CHAPTER 2. SURVEY

2.1 General

This chapter prescribes the standard methodology for necessary surveys which provide the basic and preliminary information for analysis and formulation on the urban drainage improvement plan.

Explanation:

There are various alternative structural measures for urban drainage improvement such as drainage channel improvement, construction of flood detention and retention facilities and installation of drainage pumps. The field conditions related to drainage should be fully surveyed in order to select the optimum measure among these alternative measures. The major items to be surveyed are enumerated as below:

(a) Topographic and land use survey;

(b) Survey on the existing drainage channels;

(c) Survey on the existing drainage facilities and;

(c) Survey on potential infiltration capacity of the ground;

2.2 Topographic and Land Use Survey

The field survey on the topography, land use and vegetation in the objective drainage area should be made to clarify the sub-basin boundaries, the potential infiltration capacity of the basin and the potential storage effect by the basin.

Explanation:

The topographic and land use survey could provide the basic information on basin flood runoff conditions, basin flood inundation conditions and conditions of construction site for the drainage facilities. In order to facilitate the survey works, the objective drainage basin should be divided into several sub-basins by trunk drains and major river tributaries.

The topographic map should be developed through the survey. The map should have the contour lines at intervals of 25 to 50cm so as to clarify the precise relationship between the ground levels and the flood water levels of drainage channels. Moreover, the map should provide the information on the height of the roads and drainage dikes for flat land of less than 1 to 1000 in ground slope which could become an important factor to dominate the flood inundation in the objective basin. When the intensive land development is being made in the objective sub-basin, the topography and vegetation tends to remarkably change due to land leveling, which could seriously influence to the basin runoff conditions. Accordingly, the detailed field reconnaissance is required io have supplementary information on the topographic map.

The existing and projected land use map should be also developed to present the land use classifications of the objective drainage basin. The standard land use classification is divided into the following eight (8) categories: (1) residential area, (2) commercial area, (3) industrial area, (4) road, (5) recreational area (6) natural land, (7) dry crop land and (8) paddy field. Each of these land use classifications have their own particular flood runoff characteristics and could be the essential information for the flood runoff simulation.

Reference:

The existing available topographic map in Malaysia has a scale of 1 to 50,000 and could not provide the contour lines with the aforesaid interval of 25 to 50cm. Accordingly, aerial-photo survey would be usually required to obtain the required counter lines. As for the land use map, the Town and Country Department as well as many of the local governments has completed the digital land use map for existing and projected states, which cloud be used for the objective urban drainage improvement plan.

2.3 Survey on Drainage Channels

The survey should be made to clarify the watercourse and flow capacity of drainage channels. When the dominant bottleneck channels and/or the extensive wetlands exist in the objective drainage basin, their hydraulic features should be also clarified through the survey.

Explanation:

The survey aims at providing the basic information on watercourse and flow capacity of existing drainage channels. The foregoing sub-section 2.2 prescribes the survey on the plane expanse of the drainage area, while this sub-section prescribes the line survey in the drainage area. The major objectives of the survey are as enumerated below:

(1) Watercourse and Destination of Drainage Channels

The objective drainage area is usually located in the flat and low-lying area where the watercourse of the existing drainage networks will have the various directions and destinations. The destinations of the drainage channels are such as the ocean, river channels, and the flood detention ponds. Moreover, the watercourse could be changed by the land development activities.

(2) Structures across the Drainage Channels

There are several structures (such as bridges, pipes and culverts) across the drainage channels. These structures could be a hindrance of channel flow and needs to be reconstructed and/or removed in case of the channel improvement work.

(3) Longitudinal Profiles and Cross Sections of Drainage Channels

The longitudinal profiles and the cross sections are an essential information for evaluation of channel flow capacity and designing for channel improvement. The channel survey is required to measures the longitudinal profiles and the and cross-sections. In parallel with the channel survey, the field reconnaissance is required to confirm the dominant channel bottlenecks and the wetland long the channel. The bottlenecks are the great hindrance of channel flow, while the wetland is expected to have a function of natural flood retarding.

(4) Roughness Coefficient of Drainage Channels

The field survey on the roughness coefficient of drainage channels should be made to provide the basic information on the uniform and/or non-uniform calculation for evaluation of channel flow capacity. The major objectives of field reconnaissance include materials and vegetation of the channel bed and bank, the shape of channel cross-sections, the dead flow area in the channel, and the saltwater intrusion from the river mouth.

