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A Study on Storm Water System in a City with Rapid Urbanization

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Abstract

Severe floods occur frequently in every monsoon season in some parts of Yangon (former capital of Myanmar) including Mingalar Taung Nyunt Township since storm water increases due to the rapid growth of urbanization in Yangon City. The city has grown rapidly in recent years causing reduction of pervious area and natural flood retention storage. The study area is situated in the south and south-eastern part of Yangon central downtown area. The catchment area constitutes 4.09 km^2 (1.58 sq miles) covering mostly of Mingalar Taung Nyunt Township. The study area is the largest drainage basin in Yangon central area including Kandawgyi Lake having the surface area of 0.45 km^2 (0.17 sq miles). The average annual rainfall in Yangon City is 2711 mm (107 inches). The monsoon season starts from mid-May and ends at the end of October. Since flooding occurs frequently in the study area whenever rainfall intensity exceeds 25 mm/hour (1 in/hr) or more, the objectives of this study are to evaluate the capacity of existing drainage system and to propose the integrated system in order to reduce the occurrence of floods in the area. Input data are 1 hr and 2 hr rainfalls with return periods of 5, 10 and 25 years, channel and pipe characteristics, elevations and slope. Peak discharges are obtained using XP-SWMM software. It is observed that the existing drainage system must be improved by lining as well as widening in order to increase the carrying capacity for the area with rapid urbanization. Moreover, Kandawgyi Lake can be used as a retention pond due to its large holding capacity.

Introduction

Severe floods occur frequently in every monsoon season in some parts of Yangon (former capital of Myanmar) including Mingalar Taung Nyunt Township since storm water increases due to the rapid growth of urbanization in Yangon City. Yangon is situated in the delta of the Ayeyarwaddy River with a population of over 5 millions. The city has expanded rapidly from 133 sq. miles to 260 sq. miles within 12 years causing reduction of pervious area and natural flood retention storage. It has an average annual rainfall of 107 inches (2711 mm) during the monsoon period of May through October (average during the period of 1968 to 2001).

The study area is situated in the south and south-eastern part of Yangon central downtown area. The catchment area constitutes 1.58 sq miles covering mostly of Mingalar Taung Nyunt Township. The study area is the largest drainage basin in Yangon central area including Kandawgyi Lake having the surface area of 0.17 sq miles and consists of residential area. The underground drainage system (in thick line) in the study area is shown in Figure 1. The upstream starts from the area around Shwe Gon Daing junction and it flows through underground drain along west Shwe Gon Daing, Yae Tar Shay, and across Zoological garden and join to upper Pansodan channel and channel along Daw Thein Tin Street, Myanma Gon Yee Street and finally drains into Pazun Taung creek.

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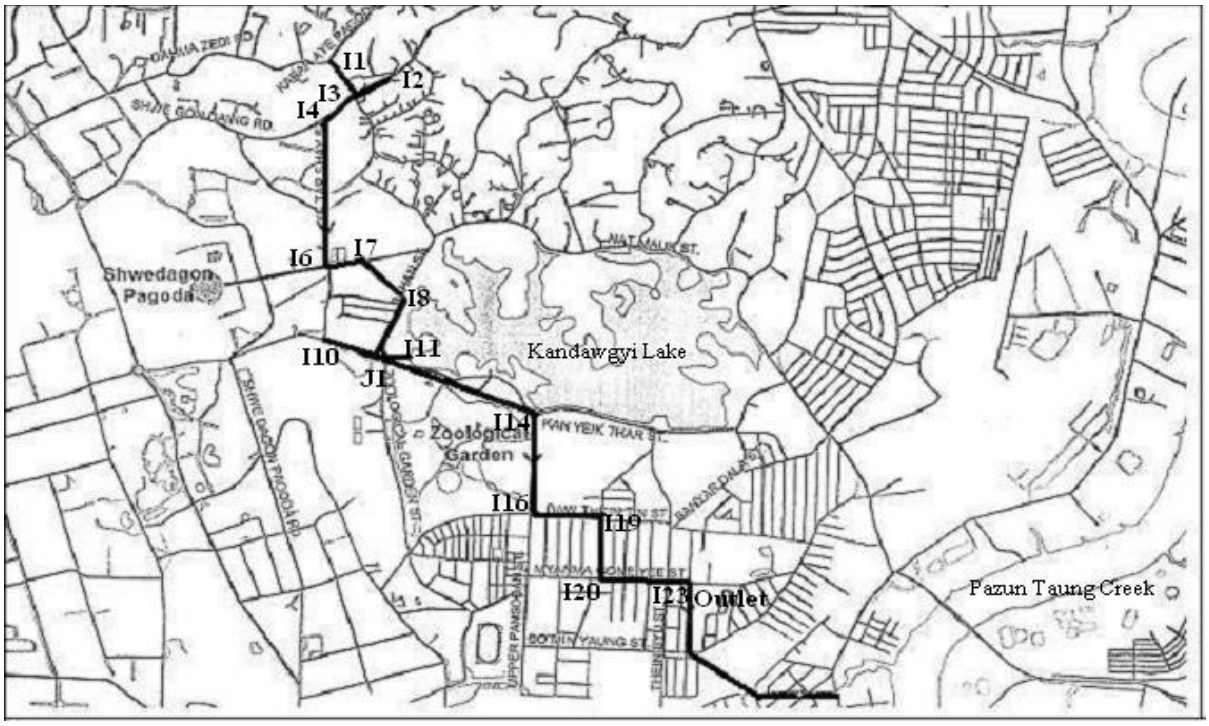

