UNIVERSITAS GADJAH MADA

JASA TIRTA I
JALAN SURABAYA 2A, MALANG

MSD NetWork

IAHR AIRH
International Association for Hydro-Environment Engineering and Research
Supported by Spain Water and IWHR, China

IAHR-APD 2018
Yogyakarta, Indonesia

PROCEEDINGS

21st IAHR-APD Congress

International Association for Hydro-Environment Engineering and Research (IAHR) Asia Pacific Division (APD)

Multi-perspective Water for Sustainable Development

Volume 1

- Keynote Speech
- River (River Hydraulics, River Basin Engineering and River Basin Management)
- Port, Harbor, Coastal Engineering and Management
- Environmental Hydraulics and Hydrology
- Irrigation, Water Supply and Sanitation

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FOREWORDS FROM CHAIRMAN OF THE LOCAL ORGANIZING COMMITTEE

Dear Readers,

Universitas Gadjah Mada was honored to host the 21st Congress of International Association for Hydro-Environment Engineering and Research-Asia Pacific Division (IAHR-APD) on 2-5 September 2018 in Yogyakarta which was co-hosted by PT. Jasa Tirta I (Jasa Tirta I Public Corporation) and Multimodal Sediment Disaster Network (MSD-Network). The Congress brought up the theme "Multi-perspective Water for Sustainable Development". This phrase was adopted as the main theme of the Congress to maintain awareness of the stakeholders that water should be valued from various viewpoints namely technical, socio-economic, cultural and environmental viewpoints which integrate all efforts on water resources-related development to contribute to people's welfare.

The 21st Congress of IAHR-APD accommodated the 6th AUN/SEED-Net Regional Conference on Natural Disaster (RCND 2018) which was mostly relevant to water-related natural disasters to be part of the Congress. The joint congress was aimed at introducing the IAHR-APD organization to even wider areas of hydro-environment engineers and scientists as well as strengthening cooperation with similar organizations.

The Congress has successfully encouraged the interactions among researchers, industries, and communities, on the dissemination of water-related research achievements and ideas that paves the way for sustainable water and environment-related development. The local organizing committee especially appreciates all of the staff of the IAHR and IAHR-APD for their endless and excellent support to the congress.

The cooperation and support of Universitas Katolik Parahyangan, Sekolah Tinggi Teknik Nasional Yogyakarta, Universitas Kristen Duta Wacana are also highly appreciated. We would like to thank all of the sponsors and participants for their contributions to make the Congress fruitful and memorable. Our special thanks go to the reviewers of the papers and the editors of the proceedings without whom the publication of such excellent quality proceedings would not have been possible. We hope that this proceedings will furnish the readers with excellent references and stimulate further studies and researches in the related areas.

Thank you very much and God bless you all.

Radianta Triatmadja

21st IAHR-APD 2018 Congress Chair

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FOREWORDS FROM CHAIRMAN OF THE IAHR-APD

It is my great honor and pleasure to say 'Welcome' to all the attendees of the 21st Congress of the International Association for Hydro-Environment Engineering and Research-Asia Pacific Division. The IAHR-APD Congress is the official and most important open forum for all persons, not only the members but also general participants, who are interested in presenting, discussing, and exchanging their knowledge and experiences in hydro-environment areas. Since the first congress was held in Bangkok, Thailand in 1978, this is the 21st, following the previous congress that was held in Colombo, Sri Lanka two years ago with great success in terms of numbers of papers presented and participants. You can see about the past APD congresses at the official website of IAHR-APD http://www.iahrapd.org/Apd/Congress/webinfo/2014/08/1408074914387664.htm.

We, the APD members, have tried to delineate as well as generalize the conference characteristics such as by emphasizing specialty sessions dealing with the water-issues which are especially important and sometimes unique in the Asia and Pacific region such as typhoon, monsoon, and tropic-affected water issues, as well as historical water projects and traditional water technologies in the region. For example, we have special sessions of Historical water projects and traditional water technologies in the Asia-Pacific region, Green infrastructure as disaster risk reduction measure, Ecosystem-based disaster risk reduction for floods and tsunamis, Adapting to climate change using green infrastructure and LID measures, Conceptual ideas to solve problems related to hydro-environment engineering, Volcano and multimodal sediment disaster, Simulation and risk mitigation, and Hydrology-geomorphology links in tropical rivers. At this congress, we are also hosting some international panels with recognized high-ranking officials on the water issues that are of mutual interests in the region.

