Evaluation of the Condition of Ngancar Dam in Wonogiri Regency is Reviewed from the Safety Aspect of the Dam

Hendra Wahyudi
Civil Infrastructure Engineering Department,
Institut Teknologi Sepuluh Nopember, Sukolilo,
Surabaya, Indonesia

***Abstract*:- Ngancar Dam is one of the dams that managed by Balai Besar Wilayah Sungai (BBWS) Bengawan Solo. Ngancar Dam is built on Jarak river, precisely located in Selopuro Village in Baturetno Sub-district and geographically located at 7O48'5" LS and 110O53' 53" BT. In addition, ngancar dam is also a historical building because it was built during the Japanese colonial era in 1944. In 1976 The Republic Indonesia goverment built gajah mungkur, Then it made Ngancar Dam located upstream.**

After approximately seventy-five years of more operation and various maintenance during the operation and the enactment of various regulations set by the government especially regulations issued by the Ministry of Public Works and Housing of Republic Indonesia No. 27/PRT/M/2015 on dams that emphasize the safety aspects of the operation process then it is necessary to conduct a review of the condition of ngancar dam if reviewed from the safety aspect of the dam after carrying out its function during this time.

By using hydrological analysis to calculate flood discharge and hydraulic analysis to calculate water depth and analyze cremation and stability analysis by using geostudio software 2012 and supported by non-instructional testing with hammer test method to know the strength of concrete quality.

The results show the condition of Ngancar dam is reviewed from the safety aspect of the dam is still in a safe state because in the event of maximum flood discharge (Qpmf = 256,487 m3/sec) there is no overtoping, no deformation in static conditions or dynamic conditions and cracking on the dam at the time of flood or normal water is still smaller than 0.1% of the discharge of the base flow that enters ngancar dam

Keywords : Ngancar Dam, Safety Aspects, Government Regulation and Safety

1. BACKGROUND

Ngancar Dam is one of the dams managed by Balai Besar Wilayah Sungai (BBWS) Bengawan Solo. Ngancar Dam is built on Jarak river, precisely located in Selopuro Village in Baturetno Sub-district and geographically located at 7O48'5" LS and 110O53' 53" BT. In addition, ngancar dam is also a historical building because it was built during the Japanese colonial era in 1944. In 1976 The Republic Indonesia goverment built gajah mungkur dam then it made Ngancar Dam located upstream.

Ngancar Dam has the function to irrigate rice fields in Temon Irrigation Area which has an area of 637 hectares with intake building in the form of a sewer-shaped tapping tower with a diameter of 1.5 meters and has a length of 65.7 meters and is arranged with a regulatory door that has a width of 1 meter and a height of 1 meter Ngancar Dam is a dam of gound and stone layer with Zonal clay core with dam peak length of 179 meters and dam height of 20.5 m at elevation of +250.54 meters and peak width of 5 m, with a guard height of 0.9 m and has upstream slopes with a ratio of 1:3 and downstream slopes with a ratio of 1:1,5. This dam has a concrete building with a wide threshold with a width of 34.10 meters at an elevation of +248.70 meters above sea level with the ability to drain water by 201.73 m3/sec and has a launcher channel of 84.75 meters and has a type of olak pond as a water energy silencer in the form of USBR type III made of concrete. The dam is in flood condition at an elevation of +249.49 mdpl capable of accommodating flood water of 3.05 million m3 while in normal conditions with elevation + 248.70 meters above seam able to hold water of 2.15 million m3 and at minimum conditions at elevation + 236.18 mdpl able to hold water by 0.89 million m3.

After approximately seventy-five years of more operation and various maintenance during the operation and the enactment of various regulations set by the government especially regulations issued by the Ministry of Public Works and Housing of Republic Indonesia No. 27/PRT/M/2015 on dams that emphasize the safety aspects of the operation process then it is necessary to conduct a review of the condition of ngancar dam if reviewed from the safety aspect of the dam after carrying out its function during this time.

2. PROBLEM FORMULATION

Based on the background described above, the research on " Evaluation of the Condition of Ngancar Dam in Wonogiri Regency is reviewed from the safety aspect of the dam" can be formulated the following problems namely how the safety condition of Ngancar dam if reviewed from the safety aspect to carry out its operations.

3. PROBLEM LIMITATIONS

Research conducted with "Evaluation of The Condition of Ngancar Dam in Wonogiri Regency is reviewed from the safety aspect of the dam" has the following limitations:

• Aspects of dam safety include hydrological and hydraulic aspects, structural aspects and aspects of the dam while the understanding of each aspect is to include

1. Aspects of hydrology and hydraulics namely dams are able / safe to drain flood water so that there is no overtoping.
2. Aspects of the stability of the dam body include the ability of the dam structure to withstand static loads as well as dynamic loads.
3. This aspect of the spill includes the ability of dams to withstand water from piping hazards.
• While the safety aspect in carrying out operations related to water availability in this study was not carried out review.

4. EXPECTED BENEFITS AND OBJECTIVES

The benefits and objectives to be achieved from this research activity are :

a. The benefits of this research, when viewed from the science side, are expected to add to the benefits of science, especially the issue of dam safety.
b. The benefits of this research can be used as a guideline for policy makers in managing dams because dams in addition to carrying benefits also save potential disasters.

5. THE FOUNDATION OF THEORY.

The design flood hydrograph in this study used nakayasu synthetic unit hydrograph method. With the following equation form:

$$Q_p = \frac{A.R_o}{3,6(0,3.t_p + T_{0,3})}$$

Where:
Qp = peak flood discharge (m3/secec)
Ro = rain unit (mm)
Tp = time log from the beginning of the rain to the peak of the flood (hours)
T0.3 = time required by decreased discharge, from peak debit to 30% of peak debit (hours)

Filtration capacity is water flowing into hili through the body and foundation of the dam based on the jarring of filtration flow routes that can be calculated by the following equations