Figure 1. The study area (Mingalar Taung Nyunt underground drain system)

Flooding occurs frequently in the study area between Upper Pansodan and Thein Byu Street, Daw Thein Tin Street and Myama Gon Yee Street whenever rainfall intensity exceeds 25 mm/hour (1 in/hr) or more. Guo (2003) mentioned that from the view point of public safety, storm water in an urban area must be quickly collected and transported to nearby streams and lakes. Urban storm water management plays vital to the quality of urban water environment. Therefore, the objectives of this study are to evaluate the capacity of existing drainage system and to propose the integrated system in order to reduce the occurrence of floods in the area.

Methodology

Network for the drain system having 24 nodes including outlet and 24 links in the Mingalar Taung Nyunt area is prepared in this study. The system is composed of 4 branches (node I1, node I2, node I10 and node I11), consisting of rectangular channels discharging into a free outfall (near Theinbyu Street). Tables 1 and 2 show the properties of the nodes and links used in the network. The data are obtained from City Planning and Land Administration Department, Yangon City Development Committee (Maung Tun Than Tun, 2001).

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Table 1. Properties of links

Link	u/s Node	d/s Node	Length (ft)	Size (ftxft)	u/s elevation (ft)	d/s elevation (ft)	slope	Manning (n)
P1	I1	I3	900	1.92'x1.17'	90	63	0.03	0.013
P2	I2	I3	600	1.92'x1.17'	78	63	0.025	0.013
P3	I3	I4	600	5'x3.17'x2	60	51	0.015	0.013
P4	I4	I5	750	5'x3.17'x2	51	45	0.008	0.013
P5	I5	I6	1350	5'x3.17'x3	45	43	0.0015	0.013
P6	I6	I7	1350	5'x3.17'x3	43	41	0.0015	0.013
P7	I7	I8	900	5'x3.17'x3	41	36	0.0056	0.013
P8	I8	I9	150	5'x3.17'x3	36	35.5	0.0033	0.013
P9	I9	J1	920	12'x6'	35.5	31.82	0.004	0.013
P10	I10	J1	800	6'x4'	35.2	31.82	0.0042	0.013
P11	I11	J1	150	3'x2'x8	34.8	31.82	0.02	0.013
P12	J1	I12	845	8'x7'x2	31.82	18.8	0.0154	0.013
P13	I12	I13	388	8'x7'x2	18.8	17.1	0.0044	0.013
P14	I13	I14	483	8'x7'x2	17.1	15.6	0.0031	0.013
P15	I14	I15	1150	7'x6'x2	15.6	14.5	0.001	0.013
P16	I15	I16	150	8'x6'x2	14.5	14.2	0.002	0.013
P17	I16	I17	800	10'x6'x2	14.2	13.2	0.0013	0.013
P18	I17	I18	300	10'x6'x2	13.2	12.9	0.001	0.013
P19	I18	I19	300	12'x4'	12.9	12.6	0.001	0.019
P20	I19	I20	910	10'x6'x2	12.6	9.94	0.0029	0.035
P21	I20	I21	150	10.5'x4'	9.94	9.0	0.0063	0.015
P22	I21	I22	850	9'x5'x2	9.0	6.8	0.0026	0.025
P23	I22	I23	120	10'x5'x2	6.8	6.0	0.0067	0.022
P24	I23	Outlet	38	10'x5'x2	6	5.6	0.0105	0.035