(5) Water Level at the Down End of Drainage Channel

When the drainage channels are influenced by the backwater effect of tidal levels and/or the water levels of the downstream river channels, the non-uniform calculation should be applied to estimation for the flow capacity of the drainage channels. The boundary condition for non-uniform calculation is given from either (a) the design tidal level (usually the mean spring high tide is applied) at the river mouth or (b) the design high water level of the river channel at the junction with the drainage channels. If the design high water level of the downstream river channel has not been determined, the bank-full water level of the river channel should be applied as the boundary condition.

The above design high water level as well as the bank-full water level is regarded as the maximum water level of the downstream river on the condition that the river does not cause overflow. When the river causes overflow, its water level at the junction with the objective drainage channel could be higher than the design high water level or the bank-full water level. Nevertheless, once the overflow occurs, the flood discharge spreads out into the hinterlands, and therefore, there will be not any significant difference between the bunk-full water level (or the design high water level) and the overflow water level. Moreover, it is virtually difficult to simulate the overflow water level based on the detailed information on ground levels. From these viewpoints, the design high water level and/or the bank-full water level could be practically applied as the boundary condition for estimation of the channel flow capacity.

(6) Flood Mark

There could be several flood marks such as the line tracks of flood water level along the drainage channels and the floating derbies stuck to the drainage channels. These flood marks could present the maximum water level in the previous floods, and be the useful information for evaluation of the channel flow capacity. The elevation of flood marks should be measured immediately after a flood with a particular attention to the possible errors caused by the following factors: (a) error in determination on location of flood marks, (b) rise of water level by wind, (c) difference of water levels between left and right bank at meandering portion of the channel and (d) man-made transfer of flood marks.

2.4 Survey on Drainage Facilities

The survey should be made to clarify the location, structural features, and functions of the existing drainage facilities such as the flood detention pond, drainage gates and drainage pumps.

Explanation:

The survey aims at providing the basic information on the drainage capacities of the existing. drainage facilities. The major objectives of the survey are as enumerated below:

(1) Location and Catchment Area

The location of each drainage facility should be confirmed, and presented on the topographic map. Then, its watershed boundary should be delineated on the topographic map, and its catchment area of the facility should be measured.

(2) Structural Features and Functions of Flood Detention Pond

The storage size as well as the size of outlet of the pond should be confirmed through the actual field measurement and/or through the construction drawings of the structure. Moreover, water quality of the water impounded and sediment/solid waste accumulated in the pond should be clarified through the field reconnaissance and survey.

(3) Structural Features and Functions of Other Drainage Facilities

When there exist major drainage facilities such as the drainage pumps, drainage gates. sluice gates/pipes in the objective drainage area, their structural features such as type of structures, design water levels and drainage capacities should be confirmed through the field reconnaissance. It is also necessary to confirm mechanical troubles which often occurs to the facilities.

2.5 Survey on Infiltration Capacity of Ground Surface

2.5.1 Procedure

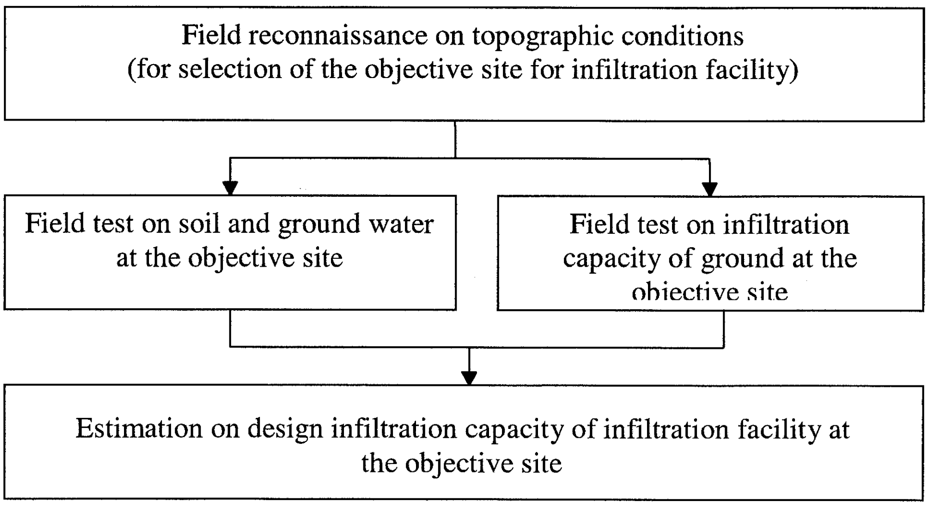
This sub-section prescribes the method to estimate actual infiltration capacity at the site.