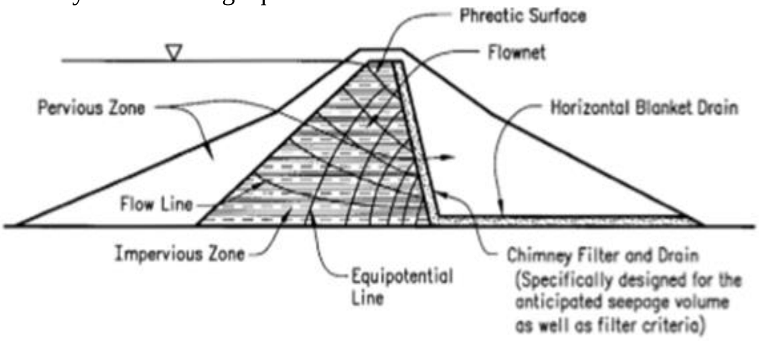

Figure 1. Trajektori network on a urugan dam

$$Qf = \frac{Nf}{Np} \times k \times H \times L$$

Where
Qf = Rembesan capacity (m3/secec)
Nf = the division number of the filtration flow route line
Np = the number of divisions of the equipotensial line
K = filtration coefficient (m3.dt)
H = total water pressure height (m)
L = Transverse profile length

A dam is declared safe against cracking that occurs when the critical rembesan speed (Vc) > the speed of the spill (Vs). Rembesan analysis uses geostudio seep/w software based on finite element. The result of the calculation is flux i.e. discharge (Q) of the spillway that passes through the dam with the treatment of the surface condition of the reservoir in a flood state (FWL) and the condition of the reservoir in normal water conditions (NWL).

The stability of the dam slope is analyzed using the Bishop method assuming the total normal force works in the center of the piece base and can be determined by deciphering the force on the piece vertically (normal). Balance requirements on the pieces that make up the slope as seen in the following image

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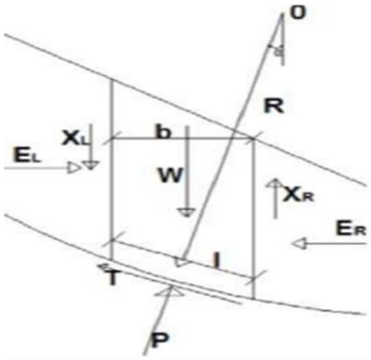


Figure 2 Style styles that work on a slice

Description:
W = Total weight on slices
EL, ER = Style between slices working horizontally on the left and right cross section
XL, XR= The style between slices that work vertically on the left and right cross section
P = Total normal style on slices
T = Slide style on the base of the slice
B = Width of slice
L = Length of slice
□ = Slope Angle

Taking into account the entire balance of styles then the formula for the security factor (Fk) of the Bishop method is obtained with the following equations

$$Fk = \frac{[c'l + (P - ul)\tan \emptyset']}{W \sin \alpha}$$

With the level of security factor value presented in the table

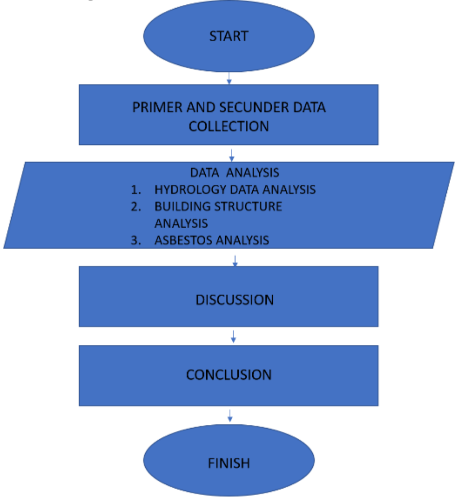
Table 1 Fk security value level in practice

Fk	**Description**
>1,5	Stable
1,07<Fk<1,5	critical
<1,07	Unstable

6. Research Method.

The research method is the whole stage of research conducted from start to finish so that a conclusion can be drawn. The steps can be seen in Figure 3. the following.

Figure 3. Research Flow Chart



7. RESULTS AND DISCUSSIONS.

Hydrology Analysis is a basic analysis that must be done to evaluate the safety of the dam because the overall analysis of the water building of the pumping system depends on this analysis. Hydrology analysis in this study used data from TRMM from 2000 to 2019 as calibration data while stations around the site include Baturetno, Giriwoyo, Ngancar and Batuwarno stations because the data at the surrounding stations is incomplete especially from Batuwarno station no data from 2004 to 2011 with a watershed area of 693.7 hectares. For more details of thiesennya watershed and polygon shape can be seen in Figure 4

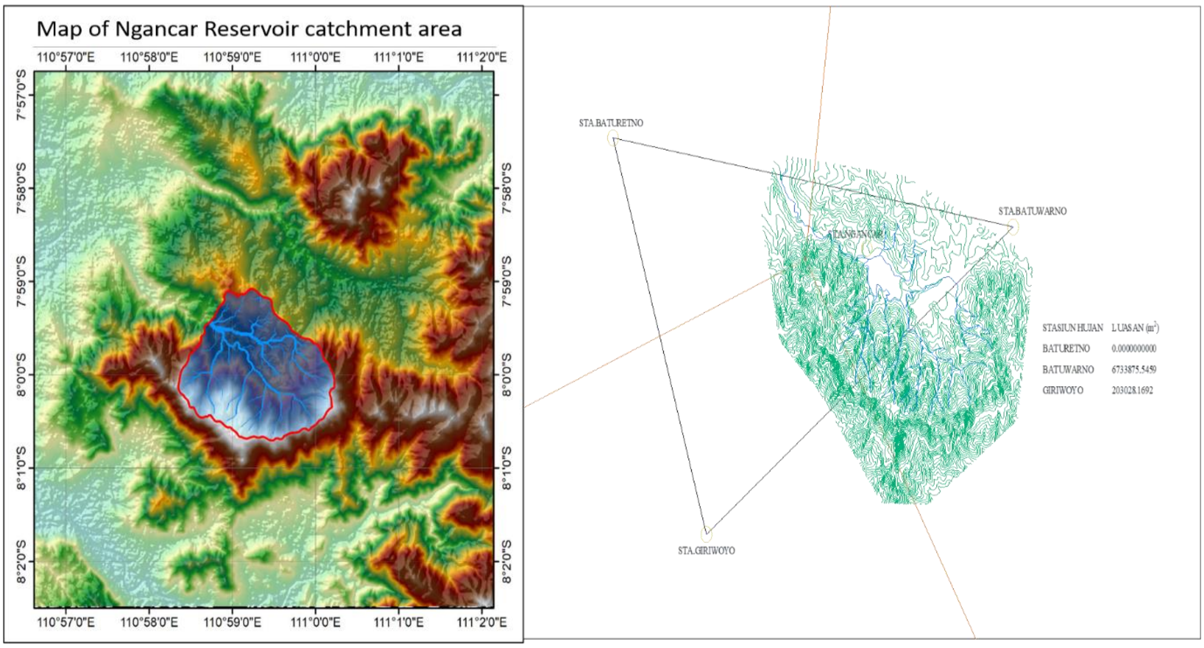


Figure 4. Thiesen Watershed and Polygon Shapes

By knowing the rain of the area with thiesen polygon, it is determined rain plan while to determine the size of the flood plan by using nakayasu method. The results of the flood discharge plan can be seen in Table 2

