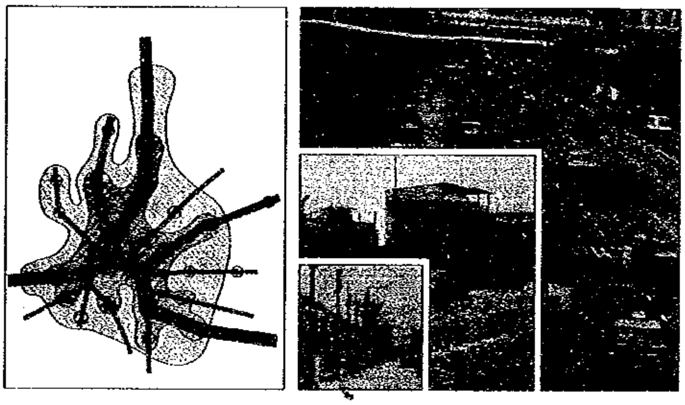
社会開発調査部報告書

THE STUDY ON MEDIUM TO LONG TERM IMPROVEMENT/MANAGEMENT PLAN OF ROAD AND ROAD TRANSPORT IN BANGKOK IN THE KINGDOM OF THAILAND

STUDY ON COMMON UTILITY DUCT SYSTEM

MAIN REPORT



MARCH 1990

JAPAN INTERNATIONAL COOPERATION AGENCY

THE STUDY ON MEDIUM TO LONG TERM IMPROVEMENT/MANAGEMENT PLAN OF ROAD AND ROAD TRANSPORT IN BANGKOK IN THE KINGDOM OF THAILAND

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PREFACE

In response to a request from the Government of the Kingdom of Thailand, the Japanese Government decided to conduct a study on the Study on Medium to Long-term Improvement/Management Plan of Road and Road Transport in Bangkok and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Thailand a study team headed by Dr. Juro Kodera, and comprising of members from Yachiyo Engineering Co., Ltd., International Engineering Consultants Association and Almec Corporation from November, 1988 to March, 1989 and from May, 1989 to January, 1990.

The team held discussions with concerned officials of the Government of Thailand, and conducted field surveys. After the team returned to Japan, further studies were made and the present report was prepared.

I hope that this report will contribute to the realization of the project and the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Kingdom of Thailand for their close cooperation extended to the team.

March, 1990

Kensuke Yanagiya

Kensuke Yanagiya
President
Japan International Cooperation Agency

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LIST OF ABBREVIATIONS

AASHTO	American Association of State Highway and Transportation Officials
ANSI	American National Standard Code for Pressure Piping
BMA	Bangkok Metropolitan Administration
CAB	Cable Box
CAT	Communication Authority of Thailand
CBD	Central Business District
CMD	Cubic Meter per Day
DDS	Department of Drainage and Sewerage, BMA
EGAT	Electricity Generating Authority of Thailand
ETA	Expressway and Rapid Transit Authority of Thailand
KV	Kilovolt
MEA	Metropolitan Electricity Authority
MTS	Mass Transit System
MVA	Mega-Volt Ampere
MWA	Metropolitan Water Works Authority
NESDB	National Economic and Social Development Board
PTT	Petroleum Authority of Thailand
PVC	Polyvinylchloride
SRT	State Railway of Thailand
TOT	Telephone Organization of Thailand

1

INTRODUCTION

COMMON UTILITY DUCT PLAN

1. INTRODUCTION

1.1 Background

The rapid expansion of social and economic activities and the concentration of population in the Bangkok Metropolitan area have entailed a sharp increase of demand for public utilities such as telephone, electricity, water supply and drainage. These public utilities are so indispensable to sound urban lives, that can be called a life line at present.

The cope with the ever increasing demands for public utilities, their relevant enterprises have been making efforts by both installing new facilities and improving existing ones. The number of telephone, for instance, has become fourfold of the past decade and it is still envisaged to double the number in the next few years.

Most of public utilities in Bangkok have been and will be installed underneath the roads, as being the case as other major cities around the world. The installation works necessitate excavations of road surface, adding to serious traffic congestions in the roads which are inherently insufficient for the present traffic needs.

What is worse, the installation works are undertaken at the most convenient times of each public utility enterprise, and thus leading to repeated road excavations one after another. It should also be noticed that even a minor obstruction to a traffic flow at one spot can easily cause a serious traffic paralysis for substantially wider areas in Bangkok where road networks are chronically oversaturated.

An answer to this problem is a so-called common utility duct which generally constructed underneath roads. Although there are diversified types of common duct, the basic concept of a common duct is to provide necessary spaces for placement and maintenance of different public utilities in one structure without causing any substantial obstruction to traffic, once it is constructed.

1.2 Objectives

The objectives of the study on common utility duct plan are to provide BMA with general knowledge and practice of common utility ducts together with basic engineering and administrative information and materials necessary for planning and facilitating common utility ducts in Bangkok.

In order to attain the objectives, the following works are carried out in this study;

1) General review as of the necessity of common utility duct in Bangkok;

2) Preparation of technical guidelines for planning and designing common utility ducts;

3) Production of materials necessary for proposing regulation or/law; and

4) Execution of case study plans of common utility ducts at selected road sections.

Common utility ducts, as described in the following paragraphs that follow, have advantages to a large extent both in traffic engineering and economic points of view. Some countries are eager to build common utility ducts of which names vary with countries either merely on account of naming or according to their functions.

As the experiences and practices in various countries will surely help BMA to discuss and introduce common utility ducts to be materialized in Bangkok, a brief outline of common utility ducts in a few countries is attached in Appendix B.

1.3 Study Flow

This study was carried out in two(2) Stages for a total of ten(10) months. The work flow is shown in Figure 1.1.

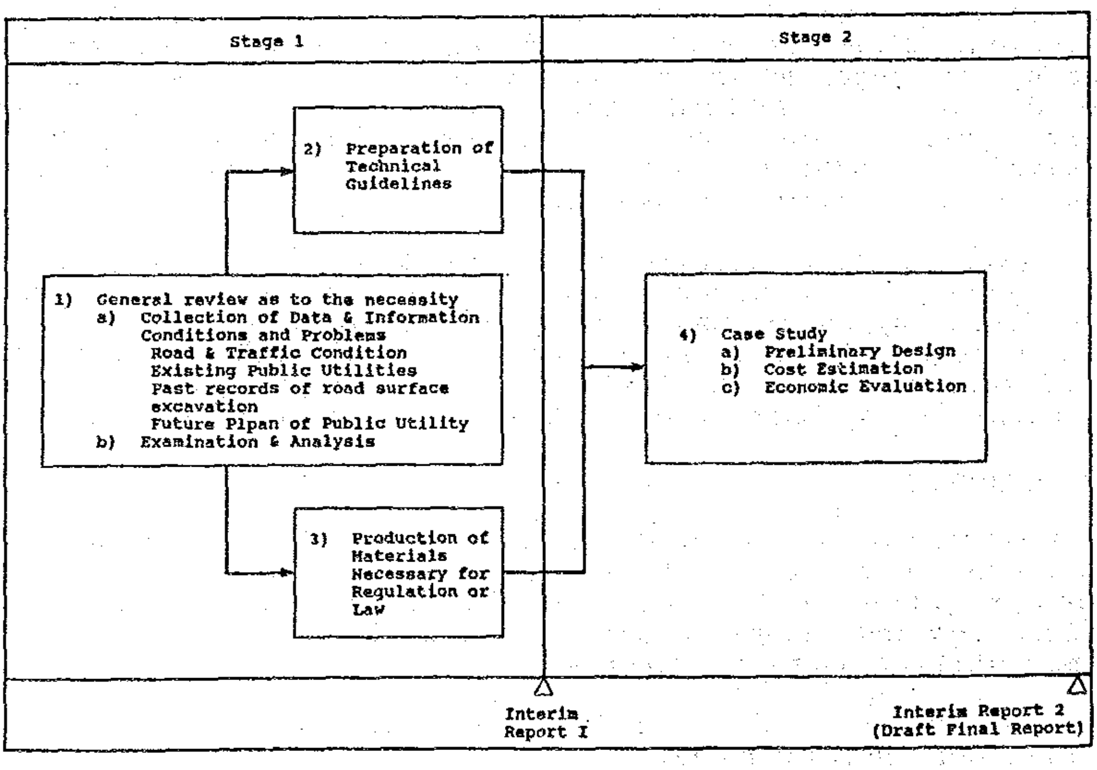

Figure 1.1 Work Flow of Study

1.4 Study Organization

The Study was carried out in Thailand jointly by JICA and the related agencies of the Government of Kingdom of Thailand.

The Study organization is shown in Figure 1.2 and List of Participants are shown in Table 1.1.

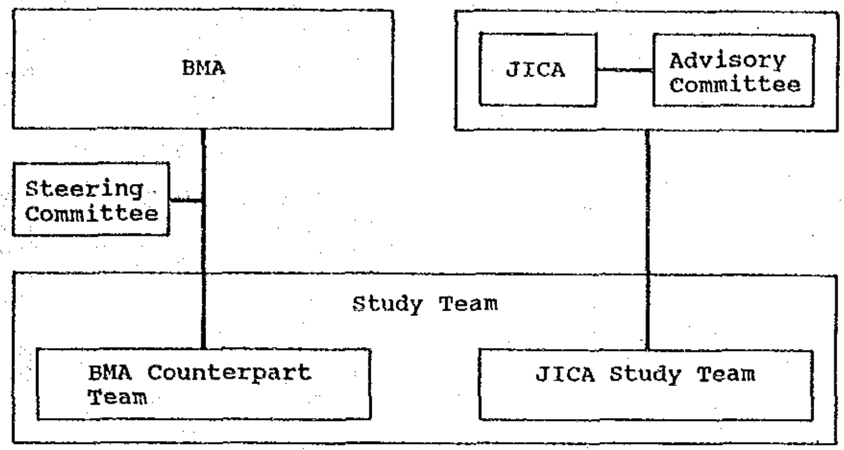

Figure 1.2 Study Organization

Table 1.1 List of Participants

<THAI SIDE>

Steering Committee (SIMR)

Dr. Wicha Jiwalai	Deputy Governor, BMA
Mr. Prasert Samalapa	Deputy Permanent Secretary, BMA
Mr. Bamphen Jatoorapreuk	Director, PWD, BMA
Mr. Chalit Sathon	Deputy Director, PWD, BMA
Mr. Charuay Chantavali	Deputy Director, PWD, BMA
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Mr. Pallop Onkcharoen	Director, ED, DTCP
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Mr. Wisut Panutat	Director, PWD, BMA
Mr. Nikhom Prachnakorn	Director, PWD, BMA
Mr. Thanit Srichoo	Civil Engineer, PWD, BMA
Mr. Suphot Phongkidakarn	Director, PWD, BMA
Mr. Orawit Hemachudha	Civil Engineer, PWD, BMA
Mr. Chailert Panchathewakup	Civil Engineer, PWD, BMA

* As of January 1990, Professor Krisda Arunvong participated upon succeeding Dr. Wicha Jiwalai as Deputy Governer.

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Mr. Worawit Lohthong	Director, PWD, BMA
Mr. Wisut Panutat	Director, PWD, BMA
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Mr. Tetsuo Horie	Transport Survey (II)
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Mr. Seichi Horie	Traffic Management (II)
Mr. Kenji Takenaga	Signal Control
Mr. Yoshio Yoshida	System Analysis
Mr. Saburo Shimauchi	Systems Design/Cost Estimate
Mr. Shizuo Iwata	Road Planning
Mr. Tsutomu Horie	Road Design
Mr. Katsunori Fuse	Structure Planning/Design (I)
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Mr. Iwane Mizuno	Economic Analysis
Mr. Akio Miyachi	System Planning
Mr. Setsuo Ninomiya	Common Utility Duct Planning

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GENERAL REVIEW OF THE NECESSITY OF COMMON UTILITY DUCT

2. GENERAL REVIEW OF NECESSITY OF COMMON UTILITY DUCTS

2.1 Road Functions and Public Utilities

Roads function is primarily to serve as traffic facilities for going to work, going to school, shopping, leisure activities and for transportation of goods necessary for daily living and industrial activities. In addition to these primary functions, roads, especially those in urban areas, perform multipurpose functions as public spaces in cities. These additional functions include the following:

- Frameworks for urbanization, such as building of streets and inducement to urban planning.
- Amenity spaces for ventilation, lighting and green belt in cities.
- Fire shelter
- Accommodation spaces for public utilities, such as telephones, power supply, water supply and sewerage.

In other words, urban roads play a multipurpose role as "public spaces" in cities. As far as Bangkok continues to be a central city of the nation, construction or expansion of public utilities facilities are indispensable. Thus roads in Bangkok are expected to play an increasingly vital role as accommodation spaces for telephone, power supply, water supply, sewerage and other public utilities.

2.2 Type of Public Utilities

The major public utilities constructed in road spaces include the following:

- Telephone
- Electricity
- Water supply
- Drainage

The utilities in Bangkok are built, maintained and managed by TOT, MEA, MWA and DDS, respectively.

Bangkok, however, lacks such vital urban public utilities as wide-area sewage system and city gas supply system.

As regards wide-area sewage facilities development, a master plan was formulated in 1981 in the form of Bangkok Sewage System Development Plan and a feasibility study of this plan was conducted for the districts of Bangrak and Pathumwan in 1982 by JICA. The plan, however, has not been implemented for budgetary reason. DDS is currently carrying out a feasibility study of wide-area sewage system in compliance with the master plan.

As for the city gas supply system, a feasibility study was conducted by JICA in 1975, but no further study has been undertaken subsequently for the purpose of realizing the construction plan.

2.3 Facilities in Supply or Disposal System of Public Utilities

Different types of public utilities have different modes of supply or disposal. A public utility is further composed of a variety of facilities depending on their functions and locations in its system. A common utility duct should be planned and designed to best fit the requirements of the facilities of public utilities under consideration. Following are general descriptions of facilities by type of public utility.

(1) In telephone services, the section between a telephone exchange and a cabinet on sidewalk is connected with primary cable, while a cabinet is connect with feeder cable followed by a service cable to individual subscribers(see Figure 2.1).

(2) Electric power is transmitted with a high voltage transmission line from a power plant to terminal station, with a subtransmission line to a distribution substation, with a distribution line to a consumer substation in a city where the voltage is dropped for distribution to consumers(see Figure 2.2).

(3) City water is conducted from a filtration plant to a supply reservoir through a large-diameter pipe and from the reservoir to consumers' taps through service pipes of decreasing diameter(see Figure 2.3).

(4) In drainage systems, waste water from homes, offices and factories and rain water are first collected into branch pipes and carried through a main drain pipe to a treatment plant, then the treated sewerage is discharged into canals or rivers(see Figure 2.4).

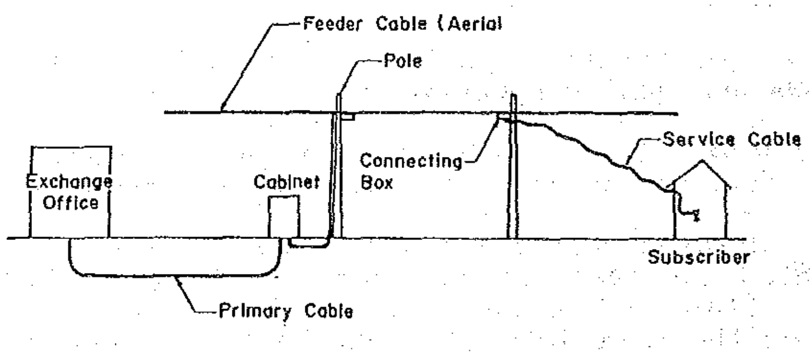


Figure 2.1 Normal Pattern of Telephone System

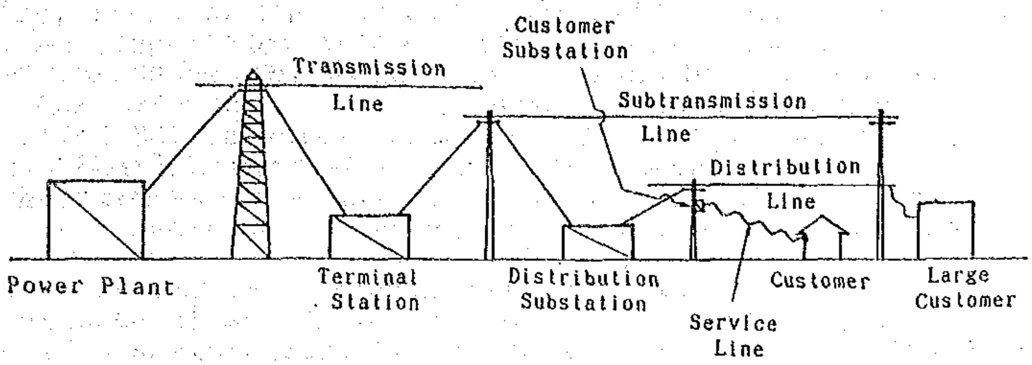


Figure 2.2 Normal Pattern of Power System

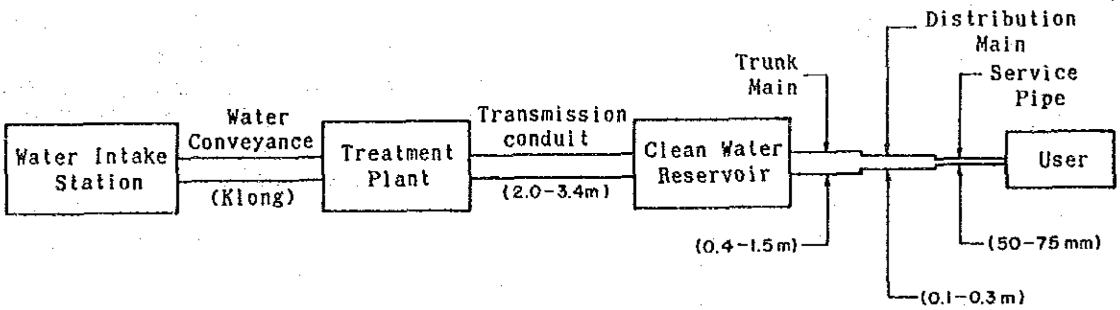


Figure 2.3 Normal Pattern of Water Supply System

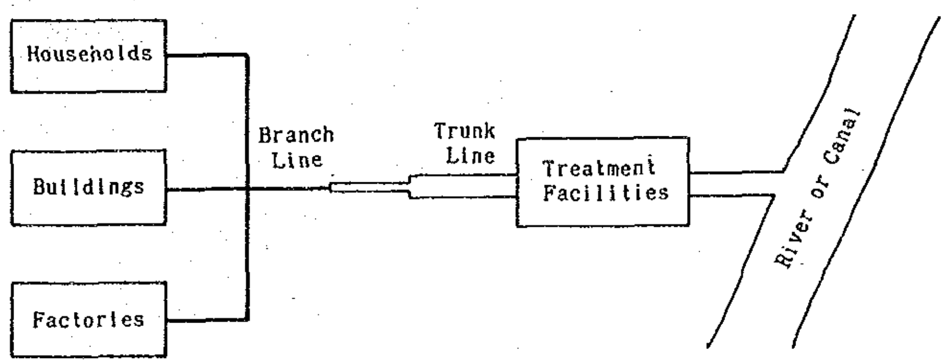


Figure 2.4 Normal Pattern of Sewerage System

2.4 Installation of Public Utilities in Bangkok

Telephone: The primary cables connecting telephone exchanges and cabinets are laid underground, while feeder cables and service cables connecting to subscribers are installed overhead. The present underground cables account for about 50% of all the telephone cables in Bangkok. The present policy of TOT calls for placing primary cables underground and feeder and service cables overhead. TOT however, envisages to switch the overhead cables to underground in the aesthetic view preservation areas.

