SEGi Review ISSN 1985-5672
Vol.6, 2013
*Corresponding author. E-mail: nsukong@ump.edu.my

Short Communication

AN EVALUATION OF THE DESIGN CRITERION FOR SEWERAGE PEAK FLOW FACTOR AT SEGi UNIVERSITY HOSTEL

***Su Kong Ngien[1], Ng Sook Pian[2]**
[1]Faculty of Civil Engineering and Earth Resources, Universiti Malaysia Pahang, Pahang, Malaysia; [2]Schools of Engineering and the Built Environment, SEGi University, Selangor, Malaysia.

ABSTRACT

Field monitoring of the sewage flows from a sewerage catchment servicing the hostel within SEGi University was performed using an area-velocity flowmeter. The data obtained were processed through the Flowlink software and the results show that the peak flow for the monitored duration occurred at night whereas the daily peak flow occurred on a weekday. The actual per capita flow measured based on the current number of students is 35.6% higher than the design per capita flow stipulated in the Malaysian Standard MS1228:1991. On the other hand, based on the actual per capita flow and actual peak flow from the duration monitored, the actual design criterion obtained is 2.88, lower than the design criterion of 4.7 recommended in MS1228:1991. From the evaluations done, the recommended design criterion for peak flow factor by MS1228:1991 is adequate for a sewerage catchment catering to a population equivalent (PE) similar to this study.

1.0 Introduction

A sewerage system is one of the most critical considerations in the sanitary element of any residential, commercial, institutional or industrial construction projects where the final structures will be used by humans (Rahman, Alias, Salleh and Samion, 2007). Sewerage systems are designed to collect wastewater through sewer pipelines before discharging it to treatment plants to ensure that the wastewater is eventually released to natural water bodies in appropriate quality and condition (Read, 2004). In this study, the term wastewater encompasses used water generated from kitchens, toilets and bathrooms (Kamal, Goyer, Koottatep and Amin, 2008). An improperly managed sewerage system, such as those with surcharging manholes (Butler and Davies, 2011), will result in pollution and contamination of various aspects of our surrounding, ultimately leading to adverse effects on human beings since, as stated in Commoner's Law, '*Everything is connected to everything else'*.

The code of practice for design and installation of sewerage systems in Malaysia is given in the Malaysian Standard MS1228:1991. The efficiency of a sewerage system is affected by the flow of wastewater, hence the importance of the peak flow factor in sewer designs as it influences the amount of potential flow within the sewerage system. The peak flow factor is in turn dependent on both the design criterion, which is currently fixed at 4.7, as well as the population equivalent (PE), which represents an estimation of the number of people in the area concerned that will use the sewerage system. Among these two parameters that influences the peak flow factor, the PE has to be based on the area serviced by the sewerage system and is not something that can be controlled. Therefore, it is the design criterion that has to be looked at since it is a constant, of which the value must have been arrived at by previous studies and is subject to possible revision.

This study was initiated based on the fact that the MS1228:1991 has been around for an arguably long time. The initial version of the British Standards on which the MS1228:1991 was largely based had been revised twice with the latest version dated year 2008 (BS EN 752:2008), posing the question of a possible relook at our own MS1228:1991. This study forms part of the overall research where the main purpose is to evaluate the appropriateness of the design criterion and, by extension, the peak flow factor for sewerage systems as recommended in MS1228:1991.

2.0 Methodology

2.1 Study Site

Figure 1 shows a schematic of the study site location inside SEGi University' compound as well as a view of the manhole in which the study was performed. Certain criteria were imposed to determine the suitability of the stretch of sewer where the flow is to be measured:

1. The sewer line must have no lateral connections.
2. The flow must be stable and not turbulent.
3. No presence of backflow due to pumping or surcharge.
4. The sewer line must be of the same diameter throughout its length.

Although Figure 1 shows the location of the manhole to be at a bend of the sewer connection, the sensor of the flowmeter was actually situated to measure the flow before the bend, thus fulfilling all the criteria listed.