Table 2 Debit Flood Plan

No	Reset	Debit (m3/S)
1	5	59.495
2	10	71.157
3	25	91.136
4	50	107.739
5	100	128.628
6	200	154.590
7	1000	229.892
8	½ PMF	132.743
9	PMF	256.487

The flood discharge plan is checked by Creager method with the results can be seen in Figure 5

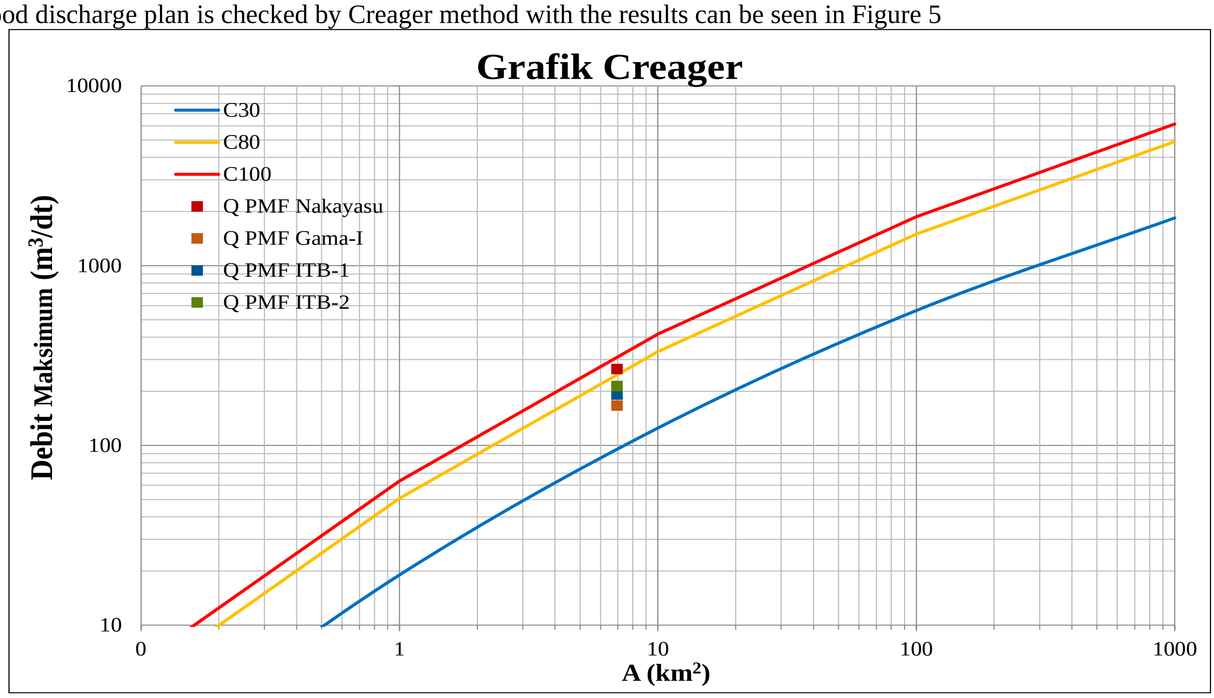


Figure 5. Creager Method Graph

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To evaluate the safety of dams against the danger of overtoping, a flood search is carried out on reservoirs that pass through the reservoir with the form of flood tracing as in figure 6

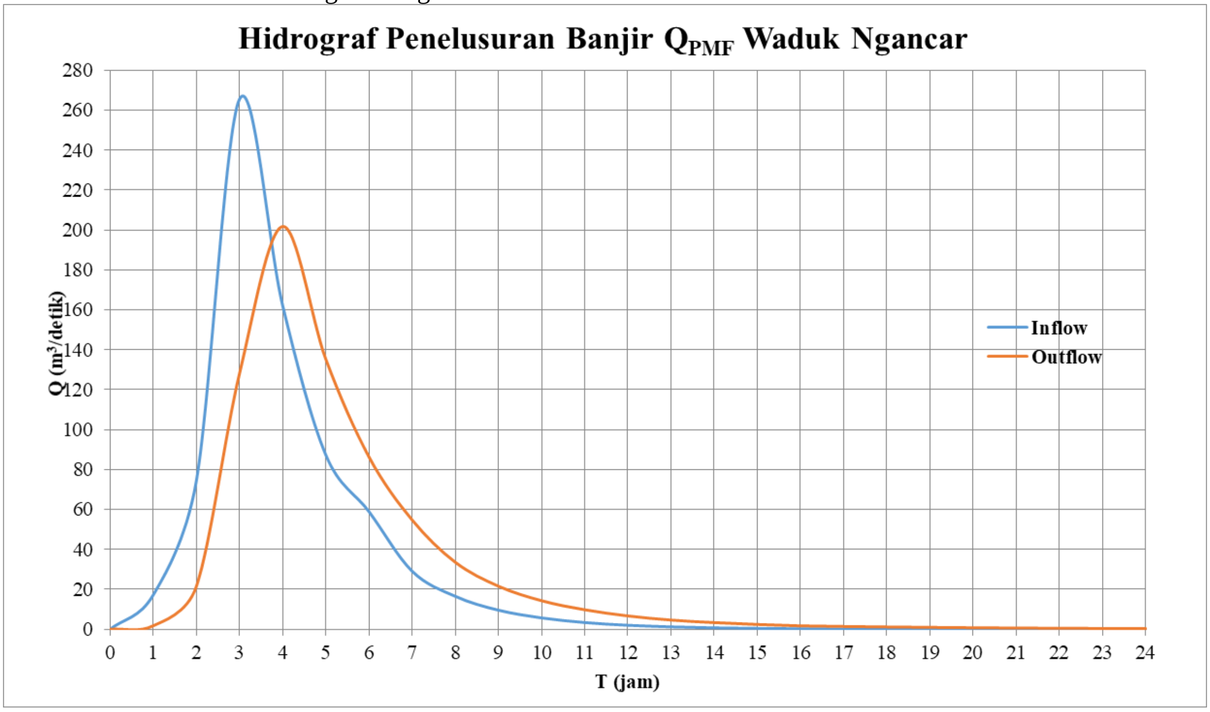

Figure 6 Hydrograph of Ngancar Dam Flood Search

While flood search results against high guard can be seen in the following table 3