Electricity: Electric power is transmitted from the EGAT-owned 230 KV outer loop cable to MEA's terminal stations in Bangkok and then to distribution substations via 69 KV subtransmission lines. From the distribution substations, 12 KV distribution lines conduct electricity to transformers(customer substations) on electric poles which drop the voltage to 220 V for distribution to users. Major consumers are, however, supplied directly from distribution substation with electricity of either 12 KV or 24 KV cables(see Figure 2.5).

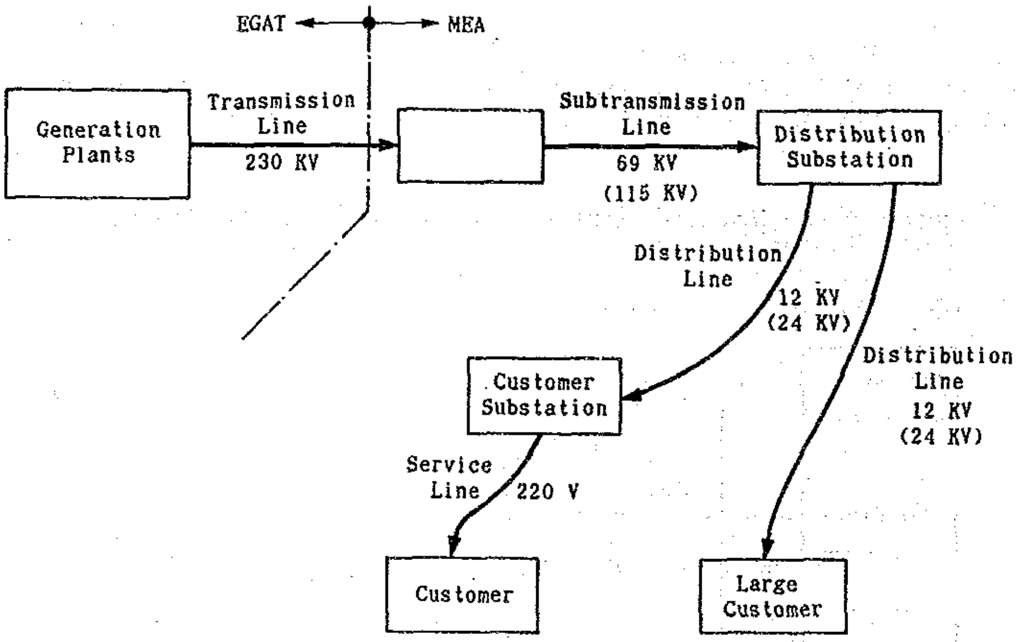


Figure 2.5 Electric Power Distribution System in Bangkok

Most of the 69 KV and 12 KV secondary transmission lines are overhead in the large areas of Bangkok, but in the three districts of Bangrak, Pathumwan and Phranakhon where designated as the need of aesthetic view preservation are high, some transmission liens are laid underground. In Pharankhon district where the royal palace and many famous temples are located, most of the 69 KV secondary transmission lines are laid beneath roads. Approximately 20% of the 12 KV transmission lines in Pathumwan and Bangrak are also placed beneath sidewalks.

Amid the rapid urbanization taking place in Bangkok, the MEA's efforts to expand electric power supply facilities have been facing with problems such as difficulties in ensuring the right-of-way and access to consumers' buildings, preservation of aesthetic view and securing of safety. Thus MEA has been actively studying the possibility of expanding the underground lines.

Water Supply: City water runs through water pipes of 2.0 to 3.4 meters in diameter from the filtration plants in Bangken, Thonburin and Samsen to the clean water reservoirs with the pump stations in different parts of Bangkok, from where the water is supplied to users through trunk mains (ø400 - 1,500mm), distribution mains (ø100 - 300mm) and service pipes (ø50 - 75mm).

Distribution mains and service mains are generally placed beneath sidewalks, while trunk mains are laid under carriageways adjacent to the sidewalks. Transmission pipes are installed within the land owned by MWA itself.

Drainage: The drain pipes and box culverts of 2,700 x 2,550mm are laid either beneath sidewalks or adjacent carriageways, in accordance with their functions, i.e., branch lines or trunk lines.

Natural Gas: According to PTT master plan, there will be a 8-16 inch natural gas distribution pipeline loop around Bangkok in the future and gas will be introduced into Bangkok by 4-10 inch main distribution pipeline system from loop and then supplied to each consumers by 1-6 inch pipeline.

2.5 Congestion in Underground Spaces of Roads

Figure 2.6 shows public utility installations underneath Silom Road, a trunk road in the heart of Bangkok. 2 ducts with 24 pipes for power cables, 4 ducts with 32 pipes for telephone cables, 2 drainage pipes and 1 duct (ø1,500mm, ø400mm and 1500mm), and 3 water main pipes (ø600mm and ø300mm x 2), totaling 12 pipes and ducts are laid underneath either sidewalks or carriageways. These pipes and ducts were laid beneath the sidewalks to avoid interference with vehicular traffic in the past. Recently, however, new pipes have come to be laid beneath carriageways due to congestion of spaces under the sidewalks.

As the public utilities have been constructed pursuant to the individual expansion plans of each public utility providers, the roads in Bangkok are not necessarily properly used in view of utility accommodation space. Therefore it is hoped that efficient and orderly utilization with full coordination among concerned parties be attained in such a way so that not only public utilities but also construction of mass transit railways, expressways and sewerage system will be properly executed.

2.6 Traffic Congestion and Road Surface Excavation

The number of automobiles in Bangkok, growing at an annual rate of 10%, attained nearly 600,000 in 1988. In the light of Bangkok's economic growth, this trend is expected to continue for some time to come. The growth in the number of automobiles has combined with delayed road network development in Bangkok to give rise to a notorious road traffic congestion in the capital city. In the heart of Bangkok, in particular traffic congestion lasts all day long with rush-hour traffic speeds of 13 to 15 km hour.

This situation has produced harmful effects on Bangkok's social and economic activities. Amid such traffic congestion on Bangkok's streets, public utility providers have undertaken utilities laying in accordance with their respective plans. Despite partial schedule adjustments, repeated road surface excavations on the same road have aggravated already serious traffic congestion.

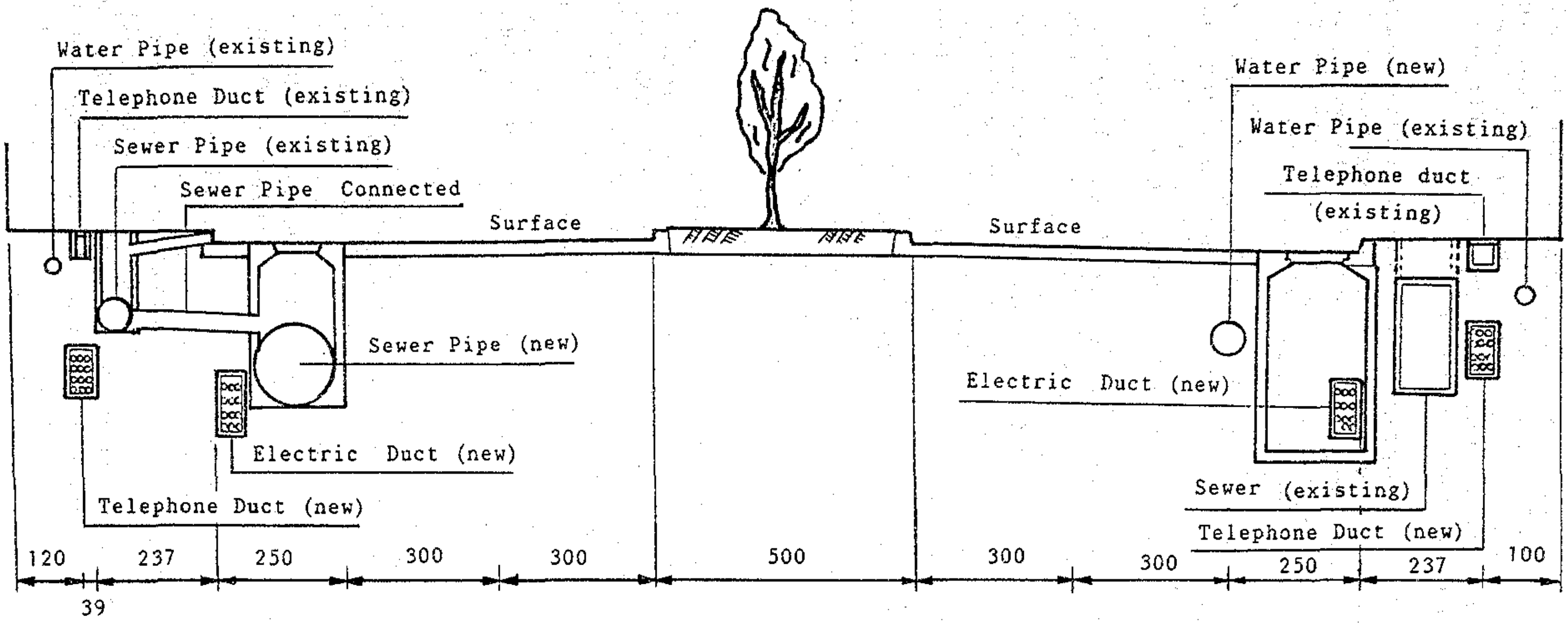


Figure 2.6 Public Utility Installations Beneath Silom Road

Excavations for public utilities installation are authorized for night time as a rule, but during construction periods in the day time when excavations are not carried out, vehicle lanes are not restored to the normal state and road capacity suffers a drop due to restraints imposed on vehicle lanes.

Figure 2.7 shows the frequency of road surface excavations involved in expansion and repair projects undertaken by public utility providers. The frequency trends to increase year after year. Summary of the expansion plans or the demand for public utility facilities is given below(see Figure 2.7).

<u>Telephone circuits</u>: It is planned to expand the telephone circuits (primary pair) from 870,000 in 1986 to 1,760,000 in 1992 (TOT data). The demand of telephone circuits is expected to increase to 2,100,000 in 1997 and to 2,800,000 in 2002.

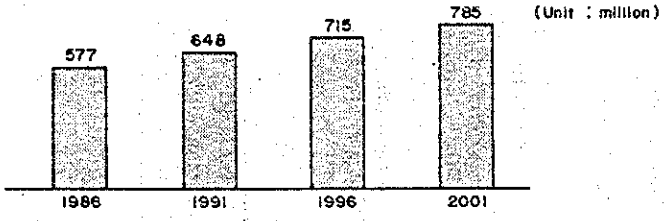
<u>Power supply</u>: According to the Master Plan Study executed by JICA, 1982, the demand of distribution load is expected to increase from 1.834 MVA in 1986 to 3.210 MVT in 1996 and to 4.260 MVA in 2001. In compliance with the demand an expansion plan for subtransmission lines calls for construction of additional lines of 68.8 km in length during the 1982/1991 period and of 214.1 km in length during the 1992/2001 period, and a distribution line expansion plan calls for increasing the number of lines from 345 in 1981 to 487 in 1991 (total cable length of 914 km) and construction of 770 additional distribution lines (total cable length of 1,538 km) in the year 2001. Of the planned subtransmission lines, a line length of 18.2 km will be laid underground. Feeder lines are likely to be laid underground in CBD and aesthetics view preservation areas.

<u>Water Supply</u>: According to the Revised Master Plan of MWA, the demand of water supply(day average demand of central system) increases from 2,097,000 CMD in 1985 to 3,214,000 CMD in 1995 and to 3,750,000 CMD in 2000. In compliance with the demand, MWA's Third Water Supply Project (1986 - 1990, Stage II Phase IA) consists of the laying of 1,000 km of distribution pipeline, and the rehabilitation of 125 km of trunk pipeline and 1,000 Km of service mains. The Fourth Water Supply Project (1988 - 1991, Stage II Phase IB) calls for the laying of 1,000 km of distribution pipeline.

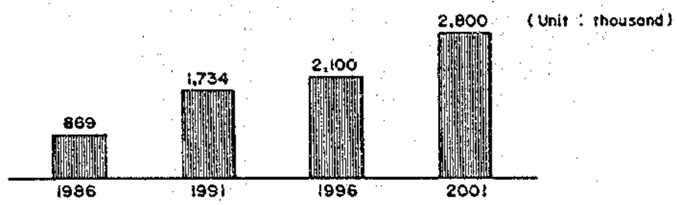
<u>Drain Pipeline</u>: In Bangkok, a drainage pipeline network has been completed, and it is expected that rehabilitation of the network will have to be continued in future. The JICA master plan prepared in 1981 calls for the construction of 36.8 km of trunk pipeline and 1,020 km of branch pipeline during a 20-year period following the start of a sewage system development plan.

With a Bangkok's high pace of urbanization, road surface excavations necessitated by expansion plans for public utilities are likely to continue to increase in the future. Increased road surface excavations will obviously not only accelerate traffic congestion but undermine road structures, thereby seriously affecting the daily life of residents along the roads involved.

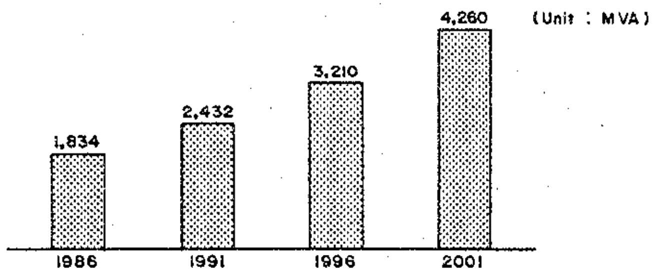
Population in BMA[1)]



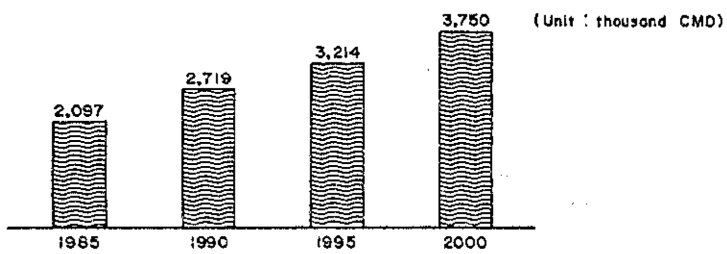
Telephone in BMA[2)] (Primary pair circuit)



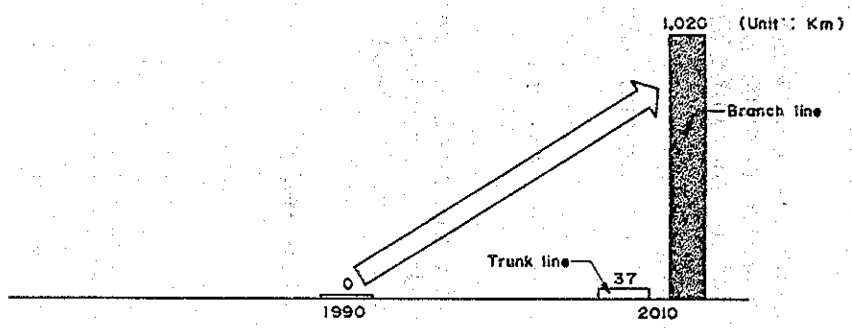
Electric Power[3)] (Distribution load)



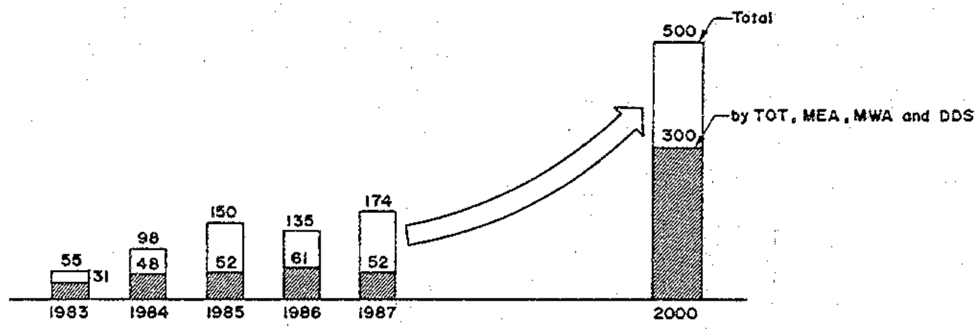
Water Supply[4)] (Total ave. day demand; Central system)



Sewerage System[5)] (Pipe line length)



Excavation Works Number



Source: 1) BMR, 1986 BY NESDB
2) TOT Data
3) M/P, 1982 by JICA
4) M/P, 1984 by MWA
5) M/P, 1981 by JICA

Figure 2.7 Public Utility Demand and Excavation Works

2.7 Need of Common Utility Duct

Problems associated with the use of road spaces for the telephone, power supply, water supply, and drainage facilities may be summarized as follows:

(1) Aggravation of traffic congestion, deterioration of road structure and increased nuisance to residents as a result of road surface excavations for the installation of public utilities;

(2) Increased congestion inside road spaces as a result of expansion of public utilities;

(3) Impairment of aesthetic view of urban roads by overhead electric and telephone cables.