Among many special sessions that are held at this conference, the session of Historical water projects and traditional water technologies in the Asia-Pacific region, would be worthwhile to introduce more in detail. It has the purpose of giving international professional recognition to the works of: 1) past water projects that contributed or are still contributing to the welfare of the people, and 2) past brilliant water technologies that blossomed once and are still useful in the Asia – Pacific region. The first special session was held in Sri Lanka congress in 2016 with seven presentations from different countries in the region. Those are now in the process of being published in the Journal of Hydro-environment Research (JHER), the official journal of IAHR-APD, as a special issue. This type of special session will continue at every APD congress and a few papers presented at the session will be strictly screened and submitted for a possible publication in JHER along with the ones receiving the best-paper award in the congress.

I strongly believe that this conference should be a very useful and effective forum in which we are able to foster interdisciplinary research and collaboration, rapid dissemination of latest findings, and will provide an opportunity for discussing how novel methods and techniques can be used interchangeably in various fields and application areas of hydro-environment engineering and research especially in the Asia and Pacific region.

Last, but not least, I as the IAHR-APD chair express many thanks to the LOC members including Prof. Radianta Triatmadja, the conference chair, for their full devotions to the preparation and proceedings of the conference for the last two years. I strongly believe that this conference will be one of the most successful events ever in the history of the IAHR-APD activities.

Hyoseop Woo

IAHR-APD Chair

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VOLUME 2

SUBTHEME 5: WATER RESOURCES

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CALIBRATION OF IRRIGATION GATES IN PUNGGUR UTARA IRRIGATION AREA

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ABSTRACT

Sekampung irrigation system consists of seven irrigation areas, which are supported by two feeder canals. Feeder Canal I serves Sekampung Bunut, Sekampung Batanghari, Raman Utara, and Batanghari Utara irrigation areas. Feeder Canal II serves Punggur Utara, Bekri and Rumbia irrigation areas. Land use, climate and social economic changes impact on supply and demand of irrigation in Sekampung Irrigation System. Significant decrease of discharge of Sekampung river impacts on discharge for irrigation released from Argoguruh Weir. As a result, distribution and irrigation efficiencies decrease. In order to improve operational of water distribution it needs to calibrate irrigation gates so that gate coefficient (C_d) for each gate can be determined. Research method for gate calibration includes measuring discharges and corresponding elevations in the canal for various opening gates. Procedure for measuring discharge in irrigation canals used the national standard procedure for measuring discharge in open channel using current meter as written in SNI 8066:2015. Analysis used includes constructing rating curves, comparing the observed rating curves to the empiric ones, and calculating the gate coefficients and presenting the discharge Table for each calibrated gate. Results from calibrating 425 gates show that the percentage of the number of gates having C_d between 0.4 and 1 is 61.224%, less than 0.4 is 21.089% and greater than 1 is 17.687%. This result will be useful for water managers to control water distribution as well as do the appropriate operation and management for Punggur Utara irrigation area.

Keywords: Sekampung irrigation system, Punggur Utara irrigation area, calibration, gate

1. INTRODUCTION

Irrigation system by utilizing Sekampung river as water resources through Argoguruh weir is known as Irrigation Sekampung System. Irrigation Sekampung System is divided into seven irrigation areas including Sekampung Bunut, Sekampung Batanghari, Raman Utara, Batanghari Utara, Punggur Utara, Bekri and Rumbia Barat. The division of the irrigation areas are based on related Feeder Canals. Feeder Canal I serves Sekampung Bunut, Sekampung Batanghari, Raman Utara, Batanghari Utara Irrigation Areas, while Feeder Canal II serves Punggur Utara, Bekri and Rumbia Irrigation Areas.

Argoguruh Weir was constucted in Sekampung river in 1935 in Tegineneng village South Lampung Regency with irrigation target area 20,600 Ha. By now to reach the target the irrigation project of Way Sekampung conducted capacity improvement of Feeder Canal I to have discharge of 41 m^3/s, the increase of capacity of Feeder Canal II from 15 m^3/s to 72.5 m^3/s, and the increase of primary canal in Punggur Utara from 26 m^3/s to 64 m^3/s.

