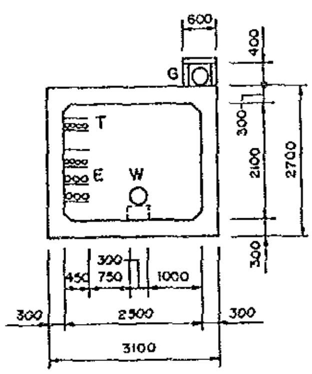


Figure 5.26 Section at Branch

4) Ventilation Plan

As in the trunk-line CUD, natural and forced ventilation is provided every 200 meters or so in alternate positions. The ventilation port, as shown in Figure 5.27, is placed on the sidewalk.

5) Alignment Plan

a) Horizontal Alignment

Of the existing underground installations found below the sidewalks, water pipes take up a large space. Since the subject route to the west of Ratcha Damri intersection has sidewalks of sufficient width (over 6 meters), the alignment plan places the subject CUD in the near center of the sidewalk in this section (Type 1).

To the east of the Ratcha Damri intersection (Phloen Chit side), the sidewalks are only 4 meters wide. In addition, there is a pedestrian bridge in front of the department store. Since these factors prevent the CUD from being placed under the sidewalk without hitting a sewer pipe, the subject CUD is designed to run below the carriageway in this section (Type 2). Figure 5.28 shows the two placement positions.

b) Vertical Alignment

Minimum earth cover was established as 1.0 meter, taking into consideration the positions of existing trunk line installations below ground. At intersections, the subject CUD dips downwards to pass under the transverse pipes; earth cover in this case is 2.5 meters. Minimum gradient is 0.2%. In addition, drainage facilities are provided at intersections owing to the deeper earth cover. Figure 5.29 shows the horizontal and vertical alignments of the subject CUD.

Type 1, 2 and 3 shown in Figure 5.24 all have the same cross section. However, Type 1 is planned for placement under the sodewalk and Type 2 under the carriageway. Type 3 is planned for placement under the transverse road and has a deep earth cover.

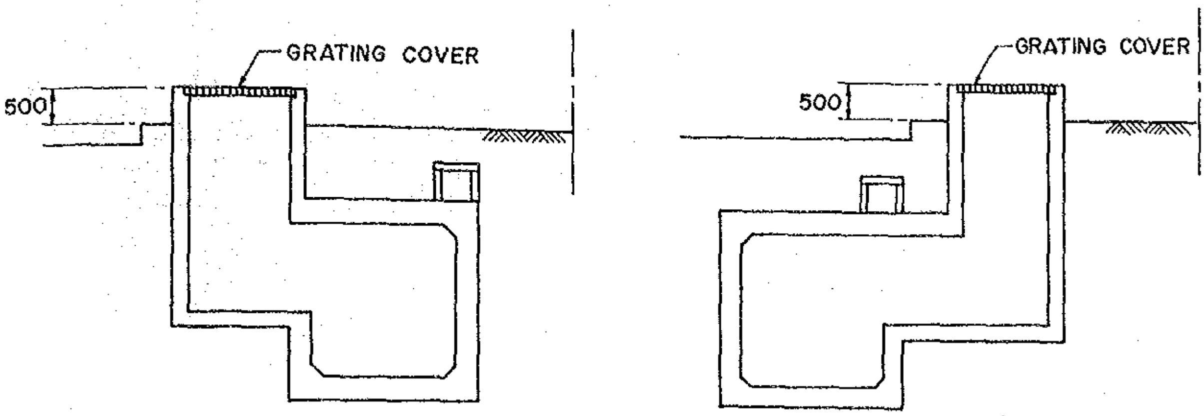


Figure 5.27 Section at Ventilation

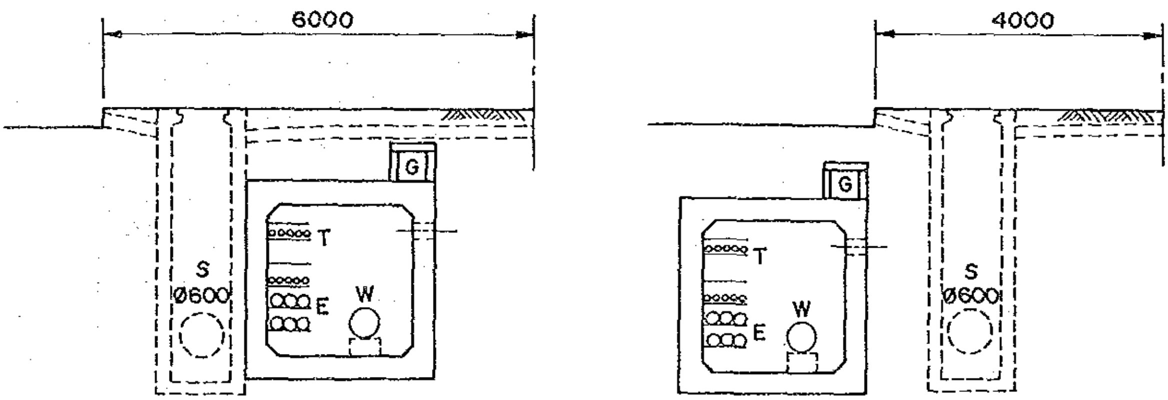


Figure 5.28 Relationship between CUD and Sewer Pipe

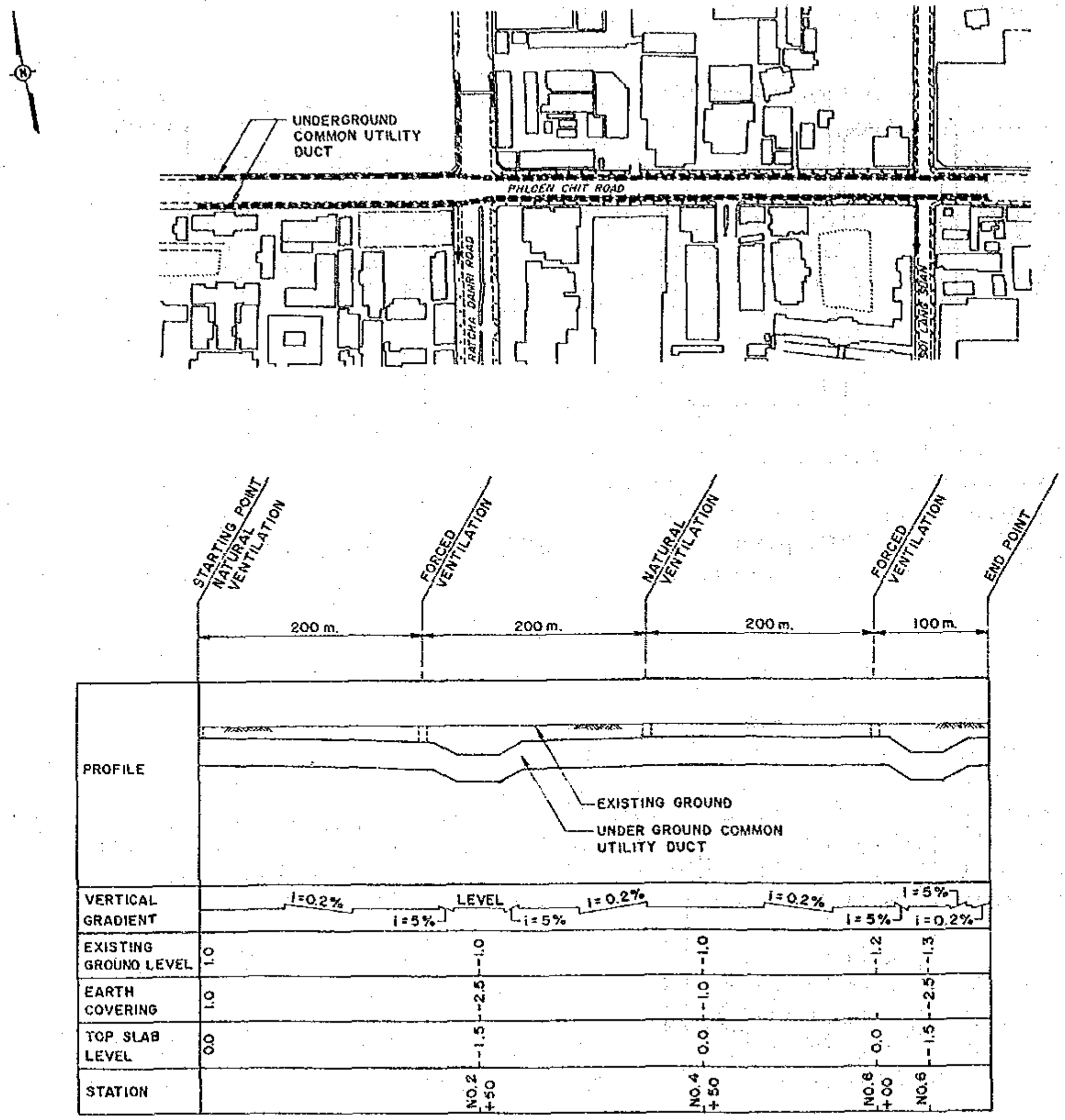


Figure 5.29 Plan and Profile of Supply Line CUD

5.4 Project Cost and Implementation Plan

Project costs of the subject CUD's were calculated on the basis of their preliminary designs, and economic costs necessary for economic analysis were also calculated.

5.4.1 Preconditions

The calculation of project costs was based on the following preconditions:

- o Unit construction costs are based on July 1989 prices.
- o The project cost consists of direct construction cost, indirect construction cost (administrative expenses, profits, etc.), contingency, and expenses for detailed design and construction supervision.
- o The unit cost of a job item is obtained by adding together the costs of materials, equipment and labor. Job items are determined with reference to recent construction works in Thailand.
- o The cost of building incidental and accessory CUD facilities is included in direct construction cost.
- o Indirect construction cost is given as 25% of direct construction cost, in accordance with past examples in Thailand.
- o Expenses for detailed design and construction supervision are given as 10% of total construction cost (direct + indirect).
- o Contingency corresponds to 10% of the total cost of construction, detailed design and construction supervision.

The above preconditions are outlined in Figure 5.28.