A desirable solution for these problems is the introduction of common utility ducts whose effectiveness is widely recognized. The benefit expected from common utility ducts are shown in Table 2.1.

Table 2.1 Expected Benefits of Common Utility Ducts

Benefits		Details of Benefits
Benefits to Authorities Responsible for Road Management	Smooth flow of road traffic	- Elimination of traffic congestion due to road surface excavations. - Avoidance of traffic accidents due to road surface excavations.
	Preservation of road structure	- Reduced maintenance and repair costs of roads. - Prevention of vibrations and noise due to deterioration of road surfaces.
	Prevention of public nuisance (noise and vibrations) due to construction works	- Noises and vibrations due to construction works can be prevented since they are undertaken in duct.
	Effective utilization of road spaces	- Larger road spaces available as a result of concentration of public utility facilities. - Larger spaces available for planting and pedestrian traffic as a result of expansion of road spaces.
Benefits to public utility providers	Higher priority to expansion or renewal of public utility facilities	- Easier to expand or renew public utility facilities according to public demand and changes in land utilization.
	Increased safety of public utility facilities and stabilized supply of power, water and gas	- Visual inspection helps achieve, reliable maintenance which in turn ensures safety of public utility facilities and and stable supply of power, water and gas.
Improved scenes of streets		- Improvement of street scenes as a result of laying overhead cables underground. - Improved street scenes contribute toward enhancing the value of cultural and tourist resources of Bangkok.

The need of constructing common utility ducts in Bangkok is obvious in the light of their benefits against the background of Bangkok's rapid socioeconomic growth and resulting urbanization at a rapid tempo, growing road traffic congestion and execution of expansion plans for public utility facilities.

It should be, however, noted that a common utility duct construction involve a large scale of civil works, a long construction period as well as a large amount of budget.

Common duct planners should expect some traffic problems and financial difficulties, at the stage of initiating of common ducts and to take precautious measures to minimize traffic problems during their construction.

In effect, the need of common ducts, which will bring about a great benefit to the concerned agencies and the general public over a long period of time, are only appropriately to be assessed in the long run.

2.8 Classification of Common Utility Ducts

The structural planning and design method of common utility ducts vary depending on what part of public utilities-trunk line, supply line is to be housed in the ducts. Thus the ducts are classified broadly into trunk line common utility ducts and supply line common utility duct. The simplest of the supply line common utility ducts which accommodates only power, telephone and other similar cables is customarily termed a cable box (CAB).

(1) Trunk Line Common Utility Duct

Trunk line common utility ducts accommodate main cables (for example; cables connecting a terminal station with a distribution substation and main pipes (for example, pipes leading from a treatment plant of water supply to a pump station which are not intended to directly serve areas adjacent to the road along which the common utility ducts are constructed. They are primarily to be constructed beneath roadways.

(2) Supply Line Common Utility Duct

The common utility ducts accommodate cables and pipes which serve users of neighboring areas with power, water, gas and telephone and other public utilities. The public utility providers can serve users directly without having to dig roads when new supply demands arise. Thus supply line common utility ducts are normally constructed under sidewalks to facilitate and supply to avoid adverse effects on traffic movement.

(3) Cable Box (CAB)

The cable box, a kind of supply line common utility ducts is an answer to the problem of high cost construction in normal common utility ducts. In general, the CAB system is of U-shaped precast concrete structure with covers at the level of road surface and is built under sidewalks. Cable boxes accommodate not only power and telephone cables but also cables needed for new media of communication which is expected to come into wide use with the progress of the highly information oriented society.

Figure 2.8 shows the schematic cross section of each common utility duct.

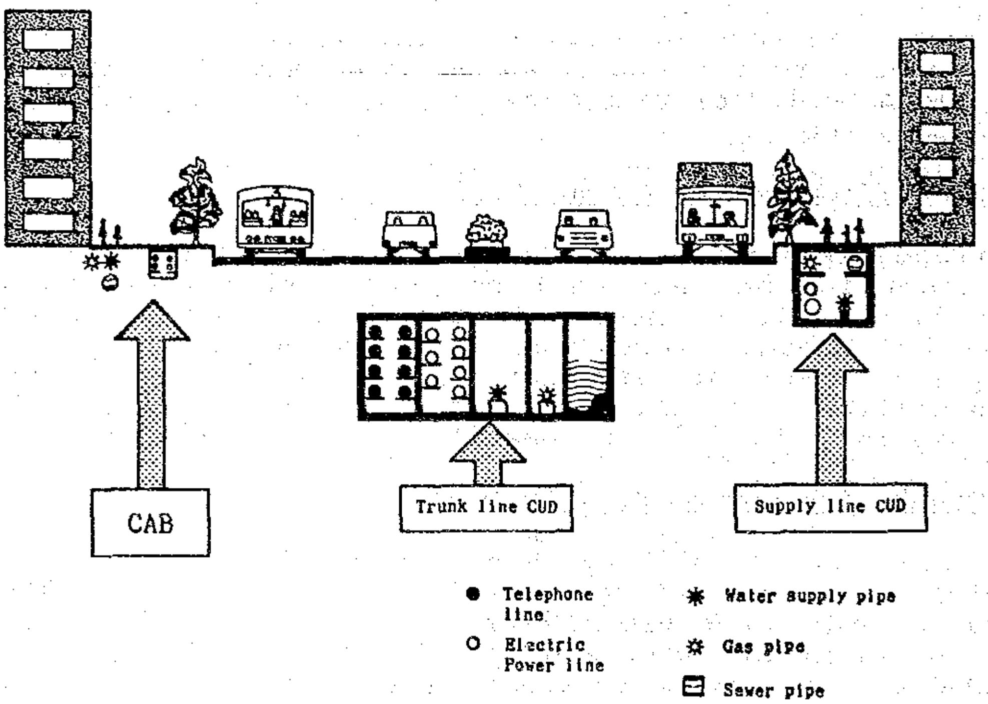


Figure 2.8 Schematic Cross Section of Common Utility Ducts

3

TECHNICAL GUIDELINE

3. TECHNICAL GUIDELINE

This technical guideline is prepared to provide a guide for planning and design of trunk-line ducts, supply-line ducts and CABs. However, a substantial part of the guideline has a common element for both trunk-line and supply-line ducts that they are described in the same chapter.

3.1 Trunk Line and Supply Line Common Utility Ducts

3.1.1 General Planning Consideration

1) In planning common utility duct construction, it is necessary to check the conditions of utilities built in roads, to determine if related projects are planned and to hold consultation with relevant authorities with a view of maintaining close coordination with these authorities.

2) Common utility ducts and piers for elevated roads should preferably be of separate construction. If the two structures are to be of integrated construction, the common utility duct construction plan should be worked out on the basis of consultation with the authorities concerned as to the location and structural type of the common utility duct. Where the planned common utility ducts will adjoin the pier for elevated roads, their location and structural type should be planned taking into account the opinion of the executing authority of the elevated road projects.

3) When there is possibility of roads being widened in future under city planning, common utility ducts should be so planned as to be built in the center of a roadway as a rule, and there should be prior coordination with the authorities concerned as to the location of ventilating opening to be provided on the road.

4) When common utility ducts are to be built parallel to an underpass, they should be constructed adjoining the retaining wall or the two structures should be of integrated construction as a rule. When the construction of both structures cannot be started at the same time, an extra space for the construction should be provided between both structures.

5) When an underpass crosses the road where common utility ducts are to be built, they should be beneath the underpass as a rule. When the construction of the two structures is started

concurrently, the common utility duct construction plan should be prepared on the basis of mutual consultation with the authorities concerned.

6) When common utility ducts are constructed at an overpass, the provision of 2) above shall be applied.

7) When common utility ducts are to cross railways or rivers, the common utility duct construction plan should be worked out after consultation with the authorities concerned as to the location and structural type of the common utility ducts.

(Comment)

1) When related projects are planned, the timing and method of execution, project size and other pertinent information should be obtained, and the common utility duct construction should be implemented at the same time as the related projects, if possible.

2) Common utility ducts should be separated from the piers for elevated roads as much as possible for reasons of the different subsidence and thermal expansion characteristics of the two structures. When the common utility ducts and the piers are to be of integrated construction, it is necessary to discuss and study the location and structural type of the common utility ducts thoroughly.

3) When the amount of road widening under city planning is large, most of the common utility ducts can be constructed within the widened strip and this results in smooth handling of traffic during construction and shorter construction period, it is recommended to construct common utility ducts in the widened strip.

4) Where common utility ducts are built parallel to an underpass, the extra width to be provided includes the width of sheet piles for breasting and their extra width. If the removal of the sheet piles threatens to affect the structure of both the common utility ducts and underpass, the sheet piles should be left in place.

5) In consultation with the authorities responsible for railways and river management, the plans for common utility duct construction of underpasses, independent bridges and structure adjoining the existing bridge should be evaluated carefully to select the best plan.

3.1.2 Geometric Design

(1) Inner Space

The standard dimensions of inner space of a common utility duct shall be in accordance with Table 3.1;

Table 3.1 Size of Inner Space

Items	Size	Remarks
Height	2.1 m or more	
Width	(0.75+a)m	a: necessary width for each public utility

(Comment)

1) Standard Section

a) Required section for each public utility providers (hereinafter referred to as "provider") shall be calculated based on the installation plan.

b) The standard section shall be determined in consideration for structural types of non-standard sections, branching direction, etc. (Generally, there are two to four types of standard sections.)

c) When the height of inner space is different between providers by less than 1.0 m, the larger height shall be adopted to simplify the duct structure and improve workability. (as shown in Figure 3.1)

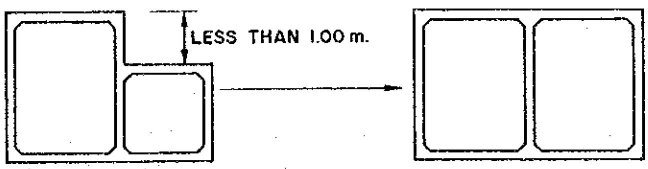


Figure 3.1 Adjustment of Height

d) The accommodating section of a structure shall desirably be separated between providers for reasons of management,disaster control, etc. However, when such separation is difficult due to structural, economic or other limitation, the section may be shared by providers.

2) Non-standard Sections

Branching parts or joint holes with special sectional shape generally require complex and larger section compared with general parts. Thus, the section of special parts shall be simplified as much as possible in consideration of such factors as economy, workability and future management.

3) Height

The minimum height of inner space has been determined at 2.1 m. in total, based on the following, as shown in Figure 3.2.

- Average height of worker with protective equipment....................................1.8 m
- Lighting device on the ceiling.........................0.2 m
- Thickness of foot floor concrete......................0.1 m

Total: 2.1 m

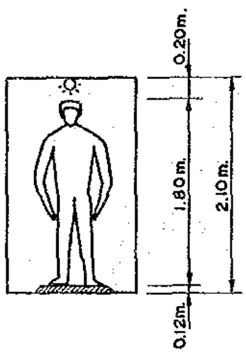


Figure 3.2 Height of Inner Space

4) Width

The width of inner space has been determined at (0.75+a)m, based on following.

- Width of working and management passage...0.75 m
- Width for facility of each providers......a

(2) Earth Cover

The earth cover between the pavement surface and the upper slab of the duct shall be in accordance with the following values as a rule.

Table 3.2 Hight of Earth Cover

Items	Trunk line duct	Supply line duct
Standard Section	2.5 m or more	pavement thickness
Non-standard section	1.0 m or more	pavement thickness

(Comment)

1) Earth cover for trunk line common utility duct

a) Standard sections

The minimum earth coverage for the standard parts has been determined at 2.5 m in total, based on the following, as shown in Figure 3.3.

- Pavement thickness or required earth coverage for buried pipes.................1.2 m
- Space for buried pipes....................1.0
- Space between the duct and buried pipes...0.3

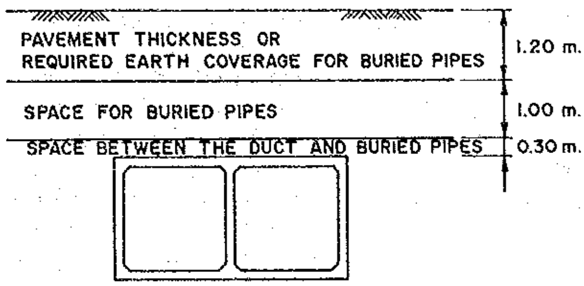


Figure 3.3 Minimum Earth Cover

b) Non-standard section

The standard earth cover for the non-standard section excluding those structures built on the road surface such as entrances, manholes and ventilating openings shall be approximately 1.0 m so that the coverage would, as a rule, exceed the design pavement thickness, thus ensuring structural safety of the road.

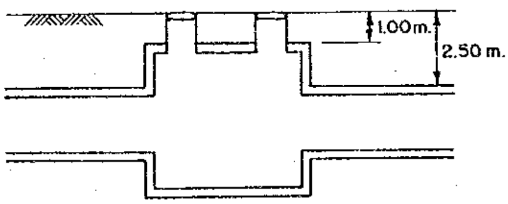


Figure 3.4 Earth Cover of Special Part

2) Earth cover of supply line common utility duct

Supply line common utility duct is usually installed underneath the sidewalk. Therefore the cover would, as a rule, exceed the design pavement thickness of sidewalk.

When the installation, however, bestrides under the carriageway, the cover is of the same value as the trunk line common utility duct.

(3) <u>Alignment</u>

3.1) Horizontal alignment

(1) Trunk line common utility duct should be constructed underneath the carriageway as a rule. (2) Supply line common utility duct should be constructed underneath the sidewalk as a rule. (3) The horizontal alignment of a common utility duct shall be determined based on careful examination of present road conditions, future plans and relations with other projects.

(Comment)

Common utility ducts to be constructed by road administrators should desirably be designed to have horizontal and vertical alignments agreeing with the road alignment. In actuality, however, there are many limitations and matters to be considered when examining the alignment of a common utility duct.

A road is accompanied with various construction plans for urban facilities, which makes it necessary to construct a common utility duct in a manner well coordinated with those facilities, with a view to ensuring effective utilization of the road space. Relevant large-scale urban facilities include:

- Expressways;
- Mass transit system;
- City planning and street improvement works;
- Artery sewage works.

Thus, it is desirable that a common utility duct be constructed with other facilities as mentioned above, and the alignment of a common utility duct is often determined in consideration with other projects.

3.2) Vertical alignment

The vertical gradient of a common utility duct, except at non-standard sections, shall be 0.2% or more to ensure effective drainage. The gradient shall be determined in consideration to the nature of the facilities contained, their maintenance, etc. so that it would agree with the gradient of road as much as possible.

(Comment)

The vertical gradient, as in the case of horizontal alignment, should be determined in consideration with the possible bending angle of the facilities contained, their maintenance and other matters. When a gradient of more than 15% is inevitable due to topographical or other conditions, stairs, desirably those with hand rails, should be provided to facilitate the maintenance and management of the facilities contained.

When the gradient exceeds 35%, it should rather be made vertical for ease of work and management.

(4) <u>Other matters to be considered</u>

4.1) Distance to public-private boundary

The distance between the external wall of a common utility duct and the nearest public-private boundary shall be at least 1.0 m as a rule.

(<u>Comment</u>)

The distance between a common utility duct and the nearest public-private boundary should desirably be as large as possible, to improve workability and minimize effects on water-supply and sewerage pipes for roadside private buildings. Even when the duct is constructed near to the road edge due to inevitable reasons, the distance should at least be 1.0 m. as shown in Figure 3.5.

When it is impossible to keep the distance of 1 m. away from private land, it should be determined through the careful consideration.

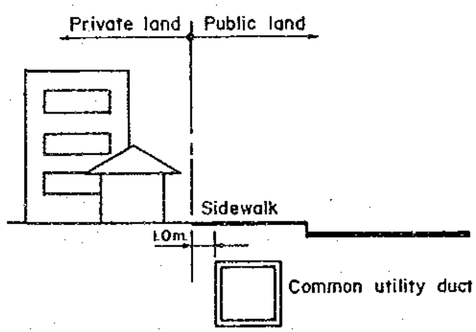


Figure 3.5 Distance from Private Land Boundary

4.2) Relations with existing structures

When existing structures are built at a place where a common utility duct is planned, the duct's relations with those structures shall be determined through careful consultations between the parties concerned.

(Comment)

When those existing structures become obstacles for a common utility duct, proper measures including relocation of existing structures or the duct's passing over or under those structures should be taken based on consultations with the administrators of the structures in consideration to their scale and construction.

4.3) Relations with underground tanks of dangerous articles

A common utility duct shall desirably be away from an underground tank of dangerous articles by 10 m. or more.

(Comment)

When an underground tank of a gas station exists in the neighborhood, the conditions at the site must be checked against the provision of the regulation (if existing), and any problem confirmed must be properly dealt with through consultations with the relevant authorities.

