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HASIL PENILAIAN SEJAWAT SEBIDANG ATAU *PEER REVIEW*
KARYA ILMIAH : JURNAL ILMIAH

Judul Jurnal Ilmiah (Artikel)	:	Prediction of Missing Streamflow Data using Principle of Information Entropy		
Jumlah Penulis	:	3 orang (Santosa, B., Legono, D., **Suharyanto**)		
Status Pengusul	:	penulis ke - 3		
Identitas Jurnal Ilmiah	:	a. Nama Jurnal	:	CIVIL ENGINEERING DIMENSION (CED), Journal of Civil Engineering Science and Application No. SK: 80/DlKTl/Kep/2012, Tgl. 13 Desember 2012
		b. Nomor ISSN	:	Online ISSN: 1979-570X, Print ISSN: 1410-9530
		c. Vol, No., Bln Thn	:	Vol 16, No 1 (2014)
		d. Penerbit	:	The Institute of Research & Community Outreach - Petra Christian University, Surabaya, Indonesia
		e. DOI artikel (jika ada)	:	DOI: https://doi.org/10.9744/ced.16.1.40-45
		f. Alamat web jurnal	:	http://ced.petra.ac.id/index.php/civ/article/view/18935
		Alamat Artikel	:	http://ced.petra.ac.id/index.php/civ/article/view/18935/18611
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Prof. Dr. Ir. Suripin, M. Eng
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		c.	Vol, No., Bln Thn	:	Vol 16, No 1 (2014)
		d.	Penerbit	:	The Institute of Research & Community Outreach - Petra Christian University, Surabaya, Indonesia
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Nama Terbitan Berkala Ilmiah
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Penerbit: Unviersitas Kristen Petra Surabaya

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Prediction of missing streamflow data using principle of information entropy

B Santosa, D Legono - Civil Engineering Dimension, 2014 - ced.petra.ac.id

Incomplete (missing) of streamflow data often occurs. This can be caused by a not continous data recording or poor storage. In this study, missing consecutive streamflow data are predicted using the principle of information entropy. Predictions are performed using the complete monthly streamflow information from the nearby river. Data on average monthly streamflow used as a simulation sample are taken from observation stations Katulampa, Batubeulah, and Genteng, which are the Ciliwung Cisadane river areas upstream. The …

ISSN 1410-9530 (Print)
ISSN 1979-570X (Online)

CIVIL ENGINEERING DIMENSION
Journal of Civil Engineering Science and Application

Dimensi Teknik Sipil
Jurnal Keilmuan dan Penerapan Teknik Sipil

Vol 16, No 1 (2014)

MARCH 2014

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CED is published by The Institute of Research & Community Outreach - Petra Christian University, Surabaya, Indonesia

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ISSN 1410-9530 print / ISSN 1979-570X online CED 2013, 16(1), DOI: 10.9744/CED.16.1.1-7

Analyses of Steel Bridge Circular Columns using Fiber Model considering Local Buckling

Kinoshita, K.[1]

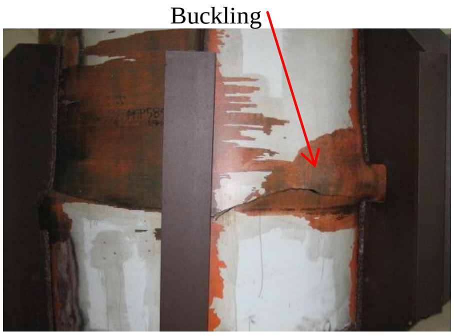
Abstract: One of the most concerned problems for analytical estimation of ultimate strength and ductility of steel bridge columns is the consideration of local buckling. Stress-strain curves with softening behavior to include local buckling in fiber model analysis method were proposed by several researchers. However, accuracy of those models is still relatively low. As a consequence, most steel bridge designs have been done using fiber model analysis method without consideration of local buckling. In order to improve the analytical response estimation of steel bridge columns, a fiber model analysis method considering local buckling is proposed in this study. In this method, multi-fiber elements were used to model the local buckling length to simulate local buckling deformation. The proposed method shows good results not only for estimating peak strength but also post-peak strength compared to previous experimental results. However, further research should be directed to improve the accuracy of the deformation modes.

Keywords: Fiber model, local buckling, steel bridge circular columns.