Researches which had been done in Sekampung irrigation system include optimation of cropping pattern (Setiawan and Anwar, 2017), evaluation of irrigation network performance at tertiary level in Sekampung Batanghari irrigation area (Viqhy et al., 2012), optimation of providing water irrigation in Sekampung Batanghari area (Asnaning et al., 2017), study of cropping pattern in Sekampung irrigation system (Aprizal and Yuniar, 2017) and water resources management of Way Sekampung catchment area between Batutegi Dam to Argoguruh Weir to develop operational pettern of daily storage (Ridwan et al, 2013). It seems that there is no study about gate callibration in Sekampung irrigation system before. Therefore it is important to conduct research on gate calibration for Sekampung Irrigation system.

Among other irrigation areas in Sekampung Irrigation System, Punggur Utara has the largest paddy field area to serve, the longest primary and secondary canals, and the largest number of gates with more than 400 gates (Sembiring, 2015). This study aims to calibrate irrigation gates in Punggur Utara irrigation area. Irrigation primary structures in Punggur Utara Irrigation areas are called Bangunan Punggur Utara (BPU) or Punggur Utara Structures, which are numbered from 1 to 26 toward downstream. Irrigation scheme for Punggur Utara irrigation area is presented in Figure 1 and Figure 2, where Figure 1 shows the irrigation network from BPU 1 – BPU 15 and Figure 2 shows the irrigation network from BPU 16 – BPU 26.

2. METHOD

Research was conducted in Punggur Utara Irrigation Area, Sekampung Irrigation System, Lampung Province during July – November 2017. During that period there were 425 gates calibrated in Punggur Utara Irrigation Area. National Standard procedure for discharge measurement in open channel using current meter as written in SNI 8066:2015 (BSN, 2015) was adopted in conducting field measurement. Method approach to calculate discharge at a cross section of a canal is as follows:

a. Maximum distance between two verticals is one-fifteenth of canal width;
b. Minimum distance between two verticals is twice of propeller diameter of the current meter;
c. Position and number of flow velocity measurements depends on water depth (h), if water level ≤ 0.75 m then the measurement uses one point method which is conducted at 0.6 h from water surface, while water level > 0.75 m the measurement uses two point method which is conducted at 0.2 h and 0.8 h or three point method at 0.2 h, 0.6 h and 0.8 h;
d. Discharge for each vertical is computed based on average velocity of each vertical and corresponding area;
e. Total discharge is the summation of discharge for each vertical.

For each gate opening the above discharge measurement procedure was conducted. Gate openings are multiples of 2 cm from 2 cm until maximum 40 cm. However, if upstream water level is less than gate opening, then the measurement is stopped.

Analysis which had been done for this study includes :

a. producing rating curve relating discharge and gate opening relationship,
b. producing rating curve relating discharge and water elevation in canal located after the gate. This type of rating curve can be useful to estimate discharge in the canal if water elevation is known.
c. estimating suitability of measured discharge compared to discharge as in empirical rating curve. Empirical rating curve is a curve that was drawn from empirical study for a certain gate width, i.e. 30, 50, 75, 100, 125 and 150 cm. Rehabilitation of Punggur Utara irrigation system was supported by European Economic Society and they had done laboratory research for those gate width and resulted rating curves was attached to most gates in this irrigation area.
d. calculating gate coeffficient using equation

$$Q=C_d.a.b\sqrt{2.g.z} \quad (1)$$

where Q is discharge (m^3/s), C_d is gate coefficient, a is gate opening (m), b is gate width (m), g is gravity acceleration (m^2/s) and z is the difference between water elevation at upstream gate and gate opening (for Crump de Gruyter Gate) or the difference between water elevation at upstream and downstream gate (for Sluice Gate).

e. producing discharge Table for each gate based on gate coefficient received from calibration.

3. RESULT AND DISCUSSION

Some of the analysis results on rating curves and coefficient of gates are presented in Figure 3 and Figure 4. Figure 3 shows the picture of the gate, rating curve for discharge and gate opening relationship, rating curve to relate discharge and water elevation in canal downstream of gate, plotting of discharge on empirical rating curve, and resulting gate coefficient for gate D6 Ka2, UD1 Ki and BT Sub Secondary which have gate width 30, 50 and 75 cm respectively. While Figure 4 shows the same item results for gate BI (Secondary), BPU24 Secondary and BGS 0 Secondary which have gate width 100, 125 and 150 cm respectively. The locations of the gates can be seen in Figure 1 and Figure 2 as their locations are marked. Plotting the measured discharge on empirical rating curve is meant to know how close is measured discharge to the empirical discharge, which can be expressed as a ratio. The results of calculated ratio between measured and empirical discharges for the gates are close to calculated gate coefficients for corresponding gates.