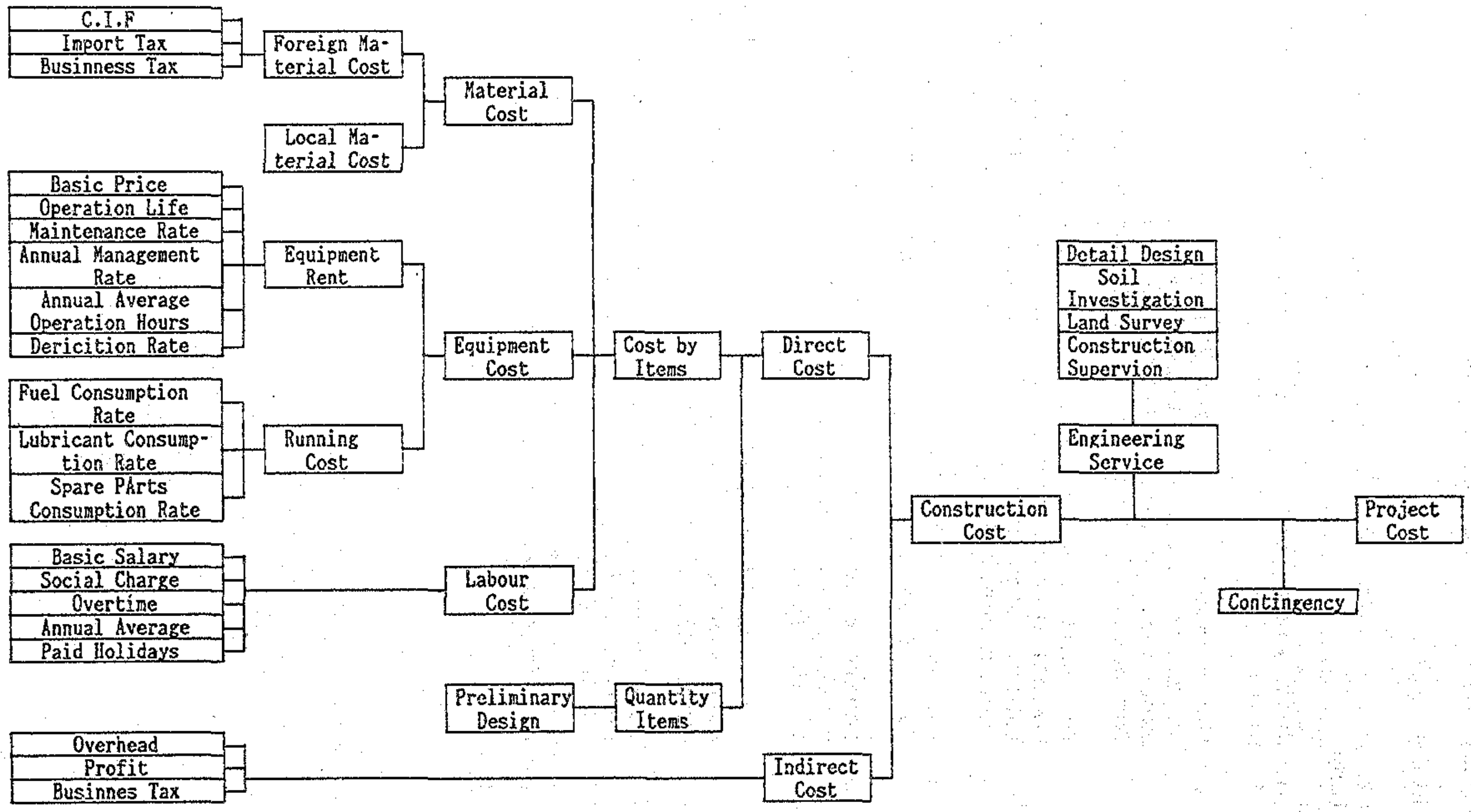


Figure 5.30 Cost Estimation Process

5.4.2 Construction Cost

Unit costs of job items were calculated by adding together the costs of labor, materials and equipment.

1) Labor Cost

As shown in Table 5.2, labor costs were calculated for five types of workers. Hourly labor cost was obtained on the basis of the average daily wage, by calculating the number of actual working hours in a year after annual leaves, holidays, sick leaves, and days on which work is halted due to rain are subtracted.

2) Materials Cost

Materials are largely divided into local and imported materials. Nearly all construction materials can be obtained locally, with the exception of a few that are in short supply owing to the recent construction boom. The foreign currency ratio of local materials cost was assumed to be as shown in Table 5.3, taking into consideration that raw materials, fuel and manufacturing equipment are often quoted in foreign currency at their production and distribution levels.

The local price of imported materials was determined by adding on custom duties and commission to the CIF Thailand price. Imported materials are mainly large-sized shaped steel.

3) Equipment Cost

Equipment cost per hour of operation was calculated on the basis of running cost, depreciation and maintenance and repairs. Expenses for determining the rental charges of main equipment are shown in Table 5.4.

4) Job Item

The various jobs involved in CUD construction were grouped into three major job items, and the unit cost of each was calculated by adding together the unit costs of components factors (labor, materials, equipment, etc.). Unit cost by major job item is shown in Table 5.5, and the unit costs of two CUD sections are shown in Table 5.6.

Table 5.2 Labour Cost

Labour Name	Unit	Unit Wage Foreign	Unit Wage Local
Driver	hour	0	28
Foreman	hour	0	38
Operator	hour	0	31
Skilled Labour	hour	0	28
Unskilled Labour	hour	0	13

Table 5.3 Foreign Currency Rate in Raw Materials

Material	Unit	Original Price(Baht)	Percentage Foreign	Percentage Local	US$	Baht
Cement	ton	1,400	50	50	28.0	700
Sand	cum	170	50	50	3.4	85
Crusher Run	cum	250	50	50	5.0	125
Reinforcement	ton	15,000	80	20	480.0	3,000
Hard Wood	cum	13,350	40	60	213.6	8,010
Soft Wood	cum	5,826	40	60	93.2	3,496

Table 5.4 Condition for Equipment Rent

Equipment	Basic Cost US$	Operational Life (year)	Residual Value (%)	Annual Operate Hour	Maintenance Rate (%)	Annual Manage Rate (%)
Bulldozer 21t	220,900	7	10.0	1,500	65.0	7.0
Compessor 4.6 m3	33,200	5	10.0	1,000	50.0	7.0
Conc. Breaker 30 kg	4,000	2	10.0	960	20.0	5.0
Conc. Bucket	18,000	5	10.0	560	55.0	5.0
Crawlor Crane 35 t	261,000	7	10.0	1,000	70.0	7.0
Hydro-Shovel 0.6 m3	155,000	7	10.0	1,200	60.0	7.0
Soil Compacter 50 kg	18,000	3	10.0	800	45.0	5.0
Truck 5 t	26,000	4	10.0	1,250	55.0	10.0
Truck Crane 11 t	140,000	7	10.0	900	35.0	7.0
Vibrater	960	3	10.0	12,800	35.0	5.0
Vibro Hammer	43,200	4	10.0	800	35.0	7.0

Table 5.5 Cost by Work Item

Structure Concrete Per 208 CUM

Description	Unit	Quantity	Unit Price Foreign	Unit Price Local Financial	Unit Price Local Economic	Total Price Foreign	Total Price Local Financial	Total Price Local Economic
Equipment								
Truck Crane 11 t	hour	28.00	37.70	61	14	1055.60	1708	392
Conc. Bucket	hour	28.00	1.02	2	0	28.56	56	0
Vibrater	hour	84.00	0.34	1	1	28.56	84	84
Miscellaneous	%	2.00	0.00	0	0	22.25	37	10
Material								
Miscellaneous	%	5.00	0.00	0	0	301.81	4607	4222
Concrete	CUM	208.00	29.02	443	406	6036.16	92144	84448
Labour								
Operator	hour	28.00	0.00	31	31	0.00	868	868
Driver	hour	28.00	0.00	28	28	0.00	784	784
Unskilled Labour	hour	910.00	0.00	13	1	0.00	11830	910
Foreman	hour	97.00	0.00	38	38	0.00	3686	3686
Miscellaneous	%	5.00	0.00	0	0	0.00	858	312
Total						7472.94	116663	95716
Per 1 CUM						35.93	561	460

Wood Forming Per 1000 SQM

Description	Unit	Quantity	Unit Price Foreign	Unit Price Local Financial	Unit Price Local Economic	Total Price Foreign	Total Price Local Financial	Total Price Local Economic
Equipment								
Miscellaneous	%	0.00	0.00	0	0	0.00	0	0
Material								
Soft Wood	CUM	22.00	93.20	3496	3496	2050.40	76912	76912
Hard Wood	CUM	8.00	213.60	8009	8009	1708.80	64072	64072
Miscellaneous	%	1.00	0.00	0	0	37.59	1410	1410
Labour								
Skilled Labour	hour	1575.00	0.00	28	28	0.00	44100	44100
Foreman	hour	259.00	0.00	38	38	0.00	9842	9842
Unskilled Labour	hour	1015.00	0.00	13	1	0.00	13195	1015
Miscellaneous	%	1.00	0.00	0	0	0.00	671	550
Total						3796.79	210202	197900
Per 1 SQM						3.80	210	198

Reinforcing Per 1 ton

Description	Unit	Quantity	Unit Price Foreign	Unit Price Local Financial	Unit Price Local Economic	Total Price Foreign	Total Price Local Financial	Total Price Local Economic
Equipment								
Truck 8 t	hour	0.16	12.92	62	28	2.07	10	4
Truck 5 t	hour	0.47	9.65	47	21	4.54	22	10
Miscellaneous	%	2.00	0.00	0	0	0.13	1	0
Material								
Reinforcement	ton	1.02	480.00	3000	3000	489.60	3060	3060
Miscellaneous	%	3.00	0.00	0	0	14.69	92	92
Labour								
Driver	hour	0.63	0.00	28	28	0.00	18	18
Skilled Labour	hour	45.50	0.00	28	28	0.00	1274	1274
Foreman	hour	4.50	0.00	38	38	0.00	171	171
Miscellaneous	%	2.00	0.00	0	0	0.00	29	29
Total						511.02	4676	4658
Per 1 ton						511.02	4676	4658

Table 5.6 Cost by Type in Trunk Line CUD (Direct Cost)

TCUD TYPE A Per 1 LM

Description	Unit	Quantity	Unit Price Foreign	Unit Price Local Financial	Unit Price Local Economic	Total Price Foreign	Total Price Local Financial	Total Price Local Economic
Material								
Structure Concrete	CUM	6.42	35.93	561	460	230.66	3601	2954
Wood Forming	SQM	23.75	3.80	210	198	90.17	4992	4700
Reinforcing	ton	0.64	511.02	4676	4658	327.06	2993	2981
Lean Concreting	CUM	0.71	29.46	525	425	20.92	373	302
Crusher Running	CUM	1.41	5.17	129	127	7.28	183	179
Water Proofing	SQM	19.10	22.26	329	78	425.17	6284	1496
Structure Excavation	CUM	42.39	5.10	23	11	216.08	963	471
Equip. Backfill	CUM	23.90	0.75	9	6	17.91	224	148
Demolish Work	CUM	8.85	19.72	99	49	174.52	876	437
Concrete Pavement 25	SQM	8.85	18.52	385	353	163.90	3407	3127
Deck Plating	SQM	7.85	49.68	558	71	389.99	4383	561
Deck Supporting	TON	1.11	316.74	3881	859	351.58	4308	954
Struting	ton	1.26	325.39	3890	827	410.00	4901	1042
Sheet Piling	TON	2.52	468.54	4647	628	1180.73	11712	1582
Total						4005.95	49200	20934