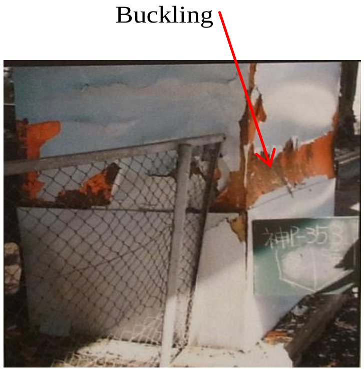
Introduction

Consideration of local buckling on analytical estimation of ultimate strength and ductility of steel bridge columns is one of the important lessons learned from severe bridge damage in past earthquakes (Figure 1). This local buckling was found in many different forms including variations from different column sections.

In general, fiber model analysis is used for seismic evaluation of not only reinforced concrete columns, but also steel bridge columns. The earliest study by Park et al. [1] used the fiber model analysis for a reinforced concrete member. Following this study, the fiber model analysis was used and developed [2,3]. A recent study on the seismic performance of a reinforced concrete bridge column tested on the E-Defense, which is a full-size, three-dimensional shake table in Japan, was reported by Kawashima et al. [4]. The study confirmed the accuracy of the fiber model analysis. For steel bridge columns, analytical studies using the fiber model analysis were reported by Watanabe and Sakimoto [5], Tokunaga et al. [6]. Moreover, for steel bridge columns with the consideration of local buckling, there are modeling techniques that include local buckling effects in the stress-strain curves of the plastic hinge zone, where local buckling is occurred.



(a) Circular Column



(b) Box Column

Figure 1. Damaged Steel Bridge Column, Kobe Earthquake, 1995

Although the modeling techniques are not new and many suggestions have been made in previous studies [7-8], in practice, a common assumption in the analysis of steel bridge columns using fiber model is to ignore the local buckling. The Japanese Standard Specification for Seismic Design of Steel and Composite Structures [9] permits these

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Note: Discussion is expected before June, 1st 2014, and will be published in the "Civil Engineering Dimension" volume 16, number 2, September 2014.

Received 17 May 2013; revised 10 June 2013; accepted 14 August 2013.

Civil Engineering Dimension, Vol. 16, No. 1, March 2014, 8-17
ISSN 1410-9530 print / ISSN 1979-570X online
CED 2013, 16(1), DOI: 10.9744/CED.16.1.8-17

Effect of Rigidity of Plinth Beam on Soil Interaction of Modeled Building Frame Supported on Pile Groups

Ravi Kumar Reddy, C.[1] and Gunneswara Rao, T.D.[1]

Abstract: This paper presents the effect of rigidity of plinth beam on a model building frame supported by pile groups embedded in cohesionless soil (sand) through the results of static vertical load tests. The effect of rigidity of plinth beam on displacements and rotation at the column base and also shears and bending moments in the building frame were investigated. In the analytical model, soil nonlinearity in the axial direction is characterized by nonlinear vertical springs along the length of the pile (τ-z curves) and at the tip of the pile (Q-z curves) while in the lateral direction by the p-y curves. Results revealed that, shear force and bending moment values which were back calculated from the experimental results, showed considerable reduction with the reduction of the rigidity of the plinth beam. The response of the frame from the experimental results is in good agreement with that obtained by the nonlinear finite element analysis.

Keywords: Building frame, cohesionless soil, nonlinear analysis, plinth beam, soil structure interaction.

Introduction

The foundation resting on deformable soils undergoes deformation depending on the rigidities of the foundation, superstructure and soil. However, the conventional method of analysis of framed structures considers bases to be either completely rigid or hinged. Hence interactive analysis is necessary for the accurate assessment of the response of the superstructure. Numerous interactive analyses have been reported in several studies [1-10]. Many numerical works and comparative studies are available on pile foundation, but comparatively little experimenttal work [11] was reported on the analysis of framed structures resting on pile foundations to account for the soil-structure interaction. In this study, an extensive experimental investigation was carried out on the model pile groups supported plane frame with plinth beam of different rigidities. Pile groups are embedded in sand. The building frame is subjected to static loads (central concentrated load, uniformly distributed load and eccentric concentrated load). From the literature review, it is observed that the study of building frame supported by pile groups embedded in sand is not reported elsewhere. Hence the sand is taken for the study.

The need for consideration of soil interaction as well as rigidity of plinth beam is emphasized by comparing the behavior of the frame obtained from the experimental analysis with that of conventional method of analysis.