Explanation:

Proper application of infiltration facilities is effective in reducing excessive runoff discharge that would be caused by intensive urban development. It is particularly important to assess actual infiltration capacity of soil prior to application of the infiltration measures.

The procedure of assessment for infiltration capacity is shown in the following flow chart.

Fig. 2.1 Procedure of Assessment for Infiltration Capacity



2.5.2 Field Reconnaissance on Topographic Conditions

A preliminary field reconnaissance on the topographic conditions in the objective drainage area should be made in order to select the objective site for installation of infiltration facility.

Explanation:

The topography forms the different durability of soil and geological characteristics, and ground water conditions, which are closely related to infiltration capacity at and around the superficial and the shallow depth. Accordingly, the field reconnaissance on the topography in the objective drainage basin should be made in order to overview the infiltration potential of the basin and select the object site for installation of infiltration facility. Selection of the objective site should be made in due consideration of the topographic classification by potential of infiltration capacity as enumerated below (refer to Table 2.1[*2-1]):

(1) Topography to show high infiltration capacity

Hilly area...Most hilly areas in Malaysia have the lateritic soil at their superficial layer, which generally shows high permeability with high void ratio and large macro-pores. Thus, the area could usually contain high infiltration capacity. However, the land development works tend to remove the lateritic soils and expose low permeable pallid zone (saprolite) on the ground. Accordingly, when the intensive land development is made in the area, the high infiltration capacity is no longer expected.

Plateau and terrace area...When the soil in the area consists of sand and gravel as terrestrial deposits origin of Pleistocene in age, the area tends to show high permeability as a whole. However, the soil of each terrace step may vary due to different sediment periods. Therefore, detailed test on soil conditions at the superficial zone is required in order to finally evaluate he infiltration capacity.

Gentle undulating lowland area...The area is topographically classified in general into the pediment, alluvial fan, natural levee and sand dune. If the major soil components are sand and gravel and, at the same time the ground water level is relatively low, the area could have high infiltration capacity.

(2) Topography to show low infiltration capacity

Lowland area...The area is such as the valley basin, flood basin, coastal plain, delta, back swamp and former river course on the low land. Low infiltration capacity is usually expected in the area due to the impermeable soil and high ground water level as a whole.

Area artificially transformed by excavation...The area usually exposes the weathered rock zone or fresh rock zone due to excavation of the surface soil, which leads to low infiltration capacity. However, when the soil of the area is composed of coarse-grained igneous rocks origin such as granite and indicates strongly weathered rock facies up to a great depth, the area may high infiltration capacity.

Area artificially transformed by earth filling and/or reclamation...The area has low infiltration capacity in general due to land compaction.

In addition to the above areas, the following areas shall not be recommended as suitable site for infiltration facility.

(a) Area with steep slope which contains a danger of landslide;

(b) Area which contains potential erosion and/or collapse due to outflow of seepage water from the infiltration facility;

(c) Area where outflow of seepage from the infiltration facility could cause adverse environmental impacts to well for drinking use, foundation of structure, etc.

2.5.3 Field Test on Soil and Ground Water

The field test on soil and ground water should be made through auger boring at the objective site for installation of infiltration facility. The survey could provide the essential information on infiltration capacity of ground.

Auger boring should be drilled at the objective site and another point of 4 to 10 m in distance from the objective site. The drilling is subject to the maximum depth of 10m, but could stop if the drilling reaches to the impermeable layer or the ground water level. Field test on soil and ground water should have the following contents:

(1) Field Test on Soil

The soil sampling should be given from infiltration layer at the auger boring site, and the soil tests should be made on grain, size distribution test, specific gravity test and water content test of the samples. When the soil at the site has the following characteristics, the site is judged to have low infiltration capacity and not recommended as suitable location for installation of infiltration facility*[2-1].