TCUD TYPE B Per 1 LM

Description	Unit	Quantity	Unit Price Foreign	Unit Price Local Financial	Unit Price Local Economic	Total Price Foreign	Total Price Local Financial	Total Price Local Economic
Material								
Structure Concrete	CUM	4.97	35.93	561	460	178.56	2788	2287
Wood Forming	SQM	18.25	3.80	210	198	69.29	3836	3612
Reinforcing	ton	0.50	511.02	4676	4658	255.51	2338	2329
Lean Concreting	CUM	0.55	29.46	525	425	16.21	289	234
Crusher Running	CUM	1.10	5.17	129	127	5.68	142	140
Water Proofing	SQM	16.00	22.26	329	78	356.16	5264	1253
Structure Excavation	CUM	32.76	5.10	23	11	166.99	744	364
Equip. Backfill	CUM	18.45	0.75	9	6	13.83	173	114
Demolish Work	CUM	7.30	19.72	99	49	143.95	723	360
Concrete Pavement 25	SQM	7.30	18.52	385	353	135.20	2811	2579
Deck Plating	SQM	6.30	49.68	558	71	312.99	3517	450
Deck Supporting	TON	0.82	316.74	3881	859	259.73	3183	704
Struting	ton	1.12	325.39	3890	827	364.44	4356	926
Sheet Piling	TON	2.46	468.54	4647	628	1152.61	11433	1544
Total						3431.14	41597	16897

TCUD TYPE C Per 1 LM

Description	Unit	Quantity	Unit Price Foreign	Unit Price Local Financial	Unit Price Local Economic	Total Price Foreign	Total Price Local Financial	Total Price Local Economic
Material								
Structure Concrete	CUM	4.61	35.93	561	460	165.63	2586	2121
Wood Forming	SQM	17.65	3.80	210	198	67.01	3710	3493
Reinforcing	ton	0.46	511.02	4676	4658	235.07	2151	2143
Lean Concreting	CUM	0.49	29.46	525	425	14.44	257	208
Crusher Running	CUM	0.98	5.17	129	127	5.06	127	125
Water Proofing	SQM	14.80	22.26	329	78	329.45	4870	1159
Structure Excavation	CUM	29.64	5.10	23	11	151.09	673	329
Equip. Backfill	CUM	16.95	0.75	9	6	12.70	159	105
Demolish Work	CUM	6.70	19.72	99	49	132.12	663	231
Concrete Pavement 25	SQM	6.70	18.52	385	353	124.09	2580	2367
Deck Plating	SQM	5.70	49.68	558	71	283.18	3182	407
Deck Supporting	TON	0.76	316.74	3881	859	240.72	2950	653
Struting	ton	0.73	325.39	3890	827	237.54	2839	604
Sheet Piling	TON	2.46	468.54	4647	628	1152.61	11433	1544
Total						3150.70	38180	15589

Table 5.6 Cost by Type in Trunk Line CUD (Cont'd)

TCUD TYPE D Per 1 LM

Description	Unit	Quantity	Unit Price Foreign	Unit Price Local Financial	Unit Price Local Economic	Total Price Foreign	Total Price Local Financial	Total Price Local Economic
Material								
Structure Concrete	CUM	3.63	35.93	561	460	130.42	2036	1670
Wood Forming	SQM	12.95	3.80	210	198	49.17	2722	2563
Reinforcing	ton	0.36	511.02	4676	4658	183.97	1683	1677
Lean Concreting	CUM	0.42	29.46	525	425	12.37	221	179
Crusher Running	CUM	0.83	5.17	129	127	4.29	107	106
Water Proofing	SQM	13.30	22.26	329	78	296.06	4376	1042
Structure Excavation	CUM	25.74	5.10	23	11	131.21	585	286
Equip. Backfill	CUM	15.07	0.75	9	6	11.30	141	93
Demolish Work	CUM	5.95	19.72	99	49	117.33	589	294
Concrete Pavement 25	SQM	5.95	18.52	385	353	110.20	2291	2102
Deck Plating	SQM	4.95	49.68	558	71	245.92	2764	353
Deck Supporting	TON	0.59	316.74	3881	859	186.88	2290	507
Struting	ton	0.69	325.39	3890	827	224.52	2684	571
Sheet Piling	TON	2.46	468.54	4647	628	1152.61	11433	1544
Total						2856.23	33922	12986

TCUD TYPE E Per 1 LM

Description	Unit	Quantity	Unit Price Foreign	Unit Price Local Financial	Unit Price Local Economic	Total Price Foreign	Total Price Local Financial	Total Price Local Economic
Material								
Structure Concrete	CUM	5.93	35.93	561	460	213.05	3326	2729
Wood Forming	SQM	19.85	3.80	210	198	75.37	4173	3928
Reinforcing	ton	0.59	511.02	4676	4658	301.50	2759	2748
Lean Concreting	CUM	0.71	29.46	525	425	20.92	373	302
Crusher Running	CUM	1.42	5.17	129	127	7.33	184	181
Water Proofing	SQM	19.20	22.26	329	78	427.39	6317	1504
Structure Excavation	CUM	41.08	5.10	23	11	209.40	933	456
Equip. Backfill	CUM	22.45	0.75	9	6	16.83	211	139
Demolish Work	CUM	8.90	19.72	99	49	175.50	881	439
Concrete Pavement 25	SQM	7.90	18.52	385	353	146.31	3042	2791
Deck Plating	SQM	7.90	49.68	558	71	392.47	4411	564
Deck Supporting	TON	0.84	316.74	3881	859	266.06	3260	722
Struting	ton	1.27	325.39	3890	827	413.25	4940	1050
Sheet Piling	TON	2.46	468.54	4647	628	1152.61	11433	1544
Total						4005.95	49200	19098

TCUD TYPE F Per 1 LM

Description	Unit	Quantity	Unit Price Foreign	Unit Price Local Financial	Unit Price Local Economic	Total Price Foreign	Total Price Local Financial	Total Price Local Economic
Material								
Structure Concrete	CUM	5.72	35.93	561	460	205.51	3208	2632
Wood Forming	SQM	22.90	3.80	210	198	86.95	4814	4352
Reinforcing	ton	0.57	511.02	4676	4658	291.28	2666	2655
Lean Concreting	CUM	0.42	29.46	525	425	12.37	221	179
Crusher Running	CUM	0.83	5.17	129	127	4.29	107	106
Water Proofing	SQM	16.80	22.26	329	78	373.97	5528	1316
Structure Excavation	CUM	36.50	5.10	23	11	186.05	829	405
Equip. Backfill	CUM	18.70	0.75	9	6	14.02	176	115
Demolish Work	CUM	6.00	19.72	99	49	118.32	594	296
Concrete Pavement 25	SQM	6.00	18.52	385	353	111.12	2310	2120
Deck Plating	SQM	6.00	49.68	558	71	298.08	3350	428
Deck Supporting	TON	0.59	316.74	3881	859	186.88	2290	507
Struting	ton	1.51	325.39	3890	827	491.34	5873	1249
Sheet Piling	TON	3.06	468.54	4647	628	1433.74	14221	1921
Total						3813.91	46186	18462

Table 5.6 Cost by Type in Trunk Line CUD (Cont'd)

TCUD BRANCH 1 Per 1 LM

Description	Unit	Quantity	Unit Price Foreign	Unit Price Local Financial	Unit Price Local Economic	Total Price Foreign	Total Price Local Financial	Total Price Local Economic
Material								
Structure Concrete	CUM	8.40	35.93	561	460	301.79	4711	3865
Wood Forming	SQM	40.53	3.80	210	198	153.88	8250	8021
Reinforcing	ton	0.84	511.02	4676	4658	429.26	3928	3913
Lean Concreting	CUM	0.42	29.46	525	425	12.37	221	179
Crusher Running	CUM	0.85	5.17	129	127	4.39	110	108
Water Proofing	SQM	18.10	22.26	329	78	402.91	5955	1418
Structure Excavation	CUM	44.55	5.10	23	11	227.09	1012	495
Equip. Backfill	CUM	20.85	0.75	9	6	15.63	196	129
Demolish Work	CUM	6.00	19.72	99	49	118.32	594	296
Concrete Pavement 25	SQM	6.00	18.52	385	353	111.12	2310	2120
Deck Plating	SQM	5.00	49.68	558	71	248.40	2792	357
Deck Supporting	TON	0.59	316.74	3881	859	186.88	2290	507
Struting	ton	1.01	325.39	3890	827	328.65	3928	835
Sheet Piling	TON	3.33	468.54	4647	628	1560.24	15476	2090
Total						4100.93	52042	24333

TCUD BRANCH 2 Per 1 LM

Description	Unit	Quantity	Unit Price Foreign	Unit Price Local Financial	Unit Price Local Economic	Total Price Foreign	Total Price Local Financial	Total Price Local Economic
Material								
Structure Concrete	CUM	8.92	35.93	561	460	320.47	5003	4105
Wood Forming	SQM	35.79	3.80	210	198	135.89	7523	7083
Reinforcing	ton	0.89	511.02	4676	4658	454.81	4162	4146
Lean Concreting	CUM	0.69	29.46	525	425	20.33	362	294
Crusher Running	CUM	1.30	5.17	129	127	6.71	168	165
Water Proofing	SQM	19.20	22.26	329	78	427.39	6317	1504
Structure Excavation	CUM	50.56	5.10	23	11	257.72	1148	562
Equip. Backfill	CUM	32.61	0.75	9	6	24.44	306	201
Demolish Work	CUM	8.90	19.72	99	49	175.50	881	439
Concrete Pavement 25	SQM	8.90	18.52	385	353	164.83	3427	3144
Deck Plating	SQM	8.00	49.68	558	71	397.44	4466	571
Deck Supporting	TON	1.13	316.74	3881	859	357.92	4386	971
Struting	ton	1.27	325.39	3890	827	413.25	4940	1050
Sheet Piling	TON	2.82	468.54	4647	628	1321.29	13106	1770
Total						4478.00	56196	26006

TCUD BRANCH 3 Per 1 LM

Description	Unit	Quantity	Unit Price Foreign	Unit Price Local Financial	Unit Price Local Economic	Total Price Foreign	Total Price Local Financial	Total Price Local Economic
Material								
Structure Concrete	CUM	10.09	35.93	561	460	362.51	5659	4643
Wood Forming	SQM	50.62	3.80	210	198	192.19	10640	10018
Reinforcing	ton	1.01	511.02	4676	4658	516.13	4723	4705
Lean Concreting	CUM	0.71	29.46	525	425	20.92	373	302
Crusher Running	CUM	1.43	5.17	129	127	7.39	185	182
Water Proofing	SQM	24.50	22.26	329	78	545.37	8061	1919
Structure Excavation	CUM	52.16	5.10	23	11	265.88	1185	579
Equip. Backfill	CUM	17.00	0.75	9	6	12.74	160	105
Demolish Work	CUM	9.15	19.72	99	49	180.43	906	452
Concrete Pavement 25	SQM	9.15	18.52	385	353	169.46	3523	3233
Deck Plating	SQM	8.20	49.68	558	71	407.38	4578	586
Deck Supporting	TON	1.16	316.74	3881	859	367.42	4502	997
Struting	ton	1.29	325.39	3890	827	419.76	5018	1067
Sheet Piling	TON	2.82	468.54	4647	628	1321.29	13106	1770
Total						4788.86	62618	30557

Table 5.6 Cost by Type in Trunk Line CUD (Cont'd)