Experimental Program

Frame and Pile Groups

Using the scaling law proposed by Wood et al. [12] and reproduced in Equation 1, the material and dimensions of the model were selected:

$$\frac{E_m I_m}{E_p I_p} = \frac{1}{n^5} \quad (1)$$

where E_m is modulus of elasticity of model, E_p is modulus of elasticity of prototype, I_m is moment of inertia of model, I_p is moment of inertia of prototype, and $1/n$ is scale factor for length. An aluminum tube with an outer diameter of 16 mm and inner diameter of 12 mm was selected as the model pile with a length scaling factor of 1/10. This is used to simulate the prototype pile of 350 mm diameter solid section made of reinforced concrete. Columns of height 3.2 m, beam of span 5 m and plinth beam of the plane frame were scaled in the same manner. Rigidity of plinth beam is varied by using 10x10 mm square bar, 8x8 mm square bar, 5 mm diameter round bar and 3 mm diameter round bar of aluminum. The rigidity values of plinth beams used in the study are tabulated in Table 1.

Table 1. Rigidity of Plinth Beam

S.No	Size of the plinth beam	Axial rigidity of plinth beam ($x10^5$ N)
1	10 x 10 mm square	70.0
2	8 x 8 mm square	44.8
3	5 mm diameter	13.75
4	3 mm diameter	4.95

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Note: Discussion is expected before June, 1st 2014, and will be published in the "Civil Engineering Dimension" volume 16, number 2, September 2014.

Received 09 December 2012; revised 29 January 2014; accepted 02 April 2014

ISSN 1410-9530 (Print)
ISSN 1979-570X (Online)

CIVIL ENGINEERING DIMENSION
Journal of Civil Engineering Science and Application

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Civil Engineering Dimension (CED) is a peer-reviewed journal supported by Petra Christian University.

The Civil Engineering Dimension (CED) was first accredited by the Directorate General of Higher Education of Indonesia in 2000, with its decree No. 395/DIKTI/Kep/2000. Since then, CED has been honored with the accreditation status without any interruption. The latest accreditation decree is No. 51/E/KPT/2017, dated 4 December 2017, valid for 5 (five) years. CED has been granted the status of green tick by DOAJ (http://www.doaj.org).

The Civil Engineering Dimension (Dimensi Teknik Sipil) is a refereed journal, published twice a year, in **March** and **September**.

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Accredited by the Ministry of Research, Technology and Higher Education, Indonesia

- **Vol 2 - Vol 4** : No. 395/DIKTI/Kep/2000
- **Vol 5 - Vol 7** : No. 49/DIKTI/Kep/2003
- **Vol 8 - Vol 10** : No. 55a/DIKTI/Kep/2006
- **Vol 11 - Vol 13** : No. 110/DIKTI/Kep/2009
- **Vol 14 - Vol 19** : No. 80/DIKTI/Kep/2012
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Prediction of Missing Streamflow Data using Principle of Information Entropy

by Suharyanto Suharyanto

Civil Engineering Dimension, Vol. 16, No. 1, March 2014, 40-45
ISSN 1410-9530 print / ISSN 1979-570X online
CED 2013, 16(1), DOI: 10.9744/CED.16.1.40-45

Prediction of Missing Streamflow Data using Principle of Information Entropy

Santosa, B.[1], Legono, D.[2], and Suharyanto[3]

Introduction

Water resources planners and managers use historical monthly average streamflows data for a variety of purposes. The data set are often not complete, missing streamflows data may exist due to various reasons such as not continuous data recording or lost in storage. In relation to the development of analysis techniques, there should be a better method so that the uncertainty concerning with frequency of field experience could be minimized, to be accurate in predicting calculation.

The purpose of this paper is to develop and to test a method to fill monthly average missing streamflows data. Predictions to fill the missing streamflows data use existing data and information data from the nearest river basins that have a complete data recording history and proximity hydrological. Information from a nearby river basin is required, because the hydrologic pattern of adjacent river basin have similarities. This information will be utilized to fill the missing streamflow data in a river basin.

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Note: Discussion is expected before June, 1st 2014, and will be published in the "Civil Engineering Dimension" volume 16, number 2, September 2014.

Received 21 November 2012; revised 04 June 2013; accepted 08 May 2014.

The approach used to predict a missing streamflows data is the principle of information entropy, which is based on the probability of distribution of each river flow events within a region [1].