3.1.3 Structural Design

(1) Loads

1.1) Types of loads

In designing the structure of a common utility duct, consideration should be given to the following loads: (1) Dead loads (2) Live loads (3) Soil pressure (4) Hydraulic pressure (5) Buoyancy (6) Ground fluctuation influence

(Comment)

In special cases, additional consideration should be paid to loads which will influence the construction of a common utility duct. Among them are (1) soil movement around a common utility duct caused by pulling out steel sheet piles, and (2) uneven earth pressure caused by unbalanced consideration of loads at the time of construction can be increased based on the condition and terms of the construction.

In order to reduce these loads to the minimum, steel sheet pipes should be left in place or should be pulled out to reduce sand to be taken out at the same time by pulling out steel sheet pipes zigzag. When this causes a hole, it is necessary to fill them with, for example, sand in order to prevent uneven earth pressure.

1.2) Dead Loads

In calculating dead loads, the following unit weight as shown in Table 3.3 may be used. In case information for the actual weight is available, this should be used for the calculation.

Table 3.3 Unit Weight of Materials

Materials	Unit weight	
	(kg/m^3)	(lb/cu.ft)
Steel, cast steel, forged steel	7,850	490
Cast iron	7,200	450
Concrete, plain or reinforced	2,500	150
Bituminous material (for waterproof)	1,100	70
Asphalt concrete pavement	2,300	145
Crushed stone	2,100	135
Cement mortar	2,150	135
Timber	800	50
Back filled soil (above ground-water level)	1,900	120
Back filled soil (below ground-water level)	1,000	65

(Comment)

1) Waterproof and protective mortar is very thin, giving little influence in comparison with other loads. Therefore, it is assumed that there is soil.

2) The weight of accommodating utilities of provider firms, and the foot floor may be neglected, because it is considered to be conveyed directly to bearing ground through bottom slab of the duct, except for special sections, such as an electric transformer room, where a double-layer transformer and heavy power cables give influence to structure.

1.3) Live Loads

Live loads are motor vehicle loads, sidewalk live loads and superimposed loads. For motor vehicle loads, impact is considered.

(1) Motor vehicle loads

Motor vehicle loads shall consist of four types of loading i.e. HS-20, HS-15, H-20, H-15.

The loads of HS-loading and H-loading should be used for trunk line common utility duct and supply line common utility duct, respectively in accordance with Table 3.4.

Table 3.4 Design Vehicle Loads

Trunk line common utility duct	Supply line common utility duct
HS-20 H -20	HS-15 H -15

HS-loading and H-loading should be used in conformance with the grade of the road.

Motor vehicle loads are loads distributed at an angle of 45 degrees, and applied in principle to carriage ways.

(2) Impact

The impact coefficient through motor vehicle loads is listed in the Table 3.5.

Table 3.5 Impact Coefficient through Motor Vehicle Loads

Height of earth cover	Impact coefficient
H < 3.5	0.3
H ≥ 3.5m	0

(3) Sidewalk live loads

Sidewalk live loads are 415 kg/m^2.

(4) Superimposed loads

Superimposed loads placing on a common utility duct are 1.0 t/m^2.

(Comment)

1) Motor vehicle loads are considered for the standard design of a common utility duct installed below a sidewalk in order to take into account the cases of the widening of a carriage way in future and entry into a parking lot.

2) A common utility duct is paralleled with the driving direction of motor vehicles except for intersections, making it necessary to consider the influence of front wheels. Vertical loads working on the surface of a common utility duct in consideration of front wheel influence are calculated through the following equation based on loads per horizontal unit length.

1) Loads per horizontal unit length

$$\text{Loads (Pi)} = \frac{2 \times \text{wheel loads i(t)}}{\text{vehicle occupied width (3 m)}} \times (1+\text{impact coefficient}) \quad .....(3.1)$$

2) Vertical loads on the surface of common utility duct

(a) Covering height (H) <2.05 m

$$q = \frac{P2}{2H + 0.2} \quad ....(3.2)$$

(b) Covering height (H)>2.05 m

$$q = \frac{P1 + P2}{2H + 0.2} \quad ....(3.3)$$

q : Uniform load by motor vehicle load
P1 : Loads per horizontal unit length by front wheel rounds
P2 : Loads per horizontal unit length by rear wheel rounds
H : Height of earth cover

Figure 3.6 shows the vertical distributed loads due to H or HS-loading. Table 3.6 indicates the wheel loads of H and HS-loading.

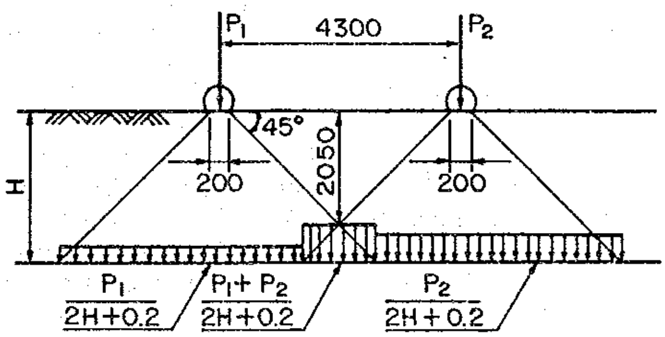


Figure 3.6 Vertical Disturbed Loads due to H or HS-loading

Table 3.6 Wheel Loads of H and HS-loading

	HS-20	HS-15	H-20	H-15
P1	14.5 t (32,000 lbs)	10.9 t (24,000 lbs)	3.6 t (8,000 lbs)	2.7 t (6,000 lbs)
P2	14.5 t (32,000 lbs)	10.9 t (24,000 lbs)	14.5 t (32,000 lbs)	10.9 t (24,000 lbs)

3) When the earth cover is extremely thin or wheel loads are directly imposed, concentrated loads shall be placed.

4) Live loads for such sections as a crossing of a railway are studied and determined separately.

1.4) Earth Pressure

(1) Vertical earth pressure

Vertical earth pressure working on the surface of a common utility duct is calculated through the following equation.

$$q_v = r.h_1 \quad \ldots\ldots (3.4)$$

(2) Horizontal earth pressure

Horizontal earth pressure working on the side of a common utility duct at any point is calculated through the following equation.

$$q_h = K_o(r.h + q_o) \quad \ldots\ldots (3.5)$$

q_v : vertical earth pressure (t/m^2)
q_h : horizontal earth pressure (t/m^2)
q_o : superimposed loads (t/m^2)
r : unit weight of soil (t/m^3)
h_1 : earth covering height (m)
h : depth below ground surface (m)
K_o : static soil pressure coefficient

(Comment)

1) In many cases, ground is excavated to construct a common utility duct, making it almost improbable that uneven subsidence in comparison with surrounding ground occurs. Therefore, vertical earth pressure is of equivalent height to earth coverage. However, when a common utility duct with solid bearing piles is constructed in the ground with high consolidation, the difference in settlement relative to surrounding ground becomes larger, boosting vertical earth pressure working on the common utility duct. In this case, vertical earth pressure is calculated through the following equation, while considering the extra coefficient (a) as shown in Table 3.7.

$$q_v = a.r.h_1 (t/m^2) \quad \ldots\ldots (3.6)$$

Table 3.7 Extra Coefficient

$K = h_1/Bo$	K<1	1<K<2	2<K<3	3<K<4	K>4
Extra coefficient(a)	1.0	1.2	1.35	1.5	1.6

B_o is the width of a common utility duct.

2) The coefficient of earth pressure at rest varies according to the methods of soil compaction, ranging from 0.4 to 0.7. It is given as Ko = 0.5 for ordinary sandy soil and cohesive soil. However, the coefficient is studied separately for soft ground.

3) As Horizontal earth pressure through live loads working on the side of culvert, regardless of depth, Ko.qo (t/m^3) works on both sides as shown in Figure 3.7.

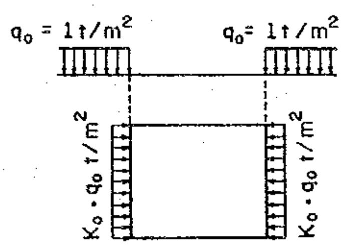


Figure 3.7 Earth Pressure through Live Loads

4) Combination of loads

1) Earth cover height is less than 3.5 m.
Calculation is made for a pair of combinations--(a) and (b) as shown in Figure 3.8. Among bending moments and shearing forces obtained at each point, larger ones are used for the design.

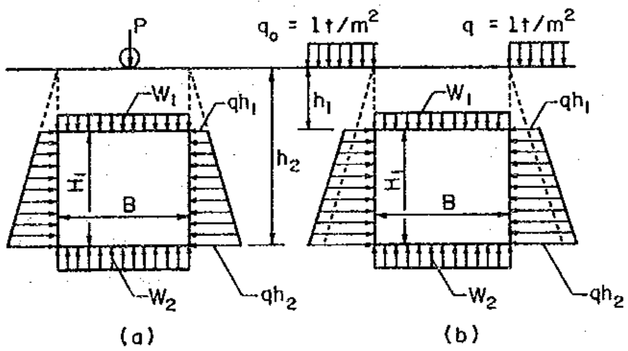


Figure 3.8 Loads Combination (hl < 3.5)

In case of (a)

$$W_1 = q + q_V + \frac{D_1}{B} \quad \text{.......(3.7)}$$

$$W_2 = W_1 + \frac{D_2}{B} \quad \text{.......(3.8)}$$

$$qh_1 = r.h_1.Ko \quad \text{.......(3.9)}$$

$$qh_2 = r.h_2.Ko \quad \text{.......(3.10)}$$

In case of (b)

$$W_1 = q_V + \frac{D_1}{B} \quad \text{.......(3.11)}$$

$$W_2 = W_1 + \frac{D_2}{B} \quad \text{.......(3.12)}$$

$$qh_1 = (r.h_1 + q_o)\ K_o \quad \text{.......(3.13)}$$

$$qh_2 = (r.h_2 + q_o)\ K_o \quad \text{.......(3.14)}$$

2) Earth Cover height is more than 3.5 m. (see Figure 3.9)

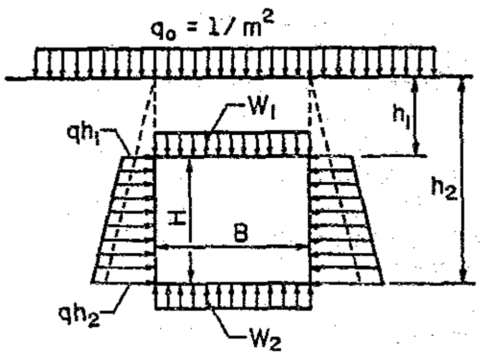


Figure 3.9 Loads Combination (hl>3.5)

$$W_1 = q_o + q_V + \frac{D_1}{B} \quad \text{.......(3.15)}$$

$$W_2 = W_1 + \frac{D_2}{B} \quad \text{.......(3.16)}$$

$$qh_1 = (r.h_1 + q_o)\ K_o \quad \text{.......(3.17)}$$

$$qh_2 = (r.h_2 + q_o)\ K_o \quad \text{.......(3.18)}$$

q : live loads working on the surface of a common utility duct (t/m^2)

q_v: vertical earth pressure working on the surface of a common utility duct (t/m^2)
r : unit weight of earth (t/m^3)
h_1: depth of the surface of a common utility duct (m)
h_2: depth of the bottom of a common utility duct (m)
B : width of a common utility duct (m)
q_0: superimposed loads (t/m^2)
D_1: weight of upper slab
D_2: weight of wall on both sides
K_o: static soil pressure coefficient

1.5) Hydraulic Pressure

Hydrostatic pressure is as follows. When it is clear that hydraulic pressure does not reach the value of theoretical hydrostatic pressure, it is reduced to the obtained value.

$$Pw = W_o . h \quad \text{.................................} (3.19)$$

Pw : hydrostatic pressure at the depth of h below ground-water level (t/m^2)
Wo : unit weight of water
h : depth below ground-water level

(Comment)

Depending on the condition of ground, Hydraulic pressure does not form triangular distribution, making different distribution from a certain depth. When different distribution is clear as a result of study on pore-water-pressure, water pressure may be reduced to the obtained value. Water pressure for back filling is considered equivalent to theoretical water pressure.

1.6) Buoyancy

Buoyancy works vertically on the structure in such manner as to be most disadvantageous to it.

(Comment)

Buoyancy is a force caused by upward hydrostatic pressure working on the bottom of a common utility duct when the pore water pressure exists in the ground or between the ground and the duct. The unfavorable effects the buoyancy has on the duct are studied in the following way.

Study on Buoyancy

For parts with a little covering at the high ground-water level, the safety factor Fs against buoyancy is calculated based on the following equation.

$$Fs = (Ws + Wb)/Pwb \quad \cdots\cdots (3.20)$$

Ws : weight of superimposed soil
Wb : weight of duct
Pwb : upward water pressure working on the bottom of duct (t/m)

The safety factor Fs must be more than 1.2.

(Comment)

The weight of a duct, Wb, does not include the weight of an accommodation utilities. Shear resistance of superimposed soil and friction resistance of side wall of the duct are left out of consideration. In order to take water weight into account, wet weight is used for the calculation of Ws.

When stability against buoyancy is studied, it is necessary to get the height of a ground-water level in advance. It is better to obtain the height through actual observation of boring holes and wells in surrounding areas. In reclaimed land along coastal lines, buoyancy is usually calculated at high water. For places with great fluctuations of ground-water levels under the influence of river water, it is necessary to obtain the maximum ground-water level.

(2) Materials and Allowable Stress

Materials used for a common utility duct and allowable unit stress are as following Table 3.8.

Table 3.8 Allowable Stress

Basic materials	Allowable stress (Kg/cm^2)		
Reinforcing bar	Tensile stress	Members in ground and below the ground-water level	1,600
		Calculation of lap joint strength of reinforcing bar	1,800
Concrete	Bending compressive stress		70
(design strength = 210 kg/cm2)	Shear stress		3.6
	Bond stress		14

(Comment)

Allowable stresses to be used in a case for the integrated structure with a elevated road and a subway are determined separately after consultation with related organizations.

(3) Other Structural Consideration

3.1) Study on Settlement

When the ground is soft and may cause settlement around a common utility duct, study is made on settlement. Subsidence due to consolidation, S, is calculated based on the following equations.

$$S = \frac{eo - e1}{1 + eo} \cdot Ho \quad \ldots\ldots (3.21)$$

$$\text{or} \quad S = \frac{Cc \quad Ho}{1 + eo} \cdot \log \frac{Po + P}{Po - 1} \text{ (in case of } Po + P > Pc) \ldots (3.22)$$

e_o: void ratio against earth cover pressure Po on a curve, (e-log p)
e_1: void ratio against vertical force, p = Po + P, after superimposed loads P on a curve, e - log p, is added.

Ho: thickness of soft layer
Cc: compression index
Pc: maximum consolidation stress

(Comment)

In general, a common utility duct is lighter than the weight of conventional ground, therefore, the construction of a common utility duct may not cause land subsidence. However, if embankment is made above a common utility duct, or new embankment loads are added, or a common utility duct is constructed in the ground with growing consolidation, influences from settlement should be fully studied.

Measures against possible subsidence of ground are divided into two types according to the characteristics of structures and settlement: measures to follow subsidence of ground and measures to prevent subsidence of a common utility duct. The former is generally adopted using a gap in lap joints between structures, while the latter is taken to prevent subsidence of structure through bearing piles.

Another measure is to use friction piles in order to prevent uneven settlement.

If measures other than the usage of bearing piles for the foundation of structure are carried out, consideration should be paid to the amount of allowable settlement in the light of structure. Subsidence should be restricted within the projected value. In this case, various measures to lessen subsidence should be taken, if a construction period is rather long. Among them are pre-load using sand drain, rod compaction process, and consolidation process.

What requires careful attention is the fact that due to no buoyancy during construction, ground reaction of the foundation is larger than after the completion. Therefore, it is necessary to study bearing force of ground, subsidence, and effects of uneven settlement at the time of construction.

3.2) Study on Longitudinal Direction of Common Utility Duct

> Study on longitudinal direction is made for a common utility duct to be constructed in the following places:
>
> (1) where loads change greatly in the longitudinal direction of a common utility duct;
>
> (2) where the foundation ground is soft and changes in the ground-water level during construction will likely cause uneven subsidence;
>
> (3) which belongs to an extensive land subsidence zone due to pumping of underground water, where thickness of soft ground is variable in the longitudinal direction.

(4) Minimum dimension of the member

> The minimum thickness shall be 300 mm for the members which are subject to the load as a part of the structural body, and 200 mm for the partition walls, manholes, etc.

(Comment)

The minimum thickness of the members shall be 300 mm considering that the structural body is underground structure, in addition to taking into account of the scale, importance, waterproofness, etc.

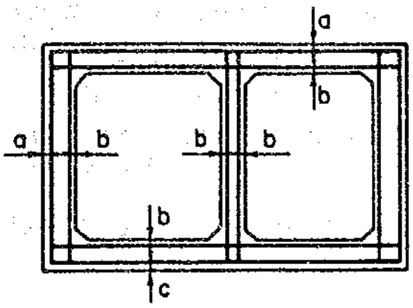
For small structures of lesser importance and those that are not subject to the load of partition walls, etc., the minimum thickness of the members shall be 200 mm, taking into account of the workability.

(5) Arrangement of reinforcing bars

5.1) Diameter of reinforcing bar and the covering

(1) The minimum diameter of the main reinforcing bar in the transverse direction shall be 13 mm, and the maximum diameter shall be 32 mm, as a rule.

(2) The covering of the reinforcing bar shall be as shown in Figure 3.10.



Distance from the concrete surface to the center of the main reinforcing bar

a = 70 mm
b = 50 mm
c = 100 mm

Figure 3.10 Covering of the Reinforcing Bar

(Comment)

The value of the covering shall be the value up to the center of the reinforcing bar irrespective of the diameter of the reinforcing bar. The above values are rounded off to 70 mm for the exterior, 50 mm for the interior and 100 mm for the walk floor slab lower surface, taking into account the work tolerance, maximum diameter of the reinforcing bar, etc.

5.2) Spacing of main reinforcing bars in the transverse direction

As for the spacing of main reinforcing bars in the transverse direction, 125 mm shall be the standard spacing. However, in case the main reinforcing bars are placed in the longitudinal direction such as two-way slab, this shall not apply.