TCUD VENTI 1 Per 1 LM

Description	Unit	Quantity	Unit Price Foreign	Unit Price Local Financial	Unit Price Local Economic	Total Price Foreign	Total Price Local Financial	Total Price Local Economic
Material								
Structure Concrete	CUM	7.73	35.93	561	460	277.72	4336	3557
Wood Forming	SQM	34.22	3.80	210	198	129.93	7193	6772
Reinforcing	ton	0.78	511.02	4676	4658	398.60	3648	3634
Lean Concreting	CUM	0.55	29.46	525	425	16.21	289	234
Crusher Running	CUM	1.10	5.17	129	127	5.68	142	140
Water Proofing	SQM	20.80	22.26	329	78	463.01	6844	1629
Structure Excavation	CUM	40.96	5.10	23	11	208.79	930	455
Equip. Backfill	CUM	13.94	0.75	9	6	10.45	131	86
Demolish Work	CUM	7.40	19.72	99	49	145.92	732	365
Concrete Pavement 25	SQM	7.40	18.52	385	353	137.05	2849	2614
Deck Plating	SQM	7.40	49.68	558	71	367.63	4132	528
Deck Supporting	TON	1.06	316.74	3881	859	335.74	4114	911
Struting	ton	1.13	325.39	3890	827	367.69	4395	935
Sheet Piling	TON	2.82	468.54	4647	628	1321.29	13106	1770
Total						4185.71	52840	23631

TCUD VENTI 2 Per 1 LM

Description	Unit	Quantity	Unit Price Foreign	Unit Price Local Financial	Unit Price Local Economic	Total Price Foreign	Total Price Local Financial	Total Price Local Economic
Material								
Structure Concrete	CUM	11.36	35.93	561	460	408.14	6372	5228
Wood Forming	SQM	46.11	3.80	210	198	175.07	9692	9125
Reinforcing	ton	1.14	511.02	4676	4658	582.57	5331	5311
Lean Concreting	CUM	0.72	29.46	525	425	21.21	378	306
Crusher Running	CUM	1.44	5.17	129	127	7.44	186	183
Water Proofing	SQM	24.50	22.26	329	78	545.37	8061	1919
Structure Excavation	CUM	52.16	5.10	23	11	265.88	1185	579
Equip. Backfill	CUM	21.46	0.75	9	6	16.09	201	133
Demolish Work	CUM	9.15	19.72	99	49	180.43	906	452
Concrete Pavement 25	SQM	9.15	18.52	385	353	169.46	3523	3233
Deck Plating	SQM	9.15	49.68	558	71	454.57	5109	653
Deck Supporting	TON	1.28	316.74	3881	859	405.43	4968	1100
Struting	ton	1.29	325.39	3890	827	419.76	5018	1067
Sheet Piling	TON	2.82	468.54	4647	628	1321.29	13106	1770
Total						4972.69	64035	31058

TCUD VENTI 3 Per 1 LM

Description	Unit	Quantity	Unit Price Foreign	Unit Price Local Financial	Unit Price Local Economic	Total Price Foreign	Total Price Local Financial	Total Price Local Economic
Material								
Structure Concrete	CUM	11.19	35.93	561	460	402.03	6276	5149
Wood Forming	SQM	48.23	3.80	210	198	183.12	10138	9545
Reinforcing	ton	1.12	511.02	4676	4658	572.35	5238	5217
Lean Concreting	CUM	0.71	29.46	525	425	20.92	373	302
Crusher Running	CUM	1.43	5.17	129	127	7.39	185	182
Water Proofing	SQM	24.50	22.26	329	78	545.37	8061	1919
Structure Excavation	CUM	52.16	5.10	23	11	265.88	1185	579
Equip. Backfill	CUM	18.28	0.75	9	6	13.70	172	113
Demolish Work	CUM	9.15	19.72	99	49	180.43	906	452
Concrete Pavement 25	SQM	9.15	18.52	385	353	169.46	3523	3233
Deck Plating	SQM	9.15	49.68	558	71	454.57	5109	653
Deck Supporting	TON	1.15	316.74	3881	859	364.25	4463	988
Struting	ton	1.29	325.39	3890	827	419.76	5018	1067
Sheet Piling	TON	2.82	468.54	4647	628	1321.29	13106	1770
Total						4920.51	63751	31170

5.4.3 Project Cost

Construction costs of the subject CUD's calculated on the basis of the foregoing are shown in Tables 5.7 and 5.8. The tables give construction cost by type of structure, broken down into foreign and local currency portions, with the former calculated in U.S. dollars.

The project cost of the trunk-line CUD is roughly $6 million in foreign currency plus 89 million bahts in local currency. Corresponding figures for the supply-line CUD is $2 million and 29 million bahts. These amounts are based on July 1989 prices and do not take inflation into account. Converting the foreign currency portion at the prevailing exchange rate of 25 bahts per U.S. dollar and adding the result to the local currency portion, we arrive at the project cost in local currency: 251 million bahts (foreign currency ratio: 65%) for the trunk-line CUD and 83 million bahts (foreign currency ratio: 64%) for the supply-line CUD.

Project cost per meter is 210,000 bahts and 117,000 bahts for the trunk-line and supply-line CUD's respectively. Temporary construction account for as much as 60% of the project cost. This is because materials used for temporary construction are mostly imported.

Table 5.7 Summary of Financial Cost of Trunk Line Common Utility Duct

UNIT: 1000 BAHT

SECTION	LENGTH (M)	CONSTRUCTION FOREIGN	CONSTRUCTION LOCAL	TOTAL	PER LM	FOREIGN (%)	LOCAL (%)
TYPE F	95.0	10,870	5,937	16,807	177	64.7	35.3
BRANCH 1	10.0	1,230	702	1,932	193	63.7	36.3
TYPE B	460.0	47,350	25,891	73,241	159	64.6	35.4
VENTI 1	5.0	628	356	984	197	63.8	36.2
BRANCH 2	20.0	2,687	1,517	4,204	210	63.9	36.1
TYPE E	502.5	57,556	31,443	89,000	177	64.7	35.3
VENTI 2	5.0	746	431	1,177	235	63.4	36.6
VENTI 3	15.0	2,214	1,288	3,502	233	63.2	36.8
BRANCH 3	15.0	2,155	1,264	3,419	228	63.0	37.0
TYPE A	72.5	8,713	4,822	13,535	187	64.4	35.6
TOTAL	1200.0	134,149	73,652	207,800	173	64.6	35.4
ENGINEERING SERRVICE		13,415	7,365	20,780		64.6	35.4
CONTINGENCY		14,756	8,102	22,858		64.6	35.4
GRAND TOTAL	1200.0	162,320	89,118	251,438	210	64.6	35.4

Table 5.8 Summary of Financial Cost of Supply Line Common Utility Duct

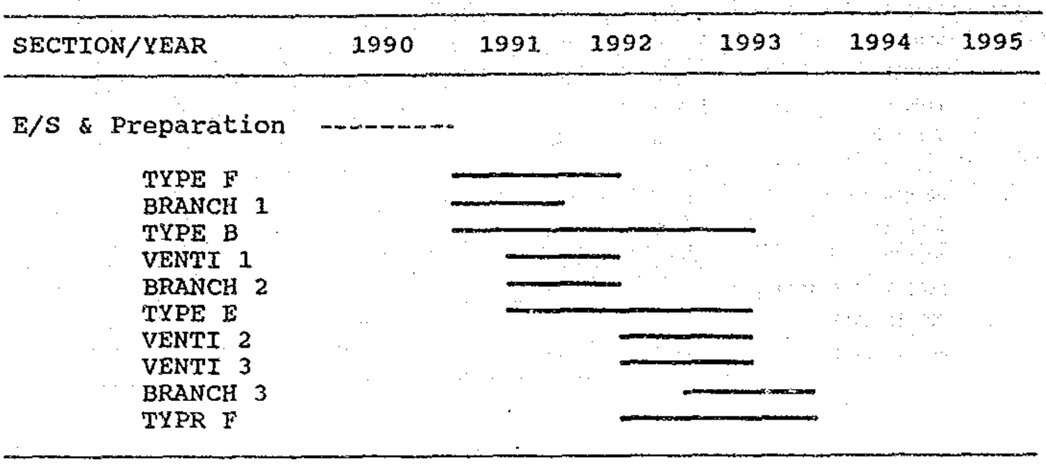
UNIT: 1000 BAHT

SECTION	LENGTH (M)	CONSTRUCTION FOREIGN	CONSTRUCTION LOCAL	TOTAL	PER LM	FOREIGN (%)	LOCAL (%)
TYPE 1	210.0	11,079	6,235	17,314	82	64.0	36.0
TYPE 2	340.0	20,850	11,627	32,477	96	65.0	35.8
TYPE 3	150.0	11,732	6,326	18,507	120	64.4	35.0
TOTAL	700.0	43,660	24,188	67,848	97	64.4	35.6
ENGINEERING SERVICE		4,366	2,419	6,785		64.4	35.6
CONTINGENCY		4,803	2,661	7,463		64.4	35.6
GRAND TOTAL	700.0	58,829	29,267	82,096	117	64.4	35.6

5.4.4 Implementation Plan

Since the CUD's will be built below the subject roads (including sidewalks), there is no need to purchase new land. However, since there are many public utility installations currently buried under the roads, it is necessary to conduct a survey on these. Accordingly, a year was allocated for the preparation and design period. Concerning the construction period, time frames were established for each CUD section according to the volume of work required. Tables 4.8 and 4.9 show the implementation schedules for the trunk-line and supply-line CUD's respectively.

Table 5.9 Trunk Line CUD Implementation Schedule

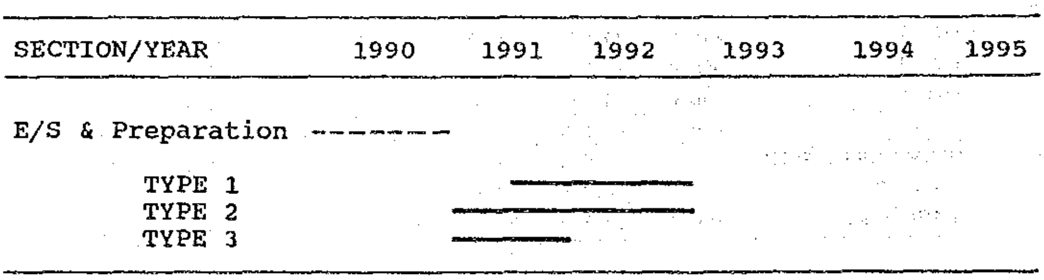


LEGEND ——— CONSTRUCTION

------ E/S & Preparation

NOTE : E/S;ENGINEERING SERVICE

Table 5.10 Supply Line CUD Implementation Schedule



LEGEND ——— CONSTRUCTION

------ E/S & Preparation

NOTE : E/S;ENGINEERING SERVICE

5.5 Evaluation

5.5.1 Evaluation Method

1) Evaluation Procedure

The case study of the CUD project will be evaluated by the unit-year cost benefit analysis, which compares the case with the CUD project ("with" case) and the case without it ("without" case). The CUD project consists of a variety of subsections. Evaluation will be made on each section independently as well as on the whole project. The work flow is shown in the following figure.