Unavailability of data has led the theory of entropy to be attractive and widely used in models of decision making in environmental and water resources [1]. Kusmulyono and Goulter [2] used of the principles of entropy as a method of analysis, that is based on the interpretation of entropy principle and characteristics, that can be used to analyze events that have a probability.

The entropy theory comprises three main parts: Shannon entropy, principle of maximum entropy, and principle of minimum entropy. The entropy theory has been applied to a great variety of problems in hydrology and water resources. Singh and Rajagopal [3] discussed advances in application of the principle of maximum entropy (POME) in hydrology. Singh and Rajagopal [3] presented new perspectives for potential applications of entropy in water resources research. The entropy principle has recently found areas of versatile and promising use in hydrology and water resources [1]. Specific area of its application covers assessment of model performance, derivation of functional relationship, evaluation of information transfer between hydrology variables data, parameter estimation, derivation of frequency distribution, streamflow prediction, assessment of uncertainty, and evaluation of data acquisition system [3]. The method is subsequently extended for purposes of spatial design in case of steamflow gaging stations by defining transferred and transferable amounts of information [4].

Entropy method has been developed to estimate the random variable when the data are series of independent observations of the variable. This method is interesting, because it meets two basic requirements used to analyze probability based on the principle of invariant systems and the principle of monotonous data. Minimum entropy method has been applied to the analysis of the flood, and then compared with the method of moments and maximum likehood [5]. The entropy theory is used to develop a univariate model for forecasting of long term streamflow [6]. The maximum entropy method is also widely applied and the maximum entropy distribution proved suitable for a variety of flooding data [7]. An entropy-based approach has been developed for estimation of natural recharge in Kodaganar River basin, Tamil Nadu, Southern India [8].

The frequency distribution is usually assumed in the analysis of frequency. The parameters of the distribution are estimated using the observed data changes. Completeness of the distribution is then used to estimate the amount of flow with different frequencies. Maximum entropy is a probability distribution which is defined as the minimum conditional probability distribution obtained by maximizing the entropy subject to constraints of the information given limits [7]. Apart from the interesting features of the distribution of maximum entropy, yet commonly used in practice, the main reason for not using the maximum entropy distribution in the general form is that the parameter estimation problem associated with the maximum entropy distribution is not easy. Recently this problem has been solved and the algorithms have been developed to estimate the parameters of the distribution of maximum entropy [7].

Study Area and Data

This research studies area are Ciliwung and Cisadane rivers with observational data obtained from the Department of Water Resources, Bandung, Indonesia. The data used in this study are drawn from the monthly average streamflows from observation stations Katulampa, Batubeulah and Genteng, at the Ciliwung and Cisadane river upstream. The monthly average flow profiles of the three observation stations can be seen in Figure 1.

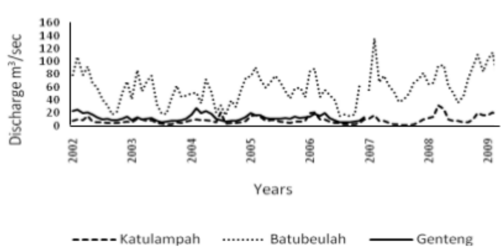

Figure 1. Monthly Average Streamflows Data from Batubeulah, Katulampa, and Genteng Stations.

Method

Second Law of Thermodynamics states that under normal conditions, all systems without disruption tend to be disorganized, dispersed, and corrupted over time. Second law of thermodynamics is a way of defining this natural process with physics equations and calculations. This law is also known as entropy [1]. Shannon [9] developed the entropy theory for expression of information or uncertainty. To understand the informational aspect of entropy, we consider a set consisting of n events. We view uncertainty as a situation where we do not know which event among n events will occur. Thus, uncertainty is about which one of those events actually occurs.

Entropy is the interval of disorder in a system. It increases when a regular, structured, and planned state system becomes more irregular, scattered, and unplanned. Law of entropy states that the whole universe moves towards a more disordered, unplanned, and disorganized. Shannon [9] illustrates that the entropy is the amount of uncertainty in probability distributions. Thus, the concept of entropy can be used as a measure of uncertainty and indirectly as a measure of the probabilistic information. According to Shannon [9], this information is achieved only when there is uncertainty about an event. This uncertainty can be assumed to indicate the presence of alternative outcomes of events and to select them. Alternative with a high probability of occurrence showed little information available and its opposite. Thus, the likelihood of occurrence of a particular alternative is a measure of uncertainty, in this case Shannon called the entropy.