Table 3. Water level elevation at Spillway with High guard

Kala Ulang Banjir	Q *inflow* Maks	Q *outflow* Maks	Hd Maks	Reduksi Puncak Banjir		Elevasi Muka Air	Tinggi Jagaan (*parapet*)	Keterangan
	(m³/det)	(m³/det)	(m)	(m³/det)	(%)	(m)	(m)	
Q 100 th	128.63	82.83	1.21	45.79	35.60%	249.915	1.19	*Tidak Overtopping*
Q 1000 th	229.89	163.10	1.85	66.79	29.05%	250.550	0.55	*Tidak Overtopping*
Q ½PMF	132.74	93.42	1.31	39.33	29.63%	250.010	1.09	*Tidak Overtopping*
Q PMF	265.49	201.73	2.11	63.76	24.02%	250.808	0.29	*Tidak Overtopping*
Kondisi Muka Air Normal						**248.70**	**2.40**	
Elevasi Puncak Bendungan						**250.50**		
Elevasi Parapet Puncak Bendungan						**251.10**		

From the hydraulic aspect done with a review of the ability of pelimpah to drain floods, the results can be seen in Table 4

Table 4 Water face in pelimpah when flooding

Kala Ulang	Debit Banjir	Elevasi Muka Air	Tinggi Muka Air	Kecepatan Air Pada Saluran Pengarah	Keterangan
-	*(m³/dt)*	*(mdpl)*	*(m)*	*(m/dt)*	*(Kecepatan < 4 m/dt)*
Q 100th	79.535	249.884	1.184	1.98	Aman
Q 1000th	158.472	250.518	1.818	2.57	Aman
Q 1/2PMF	89.942	249.979	1.279	2.07	Aman
Q PMF	195.163	250.785	2.085	2.76	Aman
Elevasi Puncak Dinding		251.180	2.480		
Elevasi Crest Pelimpah		248.700			

Analysis of dam body stability using geostudi software with a review of normal water conditions, flood water conditions and rapid low tide conditions can be seen in tables 5 through Table 11

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Table 5. Stability of Ngancar dam body against landslides under normal water conditions

Analisis	Gempa	Lereng	Y/H 0.25	Fkmin	Keterangan	Y/H 0.5	Fkmin	Keterangan	Y/H 0.75	Fkmin	Keterangan	Y/H 1	Fkmin	Keterangan
Statik		Hulu	2.374										1.300	*Aman*
		Hilir	3.251										1.300	*Aman*
Dinamik	OBE	Hulu	1.439	1.200	*Aman*	1.399	1.200	*Aman*	1.436	1.200	*Aman*	1.476	1.200	*Aman*
		Hilir	2.201	1.200	*Aman*	2.148	1.200	*Aman*	2.197	1.200	*Aman*	2.249	1.200	*Aman*
	MDE	**Hulu**	**0.803**			**0.773**			**0.801**			**0.832**		
		Hilir	1.261			1.210			1.257			1.308		

Simulasi Dinamik OBE

Simulasi Dinamik MDE

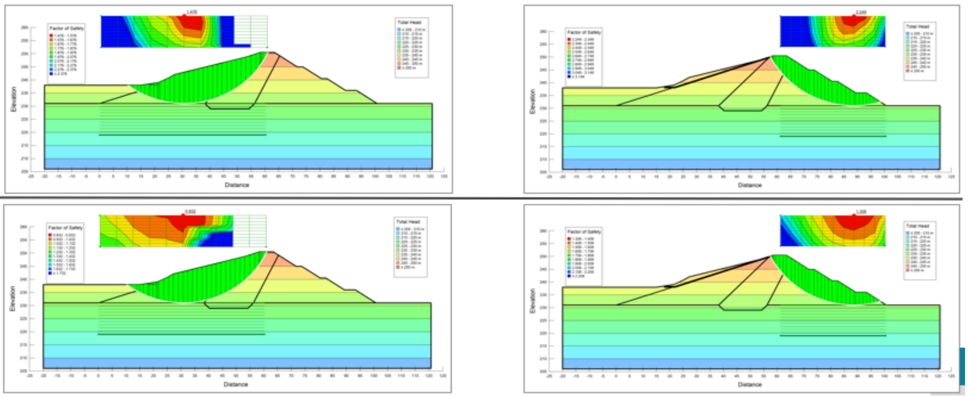

Table 6. Stability of Ngancar dam body against landslides in flood water conditions

Analisis	Gempa	Lereng	Y/H 0.25	Fkmin	Keterangan	Y/H 0.5	Fkmin	Keterangan	Y/H 0.75	Fkmin	Keterangan	Y/H 1	Fkmin	Keterangan
Statik		Hulu	5.021										1.500	Aman
		Hilir	3.342										1.500	Aman
Dinamik	OBE	Hulu	1.941	1.200	Aman	1.858	1.200	Aman	1.934	1.200	Aman	2.019	1.200	Aman
		Hilir	2.265	1.200	Aman	2.210	1.200	Aman	2.261	1.200	Aman	2.314	1.200	Aman
	MDE	**Hulu**	**0.877**			**0.838**			**0.874**			**0.915**		
		Hilir	1.295	1.200	Aman	1.242	1.200	Aman	1.290	1.200	Aman	1.344		