(Comment)

The spacing of the main reinforcing bars in the traverse direction in the above clause shall apply only to the slabs shall not apply to the beams, pillars, etc. Also, for the spacing of the main reinforcing bars in the transverse direction, generally 100 mm, 125 mm and 150 mm pitches, etc. are used. However, taking into account the maximum diameter of the main reinforcing bar, maximum size of the coarse aggregate and the workability, 125 mm is set as the standard.

5.3) Minimum amount of reinforcing bars in the longitudinal direction

> The deformed bars of 13 mm dia. or more shall be placed at an interval of 200 mm in the longitudinal direction and the amount of reinforcing bars in the longitudinal direction shall be not less than 1/5 of the reinforcing bars placed in the transverse direction.

(Comment)

The common utility duct is a continuous structure in the longitudinal direction and the cross section and the ground vary from place to place.

Therefore, the minimum amount is specified in the longitudinal direction.

5.4) Lap splice length and bend radius of reinforcing bar

> The lap slice length, bend radius and arc length shown in Table 3.9 shall be the standard.

Table 3.9 Lap Splice Length, Bent Radius, Arc Length

Diameter of Reinforcement	Lap Splice Length			Radius	Arc Length
	1	a	b	R	L
D32	1120	480	640	340	534
D29	1015	435	580	310	487
D25	875	375	500	270	424
D22	770	330	440	240	377
D19	665	285	380	200	314
D16	560	240	320	170	267
D13	455	195	260	140	220

(Comment)

1) 35d is used for the lap splice length, d is the diameter of the reinforcing bar.

2) 15d is used for the lap splice length (a), and 20d is used for (b).

3) The bend radius R is a radius at the center of the reinforcing bar 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.

4) In case that reinforcing bars of different diameters are placed in lap, the lap splice length of the larger diameter shall be used. In case it is larger than D25, the gas-pressure welded joint is desirable.

5) The maximum length of the reinforcing bar insertion shall be determined taking into account the workability (strut pitch, etc.)

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

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

6.1) Natural ventilating opening

(1) Natural ventilating opening shall serve both as an inlet and an exit. It shall have such structure that facilitates the maintenance and fire prevention. (2) The natural ventilating opening shall have such structure that can easily take in the outside air. (3) It shall be positioned on the median strip or sidewalk. In case it is installed on the sidewalk, the position shall be determined after having reviewed the presence of garages or access of vehicles. (4) The minimum height of the duct shall be 2.1 m.

(<u>Comment</u>)

1) The natural ventilating openings for which access is made frequently shall have stairs as a rule. In case it is not possible to provide stairs due to the roadside conditions, ladders or steps shall be provided.

2) A lid shall be a grating lid to take in the outside air. A lock shall be provided to the lid to prevent the unauthorized entry.

3) It is desirable to provide such structure (pit structure) that can prevent a fire that may be caused by inflow of inflammables.

4) The height of the ventilating opening above the ground level in the area where the flooding is predicted, shall be determined after having examined thoroughly the maximum height of flooding in the past.

The examples of the natural ventilating opening constructed in Japan are illustrated in Figure 3.11.

6.2) Forced ventilating opening

(1) The forced ventilating openings shall have such structure that can exhaust the air forcibly using ventilating fans, etc.

(2) The forced ventilating openings shall be arranged alternately with natural ventilating openings.

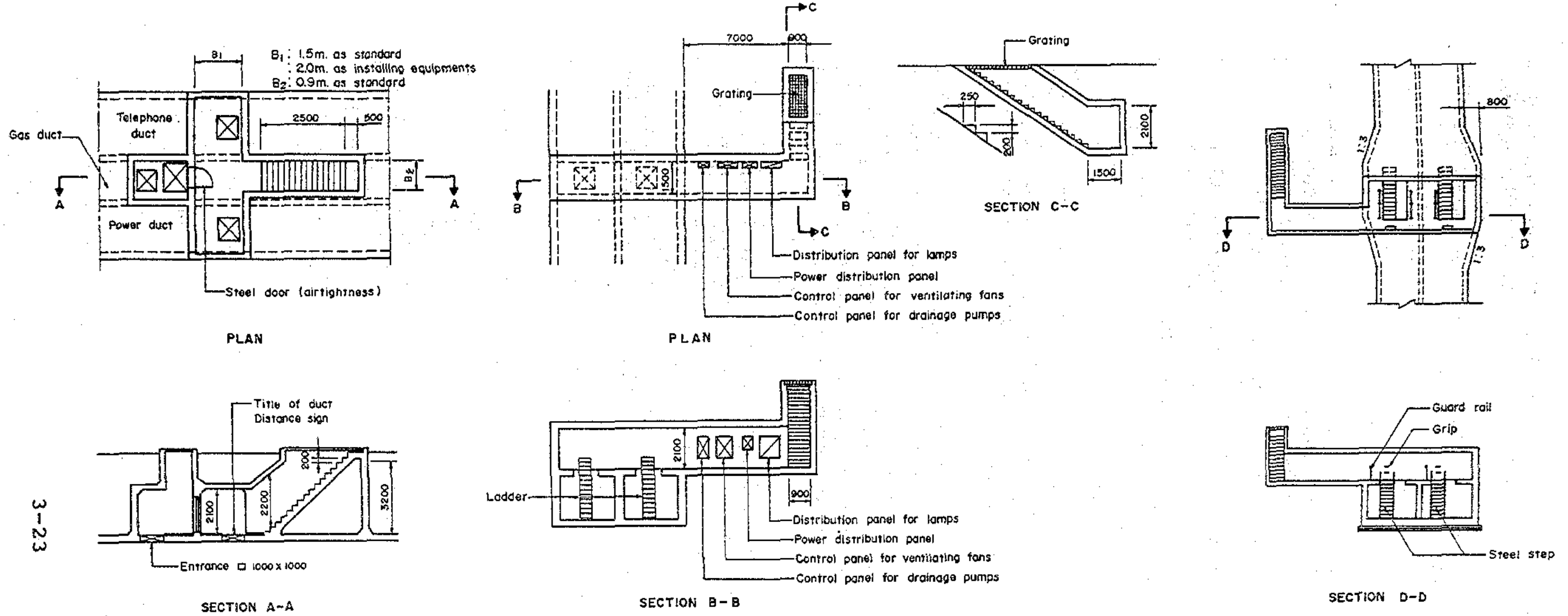
(3) As for the installation locations of the ventilating openings, the provisions for the natural ventilating openings shall also apply. In addition, when determining the locations, noise, etc. caused by the ventilating fans shall be taken into account.

(4) The minimum height of the duct shall be 1.5 m.

(Comment)

1) As for the area of the ventilating openings, structure and capacity of the ventilating fans, etc., the provisions for the design of the Accessory Facility in Chapter 7 shall apply.

2) It is desirable that the ventilating openings will not be installed near the dwelling houses when noises are taking into account. Therefore, the median strip is the optimum location for the ventilating openings. If, under unavoidable circumstances, they have to be installed near the dwelling houses, it is recommended that the ventilating fans be installed away from the ventilating openings.



(a) installed at median

(Ladder-type)

(b) installed at sidewalk

Figure 3.11 Structures of Natural Ventilating Opening

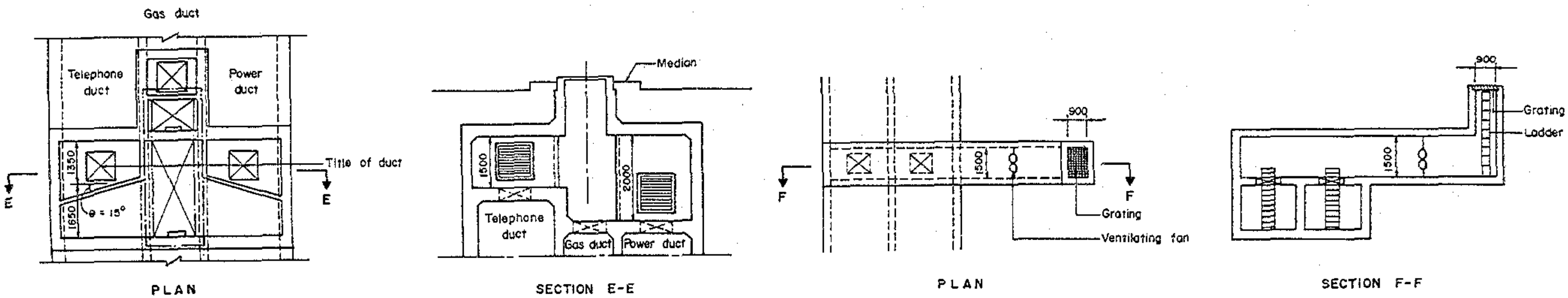


Figure 3.12 Structures of Force Ventilating Opening

3) The interval between a forced ventilating opening and a natural ventilating opening shall be, as a standard, 200 m.

The examples of the forced ventilating opening constructed in Japan are illustrated in Figure 3.12.

6.3) Drainage pit

(1) The drainage pit shall be installed at a concaved portion of the longituninal alignment. The interval shall be, as a standard, 200 ~ 300 m.

(2) It shall be equipped with a mechanism that achieves sedimentation and settling of sand and mud, as well as an oil separation unit.

(Comment)

1) The drainage pits are installed in order to collect the leakage water and seeped water from the ventilating openings, manholes, etc. via the drainage ditches, and to discharge them using drainage pumps.

2) They shall be installed at such places as a longitudinally aligned concaved point, a concaved point at appropriate branch point of underpassing and at suitable points in case there is a gradient over a long distance in the same direction. Also, if a downhill grade is unavoidable at the end of the work that will be continued at the next work phase, it shall be installed without failure.

3) Drain water will be pumped up to the catchment basin provided on the road and then discharged to the drain pipe nearby: connection to the drain pipe is required.

4) It is recommended to provide a hook at the inside of top slab above the drainage pit in order to facilitate the repair of pumps, etc.

5) For the structure of the drainage pit, Figure 3.13 shall be the standard.

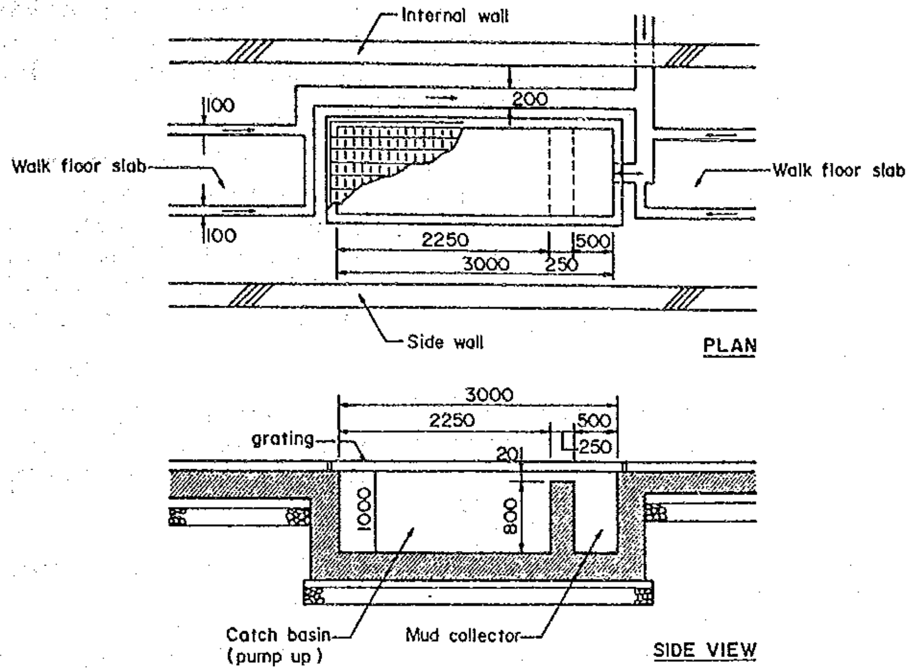


Figure 3.13 Structure of Drainage Pit

6.4) Structure of joints

(1) The common utility duct shall be equipped with joints. Joint interval of 30 m shall be the standard.

(2) For the joints for the common utility duct to be installed on such place that the ground is solid and the terrain and soil conditions are uniform, expansion joints may be used.

(3) For the common utility duct to be installed on the soft ground or where the nature of the ground changes abruptly, or for the common utility duct that is monolithic with other structures, or for the portion liable to structural changes, it is recommended to use flexible joints, as a rule.

(Comment)

1) Since the common utility duct is constructed underground, it is not necessary to take into account the expansion/shrinkage due to abrupt changes in the temperature. However, joints must be provided taking into account the expansion/shrinkage of concrete due to seasonal changes in the temperature and shrinkage due to hardening and the influence of uneven settlement.

2) Joint interval of 30 m shall be the standard for the common utility duct where the change in earth cover is small. However, where the change in earth cover is relatively large or if the uneven settlement can be predicted because of its soft ground, or in case the scale of the common utility duct is large, it is recommended to set the joint interval at 15 m.

3) In addition, it is recommended to provide joints to the portion where the cross section around the special portion is likely to change, the branch connections, turns or where the soil changes significantly.

4) For the structure of joints, Figure 3.14 and Figure 3.15 shall be the standard.

5) Water leakage is likely to occur at the joints because they are so constructed to absorb the deformation, etc. Therefore, utmost care must be given to the waterproofness.

6) It is recommended to provide a joint reinforcement such as collar joints shown in Figure 3.15 to the place where the ground is soft or where the uneven settlement can be predicted.

7) In case of planning breaking point of the horizontal or vertical alignment,it is recommended to provide them near the joints.

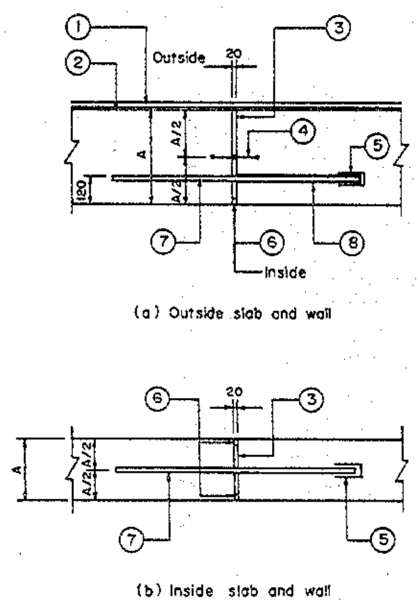


Figure 3.14 Structure of Joint (Strip Bar Type)

No.	Terms of Each Part
1	Mortar for protection (t=30 mm)
2	Waterproof sheet (t=3.2 mm)
3	Elastite (t=20 mm)
4	Water stop (rubber, center valve type, 200 mm width, 9 mm thick)
5	Cap with PVC sponge (o 28 x 150)
6	Joint sealant
7	Slip bar applied asphalt (o 25 x 1,000 ctc 500)
8	Application of asphalt
9	Board (t=10 mm)
10	Mortar for protection (t=15 mm)

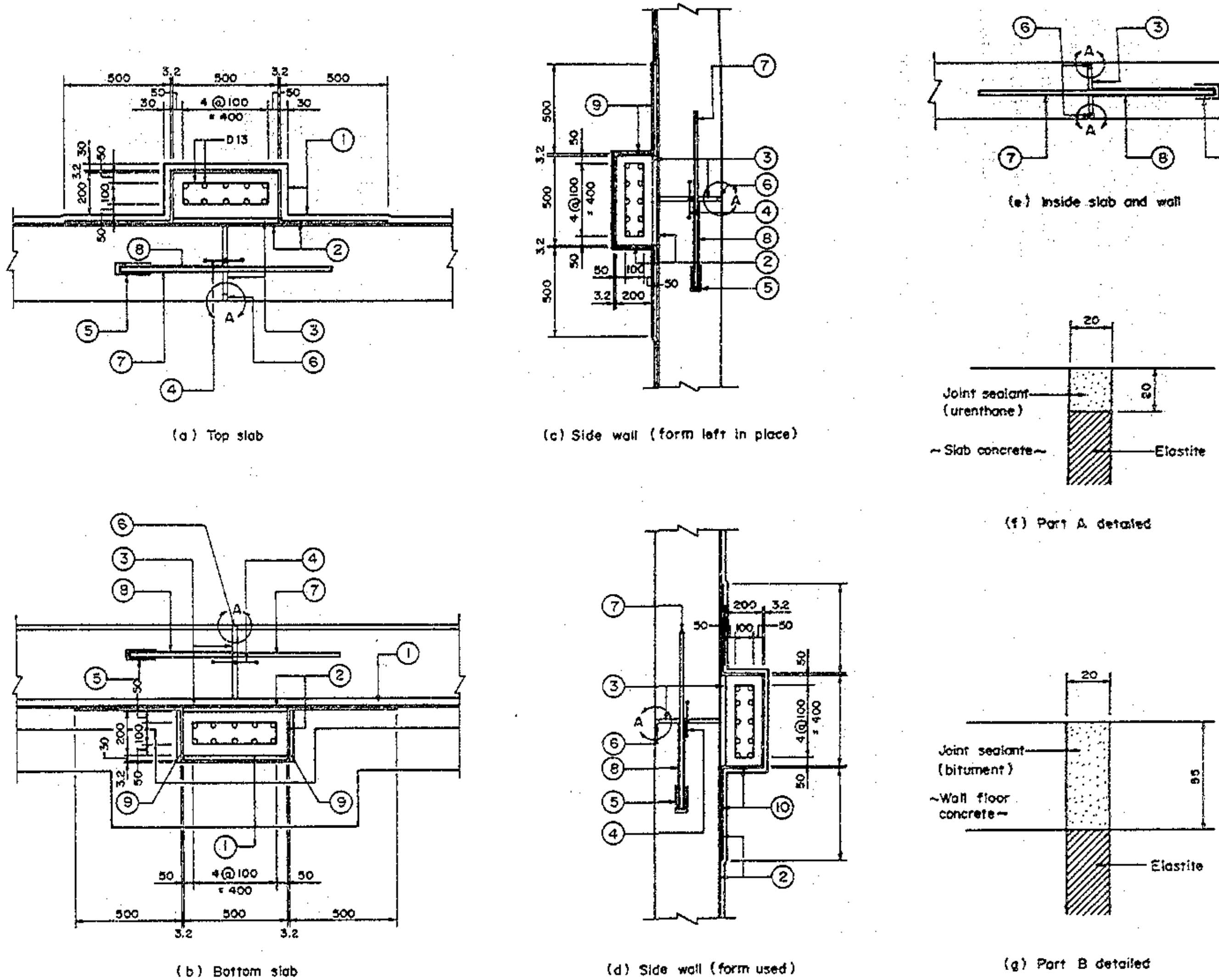


Figure 3.15 Structure of Joint(Collar Type)

8) In the general cases, the width of the water stop is as per shown in Figure 3.14 and 3.15. However, in case the ground is soft, it is recommended to use the water stop of 300 mm wide as shown in Figure 3.16. In case the structure becomes larger, it is recommended to provide strip bars shown in Figure 3.14 at the interval of 500 mm also on the outside. The water stop made of rubber is recommended because it has the following advantages.

