The PSD and Orifice Discharge in MSMA 2 OSD Calculation

MSMA · https://mes100.com/docs/the-psd-and-orifice-discharge-in-msma-2-osd-calculation/

For small developments (under 5 hectares), MSMA 2nd Edition provides a **simplified calculation** for On-Site Detention (OSD), where the design involves using **pre-computed tables and figures** (Table 5.A1, 5.A2, 5.A3, and 5.A4) to determine the permissible discharge (PSD), required storage volume (SSR) and the size of the inflow and outflow pipes. This method is a quick and easy way to design minor drainage systems specifically for 10-year ARI design storms, where engineers do not have to do detailed calculation and just extract the figures from the tables.

While MSMA guideline provided us with the PSD as a maximum allowable peak outflow, it did not indicate the calculation of orifice discharge using Equation 2.6 in MSMA.

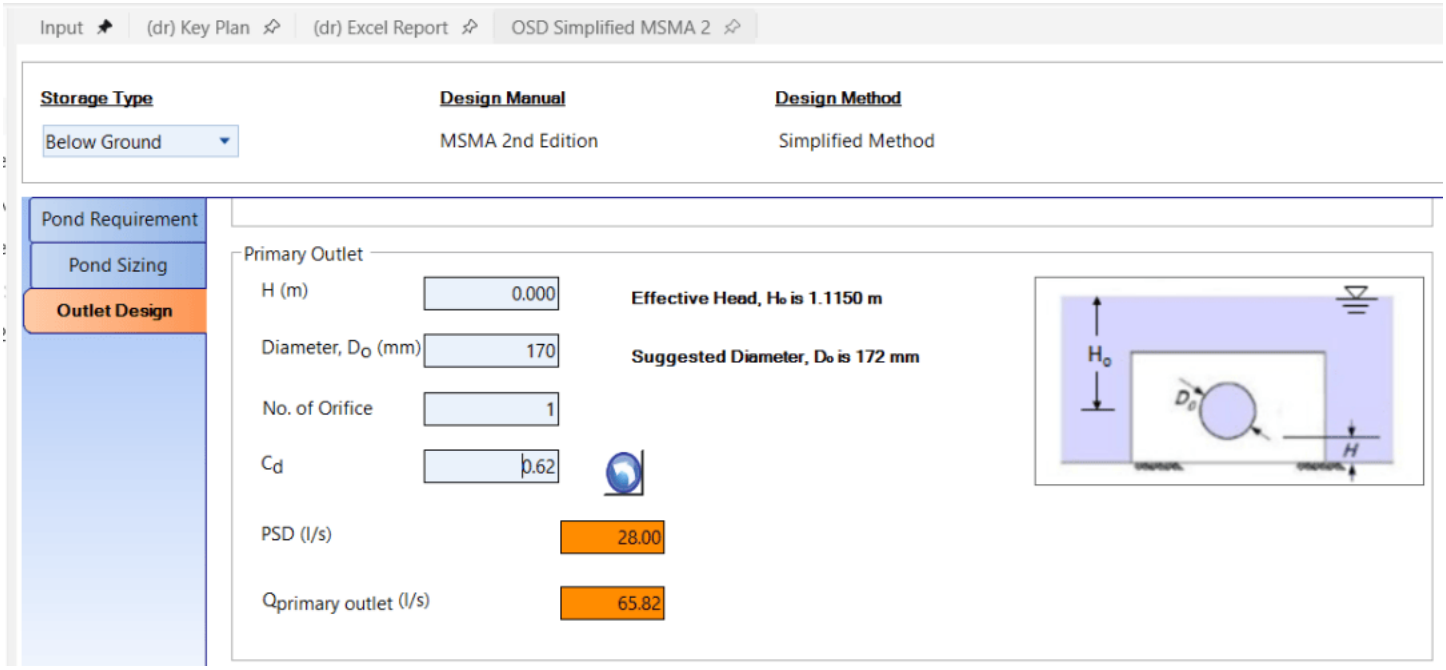
$$Q=Av=C_dA\sqrt{2gH_o}$$

Here, we go through Appendix 5.B (page 5-28), rework the example as per the table method and calculate the actual orifice discharge. We notice that the orifice discharge of the suggested outlet size is way bigger than the PSD obtained in the table. This is somehow inconsistent and questionable.

Result

Development site	: Negeri Sembilan - Kuala Pilah
Region in MSMA	: Region 1 - West Coast
Catchment area	: 0.61 ha
Terrain type	: Mild

% Impervious area	: 75.0%
Storage dimension (L x W X D)	: 20m x 12m x 1.2m
Site Storage Requirement, SSR	: 273.77 m3
Permissible Site Discharge, PSD *(whichever lesser from 5.A1 and 5.A2)*	: 0.028 m3/s
Suggested outlet pipe size from the table *(whichever lesser from 5.A3 and 5.A4)*	: 172 mm
Outlet pipe invert level	: At the bottom of the OSD (PIL 1.20)
Effective head, H_0	: 1.1140m
Actual Orifice Discharge	: 0.066 m3/s
Actual Orifice Discharge check with PSD?	: 0.066 m3/s> 0.028 m3/s (Not OK!)



For a given pipe diameter from MSMA table, the outlet discharge > PSD, which is not satisfactory and debatable

Another 5 sites of each region are selected and calculated to observe the PSD and the actual orifice discharge. All of the actual orifice discharge is way higher than the tabulated PSD as per table below.