Table 2. Properties of nodes

Location	Node	Inlet area (acres)	Elevation (ft)	Runoff Coefficient
Shwe Gon Daing	I1	7.26	92.0	0.61
Kaba Aye pagoda	I2	5.95	80.0	0.67
Shwe Gon Daing Junction	I3	6.04	65.0	0.69
Yay Tar Shay/Shwe Gon Daing	I4	28.87	56.0	0.71
Yay Tar Shay Street	I5	41.16	50.0	0.67
Kyar Taw Yar/Yay Tar Shay	I6	30.42	48.0	0.6
Kyar Taw Ya	I7	24.85	47.0	0.6
Bahan Street	I8	50.8	42.0	0.6
Magyidan	I9	5.5	42.0	0.6
Magyidan	I10	41.65	39.2	0.5
Kandawgyi	I11	497.93	38.82	0.56
Zoological garden	J1	-	38.82	-
Zoological garden	I12	13.1	26.0	0.5
Zoological garden	I13	29.4	25.0	0.5
Upper Pansodan Street	I14	58.88	22.6	0.5
Upper Pansodan Street	I15	55.8	20.5	0.5
Upper Pansodan Street	I16	13.05	20.4	0.5
Upper Pansodan Street	I17	20	19.2	0.5
Daw Thein Tin Street	I18	15.5	19.0	0.5
Daw Thein Tin Street	I19	12.4	16.0	0.8
Myanma Gon Yee Street	I20	12.4	15.0	0.7
Myanma Gon Yee Street	I21	8.26	13.0	0.7
Myanma Gon Yee Street	I22	12.4	13.0	0.8
Thein Byu Street	I23	12.4	12.0	0.6

A basic stormwater model for design storms of 1 hr and 2 hr rainfall with 5 years, 10 years and 25 years are created to calculate peak discharges for the studied area using rational formula with IDF curves in XP-SWMM software. A rational method approach is implemented in XP-SWMM to create a rising hydrograph with the peak equaling the value from the Rational formula and the time to peak equaling the time of concentration, t_c. Hydrologic data such as rainfall intensity, area and runoff coefficient for the subcatchments and hydraulics data such as ground elevation and invert elevation of the nodes, dimension and shape, length, roughness, upstream invert elevation and downstream invert elevation of

the links are used as input data to the model. Runoff coefficients are estimated based on the vegetative cover and the surface condition of land in each zone.

For urban catchments that are not complex and are generally 160 acres or less in size, it is acceptable that the design storm runoff be analyzed by the Rational Method (The Urban Drainage and Flood Control District, 2001). In this study Rational method is used since it can produce satisfactory results for urban storm sewer with limited hydrologic data. Design storms of 1 hr and 2 hr rainfalls with return periods of 5, 10 and 25 years are derived from the rainfall intensity duration frequency relationship for Yangon (Figure 3) which is obtained from Irrigation Department, Ministry of Agriculture and Irrigation, Yangon.

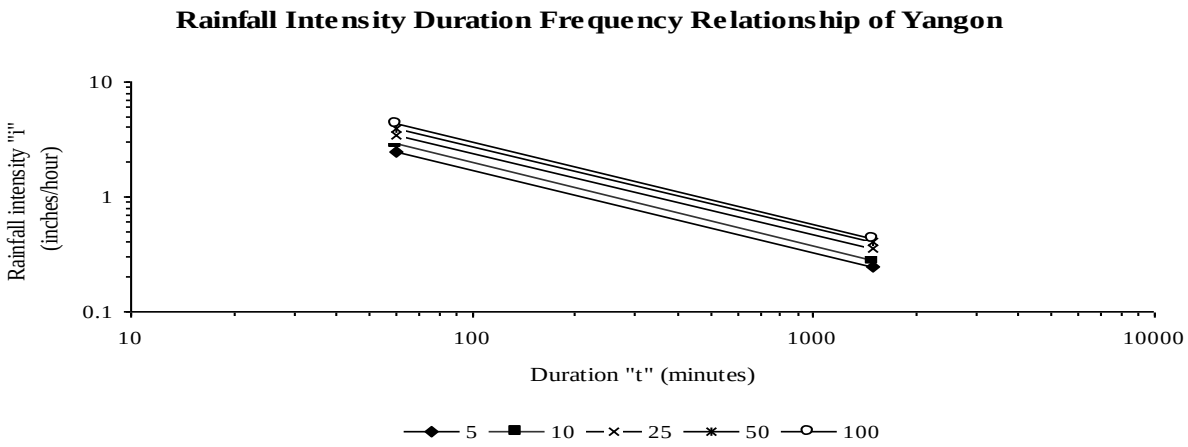

Figure 3. Rainfall intensity duration frequency curve

Results and Discussions

Analysis of Mingalar Taung Nyunt catchment is carried out for 1 hr and 2 hr rainfalls with 5, 10 and 25 years return periods. Channel carrying capacity and calculated peak discharges of each barrel are given in Table 3.