Simulasi Dinamik OBE

Simulasi Dinamik MDE

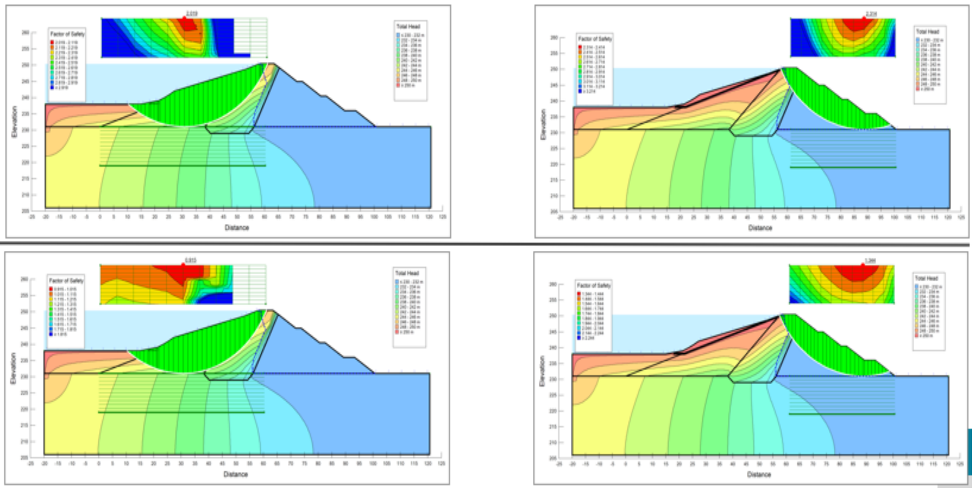

Table 7 Stability of Ngancar Dam Body against landslides in rapid low tide conditions

Analisis	Gempa	Lereng	Y/H 0.25	Fk$_{min}$	Keterangan	Y/H 0.5	Fk$_{min}$	Keterangan	Y/H 0.75	Fk$_{min}$	Keterangan	Y/H 1	Fk$_{min}$	Keterangan
Statik		Hulu	1.885										1.300	Aman
Dinamik	OBE	Hulu	1.160	1.100	Aman	1.128	1.100	Aman	1.157	1.100	Aman	1.188	1.100	Aman
	MDE	Hulu	**0.607**			**0.650**			**0.671**			**0.694**		

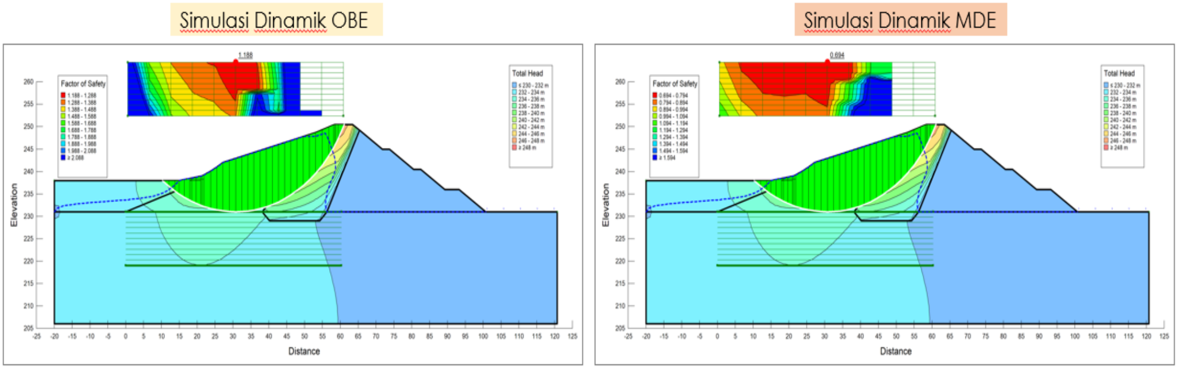

Table 8. Deformation checks due to simulation of avalanche in empty conditions

Beban	Lereng	k_y	F_k	k_{max} (MDE)	k_y/k_{max}	$U_{M-8.5}$	Keterangan $U_{M-8.5}$	F_k Simulasi
y/h = 0.25	Hulu	0.564	1.000	0.727	0.775	0.10	Tidak Terjadi Deformasi	0.803
y/h = 0.50	Hulu	0.579	1.000	0.785	0.737	0.65	Tidak Terjadi Deformasi	0.773
y/h = 0.75	Hulu	0.579	1.000	0.732	0.791	0.45	Tidak Terjadi Deformasi	0.801
y/h = 1.00	Hulu	0.550	1.000	0.678	0.811	0.20	Tidak Terjadi Deformasi	0.832

Table 9. Deformation checks due to simulation of avalanche in normal water face conditions

Beban	Lereng	k_y	F_k	k_{max} (MDE)	k_y/k_{max}	$U_{M-8.5}$	Keterangan	F_k Simulasi
y/h = 0.25	Hulu	0.666	1.000	0.727	0.916	0.90	Tidak Terjadi Deformasi	0.877
y/h = 0.50	Hulu	0.695	1.000	0.785	0.885	0.60	Tidak Terjadi Deformasi	0.838
y/h = 0.75	Hulu	0.669	1.000	0.732	0.914	0.40	Tidak Terjadi Deformasi	0.874
y/h = 1.00	Hulu	0.640	1.000	0.678	0.944	0.19	Tidak Terjadi Deformasi	0.915

Table 10. Deformation checks due to simulation of avalanche in flood water face conditions

Beban	Lereng	k_y	F_k	k_{max} (MDE)	k_y/k_{max}	$U_{M-8.5}$	Keterangan	F_k Simulasi
y/h = 0.25	Hulu	0.648	1.000	0.727	0.891	1.83	Tidak Terjadi Deformasi	0.854
y/h = 0.50	Hulu	0.669	1.000	0.785	0.852	0.89	Tidak Terjadi Deformasi	0.808
y/h = 0.75	Hulu	0.669	1.000	0.732	0.914	0.80	Tidak Terjadi Deformasi	0.842
y/h = 1.00	Hulu	0.620	1.000	0.678	0.915	0.80	Tidak Terjadi Deformasi	0.881

Table 11. Deformation checks due to simulation of avalanche in rapid receding conditions

Beban	Lereng	k_y	F_k	k_{max} (MDE)	k_y/k_{max}	$U_{M-8.5}$	$U_{M-7.5}$	Keterangan $U_{M-8.5}$	F_k Simulasi
y/h = 0.25	Hulu	0.373	1.000	0.727	0.513	0.80	0.12	Tidak Terjadi Deformasi	0.673
y/h = 0.50	Hulu	0.368	1.000	0.785	0.469	100.20	0.11	***Terjadi Deformasi***	0.650
y/h = 0.75	Hulu	0.368	1.000	0.732	0.503	0.79	0.11	Tidak Terjadi Deformasi	0.671
y/h = 1.00	Hulu	0.373	1.000	0.678	0.551	0.67	0.10	Tidak Terjadi Deformasi	0.694

Test concrete strength by conducting non destructive test using hammer test tool at the location shown in figure 7.

