Study on fluctuation of water consumption at education activity building (Universitas Pendidikan Indonesia as a case study)

by Evi Afiatun -

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Abstract. The aim of this research is to know the pattern of clean water consumption at Universitas Pendidikan Indonesia (UPI). The study was conducted in three lecture buildings. Observations and measurements are made based on changes in water level reservoir once every hour for 10 days respectively. The first building was a FPOK building consisting of 5 floors with 37 staff rooms and 19 lecture halls. The second is the FPBS building consisting of 5 floors with 1 basement with 39 staff rooms and 33 lecture halls. The third is the FPEB building consisting of 6 floors with 10 laboratory rooms and 20 lecture halls. All buildings are equipped with men's and women's toilets on each floor. The result show that the peak hour factor for the three buildings, respectively, is 2.269; 1.909; 3.09 and the maximum daily factor is 1.058; 1.079; 1.06. The highest peak hour factor occurred in the FPEB building because the water use every hour is quite high and tend to occur during rest and prayer. Significant differences occur in the peak hour factor rather than the maximum daily factor because of the same characteristics of the three buildings with different hour-to-hour but same day-to-day activities.

1. Introduction

Water demand for each activity is different, therefore the water needs is differentiated according to its function in fulfilling the needs of the community both domestic and non domestic [1]. Factors affecting water consumption are the geographic state of an area, community type, economic condition, water pressure, cost, management system and water conservation [2]. Fluctuations in water use is a decrease or increase in water use by consumers in a region, which reaches a maximum at a certain moment and a minimum at another time that is affected by the variation of community activity in the region [3]. Determination of the water flow rate in a multi-storey building, can use several methods such as based on the number of users, based on the type and number of plumbing tools, and based on the plumbing fixture unit [4].

In calculating the water needs for a multi-storey educational building , it is necessary to have a basic plan which includes the water use standard, water fluctuation, peak hour factor, and maximum daily factor. Various water use patterns cause the water usage fluctuations in different buildings. This is the basis of research on water use fluctuations, which is to know the pattern of clean water usage that causes the fluctuation of water usage in educational building with case study at three education buildings at Universitas Pendidikan Indonesia (UPI). The three buildings are the Faculty of Sport and

Health Education (FPOK), the Faculty of Language and Literature Education (FPBS), and the Faculty of Economics and Business Education (FPEB). The description of each building as in Table 1.

Table 1. Description of each building

Building	Number of Floors	Number of Office space	Number of Laboratories	Number of Lecture rooms	Number of Toilets	Reservoir Capacity
FPOK	5	37		19	10	10000
FPBS	5+1 basement	39		33	10	12000
FPEB	6		10	20	12	4000

Souce : observation

The water source in FPOK building and FPEB building comes from Cibeureum River, while the FPBS building comes from ground water. The water supply system in the three lecture buildings uses a roof tank system, where water from both sources goes into the ground reservoir and then pumped into the water rooftank and distributed to the plambing unit by gravitational energy.

2. Research Methods

Calculation of water use pattern and peak hour factor is done in the three lecture buildings, namely FPOK, FPBS, and FPEB building.

The data collected consists of primary and secondary data. Primary data was obtained by measuring the water level in the reservoir once every hour for 10 days, 13 hours each day. Secondary data is obtained from the household division, resources, academic staff of each faculty at UPI campus. The data collected is UPI Campus profile, number of civitas academic, lecture activity schedule in each UPI campus, number of clean water supporting facility.

The data analysis method used is based on the average daily water use in accordance with its use. Data on the pattern of water use during peak hours is obtained by calculating the hourly water usage in one day. According Red.T (1993) peak hour factor can be obtained as follows [5]:

2.1 Determination of hourly water usage at rooftank:

Volume out = Volume in – (Volume A-Volume B) (1)

Where :

Volume out = water usage in rooftank (m3)

Volume in = water supply at the beginning of rooftank charging (m3)

Volume A = Volume at rooftank at initial height of measurement (m3)

Volume B = Volume at rooftank at the final height of measurement (m3)

2.2 Calculation of daily average water demand in 10 days

$$Qrh = \frac{\sum Qh}{10} \quad (2)$$

Where :

Qrh = daily average debit in 10 days (m^3/day)

Qh = the number of water need in the same time (m^3/day)

2.3 Determination of peak hour usage

$$F(\text{peak hour}) = \frac{Qjp}{Qrh} \quad (3)$$

Where :

Qjp = peak hours debit in 1 day (L / hour)