The result shows that gate coefficients for D6 Ka2, UD1 Ki, BT Sub Secondary, BI (Secondary), BPU24 Secondary and BGS 0 Secondary are 0.7606, 0.8986, 0.8631, 0.8535, 0.7099 and 0.8076 respectively. Among those six gates, only one gate (D6 Ka2) is Sluice gate type while others are Crump de Gryuter type. From the survey it was found that the percentage number of Crump de Gruyter type gate in Punggur Utara irrigation area is 83.45% and the percentage number of Sluice Gate type gate is 16.55%.

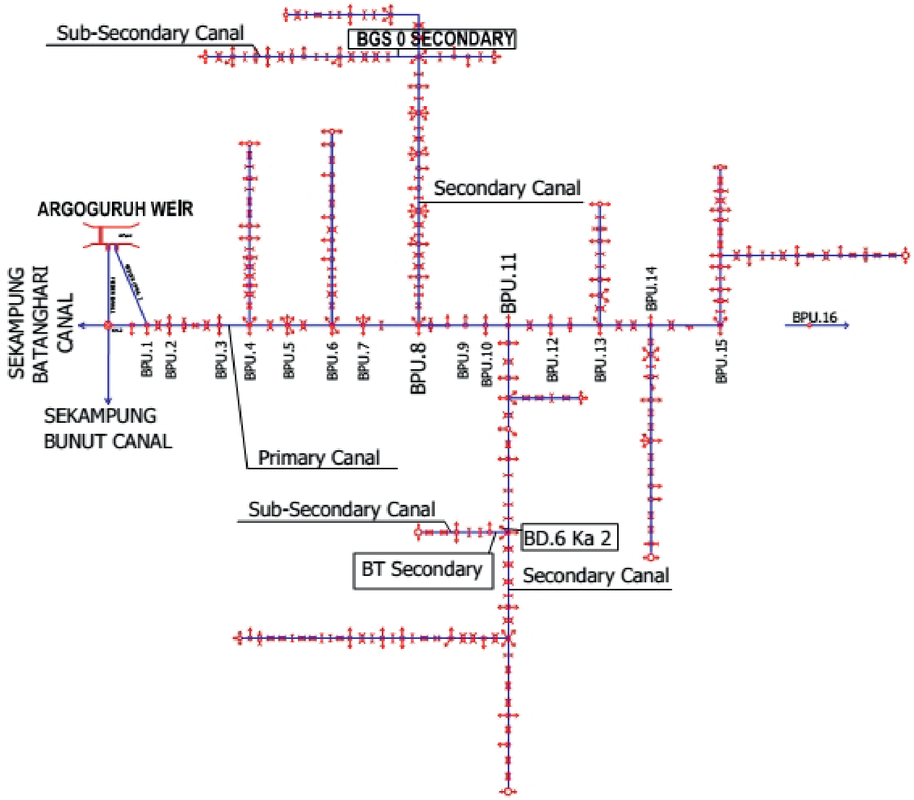


Figure 1. Irrigation network scheme for North Punggur irrigation area BPU 1 – BPU 15