1) it has excellent tensile strength and shear strength
2) expansion rate is high
3) cold resistant temperature is low
4) adhesion to the concrete is high
5) workability is excellent.

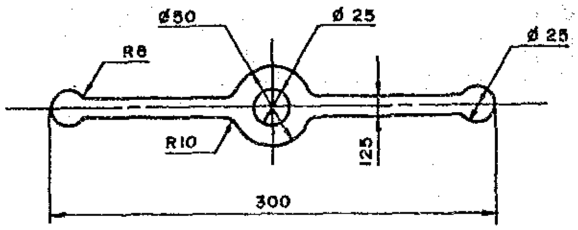


Figure 3.16 Water Stop (Valve Type, 300 mm. width)

Therefore, the water stop made of rubber can cope with relatively large deformation, and has a large resistance to the uneven settlement; it can act as the water stop most effectively.

9) For the common utility duct to be installed on the soft ground or on the place where the terrain changes abruptly, or for the common utility duct that is monolithic with other structures, it is recommended to use flexible joints as shown in Figure 3.17, as a rule.

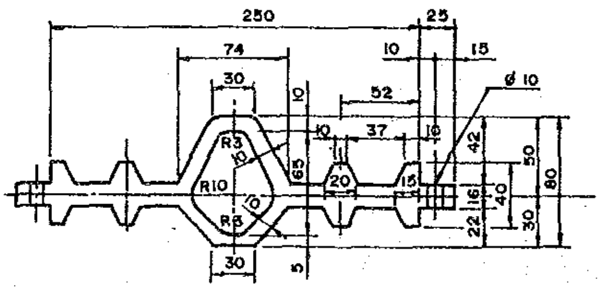


Figure 3.17 Water Stop (Flexible Type)

10) The breaking point of the horizontal and vertical alignment shall be set about 1.0 m away from the joints. However, if the break angle is large, the distance between the joint and the break point is smaller than 0.5 m in the side wall inside the break point, and it is difficult to provide the strip bars, it is recommended that the distance be more than 1.0 m. When determining the position of joint, and the breaking point of horizontal and vertical alignment, refer to Figure 3.18.

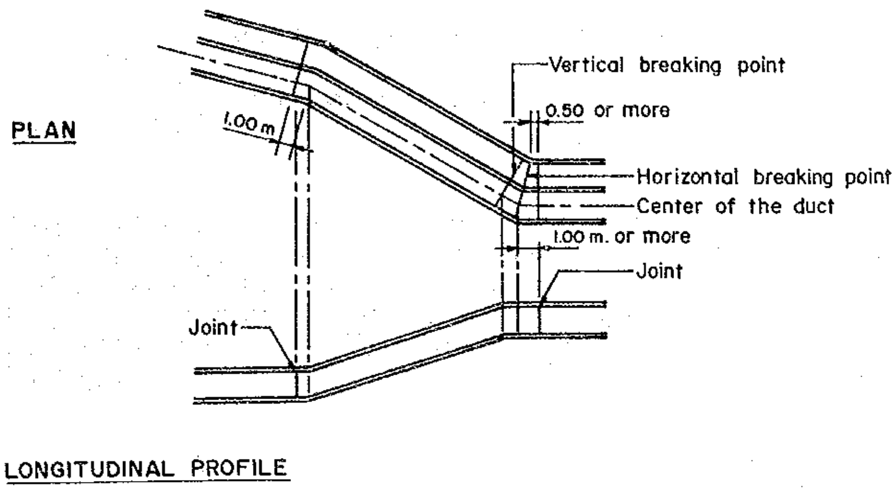


Figure 3.18 Relation between Vertical and Horizontal Breaking Points and Joint

Note: In case the break angle of the plane is large, the breaking points of the horizontal and vertical alignment should be moved.

6.5) Waterproofing

The waterproofing work shall be, as a rule, conducted to the common utility duct so as to prevent the infiltration of the underground water.

(Comment)

1) The purpose of the waterproofing is to protect the interior lighting apparatuses, ventilating and drainage facilities, cables and support apparatuses for conduit tubes from infiltration of underground water, to prevent the deterioration of the common utility duct, to reduce the drainage expenses and to maintain the functions of the common utility duct. Waterproofing shall be provided outside the structures as a rule.

2) The waterproofing work includes:

- Waterproofing
  - Membrane Waterproofing
    - Asphalt Waterproofing
    - Sheet Waterproofing
    - Coating Application Waterproofing
  - Mortar Waterproofing
  - Joint Waterproofing

The waterproofing work method shall be determined taking into account the reliability of effects, degree of difficulty in the execution of work, work cost and influence on the surroundings. In general, sheet waterproofing is recommended. The materials of waterproofing should be withstood for the influence of salty water (chemical damage).

In case of selecting the asphalt waterproofing, the environment on the surrounding residents, such as smoke, smell, fire, etc. as well as the safety and health of the workers must be taken into account.

6.6) Walk floor slab

Concrete of minimum thickness of 50 mm shall be placed on the lower slab in order to prevent abrasion inside the duct and to provide drainage ditches. On that occasion, a gradient of 2% (standard) to facilitate drainage shall be provided on the top surface.

(Comment)

For the non-standard section, if the thickness at the drainage side is set at 50 mm and the thickness at the side wall (raided according to the 2% uphill gradient) exceeds 150 mm, the maximum thickness shall be 150 mm and the degree of gradient shall be corrected accordingly. Joint interval (joint plate of approx. 10 mm thick are placed) shall be about 10 m.

Figure 3.19 shows the typical structure of walk floor slabs.

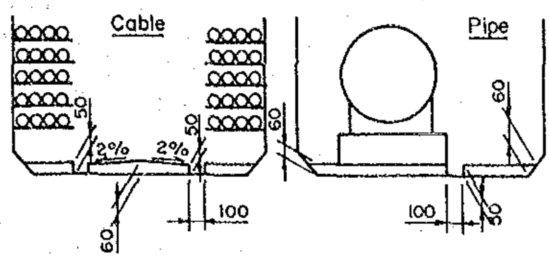


Figure 3.19 Structure of Walk Floor Slab

6.7) Accessory hardware

> The common utility duct shall be provided with the following accessory hardware as necessary.
> (1) Ladder (2) Landing steps
> (3) Lid for ventilating opening (4) Lid for manhole
> (5) Lid for drain pit (6) Guardrail (7) Drain pipe
> (8) Catchment basin

(Comment)

1) Ladder

Movable ladders shall be provided to the exit (natural ventilating opening) so as to give access to the duct.

2) Landing steps

At the rising section of the ventilating opening and manhole without stairs, landing steps shall be provided.

3) Lid for ventilating opening

As a lid for the ventilating opening, a grating with a large effective ventilating cross section shall be used. Since the natural ventilating opening serves also as an entrance, it must be so designed that the opening/closing can be made easily. A lock mechanism must be provided to the lid for security purpose. The grating lid for the forced ventilating opening shall be designed that it can be easily removed in case of replacing the ventilating fans.

In addition, since the grating tends to accept fallen leaves, dust, etc. into the duct, it may cause the clogging of the drain pipe and, thus, the rainwater would be retained. In order to prevent this, it is recommended to install the roof drain to the drain pipe.

The following are the standard for the load to be used for the design of the grating lids.

1) Roadway .... H or HS - loading
2) Sidewalk ....(to be determined in accordance with the site conditions)
3) Inside the duct ... 415 kg/m^2

4) Lid for manhole

1) The inside diameter of the lids for the manholes shall be, as a standard, 750 mm or 900 mm.

2) The material to be used for the lid of the manhole shall be, as a rule, steel that withstands the repeated load applied by vehicles, etc. A lock shall be provided to the lid of the manhole.

5) Lid for drain pit

It shall be removable during the maintenance and repair work of the drain pumps. Also, it must be safe enough when the maintenance personnel, etc. walk on it.

6) Guardrail

Guardrails shall be provided to the both sides of the entrance on the walk floor inside the duct.

7) Drain pipe

Drain pipes shall be provided to the connection of the drain ditches and drain pit, the guide drain from the ventilating opening to the duct and the drain ditches having a difference in level at the lower slab of such non-standard sections as underpassing structure.

8) Catchment basin

In order to collect water pumped up from the drain pit, a catchment basin shall be provided on the road.

(7) <u>Accessory Facility</u>

7.1) Design in general

1) Design principle

When designing the accessory facilities, the following must be taken into account; structure of the common utility duct, utility housing plan, regional situations including roadside environment, power receiving and distribution facility for fans, pumps and lightings.

2) Composition of accessory facilities

The accessory facilities shall consist of drainage, feedwater, ventilation, lighting, power receiving/distribution, and disaster prevention and safety facilities.

(Comment)

1) Drainage facility

A facility that discharges the retained water inside the common utility duct.

2) Feedwater facility

A facility that feeds water to clean the common utility duct and feeds water for fire-fighting. This facility may also be used to feed water to plants.

3) Ventilation facility

A facility that ventilates the toxic gas generated inside the common utility duct, dehumidifies and prevents the temperature increase inside the common utility duct.

4) Lighting facility

Lightings and receptacles inside the common utility duct.

5) Power receiving/distribution facility

Power receiving and distribution facilities for fans, pumps and lightings.

6) Disaster prevention and safety facility

A facility for disaster prevention and to secure the security and industrial safety and health.

7.2) Drainage facility

1) Drainage facility planning

Following shall be the standard of the drainage facility: (1) Electricity: 3 phase 3 wires 400 V (2) Operation and control: Automatic and manual operation by the level control.

(3) Pumps: For the drain pumps,use the underwater sanitary sewerage pump.

As the drainage facility, sluice valve, nonreturn valve, pressure gauge, spare end connection and power receptacles in case of pump failure shall be provided.

(4) Indication device showing pump abnormality shall be provided at the entrance for the maintenance personnel and the service board. The remote indication may be provided as required.

2) Pump capacity

When determining the pump capacity, the following shall be observed.

$$Q = 0.03\, R \cdot L \cdot Fs \quad \ldots\ldots\ldots\ldots (3.23)$$

where

Q : Volume of drainage (l/min)
R : Peripheral length of common utility duct (m)
L : Catchment distance (m)
Fs : Normally, the safety factor shall be 2.

3) Piping

(1) For piping, galvanized copper pipe (SGPW) or hard PVC lined pipes used for the city water piping shall be used.

(2) For the tube fittings, screw type tube fittings made of malleable cast iron, screw type tube fittings made of copper that are galvanized or PVC lined shall be used.

7.3) Feedwater facility

1) Feedwater planning

(1) Feedwater piping shall be carried out: branched feedwater at the feeding point.

(2) Water shall be,as a rule,received near the entrance.

(3) Hydrants shall be positioned, as a rule, at the location where the drain pump is installed, intermediate point between locations intstalling drain pump in each duct, and the natural ventilating opening or non-standard sections.

2) Hydrant and feedwater pipe

(1) Hydrant and feedwater pipe shall be, as a rule, provided near the drainage ditches in the duct and the drain pit.

(2) Feedwater volume shall be determined taking into account the needs for the disaster prevention and for cleaning.

3) Piping

The impact resistant hard PVC pipe shall be used for piping as a rule.

7.4) Ventilation facility

When designing the ventilation facility, the following must be taken into account: ventilating system, position of ventilating openings and accommodation plan of accessory facilities. The following are the standard when planning the capacity of the ventilating fans.

(1) Electricity: 3-phases 3-wires 400 V

(2) Wind velocity at the exit of ventilating opening: less than 5.0 m/sec.

(3) Wind velocity inside the common utility duct: less than 2.0 m/sec.

(4) Air temperature difference at the power duct exit: less than 8° C.

(5) Time required for ventilation: less than 30 minutes

(6) Operation control: remote operation, manual operation, automatic operation

7.5) Lighting facility

The following shall be observed when designing the facility.

(1) Electricity: Power receiving: 1-phase 3-wires 220 V or 400 V
Power distribution: 1-phase 2-wires 220 V or 400 V

(2) Average illuminance: 15 lux

(3) For the reflectance rate of the ceiling and walls made of concrete, 25% shall be the standard for power, telephone and gas ducts.

(4) Receptacles shall be provided inside each duct at an interval of 10 m as a rule. Receptacles may be provided near the non-standard sections. As for the calculation of voltage drop, the capacity per one receptacle shall be considered as 150 VA.

7.6) Power receiving and distribution facility

(1) Service board shall be the outdoor self-supported enclosed type made of steel plate with sufficient durability and must be easy to do the maintenance and inspection. In addition, the earth leakage breaker shall be provided to the service board.

(2) The distribution board for lighting facilities, control boards for fans and pumps, and instrument panel in each duct shall be the indoor wall-mounted enclosed type made of steel plate with durability and must be easy to do the maintenance and inspection.

In addition, the earth leakage breaker shall be provided to each branch circuit.

7.7) Disaster prevention and safety facility

The disaster prevention and safety facility includes the following. They must be systematically arranged, taking into account the types of utilities to be housed, roadside conditions, the purpose of installation, time of installation and the control and management manners of the facilities.

(1) Alarm system: automatic fire alarm system, inflammable gas detector, anomalous flooding alarm system, trespass monitoring system.

(2) Fire-fighting system: fire extinguisher, automatic fire-fighting system.

(3) Communication, reporting system: private telephone system for communication, emergency alarm system.

(4) Fire escape guide system: guide display board, fire escape guide lamp.

(5) Other facilities: partition wall, water break doors,oxygen deficiency detection and monitoring, sprinkler system.

7.8) Signs

The guide signs, control signs and warning signs shall be provided inside the common utility duct.

(Comment)

(1) Types of signs

There are following types of signs:

1) Guide signs: point sign, point name, name of intersection (indicates the intersection with road, river and railroad), entrance/exit, emergency exit, position guide (general plan), guide classified by company, guide for branch duct classified by company, etc.

2) Control signs: distribution panels, drain pumps, ventilating fans, control boards, switches, receptacles, security equipment (gas detector, gas alarm, sprinkler, smoke detector, fire detector, temperature detector), power boundary (powder boundary of accessory facilities), control boundary, etc.

3) Corporate signs: indicates the facility of each company

4) Warning signs: Watch your head, Danger, Do not touch, Watch your step, Caution: Flammable, No smoking, extinguisher.

3.2 Cable Box (CAB) Utility Duct

3.2.1 General Planning Consideration

(1) Installation Planning

CABs shall be constructed independently of, or side by side with, related works

(Comment)

CABs must be constructed through adjustment with public utility providers or other projects and taking into consideration the continuity of CAB's and maintenance problems. If concurrent construction is possible, it is recommended to carry out the construction simultaneously with other large scale projects, such as common utility duct construction, street construction, and reconstruction under urban planning, and other public works.

(2) Structural Classification of CAB

The structural type of CABs shall be selected taking account of the type and installation location of cables.

(Comment)

The CAB structure can be classified into the standard sections and non-standard sections. The general inner space of the standard sections is the U-shaped space with cover plate.

The non-standard sections include conduits, approaches to the starting point and terminal, deformed sections and cable connecting section. The conduits comprise curved sections (plane or longitudinal) to be constructed on sidewalks and branch road crossing sections. Both curved sections and branch road crossing sections must be constructed of sheathed pipes accommodated in box culverts or protected by concrete in order to facilitate the replacement of cables.

The structural composition of CAB is, as illustrated in Figure 3.20, a variety of structural types are selected for the non-standard sections to meet different site conditions.