(a) Coefficient of permeability of site shows $1 \times 10\text{-}5$ cm/sec or less.

(b) Soil properties show 10 % or less in effective porosity (aeration porosity).

(c) Clay materials indicate 40 % or more in the distribution of grain size.

(d) Ground conditions indicate well compacted feature at the land development sites.

(2) Ground Water Conditions

Infiltration capacity is largely influenced by conditions of unsaturated zone in the subsurface, and, therefore the conditions of ground water at/around the site should be confirmed through the auger boring prior to determination of installation site for infiltration facility. Measurement of ground water level should be made three times in minimum, before, during and after the field test on the infiltration capacity, details of which are described in the following sub-section 2.5.4.

If the ground water level of the site exists in relatively shallow subsurface (for example, within 1.0 m in depth), it is not recommended as a suitable site for infiltration facility. Such high ground water level is usually seen in the lowland areas such as coastal plain, back swamp and former river course etc. Moreover, the ground water level in the lowland areas tends to rapidly ascend after the storm rainfall, and remarkably decrease the effective infiltration capacity.

Furthermore, at the plateau and terrace areas, soil and geological conditions are composed of sand and gravel layers with occasional thin beds of clay layer, which have impermeable property. In this case, much attention should be paid to the existence of unatable water table, which has occasionally deleterious effects on infiltration capacity of the ground.

2.5.4 Field Test on Infiltration Capacity

Field test on infiltration capacity should be made at the site, when a potential of infiltration capacity is expected through the preliminary field reconnaissance described in 2.5.2 and the field test on soil and ground water described in sub-section 2.5.3.

Explanation:

The field test aims at directly estimating the infiltration capacity at the objective site. The test is made by auger hole which facilitates easy installation of testing infiltration facility and provides practicable infiltration capacity with vertical direction and horizontal direction (refer to Fig. 2.2).

The test is made through the following procedures*[2-2]:

(1) To pour water into the auger hole with controlling the pouring water volume so as to

maintain a constant water level which is in equivalent to the maximum water depth;

(2) To measure the pouring water volume with a constant time interval until the pouring water volume becomes to be almost constant;

(4) To develop the relation curve between the pouring water volume and elapsed time as shown in Fig. 2.3;

(5) To assume as the final pouring water volume as the infiltration capacity when it becomes to be almost constant.

Fig.2.2 Testing Facility of Bore Hole

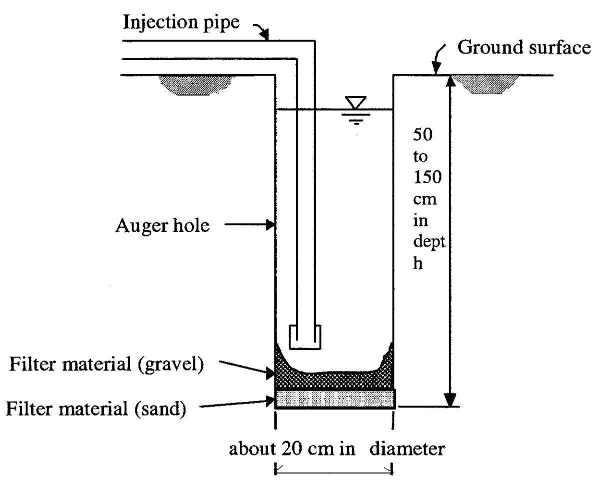
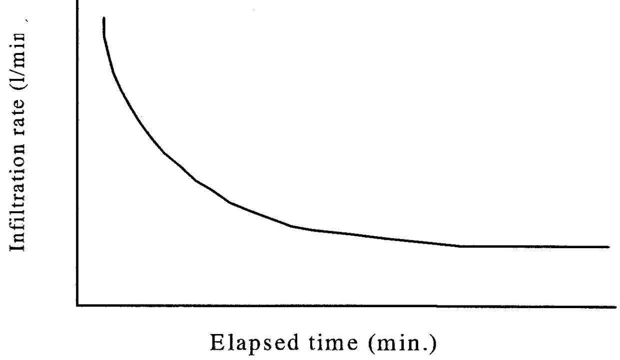


Fig. 2.3 Curve of Infiltration Rate



2.5.5 Estimation of Design Infiltration Capacity

The design infiltration capacity of the proposed infiltration facility should be estimated on the basis of the field tests described in the foregoing sub-sections 2.5.3 and 2.5.4.