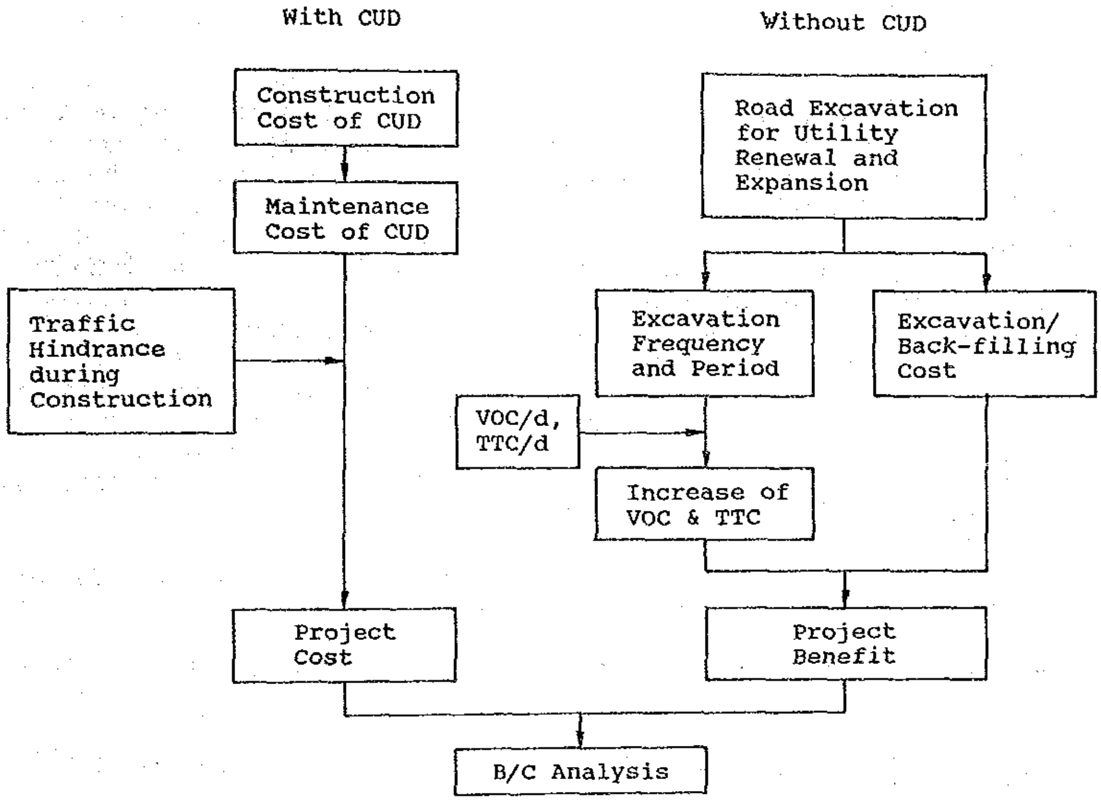


Figure 5.31 Work Flow of Cost Benefit Analysis on CUD Project

2) Project Cost

The project cost consists of the construction cost (initial investment cost), the annual maintenance and administration cost, and the traffic hindrance cost during construction. The construction cost is converted into an annual equivalent cost using the formula:

$$C = i(1+i)^n I / \{(1+i)^n - 1\} \quad \dots\dots\dots\dots (1)$$

where C: annual equivalent cost
I: construction cost
i: interest rate (12%)
n: project life

The maintenance and administration cost equivalent to 0.2% of the construction cost is considered to be necessary every year.

The traffic hindrance cost during construction should be considered necessary, since one or two lanes of roads will be excavated and cannot be used during the construction period. Therefore, annual increase in the vehicle operating cost (VOC) and the travel time cost (TTC) in the whole Survey Area will be estimated.

3) Benefit

Various socio-economic benefits expected of the CUD project were studied in chapter 2 of the Interim Report (1). Of those the below-mentioned benefits will be quantified in monetary terms and compared with the project cost.

a. If repeated excavations and back-fillings for individual renewal and expansion of various urban utilities are avoided, traffic congestion will be mitigated.

b. The excavation and back-filling cost of individual facilities will be saved.

In addition to the above-mentioned benefits, the following benefits are surely available also:

c. The road life can be extended by eliminating frequent excavation and back-filling.

d. The maintenance and administration cost of buried facilities can be lowered.

These benefits, however, are not quantified, since no reliable data are available.

The traffic congestion easing benefit is considered to avoid an increase of VOC and TTC due to individual excavations. For quantifying this, the annual equivalent increase in VOC and TTC in the whole survey Area by traffic hindrance is calculated.

The excavation and back-filling cost of each facility is calculated by multiplying the average unit cost per length by the CUD project extension distance to be compared. Annual equivalent cost is calculated by applying the service life (year) by facility to the formula (1).

5.5.2 Evaluation of Trunk Line CUD Case Study

The trunk line CUD case study was performed by establishing a 1,200 meters section in a part of the Phahonyothin Road. In this section, telephone cables, water supply and drainage pipes are installed underground, and power cables above ground.

The trunk line CUD is divided into four subsections, to each of which a different type is assigned. The total construction period is four years, while the first one year is assigned for design and preparation.

1) Project Cost Estimation

The total investment amount of the trunk line CUD is 206 million baht at economic value, and the maintenance and administration cost is 400 thousand baht per year. The length, construction period, construction cost, and maintenance and administration cost of each subsection are shown in Table 5.11.

For calculation of traffic hindrance cost, it is assumed that one lane each on both sides of the median strip, totaling two lanes, are closed during one quarter of the construction period.

The increase in VOC and TTC in the case that one lane is closed in the section of the Phahonyothin Road where the trunk line CUD is studied can be calculated by multiplying the change of vehicle kilometers estimated for each vehicle travel speed by the unit cost of VOC and TTC by travel speed in the year of 2003 (10 years after completion).

Table 5.11 Specification of Trunk Line CUD Case Study

Section	Type	Length (m)	Construc. Period (year)	Construc. Cost (B1000)	Maintenan. Cost (B1000)
1	F	100	1.5	17597	35
2	B	480	2.5	76648	153
3	E	540	2.0	96926	194
4	A	80	1.5	15181	30
Whole Project		1200	3.0	206352	413

Consequently, an increase of 71 thousand baht/day for VOC and 513 thousand baht/day for TTC, totaling 584 thousand baht/day, will occur when one lane is closed for the traffic. The traffic hindrance cost caused by such a one-lane closure is estimated to be 272 million baht in total. Together with the construction cost, this totals 478 million baht.

Converting this amount into an annual equivalent cost, and adding the annual maintenance and administration cost to it, the annual equivalent project cost will become 378 million baht. The costs by subsection are shown in Table 5.12. The project life is 75 years.

Table 5.12 Annual Equivalent Project Cost of Trunk Line CUD

Unit:B1000

Section	Construc. Cost	Traffic Hindrance Cost	Total Cost during Construc.	Annual Equival. Cost	Annual Maintenan. Cost	Annua Equival. Proj.Cost
1	17597	123690	141287	16958	35	1699
2	76648	206150	282798	33943	153	34096
3	96929	164920	261846	31428	194	31622
4	15181	123690	138871	16668	30	16698
Whole Project	206352	247380	453732	54459	413	54872

2) Benefit Estimation

Since the trunk line CUD case study is made by varying the accommodated utility facilities for each section, suitable facilities for comparison should be selected for the purpose. Telephone and power cables and water supply pipes are accommodated in all the subsections. Sewage pipes are added to section 1, and gas pipes to section 3.

The economic cost and construction period of civil works for installing various facilities underground are estimated as shown in Table 5.13, based on the construction examples in Bangkok and the opinions of the related agencies.

Table 5.13 Excavation/Back-filling Cost and Period by Utility

Utility	Capacity	Unit Cost (bht/m)	Unit Period (mon/km)
Telephone	12 cables	3175	9
Electricity	18 cables	12324	11
Water	900	4900	10
Sewerage	600	3500	14
Gas	250	3400	10

The construction for maintenance and repair of the existing facilities under sidewalks can be considered possible only by excavating a part of the sidewalk without seriously interfering with the road traffic. However, construction works for renewing the facilities whose service life is considered to be ending in 20 years and laying additional pipes and cables for increased demand will be compelled to be made under carriageways, if the current supply system is to be continued without interruption.

It is assumed that such construction works for renewing existing facilities and laying additional pipes and cables are needed at least once in 20 years for each facility, and that there is no simultaneous construction for different facilities. The existing power cables and new gas pipes are to be installed underground.

One lane of the road is to be closed for half of the construction period.

For the utility service life, 35 years is taken for sewage pipes, 22 years for gas pipes, and 25 years for others. Annual equivalent cost is calculated based on these assumptions.

The excavation cost and traffic interference cost for individual construction work are calculated for each subsection and facility under the conditions mentioned above, and they are regarded as benefits of the CUD project. The result is shown in Table 5.14.

Table 5.14 Annual Equivalent Project Benefit of Trunk Line CUD

Unit:฿1000

Section	Reduction of Excav. Cost	Mitigation of traffic Congestion	Benefit fm Avoidance of Excav.	Anl. Equiv. Project Benefit
1	3548	53434	56982	7161
2	13668	161662	175290	22349
3	17213	219179	236392	30269
4	2278	27212	29490	3760
Whole Project	36707	461446	498153	63539

3) Evaluation Result

The benefit to cost ratio (B/C) calculated from the above estimated cost and benefit is shown in Table 5.15.

Table 5.15 B/C Ratio of Trunk Line CUD Project by Section

Section	B/C Ratio
1	0.42
2	0.66
3	0.96
4	0.23
Whole Project	1.16

The B/C ratio is 1.16 overall, but it extremely small for section 1 and section 4. This is because of a large amount of traffic interference cost taken for a long construction period compared with a short CUD length. A construction of only a short 80 or 100 meter CUD is not practical. Therefore, assuming a 1,200 meter CUD prepared for each type and a three-year construction period, costs and benefits are calculated as follows.

Table 5.16 Cost, Benefit and B/C Ratio of Trunk Line CUD Project by Type

Unit:฿1000

	Type F	Type B	Type E	Type A
Cost				
Construction Cost	211164	191620	215398	227715
Traffic Hindrance Cost	247380	247380	247380	247380
Cost during Const. Period	458544	439000	462778	475095
Annual Equivalent Cost	55037	52691	55545	57023
Annual Maintenance Cost	422	383	431	455
Annual Equiv. Project Cost	55459	53074	55976	57478
Benefit				
Reduction of Excavation Cost	42576	34170	38251	34170
Mitigation of Congestion	641209	404054	487064	404054
Benefit from Avoid. of Excav.	683785	438224	525315	438224
Annual Equiv. Project Benefit	85929	55874	67294	55874
B/C Ratio	1.55	1.05	1.20	0.97

Type F includes sewage pipes, and type E includes gas pipes. Therefore, benefits are expected from installing them together in a CUD, and the B/C ratio will be greater than that of type B and type A. Although type B and type A share the same benefit, the construction cost for type A is greater. Therefore, the B/C ratio of the type A become lower.

The traffic hindrance cost during construction out of the project cost will become greater than the construction cost. The maintenance and administration cost is negligible compared with the construction cost and the traffic hindrance cost.