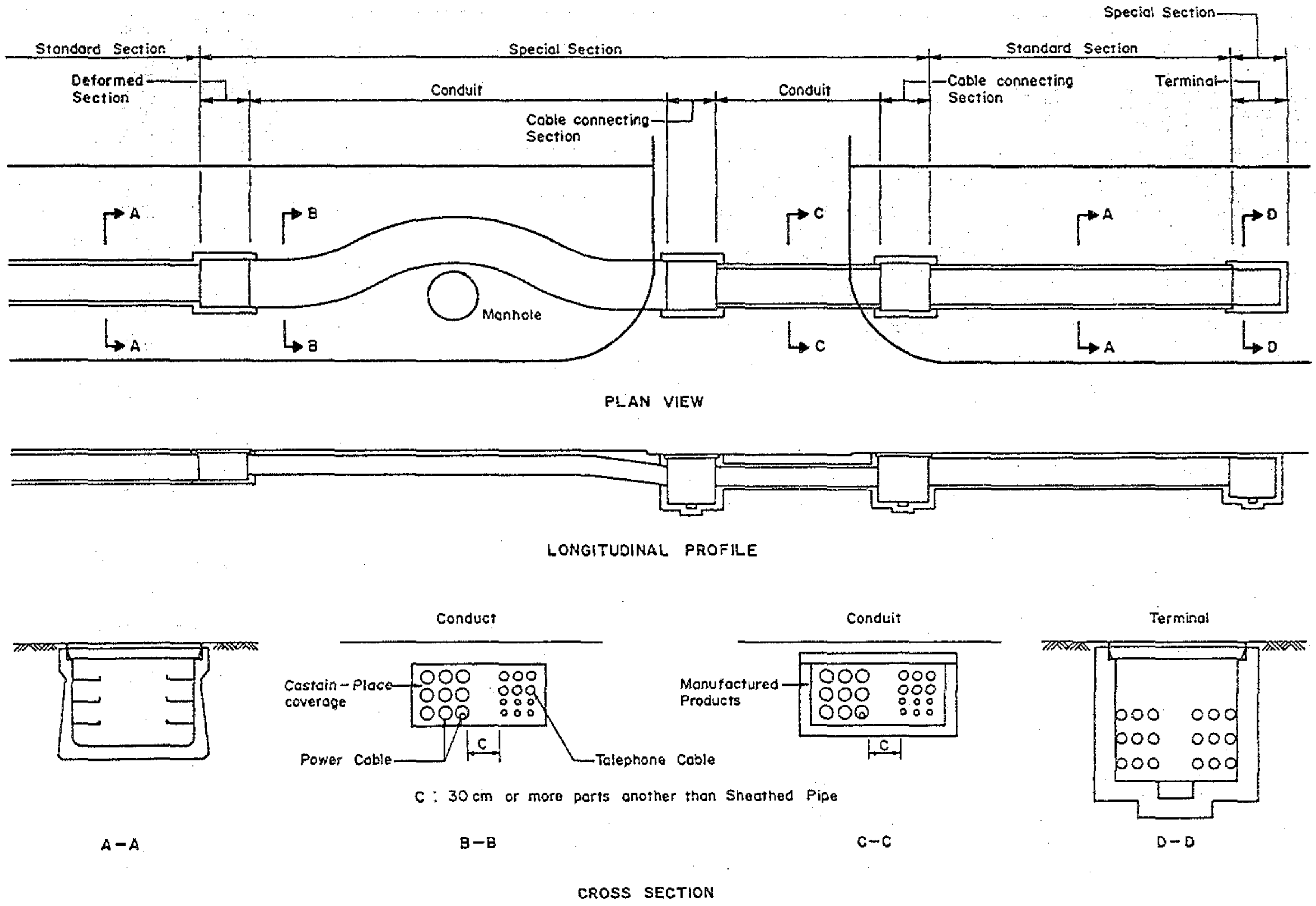


Figure 3.20 Example of Structural Composition of CAB

3.2.2 Geometric Design

(1) Inner Space

1.1) Standard Section

The inner space of standard sections shall be determined taking into consideration the type and number of cables to be housed, cable spacing, working space and other relevant factors. The inner dimensions shall be in accordance with Table 3.10 and Figure 3.21.

Table 3.10 Inner dimensions of CAB

Dimensions	Symbol	Definition
Height	H = hi+C	hi: Spacing between brackets C : Spacing between the lowermost bracket and floor slab
Width	W = a+S+b	a,b: Required width of cables to be placed by their provider S: Working space

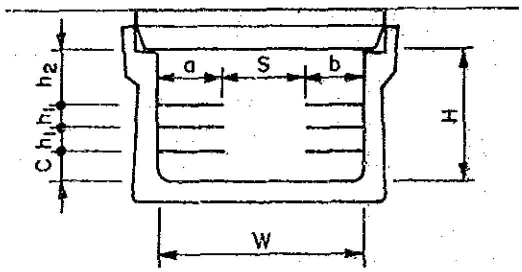


Figure 3.21 Inner Dimension of CAB

(Comment)

1) Cables to be housed in CAB include power cables, telephone cables, cables for road lighting, traffic signals and road information control, and CATV (cable television) cables. In accordance with laying plans for these cables, the basic inner space of CAB is to be determined taking account of cable spacings, required cable length, working space and other relevant factors.

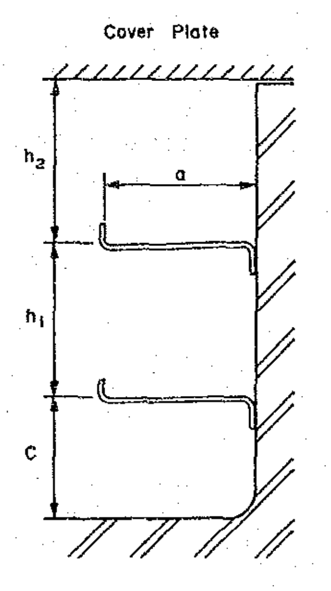
Based on the basic inner space, determination of the inner space of the standard sections will be made taking into consideration the existing buried facility, lead in cables to private land, sidewalk width, paving plan, etc.

2) Determination of the working space shall take into account the following considerations:

(a) Sidewalk width
(b) Required distance between high and low tension cables and telephone and other cables
(c) Number of tiers of shelves
(d) Inner height of CAB
(e) Type of cables and workability of connecting them

3) The standard values for the required widths of cables to be placed by their provider and spacings between brackets shall be in accordance with Table 3.11.

Table 3.11 Interval and Width of Bracket



	Type and number of cables	a	h1	h2
Power cable	3 low tension cables	25	20	25~20
	High tension cables	25	20	
Tele-phone cable	Up to 4 metallic cables	25	20	25~20
	Optical fiber cables	25	20	25~20
Others	Cables for data transmission and for road traffic control	25	20	

These values should be determined finally based on the installation plan of each provider.

4) Care shall be taken to prevent power cables from being spaced so close as to cause inductive interference to telephone and other cables. If the distance between a power cable and other cables is less than 30 cm., a solid fireproof partition wall must be provided between them.

5) Where a high tension power cable is to be spaced less than 30 cm. apart from other cables, it must be provided with noncombustible covering or a solid fireproof partition wall must be provided between them.

6) The distance, C, between the lowermost cable and the floor slab shall be determined with due regard for the need to facilitate taking out the cable.

7) The position where the lowermost cable is to be drawn out shall, as a rule, be 60 cm. or more below the ground level as shown in Figure 3.22, except where there is no safety problem and no interference with road construction works.

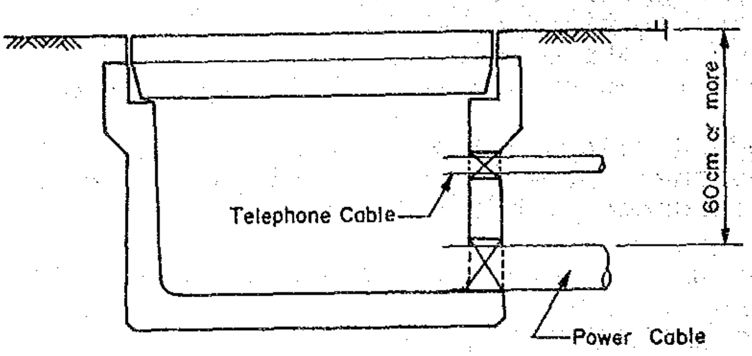


Figure 3.22 Position of Cable Drawn Out

8) The standard inner space of CAB is as illustrated in Figure 3.23 (an example of CAB accommodating relatively large number of cables and a wide sidewalk)

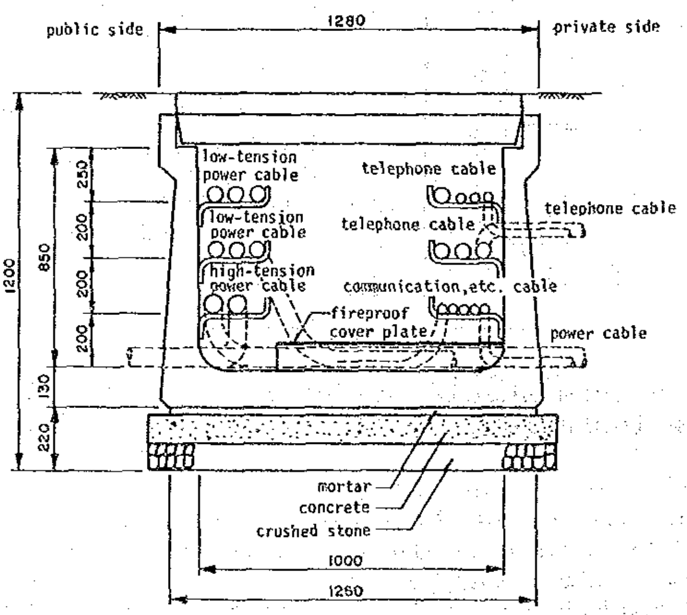


Figure 3.23 Standard Inner Space of CAB

1.2) Non-Standard Section

a) Conduit

The conduit shall have the alignment so as to permit accommodating lead-in cables and shall consist of sheathed piped laid, as a rule.

(Comment)

1) The number of sheathed piped to be laid in the conduits must be determined having regard for additional pipes which may be required in future.

2) Conduits may be constructed of sheathed pipes covered with concrete or constructed of boxes with sheathed pipes or perforated pipes laid inside.

3) Where culverts are to cross a branch road and it is necessary to open the culvert system to public traffic at an early date, precast concrete box culverts shall be used. In installing the box culverts, attention must be paid to the foundation and connection of culverts so as to prevent heavy vehicle loads from inducing differential settlement of the culverts.

4) It is general practice to protect sheathed pipes in the culverts along a sidewalk with concrete or other appropriate materials.

5) Spacing between sheathed pipes is to be determined having regard for workability of the laying of the pipes and cables. Sheathed pipes may be constructed of steel, cast iron or hard PVC.

6) The inside diameter of sheathed pipes is determined from cable diameter. The standard nominal diameter is 130 mm. for power cables and 75 mm. for telephone cables.

b) Deformed Section

The deformed section shall be provided where the required inner space differs from the standard section at the joint between the U-shaped structure and the conduits.

(Comment)

1) The deformed section is the joint between the U-shaped structure and the conduit. Generally, the joint is provided at the end of the U-shaped space of a standard section.

However, the deformed section may sometimes take the form of a different U-shaped space.

2) The deformed section is the part where a large number of cables tend to be gathered. Therefore, the arrangement of sheathed pipes must be determined taking account of spacing between cables.

3) Where water tend to stay at a deformed section, it is necessary to provide a drain pit.

c) Cable connecting section

A cable connecting section shall be provided where cables need to be connected. It shall be a structure which also performs the function of a drain pit, as a rule, and shall be provided on either side of a branch road crossing.

(Comment)

1) At the branch road crossing where cables need to be connected, they require a cable connecting section. The cable connecting section accommodates both through cables and connecting cables, and it is required the inner space dimensions allowing for spaces for arranging these cables, installing a detachable ladder and working.

2) In planning the cable arrangement at the cable connecting section, spacing between high tensile cables and telephone cables or other cables should be studied carefully in full.

3) Water tends to collect at the branch road crossing section so that the cable connecting section should be a structure served as a drain pit in general.

d) Starting and terminal section

The starting and terminal section of CAB shall have an inner space allowing for leading in cables of each provider and shall, if necessary, be a structure served as a drain pit.

(Comment)

The height of required earth cover for buried cables must be 60 cm. or more in the sidewalk and 1.2 m. or more in the carriageway. In consequence, it may be necessary to adjust the position of cables in standard sections so as to secure the required thickness for earth cover outside CAB.

(2) Earth cover

The height of earth cover shall be equal to the thickness of the surface course at the sidewalk and greater than the design pavement thickness at the branch road crossing, as a rule.

(Comment)

1) The height of earth cover refers, in case of the U-shaped inner space, to the distance between the road surface and the top surface of the cover plate of CAB and, in the case of the conduit system, to the distance between the road surface and the top surface of the upper slab. The design pavement thickness refers to the distance from the surface course to the sub-base.

2) The height of earth cover shall be determined having due regard for the width and structural specifications of branch roads, etc. If it is impossible to secure a greater earth covering thickness than the design pavement thickness due to existing buried facility, it is desirable to avoid using crushed stones in the sub-base above CAB.

3) For sidewalk pavement, it is necessary to select materials to be used and pavement structure having due regard for the environment of the area where CAB is constructed, and future paving plans.

4) The height of earth cover for the sidewalk shall be equal to the thickness of the surface course of an asphalt pavement or that of flat block pavement.

Figure 3.24 and 3.25 show the earth cover of CAB at sidewalk and branch road crossing section, respectively.

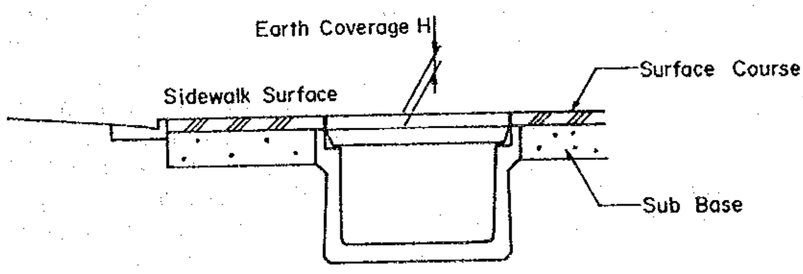


Figure 3.24 Earth Cover of CAB at Sidewalk

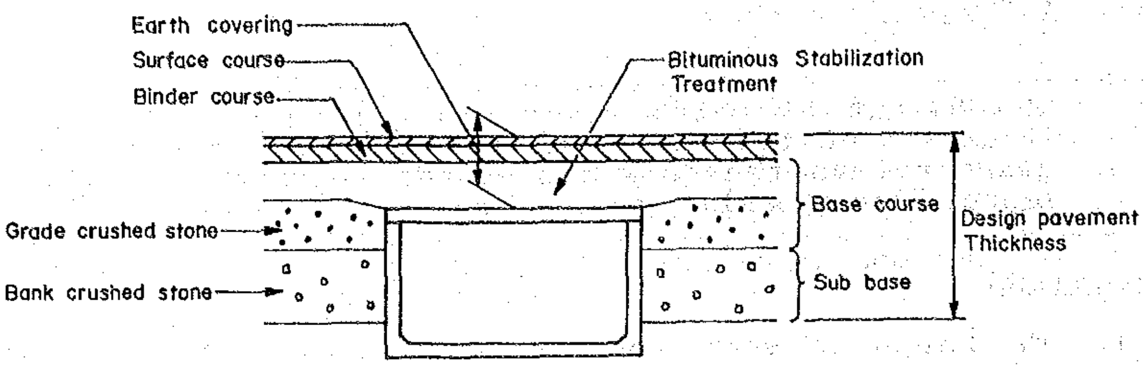


Figure 3.25 Earth Cover of Branch Road Section

(3) Alignment

3.1) Location and horizontal alignment

1) CAB shall be constructed under sidewalks as a rule.

2) The horizontal alignment of CAB shall be parallel to the boundary between the sidewalk and roadway as a rule. It shall be determined taking full account of the actual conditions of the sidewalk and future plans (including adjustment to other projects).

3) The distance between the external wall of CAB and the boundary between the public and private land shall be 1 m. or more as a rule.

4) If CAB is to be curved,the radius of curvature shall be determined taking account of the workability of laying cables.

(Comment)

1) From the standpoint of planting zones and pavements, it is necessary to provide CABs parallel to the boundary between the sidewalk and the roadway.

In constructing CABs, care must be taken so as to minimize the need for relocation of existing buried facility. If the construction of CAB affects the rooting of street trees, it is necessary to take measures, such as preservative treatment of cut roots and reinforcement of supports for the trees.

2) It is desirable that the distance between the external wall of CAB and the nearest public - private boundary should be

kept 1 m. or more, to improve workability of the construction of CAB and leading-in of cables. If this cannot be done due to the sidewalk width and the condition of existing buried facility, it is necessary to determine the distance with due regard for the workability of the construction.

3) The installation location of CAB must be determined taking into account of existing buried facility, distance to the boundary between the public and private land, spaces for installing a distribution boards, transformer, multi-circuit switch and other, future need for lowering the sidewalk and other relevant factors.

4) If sheathed pipes are to be provided with a curve, it is necessary to calculate lateral pressures or tensile forces acting on cables during their laying and to determine the radius and length of curvature which will not damage the cable characteristics. Generally, the desirable minimum radius of curvature of cables is 5 m. or more.

3.2) Vertical Alignment

1) The vertical gradient of CAB shall be adjusted to that of the sidewalk as a rule.

2) The vertical gradient may make level at the section crossing the branch road.

3) If the CAB is to be provided with a vertical curve, the radius of curvature shall be determined with due regard for the laying of cables.

4) The horizontal curve and vertical curve shall not be combined, as a rule.

(Comment)

1) The vertical gradient of CAB in the sidewalk must be adjusted to that of the sidewalk as a rule, where water tend to stay, it is necessary to provide drain pits.

2) For the branch road crossing section, CAB is generally constructed of conduits and has a limited length. For this reason, the gradient may be level. For the approach to the crossing sections, a drain pit must be provided.

3) For the approach to the branch road crossing as shown in Figure 3.26, care must be taken to avoid providing a steep gradient which makes it difficult to lead cables in.

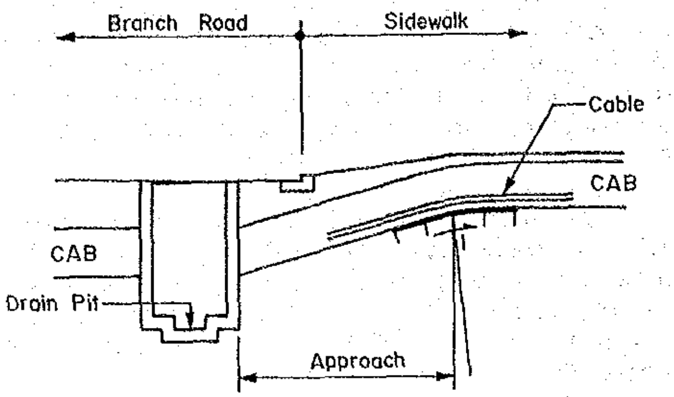


Figure 3.26 Profile of Approach

4) A combination of a horizontal curve and vertical curve will make the CAB structure complex and result in a limited cable radius of curvature, thus rendering it difficult to lead cables in.