2.4 Maximum daily usage

$$F(\text{peak day}) = \frac{Qhm}{Qrh} \quad (4)$$

Where :
Qhm = Maximum daily debit in 10 days (L/day)

3. Result and Discussion

The pattern of water use at certain times can be distinguished:

3.1 Average Daily Debit

The results of direct measurement of water consumption in the reservoir every lecture building for 10 consecutive days in which the amount of water consumption for 10 days divided by the number of days during the measurement, so that the results are as follows:

- Average daily debit in FPOK building: 6,671.87 L/d
- Average daily debit in FPBS building: 8,214.97 L/d
- Average daily debit in FPEB building: 3,625.56 L/d

Based on the average daily water consumption, it can be seen that the water consumption in FPBS building is the highest because the number of academic activities is quite a lot.

3.2 Fluctuations in Water Consumption

Fluctuations in water consumption were measured in all three buildings (Figures 1, 2, and 3). Differences occur because the allocation of each building and the number of academicians vary so that the effect on the amount of water use. From the measurement results seen that the peak hours that occur in each building as follows:

3.2.1 FPOK Building:

FPOK building as shown in Figure 1, experiencing various fluctuations, where the peak hour is dominated at 11:00-12:00 pm. The peak usage at this hour occurs 7 times in 10 days of observation, which occurs on Monday1, Tuesday 1, Wednesday 1, Friday 1, Monday 2, Thursday 2, and Friday 2. It happens because at 11:00 - 12:00 pm which caused by resting, praying, and eating, resulting in more water usage activities.

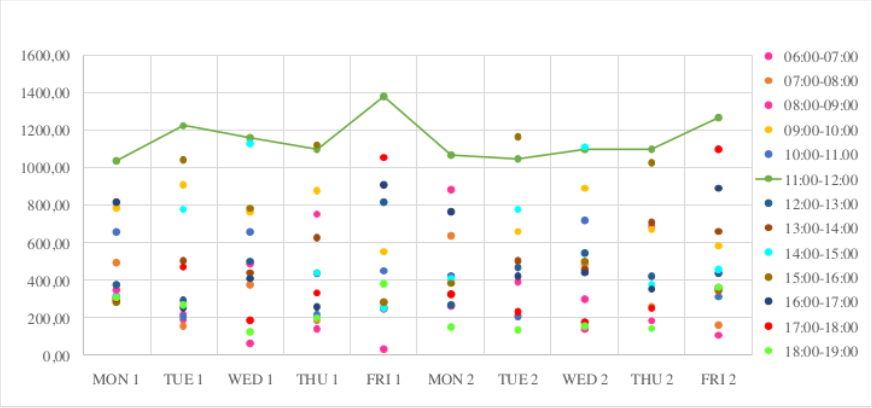

Figure 1. Fluctuation of water consumption in FPOK building

3.2.2 FPBS Building:

As shown in Figure 2, the peak hour of water consumption is dominated at 11:00 - 12:00 pm, 6 times in 10 days observation, which occurs on Wednesday 1, Thursday 1, Friday 1, Wednesday 2, Thursday

2 and Friday 2. It happens because at 11:00 to 12:00 pm which caused by resting, praying, and eating, resulting in more water usage activities.

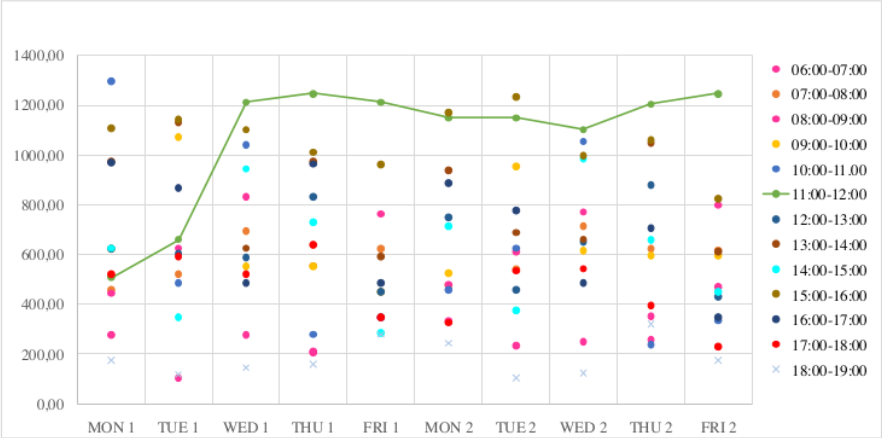

Figure 2. Fluctuation of water consumption in FPBS building

3.2.3 FPEB Building:

FPEB Building as shown in Figure 3, experiencing various fluctuation with the dominant peak water usage hours at 12:00 - 13:00 WIB as much as 4 times in 10 days observation, that is on Monday 1, Thursday 1, Monday 2, and Thursday 2, which caused by resting, praying, and eating. On the other days, the activities of the academic community are also quite diverse, so the fluctuations in the use of each hour are very diverse.