As to the benefit, the traffic congestion cost reduction effect is much larger than the excavation and back-filling construction cost reduction effect. This benefit varies greatly depending on the period and frequency of individual construction work. The benefit will decrease or increase, if they are respectively less or more than the assumed construction period and frequency.

In this evaluation, it is assumed that the road should be excavated at least once in 20 years for renewal and expansion of individual utilities. It often happens, however, that no renewal is made even when the economic service life is reached, and that the excavation frequency becomes lower than the assumption.

In order to raise the economic effect, it is important to decrease the traffic interference during the construction period by improving the construction method and procedure.

5.5.3 Evaluation of Supply Line CUD Case Study

The supply line CUD case study was performed by establishing a 700 meter section ranging from Ploenchit Road to Rama I Road. In this section, telephone cables, water supply and sewage pipes are installed underground, and power cables above the ground. Currently, however, trunk power cables are being installed underground at a part of Ploenchit Road.

Supposing that the supply-line CUD is to accommodate telephone, power, water supply and gas lines, three types of structure, that is, type 1: under the sidewalk of Rama I Road, type 2: under the carriageway of Ploenchit Road, and type 3: under the road crossings will be studied. The total construction period is three years including the initial one year for design and preparation.

1) Project Cost Estimation

The economic value of the supply line CUD investment amount is 67 million baht, and the maintenance and administration cost is 135 thousand baht per year. The length, construction period, construction cost, and maintenance and administration cost by type are shown in Table 5.17.

Table 5.17 Specification of Supply Line CUD Case Study

Type	Length (m)	Construc. Period (year)	Construc. Cost (B1000)	Maintenan. Cost (B1000)
1	210	1.5	17320	35
2	340	2.0	32178	64
3	150	1.0	17784	36
Whole Project	700	2.0	67282	135

The supply line CUD should be installed on both sides of the road. The above-mentioned costs, however, are for one side only, and the following study is made only on one side.

No carriageway closure during construction is assumed for the part of Rama I Road. For Ploenchit Road and the intersections, one lane of the road is assumed to be closed for one quarter of the construction period.

The VOC and TTC increase attributable to one lane closure at the CUD study section of Ploenchit Road is 223 thousand baht/day for VOC and 1,950 thousand baht/day for TTC, totaling 2,173 thousand baht/day. An estimation of the traffic hindrance cost due to lane closure using the said figures finds 337 million baht in total and 486 million baht including the construction cost.

This amount is converted into annual equivalent cost and added to the annual maintenance and administration cost. Consequently, the annual equivalent project cost is 48.6 million baht in total. The costs by type are shown in Table 5.18.

Table 5.18 Annual Equivalent Project Cost of Supply Line CUD

Unit:B1000

Type	Construc. Cost	Traffic Hindrance Cost	Total Cost during Construc.	Annual Equival. Cost	Annual Maintenan. Cost	Annual Equival. Proj.Cost
1	17320	0	17320	2079	35	2113
2	32178	306125	338303	40605	64	40669
3	17784	153063	170847	20505	36	20541
Whole Project	67282	306125	373407	44818	135	44953

2) Benefit Estimation

In the supply line CUD case study, all types are assumed to accommodate telephone, power, water supply and gas supply lines. The benefit is, therefore, calculated as the reduction of excavation and traffic hindrance cost for individual installation of the same facilities.

The economic cost and period of the supply pipe and cable construction is assumed to be 70% of the case of the trunk line as shown in Table 5.13.

In the case of Rama I Road, where there is enough space under the sidewalk, it is assumed that the sidewalk is excavated to replace the existing pipes and cables and add new ones for telephone and water supply, to accommodate power cables underground, and to newly install gas pipes. No traffic interference is assumed. At Ploenchit Road, there is no space under the sidewalk, and a space under the carriageway is assumed to be used. Under this assumption, one lane is closed for half of the construction period, and the same condition is applied to intersections. Taking the same service life for each facility as in the case of the trunk line CUD, the annual equivalent cost is estimated, and its amount is taken as the supply line CUD project benefit.

The result is shown in Table 5.19.

Table 5.19 Annual Equivalent Project Benefit of Supply Line CUD

Unit:B1000

Section	Reduction of Excav. Cost	Mitigation of traffic Congestion	Benefit fm Avoidance of Excav.	Anl. Equiv. Project Benefit
1	4686	0	4686	599
2	7587	358074	365661	46825
3	3347	158358	161705	20707
Whole Project	15620	516432	532052	68131

3) Evaluation Result

The B/C ratio calculated from the above-mentioned cost and benefit is shown in Table 5.20.

Table 5.20 B/C Ratio of Supply Line CUD Project by Type

Type	B/C Ratio
1	0.28
2	1.15
3	1.01
Whole Project	1.52

For type 1, the CUD is unfavorable because no traffic hindrance factor is included and only the construction cost is compared. In the central part of the city where there is a heavy traffic volume, the traffic hindrance cost is significant compared with the construction cost in case of the CUD and also in case of individual construction. So to speak, it is a comparison of invisible cost and benefit.

Therefore, in order to increase the economic effect, a careful study should be made on the reduction of the construction period and on the construction method so that the traffic congestion cost reduction, which is one of the purposes, may not be sacrificed. The construction cost, even if running a little higher, may be under an amount one digit smaller compared with the traffic hindrance cost.

5.5.4 Sensitivity Analysis

The Benefit of a CUD project varies greatly with the frequency and period of excavation for renewal or expansion of individual urban utilities. Similarly, the disbenefit during the construction period of CUD depends on its length.

Considering this fact, the change of B/C ratio is studied by varying the frequency of individual civil works and their lane closure period for each alternative case of CUD construction period.

1) Trunk-Line CUD

The annual equivalent cost of the trunk-line CUD presented in the case study is 57,774 thousand baht on condition that the construction period is three (3) years (Base Case). If the construction period is reduced to 2.5 years (Case 1) and to 2 years (Case 2), the annual equivalent cost will be reduced to 52,342 thousand baht and to 46,909 thousand baht, respectively. This is because the traffic hindrance cost will decrease, although the construction cost is unchanged.

The traffic hindrance and period of individual civil works should be more than 29 months in 10 years, in order that the annual equivalent benefit exceeds 57,774 thousand baht (B/C ratio is over 1) in the Base Case.

This value will be lower in proportion to the decrease in the annual equivalent cost of CUD in the Cases 1 and 2.

Table 5.21 shows the change of the B/C ratio according to the excavation frequency and period. It can be read from the table that a trunk-line CUD project of 3 years construction period as presented in the case study will be economically feasible on condition that individual excavations of average 3 months long are occurring more than once a year, or if average 15 months long, more than once every 5 years, of if average 29 months long, more than over every 10 years on Phahonyothin Road.

As shown in Table 5.21, if the construction period of CUD can be reduced to 2 years (2/3 of that in the Base Case), the project will be feasible on condition that individual excavations of average 12 months long are occuring more than once every 5 years, or if average 23 months long, more than once every 10 years.

Table 5.21 Individual Excavation Frequency and Traffic Hindrance Period by Case for B/C Ratio of 1 (Trunk Line CUD)

Unit:month

Excavation Frequency	Traffic Hindrance Period		
	Base Case	Case 1	Case 2
Once during 10 years	14.5	13.2	11.9
9	13.1	11.9	10.7
8	11.6	10.6	9.5
7	10.2	9.2	8.3
6	8.7	7.9	7.1
5	7.3	6.6	5.9
4	5.8	5.3	4.8
3	4.4	4.0	3.6
2	2.9	2.6	2.4
1	1.5	1.3	1.2

2) Supply-Line CUD

In the supply-line CUD case study, the annual equivalent project cost is estimated at 48,636 thousand baht with the construction period of 2 years. This case is called the Base Case and cases in which the construction period of CUD is shortened to 20 months and to 18 months are called Case 1 and Case 2, respectively.

If the reduction of construction period does not affect the construction cost, the annual equivalent costs are 41,899 thousand baht in Case 1 and 38,530 thousand baht in Case 2, respectively.

Table 5.22 show the range in which the B/C ratio exceeds in respective case.

As Ploenchit Road is located in the central part of Bangkok and a closure of its lanes has a serious impact on the traffic condition, possibility that a CUD project becomes feasible seems to be comparatively high, even if the month-times individual excavation is not very large.

In the Base Case, the CUD project will be feasible on condition that individual excavations of one month long occurs once a year, or 4 months long, once every 5 years, or 7 month long, once every 10 years.

In the Case 2 of 18 months construction period, the feasibility of the project will be realized at about 80% level of excavation frequency.

In addition, if a reduction of the construction period raises the construction cost of CUD, the annual equivalent cost will decline, because the cost of construction is extremely smaller than that of traffic hindrance.

For example, if the construction cost rises by 20% in the Case 1 and by 50% in the Case 2, the annual equivalent cost will decline to 43,541 thousand baht and to 42,636 thousand baht, respectively, compared to the Base Case.

As described above, the traffic hindrance period of CUD and individual excavation is vital to the feasibility of CUD project, therefore, it is important to make effort to reduce the construction period of CUD which causes traffic hindrance.

Table 5.22 Individual Excavation Frequency and Traffic Hindrance Period by Case for B/C Ratio of 1 (Supply Line CUD)

Unit:month

Excavation Frequency	Traffic Hindrance Period		
	Base Case	Case 1	Case 2
Once during 10 years	5.0	4.4	4.0
9	4.5	4.0	3.6
8	4.0	3.5	3.2
7	3.5	3.1	2.8
6	3.0	2.6	2.4
5	2.5	2.2	2.0
4	2.0	1.8	1.6
3	1.5	1.3	1.2
2	1.0	0.9	0.8
1	0.5	0.4	0.4

5.6 Conclusions and Recommendations

The case studies of common utility ducts (CUDs) have revealed that two kinds of benefits by CUDs (savings in excavation cost and transportation cost) could exceed the initial cost for CUDs construction. Diseconomy by traffic hindrance is extremely large, especially in the central part of Bangkok with heavy traffic. As road traffic demand is deemed to continuously increase and congestions become more serious in the Metropolitan Region, CUD network development will become one of the most important long-term subjects.

On the other hand, the CUD network development will call for a huge amount of investment. According to the case studies, construction cost per one meter is estimated to be 160 to 230 thousand baht for trunk line CUD and 80 to 120 thousand bahts for a supply line CUD. This means that to develop 20 km trunk line and 80 km supply line CUDs for example, total required investment will reach 12,000 million bahts at 1989 price.

While investment demand for various kind of urban infrastructure has been sharply increasing, capacities of financial resources are severely limited. Therefore, development priorities should be carefully determined among various urban needs. In any case, CUD network is to be gradually developed in accordance with a long-term comprehensive plan. In order to make the first step of CUD development, the followings are recommended;

(1) Formulation of CUD Masterplan

Each agency of a common utility should develop a long-term plan, if it does not have, to establish a future network. Based on those long-term plans of various utilities, a CUD masterplan should be formulated. For this purpose a body consisting of representatives of all the organizations concerned should be set up with the coordination purpose of planning, construction and maintenance of CUDs.