3.2.3 Structural Design

(1) <u>Loading</u>

1.1) Type of Loads

The CAB design shall take account of the following loads: 1) Dead load, 2) Live load, 3) Impact, 4) Earth pressure, 5) Water pressure, 6) Buoyancy, and 7) Load to be hoisted.

(<u>Comment</u>)

Listed above are the loads considered in CAB designs. These design loads are described below in some detail.

1.2) Dead Loads

Calculation of dead loads may use unit weights shown in Table 3.12. However, where real weights are known, they shall be used for the calculations.

Table 3.12 Unit Weight of Materials

Material	Unit Weight	
Steel, cast steel, forged steel	7,850 kg/m3	490 lb/cu.ft
Cast iron	7,200	450
Concrete, plain or reinforced	2,400	150
Bituminous material (for waterproof)	1,100	70
Asphalt concrete pavement	2,300	145
Crushed stone	2,100	135
Cement mortar	2,150	135
Timber	800	50
Back filled soil (above ground-water level)	1,900	120
Back filled soil (below ground-water level)	1,000	65

1.3) Live Load

Live load shall be vehicle load or sidewalk live load.

(1) Live load for designing CAB in sidewalk

1) Vehicle load shall be H-15 loading as a rule and shall be placed in such manner as to produce the most disadvantageous stress in structural members to be designed. However, the H-20 loading shall be taken for those areas where heavy vehicles are likely to pass.

2) Sidewalk live load shall be a uniform load of 415 Kg/m2.

(2) Live load for designing CAB in branch road

1) Vehicle load shall be H-20 loading as a rule and shall be placed in such a manner as to produce the most disadvantageous stress in structural members to be designed.

2) For branch roads of low class, H-15 load shall be taken depending on the condition of vehicular traffic.

(Comment)

1) H-loadings are as listed in Table 3.13.

Table 3.13 H-loadings

Load	Gross load	Front wheel load	Rear wheel load	Front wheel zone breadth	Rear wheel zone breadth	Length of ground contact of wheel
	W(t)	W(t)	W(t)	b_1(cm)	b_2(cm)	a(cm)
H-20	36.2	3.6	14.5	12.5	50	20
H-15	27.2	2.7	10.9	12.5	50	20

2) The reasons for using the H-loading in CAB design for sidewalks as live loads are as listed as follows.

(a) CABs are generally constructed in commercial areas.

(b) Land use along roads has undergone drastic changes.

(c) Sidewalks are lowered at many places.

(d) The heavy weight vehicles (HS-loading) reach service stations, but there is not much of this vehicular traffic.

(e) In case of disasters, fire engines sometimes enter sidewalks, but this happens with limited frequency.

However, live loads may be reduced according to the actual conditions of the road where CABs are to be constructed.

3) Vehicle loads considered in designing CAB in the sidewalk are assumed to be those moving at right angles with the CAB.

In case of vehicular movements not limited to the direction normal to the CAB, it is necessary to examine those vehicular loads moving in assumed directions as well.

4) For branch roads of low class, H-15 loading can be used for design live load if they are narrow in width and rarely have heavy-duty vehicle traffic.

5) These loads should be loads distributed at an angle of 45 degrees.

6) Distributed load, L, due to of live loading.

a) The distributed load with earth covering height of 40 cm. as shown in Figure 3.27 is calculated following equation:

$$L = \frac{P}{(2H + a) \cdot (2H + b2)} \quad \text{.........................(3.24)}$$

where

P : Rear wheel load x (1 + impact coefficient)
H : Earth covering height
a : Length of ground contact of wheel
b_2: Rear wheel zone breadth

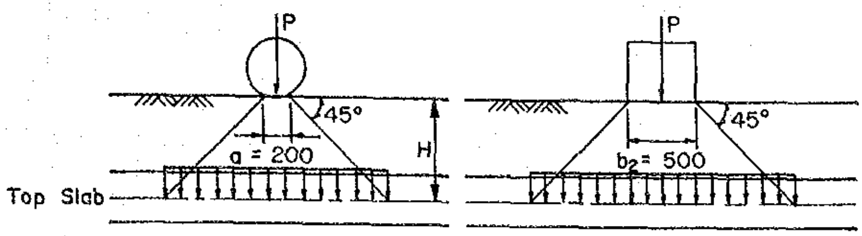


Figure 3.27 Distributed Load due to Live Loading (H < 40cm)

b) Distributed loads with earth covering height of over 40 cm. as shown in Figure 3.28 are given by the following equation.

$$L = \frac{P}{2H + a} \quad \text{.....................................(3.25)}$$

where

$$P = \frac{2 \text{ x rear wheel load}}{\text{vehicle occupied width}} \cdot (1 + \text{impact coefficient}) \quad \text{...................(3.26)}$$

H: Earth covering height
a: Length of ground contact of wheel

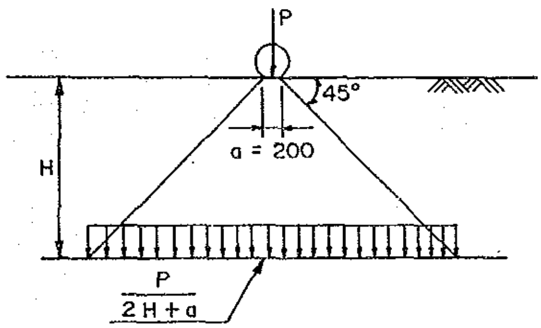


Figure 3.28 Distributed Load due to Live Loading (H > 40cm)

1.4) Impact

> Live loads shall be considered as producing impact. However, impact may be neglected for sidewalk live loads and those loads used for designing the side wall for U-shaped structure.
>
> The impact coefficient shall be in accordance with Table 3.14.

Table 3.14 Impact Coefficient

Description	Impact coefficient
Cover plate and base slab of side walk	i = 0.1
Structure of branch road	i = 0.3

(Comment)

1) The U-shaped structure must be constructed in the sidewalk as a rule and is assumed to be little affected by wheel loads on the carriageway. If the structure is constructed very close to the roadway, however, it is necessary to take into account of the effects of impact produced by wheel loads on the carriageway.

2) For the sidewalk, the impact coefficient for cover plates and base slabs is taken as i = 0.1 in consideration of a very slow speed of vehicles.

3) For the structure of branch road, the impact coefficient is taken as i = 0.3 as same as trunk line & supply common utility duct.

1.5) Earth Pressure

Earth pressure shall be considered as a distributed load acting on the side wall. Its load per unit area shall be as follows:

(1) Earth pressure acting on the U-shape structure shall be obtained by the equations of 3.26 and 3.27.

1) Earth pressure

$$Pa = KA \cdot r \cdot x \quad \text{......................} (3.27)$$

2) Wheel load per unit area

$$Px = KA \cdot \frac{T}{(a + x)\ (b + 2x)} \quad \text{.............} (3.28)$$

Pa: Active earth pressure per unit area at depth x (t/m^2)

Px: Earth pressure per unit area due to wheel load at depth x (t/m^2)

KA: Coefficient of active earth pressure at Coulomb earth pressure

r: Unit weight of earth (t/m^3)

T: Wheel load (t)
a: Length of ground contact of wheel (m)
b: Wheel zone breadth (m)
x: Depth at which earth pressure Pa and Px act on wall(m)

(2) The earth pressure acting on box conduits shall be obtained by the equation of 3.29.

$$Ps = K \cdot (L + r \cdot x) \quad \ldots\ldots (3.29)$$

Ps: Static earth pressure at depth x (t/m^2)
K: Coefficient of static earth pressure(generally 0.5)
L: Distributed load per unit area of live load at depth x (t/m^2)
r: Unit weight of earth (t/m^3)
x: Depth at which earth pressure Ps acts on wall (m)

(Comment)

1) The magnitude of earth pressure varies with the type of structures and soil characteristics.

Assuming that in the U-shaped structure the wall tends to be displaced as compared with the box conduit, the active earth pressure was adopted. On the other hand, the static earth pressure was taken for the box conduit on the assumption that the wall does not develop displacement in the box conduit.

2) The Coulomb's coefficient of active earth pressure was adopted in accordance with the "Japanese Specifications for Highway Bridges". If the ground surface is horizontal and the wall is vertical, the coefficient is given by the following equation.

$$KA = \frac{\cos^2(F)}{\cos(S) - 1 + \left(\sqrt{\frac{\sin(S + F) \cdot \sin(F)}{\cos(S)}}\right)^2} \quad \ldots\ldots (3.30)$$

F: Angle of shearing resistance of earth (degree)
S: Angle of friction of wall between the back of the wall and earth (generally S = F/3)

3) The coefficient of static earth pressure (K) varies with the soil characteristics and the method of compaction, ranging from about 0.4 to 0.7. For the purpose of our design, however, the value K = 0.5 was adopted for normal sandy soil or cohesive soil.

1.6) Water Pressure

The value for static water pressure shall be obtained by following equation;

$$Pw = Rw.h \quad \cdots\cdots (3.31)$$

where
- Pw: Static water pressure at depth h(m) from ground water level (t/m^2)
- Rw: Unit weight of water (t/m^3)
- h: Depth from ground water level (m)

(Comment)

The calculation of static water pressure complies with the Design Guideline for Underground Utility Ducts. For the purpose of our design, however, the effects of pore water pressure are ignored in consideration of ordinary CMB's being constructed at shallow depth.

1.7) Buoyancy

Buoyancy works vertically on the structure in such a manner as to be most disadvantageous to it.

(Comment)

Buoyancy as termed herein refers to a force produced by upward static water pressure acting on the bottom of a structure. Fig. 3.29 illustrates an example of clear behaviours of buoyancy and Fig. 3.30 an example of unclear behaviours of buoyancy.

Fig. 3.29
Ground of High Water Permeability, such as Sand Layer or Gravel layer

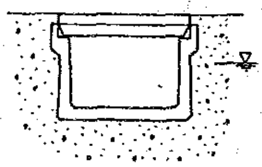
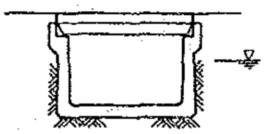


Fig. 3.30
Cohesive Ground of Non-permeability



Where the behaviour of buoyancy is clear, this must be considered. If the behaviour is not clear, buoyancy is considered to act where water tends to enter over time, and depending on how a structure rests on the soils and how it shuts off water.

Thus, in order to be conservative, the design must adopt an adequate factor of safety against buoyancy.

In ordinary sidewalks, however, the ground water level is low and buoyancy can often safely be ignored. In case of obviously high ground water level, however, an appropriate measure must be considered to prevent the effects of buoyancy from being produced on the structure.

1.8) Load during Hoisting of Structural Members of CAB

It is necessary to take account of the effects of loads acting on structural members of CAB while they are hoisted for installation in place during the CAB construction.

(Comment)

When the cover plates of CAB are opened and closed during its installation in place and after its completion, it is necessary to ensure that the structure remains secure against a load acting during hoisting of the structure.

(2) Allowable Stresses

The allowable stresses shall be as indicated in Table 3.15.

Table 3-15 Allowable Stresses

Material	Item	Allowable Stress (Kg/cm^2)	
		Cast-in-place Concrete	Factory-produced concrete
Concrete	Design strength	210	300
	Bending compre-ssive stress	70	105
	Shearing stress	3.6	5
	Bond stress (deformed bar)	14	18
	Bearing stress	60	90
Reinforcing bar SD30 of slab	General member	1,800	
	Member of Upper floor slab and cover plate subjected to heavy-duty traffic	1,400	
	Member below ground water level	1,600	
	When calculating length of lap joint and auchored length of bar	1,800	
Steel	(SS41)	a = 1,400	a = 800

(Comment)

1) The allowable stress for cast-in-place concrete conforms to the Part III, concrete Bridge, of the Japanese Specifications for Highway Bridges and the allowable stress for factory-produced concrete conforms Standard Concrete Specifications prepared by the Japan Society of Civil Engineers.

2) The allowable stress for reinforcing bars conforms to the Part III, Concrete Bridge, of the Japanese Specifications for Highway Bridges. General structural members referred to include the following:

   (1) Cover plates of that part of CAB installed in the sidewalk.
   (2) Upper slabs of the structure in the branch road where the inner space is filled with concrete.

(4) <u>Arrangement of reinforcement</u>

4.1) Covering of main reinforcement

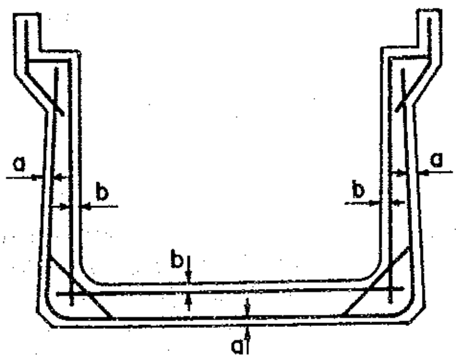
The covering of main reinforcement shall be in accordance with

Table 3.16 and Figure 3.31.

Table 3.16 Covering for Main Reinforcement

Unit: mm

Kinds of concrete \ covering	a		b	
Factory-produced concrete	D<12	$12 + \frac{D}{}$	D<12	$12 + \frac{D}{}$
	D>12	$D + \frac{D}{2}$	D>12	$12 + \frac{D}{2}$
Cast-in-place concrete	D<16	50	40	
	D>16	65		



a: Outside covering
b: Inside covering
D: Diameter of reinforcement

Figure 3.31 Covering of Main Reinforcement

(Comments)

The value for covering indicates the distance from the concrete surface to the center of reinforcement.

The above values are set in accordance with "Japanese Concrete Standard Specifications".

1) Covering of factory-produced concrete products

Taking into account of the assembly and process dimensions are more accurate and the arrangement of reinforcement is better controlled for factory-produced concrete compared to the cast-in-place concrete, it is not necessary to raise to unit fractions: the values may be used as they are calculated.

2) Covering of cast-in-place concrete

a) Outside covering (a)

In case the diameter of reinforcement is less than 16mm, supposing that net cover directly contact with earth and the diameter of reinforcement are 40mm and 13mm, respectively, the value is calculated as follows.

$a = 40 + 13/2 = 46.5mm \fallingdotseq 50mm$

In case the diameter of reinforcement is 16mm and over, supposing that net covering directly contact with earth and the diameter of reinforcement are set at 50mm and 25mm, respectively, the value is calculated as follows.

$a = 50 + 25/2 = 62.5mm \fallingdotseq 65mm$

b) Inside covering (b)

The net covering shall be larger than the diameter of reinforcement and more than 20mm.

The net covering shall be as same value as the diameter of reinforcement. The diameter of reinforcement is set at 25mm for the following reasons: the structure is relatively small, the thin members are generally used.

$b = 25 + 25/2 = 37.5mm \fallingdotseq 40mm$

The above values are raised to a unit taking into account of the construction tolerance, etc.

4.2) Maximum diameter of main reinforcement

The maximum diameter of main reinforcement shall, in general, be less than 1/10 of the thickness of members.

(Comment)

If a larger reinforcement is used for the thin members, cracks may occur at the time of concrete placing. Therefore, the diameter of reinforcement is set as above value which is appropriate to the slab thickness.

4.3) Main reinforcement

> The spacing of main reinforcements shall be more than 50mm for the shop fabricated products and 125mm for cast-in-place concrete as a standard. However, this shall not apply in case of two-way slabs, where the main reinforcement are also arranged in the direction of distribution bars.
>
> The area of longitudinal reinforcement shall be more than 1% of the cross sectional area of the concrete in case the thickness of the member wall to which shearing force is applied is thin and it is not possible to arrange the diagonal tension bars.

(Comment)

1) The spacing of main reinforcement for cast-in-place concrete are, in general, 100mm, 125mm, 150mm pitches. However, the calculation made in accordance with the Japanese Concrete Standard Specifications, in case the maximum diameter of main reinforcement is 25mm and maximum size of coarse aggregate is 25mm, indicates that the minimum spacing is 59mm for horizontal bars. The Japanese Concrete Standard Specifications specifies that the maximum spacing of slabs must be

   less than 300mm. Taking into account of those values and workability, 125mm is set as the standard for cast-in-place concrete.

   As for factory-produced concrete, sufficient execution control can be expected. Therefore, when the maximum size of coarse aggregate is set at 20mm and the maximum diameter of reinforcement is set at 19mm, the minimum spacing is calculated at 46mm. Thus, it is specified that the spacing shall be more than 50mm.

2) It is recommended that the spacing of main tension reinforcements which are subject to wheel load shall be smaller than the value of the thickness.

3) Minimum quantity of longitudinal tension reinforcements are specified in accordance with "Japanese Specifications for Highway Bridge" in order to prevent the rapid shear fracture.

4.4) Distributing reinforcements

> The quantity of distributing reinforcement shall be, as a rule, more than 1/5 of the quantity of tension main reinforcements. The spacing shall be less than twice the member thickness and shall be less than 200mm.

(Comment)

The minimum quantity and maximum spacing of distributing bars are specified taking into account the fact that, because the earth covering is thin and unit load per travel wheel similar to concentrated load may be applied, it is necessary to arrange sufficient reinforcement in the direction perpendicular to the main reinforcement.

4.5) Lap splice length and bent radius of reinforcing bar

> The lap splice length, bent radius and arc length shown in Table 3.17 shall be the standard.

Table 3.17 Lap Splice Length, Bent Radius and Arc Length.

Diameter of Reinforcement	Lap Splice Length			Bent Radius	Arc length
	l	a	b	R	L
D25	875	375	500	270	424
D22	770	330	500	240	377
D19	665	285	380	200	314
D16	560	240	320	170	267
D13	455	195	260	140	220
D10	350	150	200	110	173
D 6	210	90	120	65	102

(Comment)

1) The lap splice length and bent radius are based on "The Technical guidelines of the trunk and supply line common utility ducts; refer to chapter 4.2.2(5)"

2) 35d is used for the lap splice length, d is the diameter of the reinforcing bar.

3) 15d and 20d are used for the lap splice length a and b, respectively.