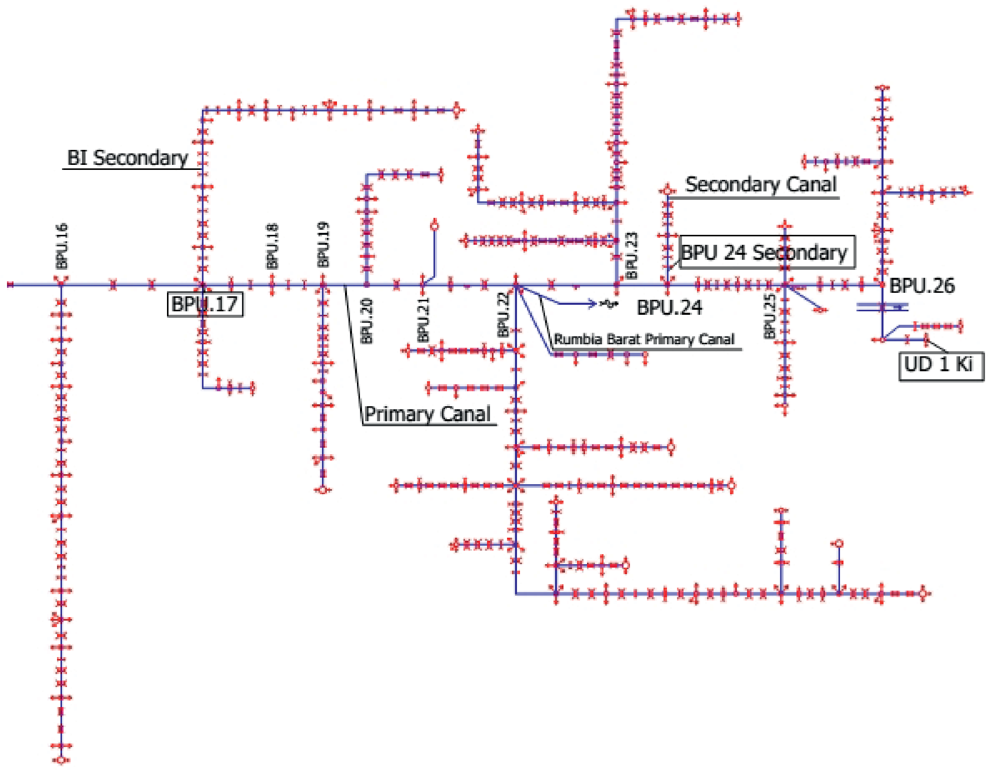


Figure 2. Irrigation network scheme for North Punggur irrigation area BPU 16 – BPU 26

Gate coefficient (C_d) or usually is called as discharge coefficient is the ratio between the actual flow discharge and theoretical flow discharge. Equation 1 which shows the relationship between discharge and gate coefficient was adopted from Bos (1989), de Graaff (1998) and Swamee (1992). According to Lazano et al. (2009) for sluice gate, C_d is mainly affected by head differential and gate opening. The empirical discharge coefficient recommended by the USBR (1997) is 0.61, while Skogerboe and Merkley (1996) considered discharge coefficient up to 0.85 depending on the geometry and installation of the structure, and the flow conditions at the structure. Lazano (2009) found that calibrated discharge coefficients were between 0.64 and 0.87.

In Sekampung Irrigation System, there is a simple manual for irrigation gate officer to control water distribution. The manual is presented as discharge table , which uses C_d 0.85 for the whole canals. Some results of this study as discussed above and presented in Figure 3 and Figure 4 show that C_d value varies among the gates. Analysis of gate coefficient which were done on 425 gates in Punggur Utara irrigation area can be summarized in Table 1.