Information is a measure of uncertainty or entropy in a situation. The greater the uncertainty, the greater the available information. If there is a circumstance, there is no information at all. Theory of information entropy is a formula in use and at follow as the basis of measurement. The probability of n possible events 1, 2, 3, ..., n is p_1, p_2, ..., p_n, and uncertainties may be defined as H (p_1, p_2, p_3, .., p_n) [10]. The basic equation of entropy is shown in Equation 1.

$$H = -K\sum_{i=1}^{n} p_i ln\, p_i \qquad (1)$$

Where H is a measure of information or the size of the uncertainty, the probability p_i that may be on events i. H will have a maximum value (ln n) if all the events is uncertain and p_i = 1/n. H will have a minimum value (0) if all the events for sure. In the probability of random occurrence the value of H will be between the two extremes. The maximum mean value of H indicates that there is no bias in predicting.

Principle of Maximum Entropy (POME)

Since the development of the entropy theory by Shannon in the late 1940s and of the principle of maximum entropy (POME) by Jaynes [11] in the late 1950s there has been a proliferation of applications of entropy in a wide spectrum of areas, includeing hydrological and environmental sciences. Maximum entropy is also called the Principle of Maximum Entropy (POME). Characteristics of the maximum entropy function in Equation 2 are uniform probability distribution that will produce the maximum entropy value for the occurrence of the specified limits. Conversely the maximum entropy function Equation 3 has a limitation that the number of probabilities of all events must be equal to one, to ensure the probability distribution is the probability uniformly on every event. The principle of entropy can be used to obtain the probability distribution by maximizing the objective function by setting limits for specific information events.

$$\text{Maximum } H = -\sum_{i=1}^{n} P_i \ln P_i \tag{2}$$

$$\text{where } \sum_{i=1}^{n} P_i = 1 \tag{3}$$

$$\sum_{i=1}^{n} p_i \, x_i = \bar{x} \tag{4}$$

Principle of Minimum Entropy (MDI)

Minimum entropy is also called the Minimum Discrimination Information (MDI). The minimum entropy principle was first introduced by Kullback and Leibler [10], the measurement approach performed with two probability distributions, namely the information to determine the difference between probability distributions P and Q. Equation presented by Kullback and Leibler [10] to measure the entropy value is as in Equation 5 as the following:

$$\text{Minimum } H(P:Q) = \sum_{i=1}^{N} P_i \ln \frac{p_i}{q_i} \tag{5}$$

Where p_i is the probability of event i of the probability distribution P and q_i probability of event i of the probability distribution of Q

Predicting Method

Prediction of missing streamflows data on the observed location are performed using the principles of information entropy of the maximum and minimum entropy. Between maximum entropy and entropy will have a minimum value of entropy with the same probability distribution for events distributed uniformly. For example in the case of throwing the dice. Real probability of throwing the dice is p_i, whereas q_i is the theoretical probability which is 1/6. Optimization of the maximum entropy (Equation 2) will yield an equal value to the optimization of minimum entropy (Equation 5) with the information value of q_i = 1/6. Figure 2 and Figure 3 are probability distribution results obtained from optimization of the maximum and minimum entropy with the constraint (Equation 3) and the average value (Equation 4) of 3.5 and 4.5 respectively, while Figure 4 is obtained by adding the standard limits deviation of 1,898 in order to get a normal probability distribution.

The minimum entropy principle with the example of throwing dice can be applied in the selection of probability distributions for hydrological parameters, especially on the observation history of discharge data on the location of the observation of a river to provide information on other locations. The principle of maximum entropy distribution factor allows to incorporate probabilities q_i, which is the initial information or (prior probability), to improve the final probability distribution p_i (posterior probability) as a basis prediction.

Figures 5 and 6 are illustrations of three adjacent river basins, where river basin data B has a vacancy that occurs in a certain time, while A and C is a river basin with complete data. Predicted loss of data in B can be done with the help of information from the river basin data A and C with the same period events, with consideration of the similarity of the flow pattern because of the proximity factor hydrology and climatology.