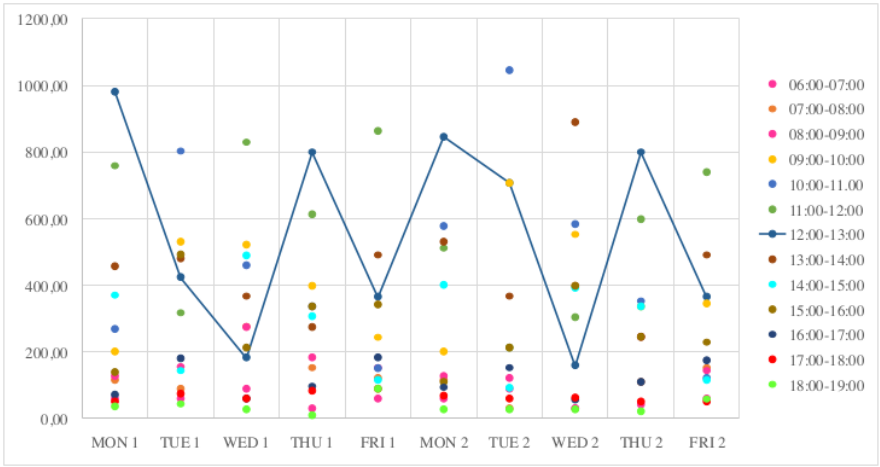

Figure 3. Fluctuation of water consumption in FPEB building

3.3 Calculation of the Peak Hour Factor and Maximum Daily Factor

The calculation of the peak hour factor and the maximum daily factor are obtained through equations (2), (3) and (4) using the average daily debit data in each building.

3.3.1 FPOK Building

Average daily water debit in FPOK Building:

$$Qrh = \frac{5132}{1} = 513.221 \text{ L/hour}$$

Peak Hour Factor in FPOK Building, range (2.101 -2.602)

$$F(\text{peak hour}) = \frac{1164,31}{513,221} = 2.269$$

Maximum Daily Factor in FPOK Building :

$$F(\text{peak day}) = \frac{542,978}{513,221} = 1.058$$

3.3.2 FPBS Building

Average daily water debit in FPBS Building :

$$Qrh = \frac{6319}{10} = 631.921 \text{ L/hour}$$

Peak Hour Factor in FPBS Building, range (1.624 - 2.276)

$$F(\text{peak hour}) = \frac{1206}{631,921} = 1.909$$

Maximum Daily Factor in FPBS Building :

$$F(\text{peak day}) = \frac{681,718}{631,921} = 1.079$$

3.3.3 FPEB Building

Average daily water debit in FPEB Building :

$$Qrh = \frac{2788,89}{10} = 278.89 \text{ L/hour}$$

Peak Hour Factor in FPBS Building, range (2.736 – 3.536)

$$F(\text{peak hour}) = \frac{861}{278,89} = 3.09$$

Maximum Daily Factor in FPBS Building :

$$F(\text{peak day}) = \frac{298,25}{278,89} = 1.06$$

Based on the calculation can be seen that the peak hour factor of FPOK buildng is 2.269, FPBS building is 1.909, and FPEB building is 3.09. This peak hour factor is obtained by comparing water usage at peak hour in a day with average daily water usage. So overall the peak hour of each building shows that the highest peak hour is in the FPEB building is 3.09, because the activity of water use every hour is quite high and tend to occur during breaks, prayers, and meals. The maximum daily factor of FPOK building is 1.058, the FPBS building is 1,079, and the FPEB building is 1.06. The value of this maximum daily factor can be obtained by comparing the daily maximum consumption with the average daily consumption.

4. Conclusion

Water consumption in FPEB buildings fluctuates more every day than the other two buildings. Fluctuations that occur due to the activities of the academic community FPEB building fewer and not diverse in every hour so that water use more fluctuate. In FPOK building and FPBS building the peak hour factor of water use fluctuates every hour in 10 days and occur because of the large number of activities requiring water and more of the number of academicians in each buildings.

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