Explanation:

The auger hole is used as the hypothetical infiltration facility in the field test on the infiltration capacity as described in sub-section 2.5.3, but its shape, size and ground permeability could be different from those of the proposed infiltration facility. Accordingly, the infiltration capacity observed in the field test could not directly present the design infiltration capacity of various types of proposed infiltration facility. Hence, this subsection prescribes the standard methodology to convert the value of field test to the design values which are subject to different size, shape and permeability.

The following are the principal formula to convert the value of the field test to the design value:

$$Qu = C \times Qt / Kt \times Kf \quad \text{(Eq. 2.1)}$$

$$Qb = \Sigma Qu \quad \text{(Eq.2.2)}$$

Iave = Qb / A ×10 ....(Eq. 2.3)

Where,

Qu	:	Design infiltration capacity per one unit of infiltration facility (m^3/hr)
Qb	:	Design infiltration capacity in the objective drainage basin (m^3/hr)
Iave	:	Design infiltration depth in the abjecvtive drainage basin
C	:	Coefficient (≑ 0.81)
Qt	:	Infiltration capacity observed in the field test (m^3/hr)
Kt	:	Specific infiltration capacity of the infiltration facility used in the field test (m^2)
Kf	:	Specific infiltration capacity of the proposed infiltration facility (m^2)

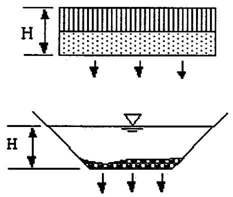
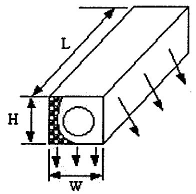
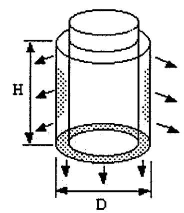
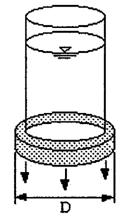
The "specific infiltration capacity" used In the above formula (Eq. 2.1) is herein defined as the infiltration capacity divided by the permeability of the site. According to the physical soil analysis in Japan*[2-2], it was clarified that the specific infiltration capacity has a almost constant value regardless of different types of physical soil characteristics at different sites. The results of the analysis reveals that the specific infiltration capacity for every site for infiltration facility could be practically determined by the design shape and the design infiltration depth of the infiltration facility. Thus, the values of "Kt" and "Kf" in the formula (Eq. 2.1) could be determined for variable design shapes and the design depth of the infiltration facility as shown in Table 2.2.

Table 2.1 Assessment by Topographic Classification and Infiltration Capacity

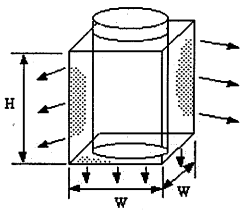
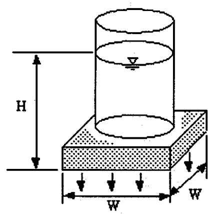
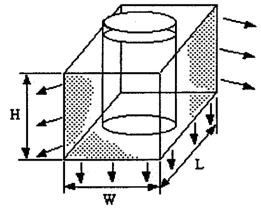
Topographical classification				Assessment by infiltration capacity				Assessment by ground water		
				High k>10^{-2} cm/sec	Medium k=10^{-2}-10^{-5} cm/sec	Low k=10^{-5}-10^{-7} cm/sec	Lowest k<10^{-7} cm/sec	Deep to medium deep depth	Shallow depth	Around ground surface
				Unconsolidated soil				D>2m	D=1m - 2m	D<1m
				conglomerate>sand	sand>silt	silt>clay	clay			
1. Hill (and mountain)				Assessment by infiltration capacity shall be performed on the basis of land condition after urban development (by cutting)						
2. Plateau and terrace	2.1. Uppermost and upper terrace			Infiltration capacity depends on the soil condition						
	2.2. Middle and lower terrace			Infiltration capacity depends on the soil condition						
	2.3. Lowest terrace			Infiltration capacity depends on the soil condition						
	2.4. Shallow valley in plateau			Infiltration capacity depends on the soil condition						
3.,4. Lowland	3. Gentle undulating lowland	3.1. Pediment								
		3.2. Alluvial fan								
		3.3. Gentle slope fan								
		3.4. Natural levee								
		3.5. Sand dune								
		3.6. Sand dike								
		3.7. Shallow valley in gentle								
	4. Lowland	4.1. Valley basin and flood plain								
		4.2. Coastal plain and delta	Inland area							
			Around river mouth							
		4.3. Back swamp and back marsh								
		4.4. Former river course	At the alluvial fan							
			At the lowland							
5. Artificially transformed land	5.1. Land by cutting			Infiltration capacity depends on the soil condition				Topographical condition is out of assessment		
	5.2. Land by filling									
	5.3. Reclaimed area									