(2) Technical Research on CUD Construction

Bad influence on road traffic by excavation works should be minimized. For this, construction method and traffic management system should be studied. Shield method is worth while studying its technical and economic adoptability, especially in the central part with heavy traffic.

The measures against ground settlement must be studied to avoid negative influence to CUDs by unequal settlement. Whether solid foundation work for CUD is necessary or not should be studied carefully in this context.

In addition, an appropriate measures against rainwater should be considered to prevent surface water from pouring into CUD, because of the low ground level and strong rainfall intensity in Bangkok.

(3) Promotion of Pilot CUD Project

In order to confirm the advantages and clarify the issues of CUD, it is recommended to promote a CUD pilot project along a road section, selected from the viewpoints of excavation demand, traffic volume and aesthetic importance.

The pilot project should cope with supply line rather than trunk line for the first time, judging from the present landuse and the present situations of telephone and power cable network in Bangkok.

(4) Legislative Arrangement

Laws and/or regulations of CUD should be established to prohibit any road surface excavation on the road section designed as CUD road and to clarify the responsibility of financing to and maintenance of CUDs.

APPENDIX

A

JAPANESE COMMON UTILITY DUCT LAW

TABLE OF CONTENTS

CHAPTER 1 GENERAL PROVISIONS

1. Purpose of the Work for Common Utility Ducts (Article 1 of the Law)

The work for common utility ducts, to be accompanied by restrictions on the use of underground parts of designated roads after digging up the same, shall be intended to maintain the structural safety of the roads and ensure smooth traffic.

2. Definition of Public Utilities (Article 2 item 3.4.5 of the Law)

1) Public utilities shall mean electric cables, telephone cables, water pipes or sewers to be laid by the following utility providers for public utility work:

   - Nippon Telegraph and Telephone Corporation;
   - Electricity enterprises as defined in the Electricity Enterprise Law;
   - Gas enterprises as defined in the Gas Enterprise Law;
   - Water supply authority and related suppliers as defined in the Water Supply Law;
   - Industrial water suppliers as defined in the Industrial Water Supply Law; and,
   - Public sewerage administrator and urban sewerage administrator as defined in the Sewerage Law.

2) Common utility ducts shall mean those facilities which are provided underground by the road administrator concerned to contain public utilities of two or more utility providers.

CHAPTER 2 DESIGNATION OF SUBJECT ROADS

1. Designation (Article 3 item 1 of the Law)

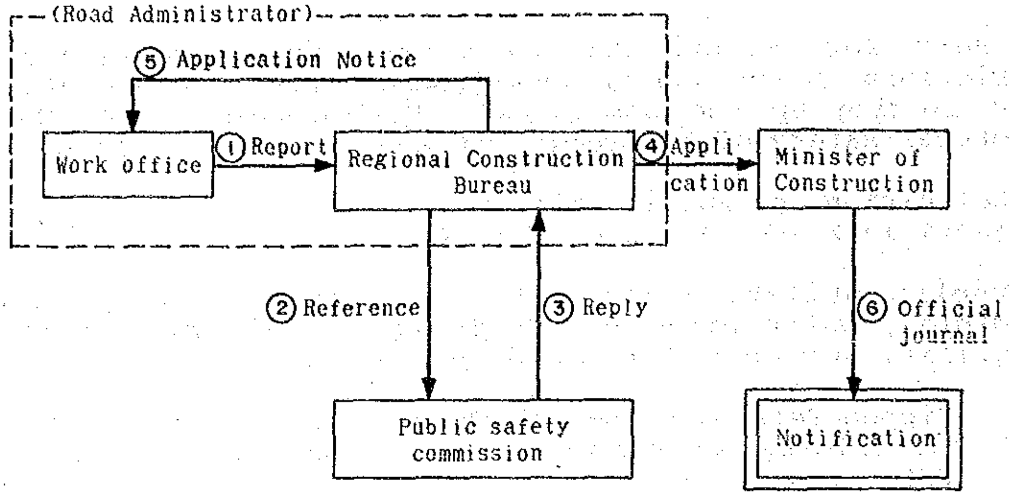
The Minister of Construction may designate those roads which are heavily congested or expected to be heavily congested as roads subject to the work for common utility ducts (hereinafter referred to as "subject roads"), if frequent work for the utilization of underground parts of those roads by digging up the same is likely to cause a considerable problem for the maintenance of structural safety of the roads or smooth traffic thereon.

2. Procedure (Article 3 items 2, 3, 4 of the Law)

The Minister of Construction, prior to designating a subject road as well as to changing or abolishing a designation, shall refer to the administrator of the road concerned. The administrator concerned, prior to expressing views thereof, shall refer to the <u>Public Safety Commission</u> of the prefecture concerned.

<u>NOTES</u>: Public Safety Commission: Representative and administrative body established to maintain neutrality of police administration

(Procedure)



NOTES: The report of 1 above shall be prepared based on consultations with each relevant enterprise on the outline of the designation.

3. Restrictions as the Result of Designation (Article 4 of the Law)

The road administrator, in cases of designation of roads subject to the work for common utility ducts shall not grant permission for use as specified in Article 32 of the Road Law nor agree to consultation as specified in Article 35 of the said Law, with respect to the use of underground parts of the roadway portion of the road concerned. Provided, that this shall not apply in each of the following cases:

1) When it has been decided that the common utility duct concerned not be constructed but that the utilities concerned be laid, maintained, repaired or restored in disaster by the applicant(s) according to the construction plan submitted with the application;

2) When laying, maintaining, repairing or restoring in disaster those utilities or other facilities with similar or more public nature which are <u>specified by the Minister of Construction</u> as unlikely to cause a problem for the maintenance of structural safety of roads or smooth traffic thereon;

<u>NOTE</u>: Those specified by the Minister of Construction:

(1) Facilities to contain public utilities:
Those facilities with respect to which it is

generally unnecessary to break up the road surface when extending, maintaining or repairing the utilities contained;

(2) Other facilities with public nature similar to or more than that of facilities to contain public utilities:
- Local railway as specified in Article 1 item 1 of the Local Railway Law;
- Railroad track as specified in Article 1 item 1 of the Railroad Track Law;
- Off-street parking area as determined under city planning;
- Drain for sewage and passage offered for public use.

3) When maintaining, repairing or restoring in disaster those structures or facilities which have been or are to be installed based on the permission or consultation under Article 32 or Article 35 of the Road Law having been granted or effected prior to the date of the designation of the subject road concerned;

4) When the Public utilities to be laid through the common utility duct concerned are, prior to the completion of the duct construction work, to be temporarily laid due to urgent need through the parts other than the planned parts under the road, and when such utilities are to be maintained, repaired or restored in disaster.

CHAPTER 3 CONSTRUCTION AND MANAGEMENT

1. Reference to Public Utility Provider and Notification of Construction (Article 5 of the Law)

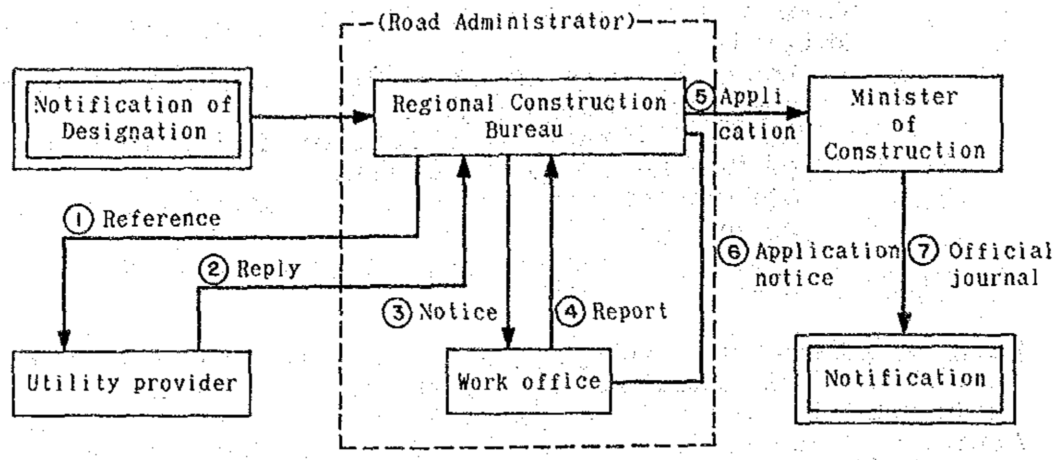
The road administrator, in cases of designation of subject roads, shall refer to the relevant utility providers with respect to such matters as whether the utility providers request construction of a common utility duct under the road concerned.

The utility providers referred to may submit an application by the date specified by the road administrator, to express their desire to construct the common utility duct.

The application shall be accompanied with a construction plan for utilities to be laid inside the common utility duct as well as other drawings and documents specified in the Ministry Order. (Other drawings and documents specified in the Ministry Order: Those summarizing the conditions of existing facilities under the roadway portion of the road concerned, in addition to other reference materials).

The road administrator, when the aforementioned application is deemed to be appropriate, shall construct the common utility duct and issue a public notification announcing the construction.

(Procedure)



<u>NOTE</u>: Criterion for the application to be deemed "<u>appropriate</u>": That the application has been made by two or more utility providers, and that the construction of the common utility duct is judged necessary for road management through comprehensive examination of the quantity of the public utilities to be laid and the relevant construction plan as well as the scale, structure and other details of the public utility duct to contain the public utilities.

2. Implementation Plan (Article 6, 7 of the Law)

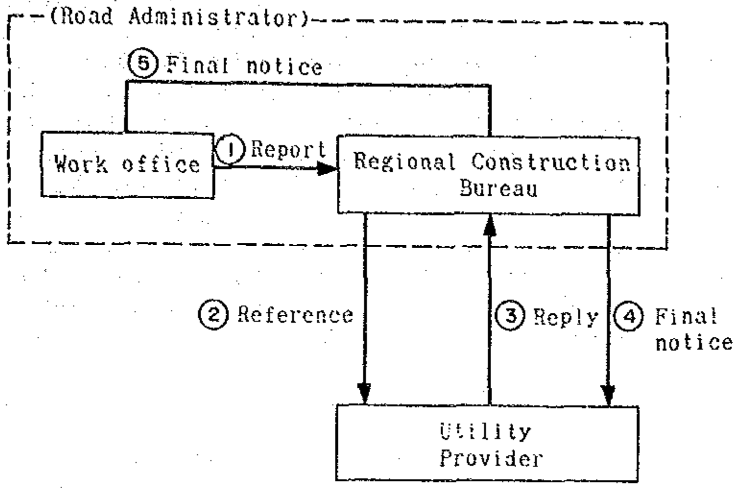
The road administrator, in constructing a common utility duct, shall prepare an implementation plan therefore.

The implementation plan shall specify the following items:

1) Location and title of work;
2) Structure;
3) Scheduled users of the common utility duct;
4) Allocation of the common utility duct for each scheduled user and a summary of utility construction plan for each scheduled user;
5) Cost for the construction of the common utility duct and a plan showing how the cost is borne;
6) Scheduled start and completion of the work.