Table 1. Percentage of number of calibrated gated and gate coefficient relation

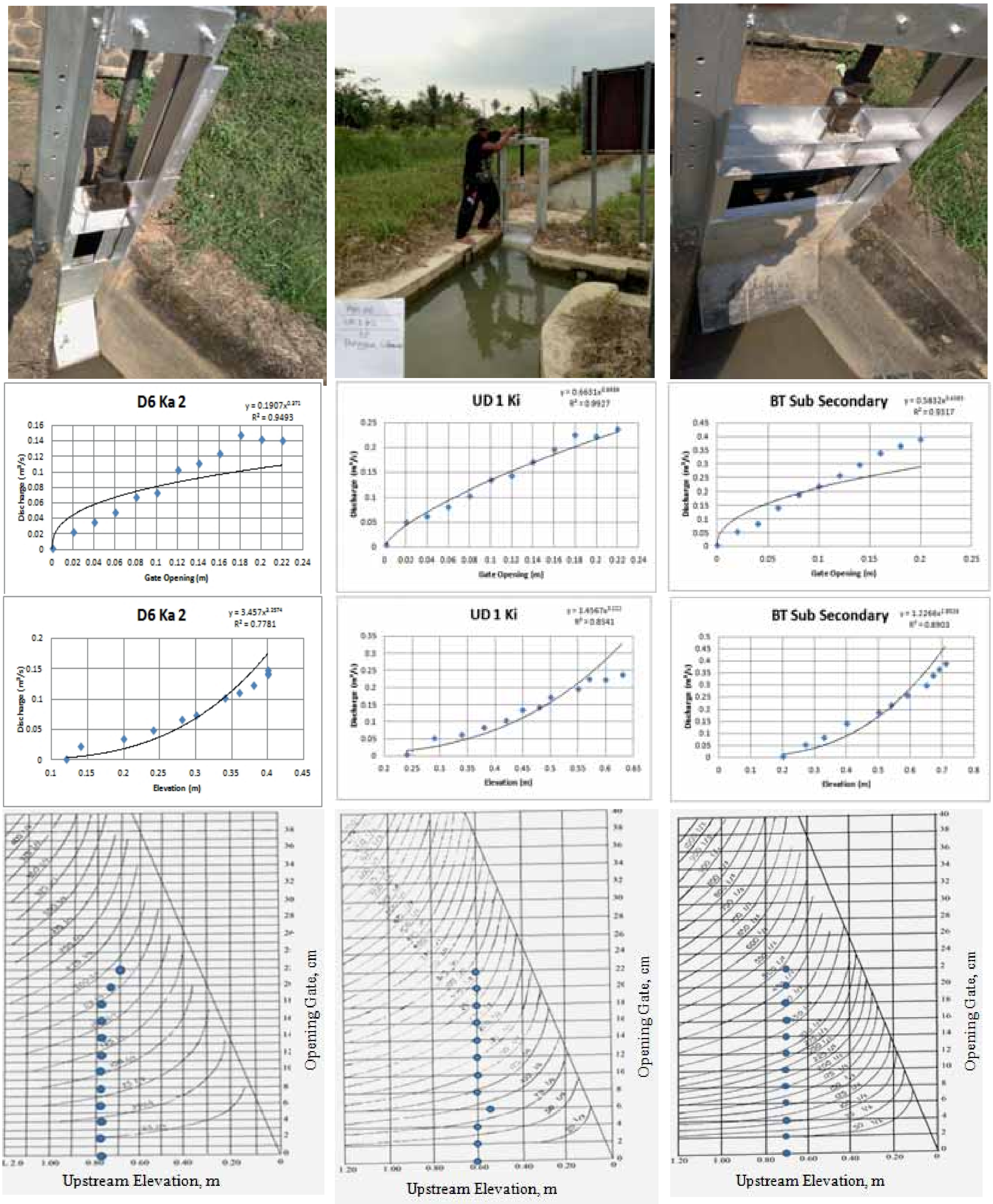
C_d	Percentage of Number of Calibrated Gates
$C_d > 1$	17.687
$0.4 \leq C_d \leq 1$	61.224
$C_d < 0.4$	21.089

The classification of C_d values as presented in Table 1 is based on observation during field measurement of the gate and canal conditions. When there are lots of sediment in canal and consequently water flows very slowly, it affects the measured discharge and results in low gate coefficient, which may fall below 0.4. Conversely, it learned from the survey that several gates cannot work properly as the bottom part of the gates were cut, or there is hole under the gate so that water will always flow although the gate is closed. This situation is not normal and therefore calculated gate coefficient from the calibration is greater than 1. Therefore, the classification above just to give an indication to the water managers in Sekampung Irrigation system, that it needs to pay attention and maintenance to the gates which have problems as discussed above. The number of gates which have those problems is 38.776 percents of 425 gates in Punggur Utara Irrigation area.

Gate coefficients which were calculated for 425 gates are used to make discharge table s which are easy to use for the gate operator to define how much to open the gate to release a certain discharge. Hence, every gate has its own discharge Table according to its gate coefficient. Table 2 presents an example of discharge Table for gate BT Secondary which is located in BPU 11.