2.2 Material and Equipment

A portable ISCO 2150 Area-Velocity Flowmeter (Bioclear Sdn. Bhd., Puchong, Malaysia) was used to measure the sewage flow characteristics inside the selected sewer line. The automatic sensor equipped to the flowmeter was fixed to the bottom of the sewer line using a mounting ring and worked based on the principle of the Doppler effect (Rosen and Gothard, 2010). Data in the form of water height, velocity as well as volume flow were measured and recorded automatically at preset intervals of 15 minutes. At the end of the measurement, the recorded data was extracted using the Flowlink software, which can also plot graphs for the three different types of data as well as handle transfer of those data to other softwares.

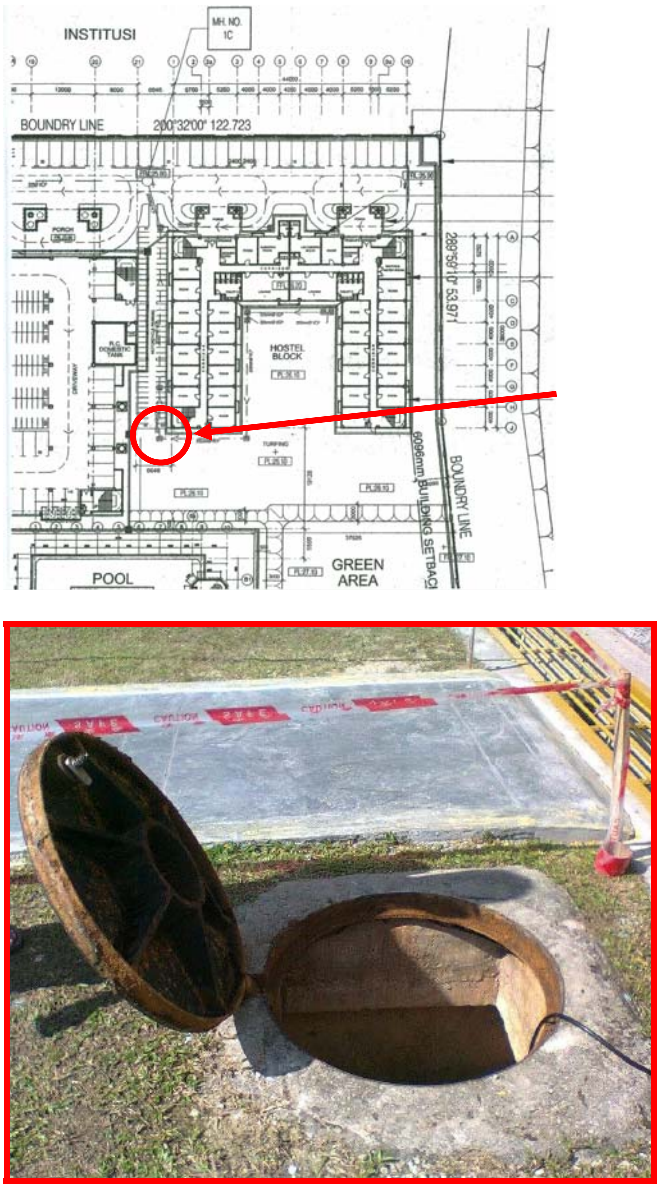

Figure 1: Location and View of Study Site

2.3 Population Equivalent (PE)

In this study, the PE is calculated based on the 'Fully Residential Education Institute' part of table 1 in MS1228:1991 where the PE is taken as 1 per student. The number of students staying in the hostel of SEGi University was provided by the warden in charge of the hostel. At the time of the study, the hostel was not fully occupied so the number of students there came up to 251.

2.4 Governing Equations

The PE described in the previous section is used in both per capita flow as well as peak flow calculations. Equation 1 shows the calculation for per capita flow,

$$Q_{pcf} = \frac{Q_{ave}}{PE} \qquad \textbf{Equation 1}$$

where Q_{pcf} is per capita flow in m^3/day/person, Q_{ave} is in m^3/day and is the average flow obtained from the measured data, and PE is in person. The peak flow of the sewer line can be obtained using Equation 2,

$$Q_{peak} = PFF \times Q_{ave} \qquad \textbf{Equation 2}$$

where Q_{peak} represents the peak flow in m^3/day, PFF is the peak flow factor, and Q_{ave} as described earlier. The peak flow factor equation is based on MS1228:1991 and is given in Equation 3,

$$PFF = K\left(\frac{PE}{1000}\right)^{-0.11} \qquad \textbf{Equation 3}$$

where K is the design criterion and PE as described previously. In order to obtain the value for the design criterion, Equations 1 to 3 can be combined and rearranged, giving Equation 4.