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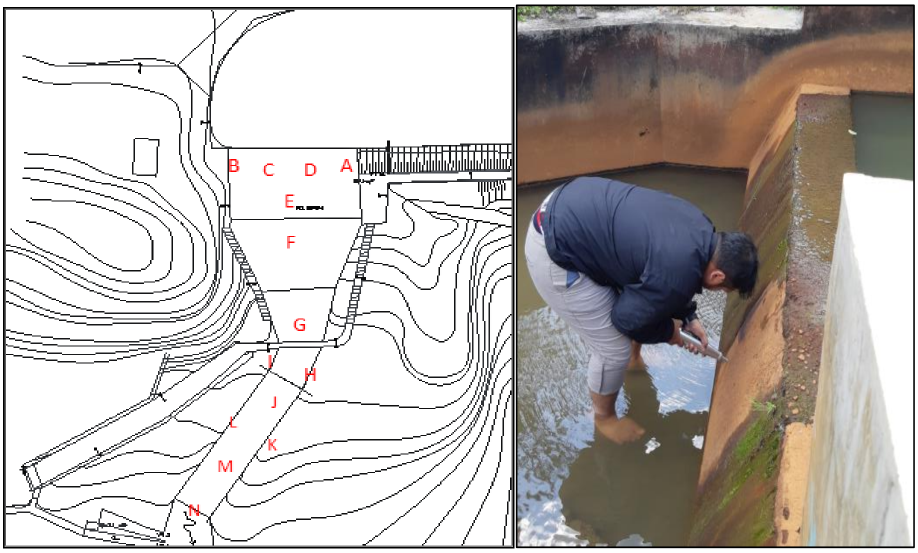

Figure 7 Location checking concrete strength with hammer test tool

Non-instructive testing using the hammer method can be seen in Table 12

Table 12. Hammer test results

Code	Location	Test Result (Mpa)
A	Dinding Mercu Kiri	38.28
B	Dinding Mercu Kanan	40.33
C	Mercu Sisi Kanan	41.56
D	Mercu Sisi Kiri	35.44
E	Lantai Peluncur Atas	35.61
F	Lantai Peluncur Bawah	37.50
G	Blok Halang	37.67
H	Dinding Peluncur Tengah Sisi Kiri	34.67
I	Dinding Peluncur Tengah Sisi Kanan	38.78
J	Lantai Peluncur Tengah	41.78
K	Dinding Peluncur Bawah Sisi Kiri	38.17
L	Dinding Peluncur Bawah Sisi Kanan	36.00
M	Lantai Peluncur Bawah	45.56
N	Blok Halang Bawah	38.60
Avarage		38.57

Based on non destructive test results with hammer test method shows concrete condition is still in good condition because the quality is greater than fc = 20.35 Mpa

The simulation of rembesan on the body is reviewed in normal water face conditions, flooding and rapid receding which can be seen in figure 8 up to the following image

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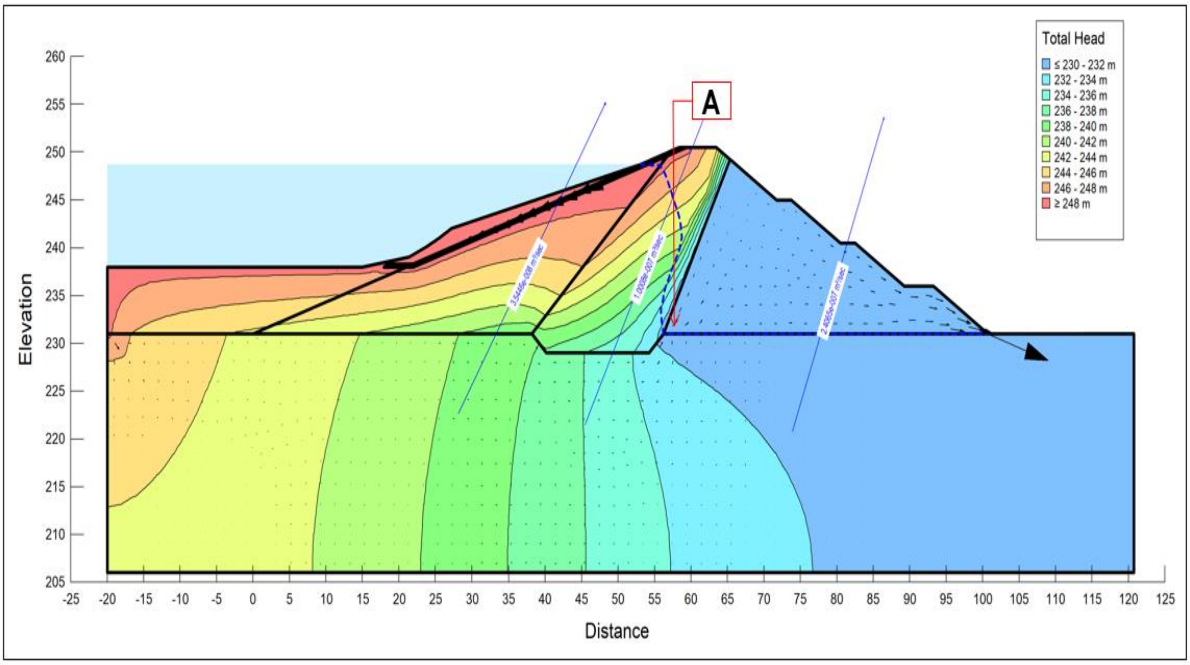

Figure 8 Simulation of spills on the dam's body under normal water-front conditions

A review of dam conditions resulting from the spillway during normal water review at point A shows the condition of the discharge of the water is 1,008 x 10-7 m3/secec < 1% Q baseflow = 0.0956 m3/secec while the safety factor against piping = 3,570 > 1.5 (safe)