* k : Coefficient of permeability, D : Depth of ground water table from the ground surface
* This table was taken and modified from 'Manual for Field test of Infiltration Capacity (Ministry of Construction, Public Works research Institute)'

Table 2.2 Calculation Formula of Specific Capacity forVarious Type of Infiltration Facility

Infiltration facility		Permeable pavement (infiltration pond)	Infiltration trench	Inlet of cylinder type			
Direction of infiltration		Vertical direction	Lateral & vertical direction	Lateral & vertical direction		Vertical direction	
Typical sketch							
Applicable range for computed formula	Design water head	about 1.5 m	about 1.5 m	about 1.5 m	about 1.5 m	about 1.5 m	about 1.5 m
	Scale of facility	In the case of infiltration pond, base area is 400 m2 or more	about 1.5 m in width	0.2m≦D≦1m	1m<D<about 10m	0.3m≦D≦1m	1m<D<about 10m
Basic formula		K = aH + b H : design water head	K = aH + b H : design water head W : width of facility	$K = aH^2 + bH + c$ H : design water head D : diameter of facility	K = aH+b H : design water head D : diameter of facility	K = aH + b H : design water head D : diameter of facility	K = aH + b H : design water head D : diameter of facility
Coefficient of formula	a	0.014	3.093	0.475D+0.945	6.244D+2.853	1.497D-0.100	2.556D-2.052
	b	1.287	1.340W+0.677	6.070D+1.010	$0.930D^2+1.606D-0.773$	$1.130D^2+0.638D-0.011$	$0.924D^2+0.993D-0.087$
	c	-	-	2.570D-0.188	-	-	-

* Permeable pavement : specific infiltration capacitycorresponds to value per unit area
* Infiltration trench : specific infiltration capacity corresponds to value per unit length

Infiltration facility		Inlet of square type						Inlet of rectangular type
Direction of infiltration		Lateral & vertical direction			Vertical direction			Lateral & vertical direction
Typical sketch								
Applicable range for computed formula	Design water head	about 1.5 m	about 1.5 m	about 1.5 m	about 1.5 m	about 1.5 m	about 1.5 m	about 1.5 m
	Scale of facility	W≦1m	1m<W≦10m	10m<D<80m	W≦1m	1m<W≦10m	10m<D<80m	about 200 m in length about 4 m in width
Basic formula		$K = aH^2 + bH + c$ H : design water head W : width of facility	K = aH + b H : design water head W : width of facility	K = aH + b H : design water head W : width of facility	K = aH + b H : design water head W : width of facility	K = aH + b H : design water head W : width of facility	K = aH + b H : design water head W : width of facility	K = aH + b H : design water head L : facility length W : width of facility
Coefficient of formula	a	0.120W+0.985	-0.453W+8.289W+0.753	0.747W+21.355	1.676W-0.137	$-0.204W^2+3.166W-1.936$	1.265W-15.670	3.297L+(1.971W+4.663)
	b	7.837W+0.820	$1.458W^2+1.270W+0.362$	$1.263W^2+4.295W-7.649$	$1.496W^2+0.671W-0.015$	$1.345W^2+0.736W+0.251$	$1.259W^2+2.336W-8.130$	(1.401W+0.684)L+(1.214W-0.834)
	c	2.858W-0.283	-	-	-	-	-	-

BIBLIOGRAPHY

2-1 "Technical Standard for Flood Regulation Pond", by Japan River Association, in 1988

2-2 "Technical Standard for Rainfall Infiltration Facility (Volume on Survey and Planning)", by Rainfall Storage and Infiltration Association, in 1995