$$K = \frac{Q_{peak}}{\left(Q_{pcf} \times PE\right)\left(\frac{PE}{1000}\right)^{-0.11}} \qquad \textbf{Equation 4}$$

3.0 Data Analysis and Discussion

3.1 Flow Characteristics

The sewage flow data was collected for a period of seven days, from 11am on the 15th of March 2013 to 11am on the 22nd of March 2013. As the data were recorded at 15 minutes intervals, a method was needed to condense the vast amount of data into a more concise form to facilitate understanding. Therefore, the data was divided into 168 hourly slots and the maximum, average as well as minimum flows (Q_{max}, Q_{ave} and Q_{min} respectively) were extracted from each hourly slot. Subsequently, the maximum flow for the equivalent hour (e.g.: 10am to 11am) of each day during the study were compared and the flow with the highest value was taken as the Q_{max} for that particular hour of a day. Q_{ave} and Q_{min} for each hour of a day were obtained through the same method. The resultant flow characteristics can be seen in Figure 2.

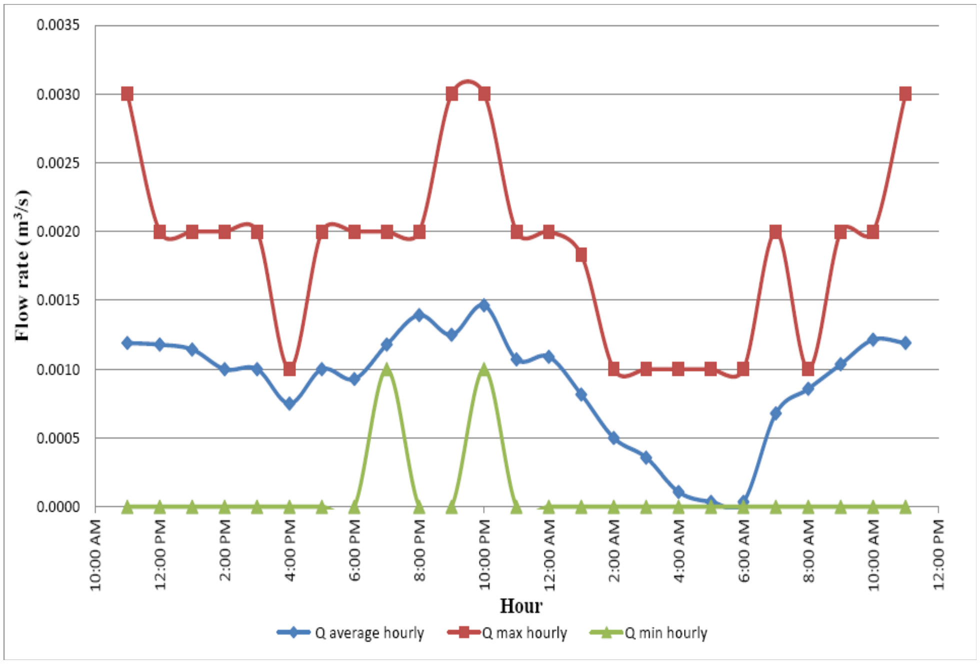

Figure 2: Hourly Flow Characteristics

During the monitoring period, the maximum flow occurred between 9pm to 10pm at a magnitude of 0.003 m^3/s, which translates to a peak flow of 259.2 m^3/day. The temporal occurrence of the peak flow indicates that students staying in SEGi University's hostel mainly prepare for sleep around that period of time. This is supported by the Q_{ave} graph line which crested between 8pm to 10pm. Figure 2 also shows that the minimum flow observed is zero. Based on the Q_{ave} and Q_{min} graph lines, most of the students go to bed around midnight as there was little or no flow from 2am to 6am.