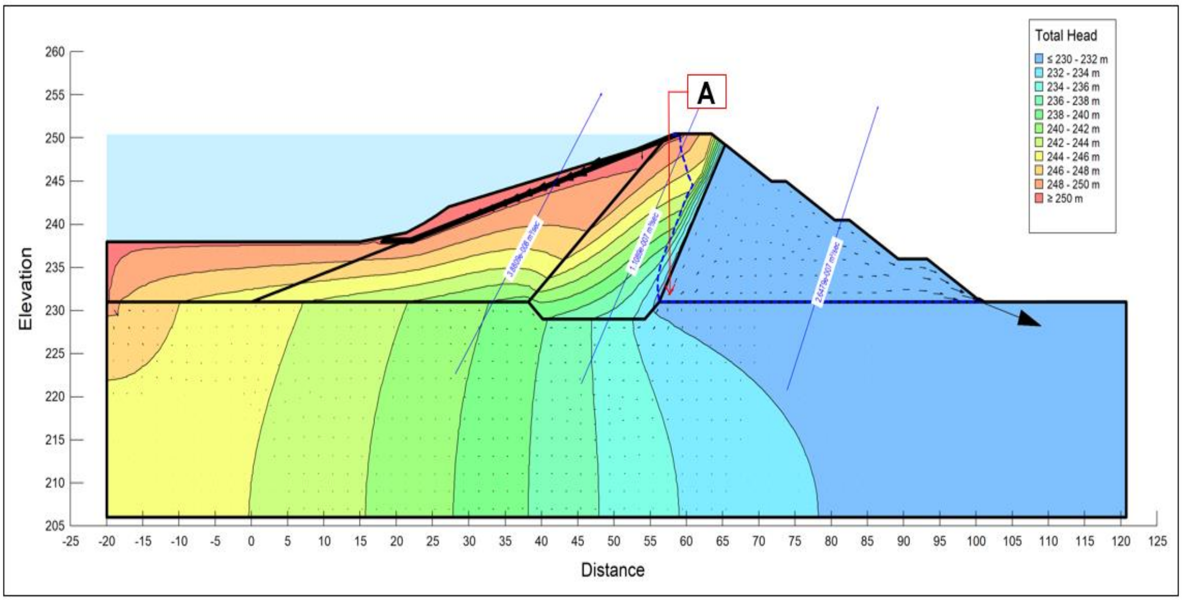

Figure 9 Simulation of the impact on the dam's body in flood water face conditions

A review of dam conditions caused by the spill during normal water review at point A shows the condition of the discharge of the water is 1,089 x 10-7 m3/secec < 1% Q baseflow = 0.0956 m3/secec while the safety factor against piping = 3,256 > 1.5 (safe)

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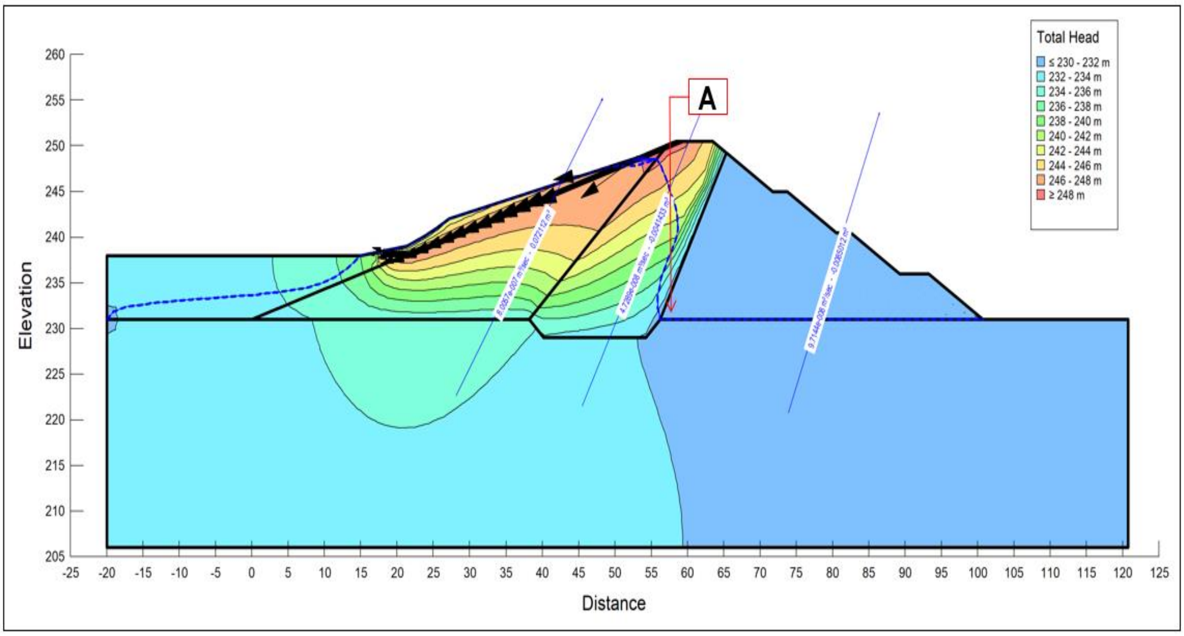

Figure 10. Simulation of fracturing on the body of a dam at rapid receding conditions

A review of dam conditions resulting from rapid low tide was reviewed at point A indicating a 4,729 x 10-8 m3/sec < 1% Q baseflow = 0.0956 m3/sec.

8. CONCLUSION.

The conclusion of ngancar dam condition if reviewed from the aspect of dam safety are:

1) Dam safety from hydrological and hydraulic aspects shows results in the event of PMF flooding of 265.49 m3/sec then pelimpah is able to drain flood discharge by 195,163 so that it does not overtoping occurred. • Dam safety reviewed from the structural aspect shows a strong concrete flat press yield of 38.57 mpa > of the permitted minimum strength (fc = 20.35 Mpa) and at the time of static and dynamic conditions there is no deformation of the dam body.
2) Dam safety is reviewed from the rembesan aspect showing the result of the spill result at the time of flood water level of 1,089 x 10-7 m3/sec < 0.0956 m3/sec.

concluded that the condition of ngancar dam is still in a safe state if it is reviewed from the safety aspect of the dam.