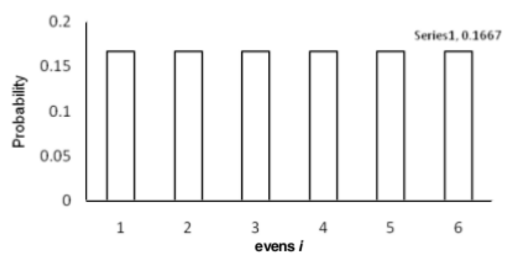

Figure 2. Throwing Dice Probability Distribution with an Average Set of Incidence = 3.5

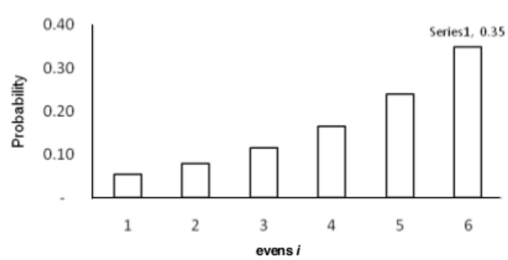

Figure 3. Throwing Dice Probability Distribution with an Average Set of Incidence = 4.5

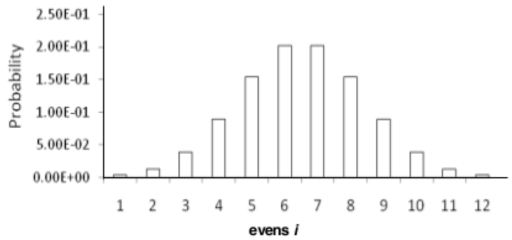

Figure 4. The Probability Distribution of 12 Events with an Average Set of Events 6.5 and Standard Deviation 1.898

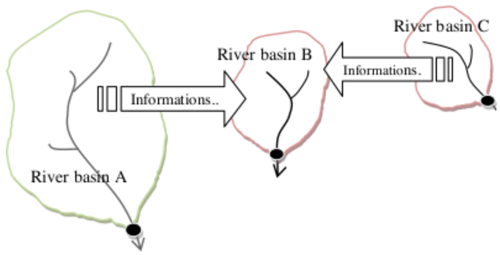

Figure 5. Prediction River Basin B used Information from the Data River Basins A and C.

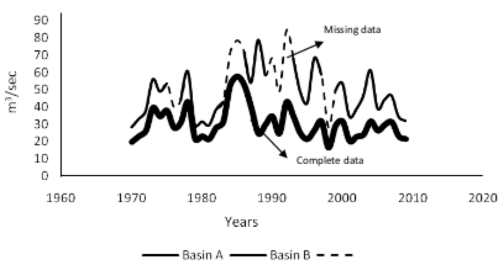

Figure 6. Illustration River Basin with Complete and Missing Data

While other information is needed in the prediction process including the amount of flow probability relationship information from both river basins namely, the joint probability between the river basin in the prediction (B) or river basin that provides information (A and C), in the same period for the other events. The information is also important to the average and deviation of the events in the long and the other time.

Results and Discussion

First simulation to predict the monthly average missing streamflows data on Katulampa station, which is located in the river upstream Ciliwung. The predictions were made using a monthly average streamflow data, with a scenario eliminating the twelve month data in 2002. Predictions of missing stramflows data, were based on monthly average streamflow data information on the nearest station which is Genteng.

Prediction is basically done by utilizing the existing probability to generate a new probability in the year in which the predictions is performed. Prediction in this case is to generate data on flow rates at Katulampa station in 2002, then it must be known probability for flow in 2002. The probability of flow at Katulampa in 2002 can be generated by utilizing the nearest station flow data at Genteng in 2002, i.e. by finding the joint probability between the flow at Katulampa and Genteng station in 2002. This can be performed by using Equation 5 with its limitations (Equation 3 and 4), and with the help of the joint probability of information between the flow at Katulampa and Genteng stations from other years (2003-2006) and then joint probability between Katulampa and Genteng can be produced for the year 2002. Joint probability between Katulampa and Genteng in 2002 was a condition that must exist to generate predictions of Katulampa flow in 2002. Other information required in this prediction is the average flow and the deviation from the station Katulampa in 2003-2006. Predictions are also performed to flow at station Katulampa 2003, using information from the Batubeulah and Genteng stations. Prediction methods and processes are the same as when predicting the flow at Katulampa of 2002.