3.2 Per Capita Flow

The average flow during the period of study was found to be 76.6 m^3/day. Based on a PE of 251 contributing to the flow, the per capita flow is 0.305 m^3/day/person. This contribution is 35.6% higher than the design per capita flow of 0.225 m^3/day/person stated in MS1228:1991. Infiltration of groundwater into the sewer pipes due to rain has been ruled out as there were no subsequent spikes in the magnitude of the flow data collected even when heavy rain occurred around 3pm to 7pm on the 21st of March 2013. Thus, the usage of water by students staying in SEGi University's hostel can be said to be very high, considering the point that the design per capita flow of 0.225 m^3/day/person would have included some allowance for higher-than-normal usage of water.

3.3 Design Criterion for Peak Flow Factor

Using the actual peak flow and actual per capita flow values presented in the previous two sections, the resultant design criterion was back-calculated to be 2.88. This value is 38.7% lower than the design criterion stated in the peak flow factor equation in MS1228:1991. This difference is quite substantial, hence it was decided to do some parametric studies to confirm the trend of the value obtained. Table 1 shows the design criterion values calculated when different parameters were applied.

Table 1: Investigation of Design Criterion Based on Different Parameters

Design Criterion (K)	*Per Capita Flow (Actual)*	*Per Capita Flow (Recommended)*
PE (Actual)	2.88	3.94
PE (Fully Occupied)	3.12	

When the actual per capita flow was replaced with the recommended per capita flow of 0.225 m^3/day/person in Equation 4, the resultant design criterion is 3.94 as shown in Table 1. Though this value is higher than 2.88, it is still lower than the 4.7 stated in MS1228:1991 by 16.2%. On the other hand, a design criterion value of 3.12 was obtained using the actual per capita flow with the PE in the peak flow factor modified to 483, which is the value if the hostel is fully occupied. Similar to the previous case, the value obtained is higher than 2.88 but lower than the 4.7 stated in MS1228:1991 by 33.6%.

4.0 Conclusion

The aim of evaluating the design criterion for sewerage peak flow factor of the sewer line servicing the hostel in SEGi University was achieved. Certain lifestyle aspects of the students staying in the hostel were deduced through the flow characteristics. The actual per capita flow calculated from the recorded sewage data is 0.305 m^3/day, which is higher than the amount a normal person would use according to MS1228:1991. The actual design criterion calculated based on the actual peak flow measured and the actual per capita flow calculated is 2.88, considerably lower than the original value of 4.7 used in MS1228:1991. Parametric studies performed to investigate the difference supported the value determined through this study. Since a lower design criterion will give a lower peak flow factor and subsequently a smaller design peak flow, it follows that the sewerage system servicing the hostel in SEGi University would have been designed for a much higher peak flow as the design criterion of 4.7 which is significantly higher than 2.88 would have been used during its design stage. As a conclusion, the design criterion for the peak flow factor equation found in MS1228:1991 is adequate for sewerage catchments catering to a PE similar to this study.

REFERENCES

British Standard EN 752: Drain and Sewer Systems Outside Buildings, British Standards Institution (BSI), United Kingdom (2008).

D. Butler and J. W. Davies, *Urban Drainage 3rd Edition*, Spon Press, Oxon (2011).

A. S. M. Kamal, K. Goyer, T. Koottatep and T. M. N. Amin, Urban Water J. **5 (4)**, 345 - 354 (2008).

Malaysian Standard 1228: Code of Practice for Design and Installation of Sewerage Systems, Standards and Industrial Research Institute of Malaysia (SIRIM), Malaysia (1991).

N. A. Rahman, N. Alias, S. S. M. Salleh and M. K. H. Samion, *Evaluation of Design Criteria for Inflow & Infiltration of Medium Scale Sewerage Catchment System*, IRPA Final Report, Research Vote No. 74281, Faculty of Civil Engineering, Universiti Teknologi Malaysia (2007).

G. F. Read, *Sewers: Replacement and New Construction*, Elsevier, Oxford (2004).

J. Rosen and L. Q. Gothard, *Encyclopedia of Physical Science*: *Volume 1*, Facts on File Inc., New York (2010).