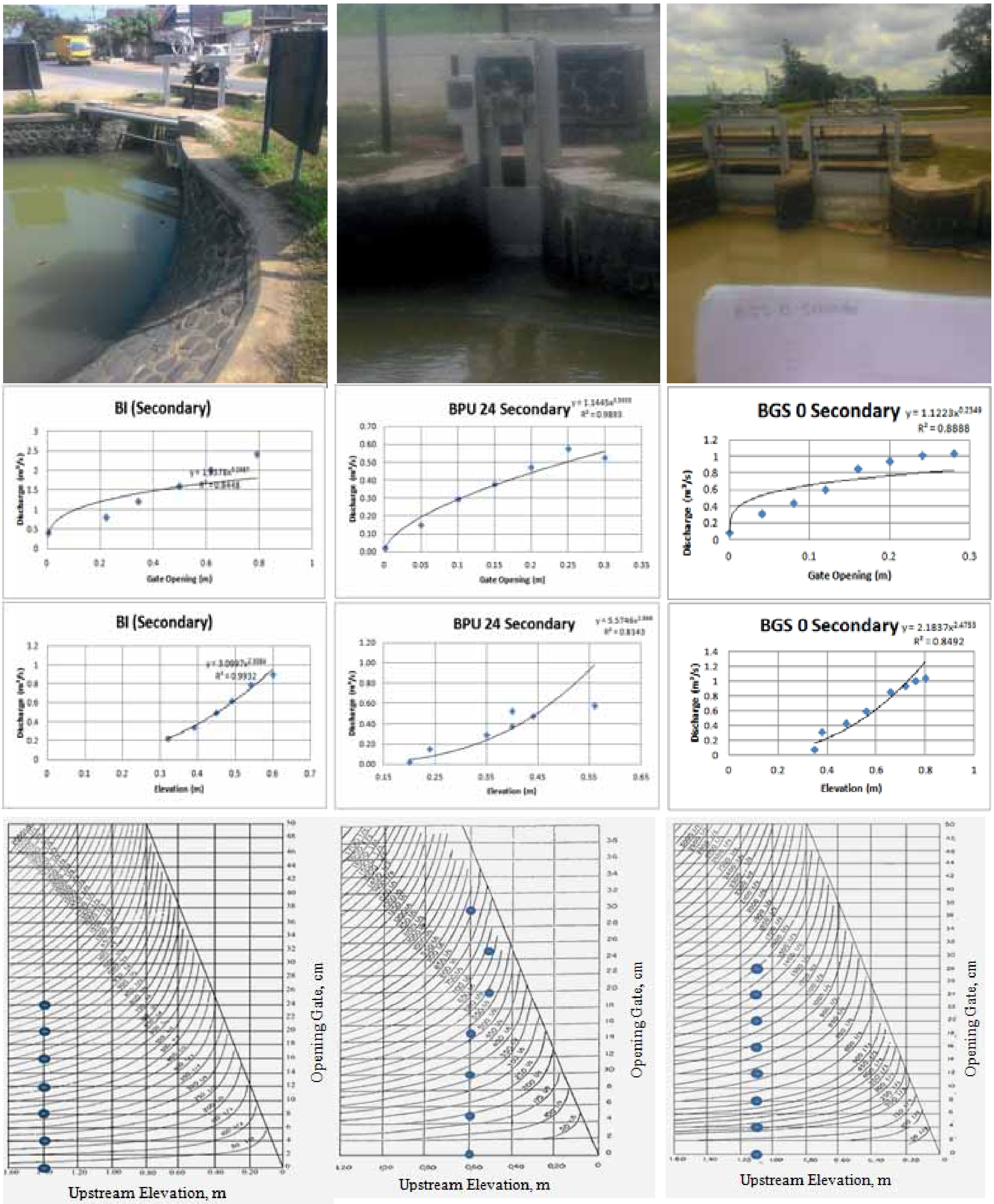
4. CONCLUSIONS

Results from this study including rating curve, gate coefficient (C_d) and correspoding discharge Table for each gate can be useful for management and operation of gates, canals and irrigation networks. Problems related to gate and canal conditions such as sedimentation, destruction of gate or canal bottom are indicated in the value of C_d which is either too low or too high.



Gate name	: D6 Ka2	Gate name	: UD 1 Ki	Gate name	: BT Sub Secondary
Location	: BPU11	Location	:BPU26	Location	: BPU11
Gate Type	: *Sluice Gate*	Gate Type	: Crump de Gruyter	Gate Type	: *Crump de Gruyter*
Dimension	: 30 x 110 cm	Dimension	: L x T = 50 x 60 cm	Dimension	: 75 x 110 cm
Coordinate	: S 05° 02' 15.27" E 105° 19' 42.83"	Coordinate	: S 04° 53' 48.4332" E 105° 23' 13.6788	Coordinate	: S 05° 02' 15.11" E 105° 19' 42.81"
Cd	0,7606	Cd	: 0.8986	Cd	: 0.8631

Figure 3. Analysis result for rating curves and gate coefficient for gate width of 30, 50 and 75 cm



Gate name : BI Secondary
Location : BPU17
Gate Type : Crump de Gruyter
Dimension : L x T = 100 x 180 cm
Coordinate : S 04° 59' 16.242"
E 105° 19' 13.9584"
Cd : 0.8535