File sample here

Information

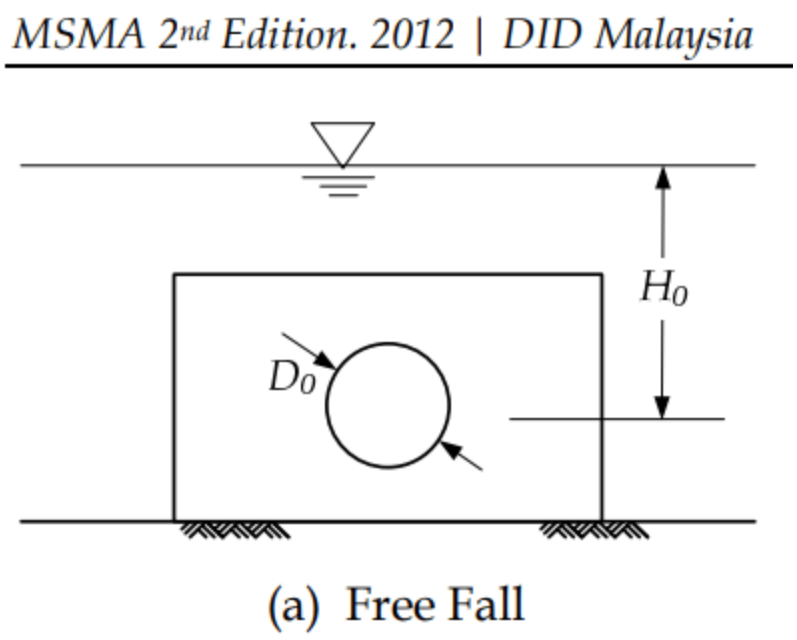
Catchment area	: 0.8ha
Terrain type	: Mild
% Impervious area	: 90%
Outlet pipe position	: At the tank bottom

Site location	Region	SSR (m3)	Storage dimension (L x W X D) (m)	Eff head,H0 (m)	PSD (m3/s)

Ipoh, Perak	1 - West Coast	403.76	20 x 15 x 1.5	1.4015	0.063
Kuantan, Pahang	2 - East Coast	542.96	20 x 15 x 2.0	1.9125	0.050
Alor Setar, Kedah	3 - Northern	417.28	20 x 15 x 1.5	1.4070	0.056
Cameron Highland, Pahang	4 - Highlands	407.36	-Ditto-	1.4220	0.035
Batu Pahat, Johor	5 - Southern	425.84	-Ditto-	1.4030	0.046

Effective head (H_0) = Height of storage - [Orifice Elevation from bottom of OSD + $D_0/2$]

Orifice discharge (Q)=Av=C_dA\sqrt{2gH_o}



How to obtain Effective Head (H_0)

Hypothesis

In order to achieve outlet discharge to be lesser than the PSD, we need to either set the outlet pipe invert level to be higher, or reduce the outlet pipe diameter. In this section, we will adjust the effective head and outlet size, to get the orifice discharge similar to the PSD value, and observe the difference.

Adjust pipe invert level (i.e.: adjust effective head)

The comparison was performed by adjusting the pipe invert level to be higher than the tank base, while keeping the pipe diameter as specified in the table.

Site location	Orifice size from table, D0 (mm)	Eff head, H_0 (m)	Adjusted Eff head,H_0 (m)	Adjusted Pipe Level from storage bed (m)	PSD (m3
Ipoh, Perak	197	1.4015	0.5715	0.830	0.063

Kuantan, Pahang	175	1.9125	0.5825	1.330	0.050
Alor Setar, Kedah	186	1.4070	0.5670	0.840	0.056
Cameron Highland, Pahang	156	1.4220	0.4420	0.980	0.035
Batu Pahat, Johor	194	1.4030	0.3130	1.090	0.046

To achieve the same discharge as the PSD, we find that we need to consistently reduce the effective head (or make the pipe level higher than the storage Invert Level). There seems to be no regularity to how high the pipe level should be adjusted upwards.

Adjust outlet pipe diameter

The comparison was carried out by adjusting the pipe diameter, while the pipe invert level was kept fixed at the tank bottom.

Site location	Eff head,H_0 (m)	Original Orifice size from table, D_0 (mm)	Adjusted orifice size, D0 (mm)	PSD (m3/s)	Orifice Discharge (m3/s)
Ipoh, Perak	1.4215	197	157	0.063	0.063
Kuantan, Pahang	1.9350	175	130	0.050	0.050
Alor Setar, Kedah	1.4265	186	147	0.056	0.056

Cameron Highland, Pahang	1.4225	156	115	0.035	0.035
Batu Pahat, Johor	1.4335	194	133	0.046	0.046

From the above comparison, to achieve the same discharge as the PSD, we will have to use a smaller orifice size, holding the effective head constant.

Conclusion

PSD is consistently smaller than the orifice discharge in the sites that we chose for our study, assuming that the orifice is lying on the bottom of the OSD. It is not immediately clear how MSMA designers come up with how many percent the Orifice Discharge has to be reduced to give us the PSD, but it does seem that from our sample calculation, the PSD value is computed by reducing the orifice diameter size to 20% to 30%.

Related



Ngu Soon Hui

I'm the Benevolent Dictator for Life for MiTS Software cum Editor of this website. Read more here.

You can also contact me at soonhui@mes100.com