Prediction is done using the minimum entropy (Equation 5), where p_i is the probability that will be generated as the basis in making predictions, whereas q_i is the initial information obtained from the joint probability of the average flow events between Katulampa and Genteng or Katulampa and Batubeulah (Equation 2). Initial information from the two observation stations function to improve the joint probability p_i when performing predictions. Prediction of flow data on Katulampa station in 2002, based on information from the Batubeulah station (prediction 1) and information from the Genteng station (prediction 2), can be seen in Table 1 and Figure 7. The mean absolute errors (MAE) average that occurred are 0.20 and 0.21. Whereas Prediction of flow data on Katulampa station in 2003, based on information from the Batubeulah station (prediction 1) and information from the Genteng station (prediction 2), can be seen in Table 2 and Figure 8. The mean absolute errors (MAE) average that occurred are 0.12 and 0.16.

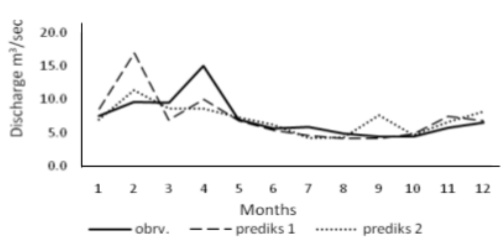

Figure 7. Prediction of Missing Streamflows Data in 2002 at Katulampa Station with Information Based from the Batubeulah and Genteng Station.

Table 1. Prediction of Missing Streamflows Data in 2002 at Katulampa Station

Month	Observations. (m^3/sec)	Predictions 1 (m^3/sec)	Predictions 2 (m^3/sec)	MAE Predictions 1	MAE Predictions 2
1	7.5	8.6	7.01	0.14	0.07
2	9.6	16.9	11.42	0.75	0.18
3	9.5	6.9	8.64	0.28	0.09
4	15.0	10.0	8.61	0.34	0.43
5	7.0	6.8	7.32	0.03	0.05
6	5.7	5.4	6.24	0.05	0.10
7	5.9	4.5	4.21	0.22	0.28
8	4.9	4.1	4.27	0.15	0.12
9	4.4	4.1	7.66	0.07	0.72
10	4.5	4.8	4.63	0.08	0.04
11	5.7	7.4	6.69	0.30	0.17
12	6.5	6.8	8.16	0.03	0.25
			MAE average	0.20	0.21

Table 2. Prediction of Missing Streamflows Data in 2003 at Katulampa Station

Month	Observations. (m^3/sec)	Predictions 1 (m^3/sec)	Predictions 2 (m^3/sec)	MAE Predictions 1	MAE Predictions 2
1	5.7	6.7	6.6	0.18	0.15
2	11.0	11.8	9.6	0.08	0.13
3	9.9	9.4	7.0	0.05	0.29
4	7.7	9.4	7.0	0.22	0.09
5	9.0	8.4	7.7	0.07	0.15
6	4.3	2.9	3.6	0.33	0.16
7	3.1	2.8	3.3	0.07	0.07
8	2.3	2.7	2.9	0.14	0.22
9	2.8	2.9	3.6	0.04	0.29
10	5.5	5.8	4.3	0.05	0.22
11	4.7	3.8	4.9	0.17	0.05
12	7.0	7.3	7.7	0.03	0.10
			MAE average	0.12	0.16

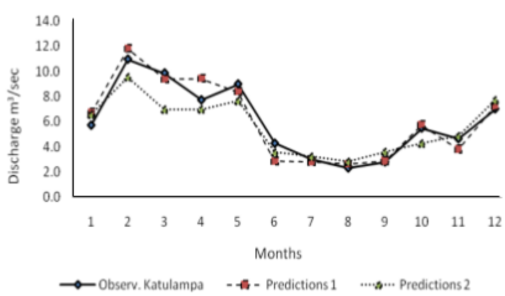

Figure 8. Prediction of Missing Streamflows Data in 2003 at Katulampa Station with Information Based from the Batubeulah and Genteng Station

Conclusion

Prediction of missing streamflows data at Katulampa Station 2002 produced a monthly average errors of 0.20 with the data information from Batubeulah station and 0.21 with data information from Genteng Station, whereas predicttion of missing streamflows data at Katulampa Station 2003 produced a monthly average errors of 0.12 with the data information from Batubeulah Station and 0.16 with data information from Genteng Station. Based on the performance of the prediction, it can be seen that the method based on information entropy principles have the potential to be developed as the methods to be used to predict the missing monthly average discharge.

Prediction of Missing Streamflow Data using Principle of Information Entropy

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