Gate name : BPU24 Secondary
Location : BPU24
Gate Type : *Crump de Gruyter*
Dimension : L x T = 125 x 90 cm
Coordinate : S 04° 55' 29.00"
E 105o 21' 15.00"
Cd : 0.7099

Gate name BGS 0 Secondary
Location : BPU8
Gate Type : Crump de Gruyter
Dimension : 150 x 130 cm
Coordinate : 48 M 0546229
UTM 9464801
Cd : 0.8076

Figure 4. Analysis result for rating curves and gate coefficient for gate width of 100, 125 and 150 cm

Table 2. Discharge Table for gate BT Sub Secondary

Gate : BT Sub Secondary

Gate width (b) : 0.75 m

Gate Coefficient (Cd) : 0.8631

Water Elevation Upstream Gate (cm)	Gate Opening (cm) - a														
	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
30	30.3	58.5	84.3	107.6	128.2	146.0	160.6	171.7	178.8	181.3	178.4	168.6	149.1	113.5	0.0
35	32.9	63.9	92.6	119.2	143.4	165.0	184.0	200.0	212.8	222.1	227.4	228.2	223.6	212.4	192.3
40	35.4	68.8	100.3	129.8	157.0	182.1	204.7	224.7	242.1	256.5	267.6	275.3	278.9	278.1	272.0
45	37.6	73.4	107.4	139.5	169.6	197.7	223.5	247.1	268.2	286.7	302.5	315.3	325.0	331.0	333.1
50	39.7	77.8	114.1	148.7	181.3	212.1	240.9	267.5	292.0	314.1	333.8	350.9	365.2	376.6	384.7
55	41.7	81.9	120.4	157.3	192.3	225.6	257.0	286.5	313.9	339.3	362.4	383.1	401.5	417.2	430.1
60	43.7	85.8	126.4	165.4	202.7	238.4	272.3	304.3	334.5	362.7	388.9	412.9	434.7	454.2	471.1
65	45.5	89.6	132.1	173.2	212.6	250.5	286.7	321.1	353.8	384.7	413.6	440.6	465.6	488.3	508.9
70	47.3	93.2	137.6	180.6	222.1	262.0	300.4	337.1	372.2	405.5	437.0	466.7	494.5	520.3	544.0
75	49.0	96.6	142.9	187.8	231.2	273.1	313.5	352.4	389.7	425.3	459.2	491.4	521.8	550.4	577.0
80	50.6	100.0	148.0	194.6	239.9	283.7	326.1	367.0	406.4	444.2	480.4	515.0	547.8	578.9	608.2
85	52.2	103.2	152.9	201.3	248.3	294.0	338.2	381.1	422.5	462.3	500.7	537.5	572.6	606.1	637.9
90	53.8	106.4	157.7	207.7	256.5	303.9	350.0	394.6	437.9	479.8	520.2	559.1	596.4	632.2	666.3
95	55.3	109.4	162.3	214.0	264.4	313.5	361.3	407.8	452.9	496.6	539.0	579.8	619.3	657.2	693.5
100	56.8	112.4	166.8	220.0	272.0	322.8	372.3	420.5	467.4	512.9	557.1	599.9	641.3	681.2	719.7
105	58.2	115.3	171.2	225.9	279.5	331.8	382.9	432.8	481.4	528.7	574.7	619.3	662.6	704.5	744.9
110	59.6	118.1	175.4	231.7	286.7	340.6	393.3	444.8	495.0	544.0	591.7	638.2	683.3	727.0	769.4
115	61.0	120.8	179.6	237.3	293.8	349.2	403.4	456.5	508.3	558.9	608.3	656.5	703.3	748.8	793.1
120	62.3	123.5	183.7	242.8	300.7	357.6	413.3	467.9	521.2	573.5	624.5	674.2	722.8	770.1	816.0
125	63.6	126.2	187.7	248.1	307.5	365.8	422.9	479.0	533.9	587.6	640.2	691.6	741.8	790.7	838.4
130	64.9	128.7	191.6	253.4	314.1	373.8	432.3	489.8	546.2	601.4	655.6	708.5	760.3	810.8	860.2
135	66.1	131.3	195.4	258.5	320.6	381.6	441.6	500.5	558.3	615.0	670.6	725.0	778.3	830.5	881.4
140	67.4	133.8	199.1	263.5	326.9	389.3	450.6	510.9	570.1	628.2	685.2	741.2	796.0	849.6	902.2

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