Table 3. Peak discharges for stormwater drain system

Link	No. of Barrels	Capacity (ft^3/s)	Peak discharge (ft^3/s)					
			1 hr rainfall			2 hr rainfall		
			5 years	10 years	25 years	5 years	10 years	25 years
P1	1	23.88	11.17	12.51	14.29	7.15	7.59	8.93
P2	1	20.68	10.05	11.26	12.86	6.43	6.83	8.04
P3	2	217.44	15.86	17.76	20.3	10.15	10.78	12.69
P4	2	158.79	41.69	46.7	53.37	26.68	28.35	33.36
P5	3	68.33	50.97	57.1	65.24	32.62	34.66	40.78
P6	3	68.33	66.31	74.26	84.87	42.44	45.08	53.04
P7	3	132.33	78.83	88.29	100.91	50.45	53.61	63.07
P8	3	102.5	104.44	116.98	133.69	66.85	71.02	83.56
P9	1	826.27	321.65	360.26	411.72	205.86	218.72	257.32
P10	1	201.37	52.52	58.83	67.28	33.6	35.7	42.0
P11	8	69.0	80.51	80.61	80.58	56.23	59.77	70.29
P12	2	1204.63	503.2	521.82	545.24	344.66	366.2	430.83
P13	2	642.37	511.46	531.08	555.81	349.94	371.82	437.44
P14	2	540.81	523.0	551.82	579.52	361.8	384.42	452.26
P15	2	204.42	302.92	302.52	301.85	304.74	304.68	304.50
P16	2	351.47	333.29	335.65	338.77	326.14	326.94	329.33
P17	2	368.71	341.65	345.01	349.48	331.44	332.57	335.96
P18	2	329.78	329.79	329.79	329.78	329.78	329.78	329.79
P19	1	155.56	385.57	386.0	385.53	379.74	381.04	380.7
P20	2	209.42	193.35	193.74	194.24	192.17	192.3	192.7
P21	1	421.63	402.30	404.94	408.43	394.33	395.22	397.88
P22	2	186.71	206.35	208.3	210.88	200.5	201.15	203.1
P23	2	387.63	214.17	217.05	220.88	205.5	206.46	209.35
P24	2	306.17	221.98	225.8	230.89	210.5	211.78	215.6

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From Table 3 it can be seen that P11 cannot carry the peak discharge resulting from 1 hr rainfall and P15, P18 and P19 cannot carry the peak discharges resulting from both 1 hr and 2 hr rainfalls. The link P11 seems to be inadequate in conveying high discharge contributed from Kandawgyi Lake. For this reason, it is suggested that Kandawgyi Lake should be used as a retention pond to hold runoff for a short period of time (say 6 hours) and then release it directly into the natural channel Pazun Taung Creek. The links P15, P18 and P19 seem to be inadequate in conveying discharge due to their smaller drain sizes. Consequently floods occur in the area which is between Upper Pansodan Street and Thein Byu Street and between Daw Thein Tin Street and Myanma Gon Yee Street. As an example, a dynamic sectional view of drainage system (from node I1 to Outlet) for maximum water level during 1 hr rainfall with 5 years return period is shown in Figure 4. It is observed from Figure 4 that floods occur at nodes I14, I17 and I18.

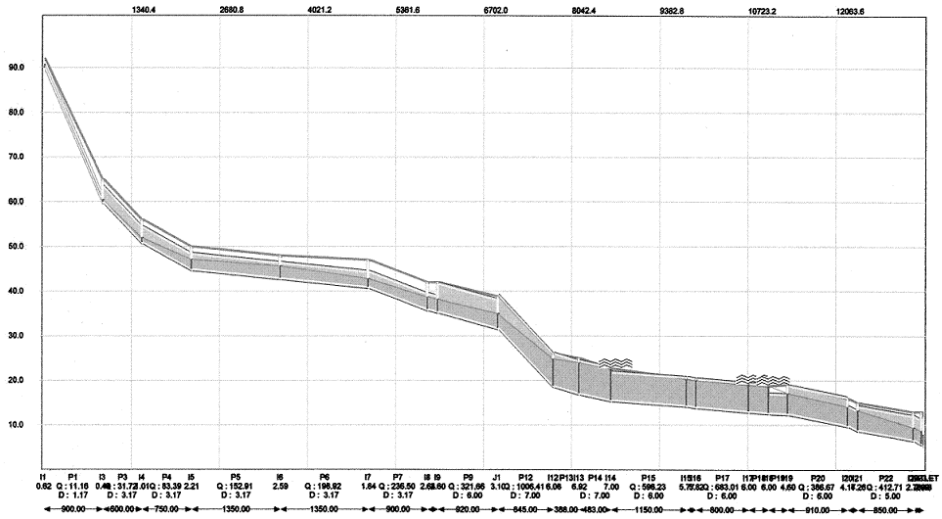

Figure 4. Dynamic section view of drainage system for maximum water level during 1 hr rainfall with 5 years return period

Conclusion

It is observed that the existing drainage system is inadequate carrying the storm water and it must be improved by lining as well as widening in order to increase the carrying capacity for the area with rapid urbanization. Moreover, it is recommended to use Kandawgyi Lake as a retention pond due to its large holding capacity.

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