The road administrator, in preparing the implementation plan, shall refer to the scheduled users of the common utility duct to be provided for in the plan. (Such reference shall be made along with the notification of each of the aforementioned items, after the lapse of 30 days from the day following the date of the construction notification, to request each scheduled user to express his view within a reasonable period.)

(Procedure)



NOTE: The implementation plan shall be prepared as a rule based on the cost estimate submitted for each of the order-placement sections. Thus, when a specific work section does not cover all of the notified construction section, division of the construction section shall be announced to request the submission of a cost estimate for the sub-section concerned.

3. Abolition of Construction Plan (Article 8 of the Law)

When a common utility duct does not have two or more scheduled users or has become redundant due to withdrawal of the application for use, the construction of the common utility duct shall be abolished, accompanied by public notification announcing the abolition and notice to the utility providers concerned.

4. Management Rules for Common Utility Duct (Article 11 of the Law)

The road administrator intending to manage a common utility duct shall establish management rules therefore, after referring to the utility providers granted permission for the use thereof.

The management rules shall provide for the following matters:

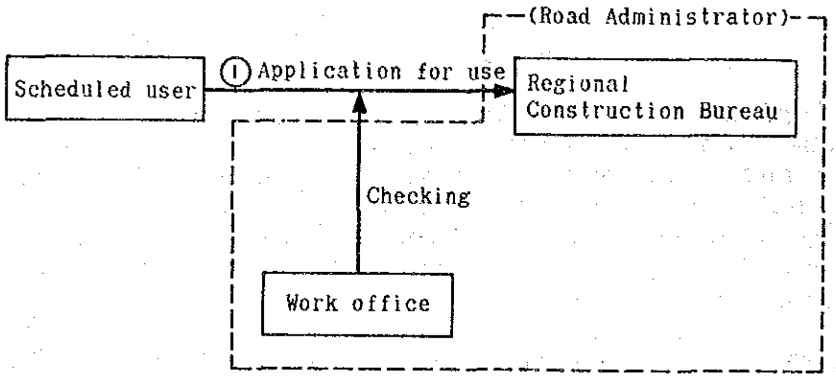
1) Matters concerning the maintenance of structural safety of the common utility duct;
2) Matters concerning the management of utility conduits to be laid through the common utility duct;
3) Matters concerning how to bear the management cost for the common utility duct;
4) Other necessary matters concerning the management of the common utility duct.

CHAPTER 4 USE OF COMMON UTILITY DUCT

1. Application (Article 12, 15 of the Law)

Utility providers having applied for the construction of a duct may apply for the use thereof (may consult for the use thereof, in the case of Nippon Telegraph and Telephone Corporation within 30 days from the following day of the date of the construction notification, together with a construction plan for the utility conduits concerned and other documents as specified in Construction Ministry Order ((1) materials required for calculating definite construction cost; (2) documents and drawings summarizing the facilities to contain utility conduits to be connected with the utility conduits to be laid through the underground multi-purpose duct concerned; (3) other documents and drawings to be referred to).

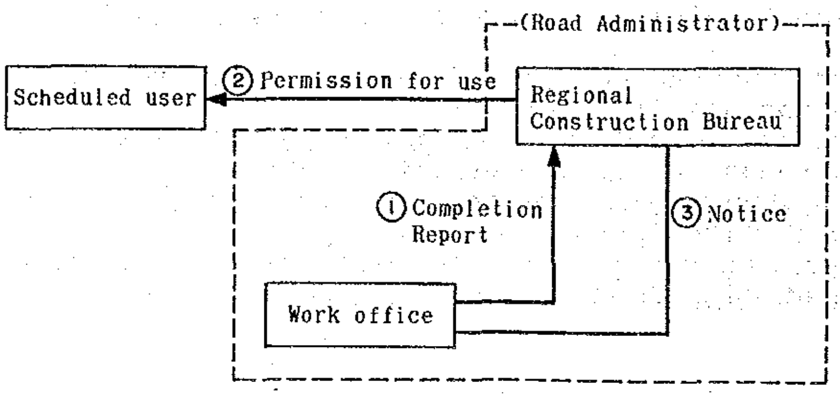
(Procedure)



2. Permission (Article 14, 15 of the Law)

The road administrator, upon completion of the construction of the common utility duct, shall grant permission for the use thereof to the scheduled users (shall effect the consultation for the use thereof with Nippon Telegraph and Telephone Corporation), specifying what portion of the common utility duct is permitted to be used and what kind of utility conduit is permitted to be laid inside the common utility duct.

(Procedure)



CHAPTER 5 COST OF CONSTRUCTION AND MANAGEMENT

1. Calculation of Construction Cost to be Borne by Scheduled Users

The scheduled users of a common utility duct shall bear a part of the construction cost therefore in consideration of such factors a the benefits to be received by the scheduled users through the construction of the common utility duct. (Article 20 of the Law)

1) Construction cost to be borne by the scheduled users shall be the estimated cost calculated by the following equation as shown as reference below.

   When the scheduled users lay the relevant utility conduits under the roadway portion of a road: where a common utility duct is constructed. The cost is deemed to include the following.

   a) Cost for the installation of the utility conduits; (+)

   b) Cost for breaking up the road and back-filling to accompany work for replacing or repairing the utility conduits; (+)

   c) Dues for use of the road; (+)

   d) Newly required cost by laying the utility conduits inside the common utility duct (new expenses): (-)

      i) Cost for supports to be required for laying the utility conduits inside the common utility duct;

      ii) Cost for leading the utility conduits to the common utility duct;

      iii) Cost for supporting materials to be required for constructing the common utility duct.
      (Inter hook, waterproof pipe, installation stick)

   Then,

2) Cost for ancillary facilities

   The cost for ancillary facilities shall be the amount to be obtained by multiplying such portion of the cost for constructing the common utility duct as is required for constructing the lighting and other ancillary facilities, by a ratio to be determined in consideration of the opinions of each scheduled user as confirmed by the road administrator and the extent of utilization of those ancillary facilities by each scheduled user.

   (Reference) Estimated Cost shall be calculated by the following equation

$$A = \sum_{i=o}^{n} ai \frac{1}{(1+r)^i}$$

A: Estimated cost

ai: Reduced cost in the 'i'th fiscal year after the fiscal year when the construction work for the common utility duct is scheduled for completion under the relevant implementation plan.

i: Per-annum rate specified by the Minister of Construction (6.5%)

- Reduced cost shall include that for breaking up the road and back-filling, dues for use of the road, conduit cost and others.

- Dues for use of the road shall be the amount (as specified in Article 19-2 of the Road Law Enforcement Order) to be charged when the scheduled users of a common utility duct intend to lay the relevant utility conduits under the roadway portion of the road concerned.

- Other ancillary facilities shall mean those for enhancing the functions of the common utility duct, such as ventilation facilities, communication facilities and alarm facilities. Drainage facilities and manholes required for the management or functional maintenance of the common utility duct shall be regarded as part thereof. Provided, that ventilation facilities, in cases where the common utility duct extends considerably long and the ventilation facilities are deemed to be indispensable, shall be regarded as part of the common utility duct.

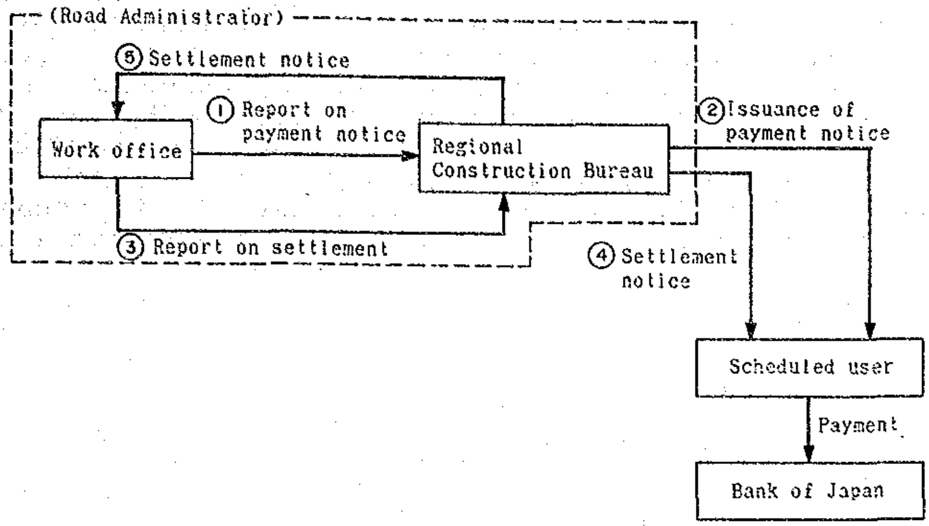
2. Payment of Amount, Payment Time Limit and Other Matters

1) The scheduled users of a common utility duct shall pay in the amount to be borne, in each fiscal year, as determined by the road administrator according to the implementation plan for the year concerned (under Article 21 item 1 of the Law) within the fixed time limit specified by the road administrator based on the financial plan for the year concerned.((Article 4 of the Enforcement Order for the Special Measures Law concerning Work for common utility ducts)

<u>NOTE</u>: Time limit of payment: Except in special cases as specified in Article 18 of the Revenue Collector Management Rules, the time limit of payment shall be determined as necessary to be 20 days or less from the date of decision after survey.

2) The road administrator, upon completion of the construction of a common utility duct, shall without delay settle the account for the amount having been borne by the scheduled users of the common utility duct as provided for in the preceding item.

(Procedure)



3. Calculation of Management Cost to be Borne by Scheduled Users

Users of a common utility duct shall bear such portion of the cost for reconstructing, maintaining, repairing, restoring in disaster and otherwise managing the common utility duct as is specified in Cabinet Order in accordance with the provisions thereof. (Article 21 of the Law)

1) The management cost to be borne by each user of a common utility duct shall be the sum of (i) the amount to be obtained by multiplying the cost for reconstructing, maintaining, repairing, restoring in disaster and otherwise managing the common utility duct (excluding ancillary facilities thereof) by the ratio of the estimated cost for the user to overall construction cost for the common utility duct (excluding ancillary facilities thereof) and (ii) the amount to be obtained by multiplying the cost for reconstructing, maintaining, repairing, restoring in disaster and otherwise managing the ancillary facilities of the common utility duct by the ratio applicable to the user under Article 2 item 2 of the Enforcement Order.

2) The road administrator, in cases where the provision of the preceding item is not applicable or where the application of the ratios provided in the said provision would cause considerable inequity, may otherwise determine the amount of cost to be borne by each user under Article 21 of the Law, after hearing the opinion of the users concerned.

NOTES: "Cases where the provision of the preceding item is not applicable" shall mean cases where the relevant rights have been transferred under Article 17 of the Law.

- "Cases where the application of the ratios provided in the said provision would cause considerable inequity" shall mean cases (i) where a certain user with less estimated cost compared with other users would be applied such ratio of the estimated cost to the overall construction cost as is considerably smaller than other ratios of the said user in terms of area occupied by the utility conduits of the said user or in terms of extent of utilization by the said user and (ii) where work for reconstructing or otherwise managing the common utility duct is implemented only by reasons of parties other than a certain user, thus it is considered to be inappropriate to make the user bear the relevant cost.

(Procedure)