REFERENCE

[1] Anonim, 2015, Permen PUPR Nomor 27 tahun 2015 tentang Bendungan.
[2] Anonim, 1998, Dam Structures Surveys Paket SID C-5 : Laporan Rehabilitasi, tidak dipublikasikan
[3] Asdak, 2002. Hidrologi dan Pengelolaan Daerah Aliran Sugai. Gadjah Mada University Press. Yogyakarta.
[4] Bishop, A. W., 1955. The use of Slip Surface in The Stability of Analysis Slope, Geotechnique, Vol 5 London
[5] Bowles, J. E., 1984. Physical and Geotechnical Properties of SoilS, McGraw-Hill Book Company, USA
[6] DAS, Braja M,. 1985. Principle of Geothecnical Engineering, 3rd ed, Southern Illinois University, PWS Publishing Company, Boston
[7] Chow,1964, Handbook of Applied Hydrology, New York: Mc. Graw-Hill Book Company.
[8] Chow, V. T. , David, R. M., Larry, W. M. 1998. Applied Hydrology. New York
[9] Cordery, I. 1991. Estimation of Design Hydrograph for Small Rural Catchments. Journal of Hydrology No 13.
[10] Fan, J. and Morris, G. L. 1995. Reservoir Sedimentation Handbook: Design and Management of Dams, Reservoir and Watersheds for Sustainable Use. New York: McGraw-Hill.
[11] Frevert, R.K. 1959. Soil and Water Conservation Engineering. New York: John Wiley & Sons, Inc.
[12] Gordon, N. D., T. A. McMahon and B. L. Finalyson. 1992. Stream Hydrology An Introduction for Ecologist. John Wiley & Sons Ltd. New York.
[13] Gray, D. M. 1961. Synthetic Unit Hydrograhs for Small Watersheds. Journal of Hydroulic Div. ASCE. July. HY 4.
[14] Gray, D.M. 1970, Handbook on Principles of Hydrology. The Iowa State University Press, Ames, Iowa.
[15] Gregory, K. J. and D. E. Walling. 1977. Drainage Basin Storm and Process. Edward Arnold Publishing. Ltd. London.
[16] Gupta, S. N., A. P. Battacharya, S. R. Jindal. 1967. Statistical Correlation of Himalayan and Bundelkhand Basin Characteristics With Flood Flows, Floods and Their Computations, Proceeding of Leningrad Symposium, IASH, Unesco, WMO, Geneva.
[17] Haan, C.T., H.P. Johnson, and D. L. Brakenseik. 1982. Hydrologic Modelling of Small Watersheds. American Society of Agricutural Engineers
[18] Hadisusanto, N. 2011. Aplikasi Hidrologi. Malang: Jogja Mediautama.
[19] Hammer, W. I. 1978. Second Soil Conservation Consultant Report. Tech. Note No. 10. FAO/Centre for Soil Research Bogor. Indonesia.
[20] Hewlett, J. D. and W. L. Nutter, 1969. An Outline of Forest Hydrology. Athens: University of Georgia Press.
[21] Kennedy, J. and W. E. Watt. 1967. The Relationship Between Lag Time and the Phisical Characteristics of Drainage Basin In Southern Ontario. Flood and Their Computations. Proceeding of the Leningrad Symposium Vol III. IASH. Unesco. WMO. Geneva.
[22] Linsley, R.K., M.A. Kohler and J.L.H. Paulus. 1949. Surface Retention andDetention and overland Flow. Applied Hydrology. New York. Mc Graw Hill Book Co.
[23] Lewis K.V., 1975. Quantification of Soil Loss and Sediment Produced from Eroded Land. Soil Science. Soc. Am. J. Vol 24.
[24] Linsley, R.K., M.A. Kohler and J.L.H. Paulus. 1986. Hydrology for Engineers. Mc Graw Hill Book Co. New York.

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[25] Mohraz, B,.1976. A Study of Earthquake Response Spectra For Different Geological Conditions, Bull. Of Seism. Soc. Of America, Vol 66, No 3., June. Pp 915-935.
[26] Mohraz., B., 1978., Influences Of The Magnetude of the Earthquake and the Duration of Strong Motion on Earthquake Response Spectra, Central American Conference on Earthquake Eng., San Salvador, CA, Jan 9-12, Proc., pp 27-35.
[27] Morgan, R. P. C. 1979. Topics in Applied Geography: Soil Erosion. Longman Group Ltd. London.
[28] Morgan, R. P. C. 1988. Soil Erosion. Longman Group Ltd. New York.
[29] Nash, J.E., and J.V. Sutcliffe, 1970. River Flow Forecasting Through Conceptual Models Part ICA Discussion of Principles, Journal of Hydrology. Vol 10.
[30] Saigal, S. and Mehrotra, D. (2012). "Performance Comparison of Time Series Data Using Predictive Data Mining Techniques", *Advances in Information Mining*, No. 1, Vol. 4
[31] SEED, H.B.; IDRISS, I.M., 1982, ” Ground Motions and Soil Liquefaction During Earthquakes “, Earthq. Engineering Research Institute, Berkeley, California , Monograph, Libarary of Conggress Catalog Card Number 82-84224.
[32] SEED, H.B.; UGAS, C.; LYSMER, J., 1974, ”Site Dependent Spectra for Earthquake Resistant Design”, University Of California, Berkeley, Earthquake Engineering Research Center, Report No. EERC 74-12, November, 14 pp.
[33] Sichuan Water Resources And Hydroelectric Investigation And Design Institute. 2010. Study Report On Dam Filling Material Of Jatigede Dam Project. Jakarta : Goverment of The Republic Of Indonesia Ministry Of Public Works Directorate General Of Water Resoure.
[34] Snyder, F. F. 1938. Synthetic Unit Graph. Trans Am Geophis Union. Report and Paper in Hydrology.
[35] Strahler, A. N. 1964. Quantitative Geomorphology of Drainage Basins and Channel Networks, in Handbook of Applied Hydrology, Ven Te Chow (ed). Mc Graw Hill. New York.
[36] Soemarto, CD. 1986. Hidrologi Teknik. Usaha Nasional. Surabaya.
[37] Soerjono, R. 1978. Kegiatan dan Masalah Kehutanan dalam DAS. Dalam Proceedings Pertemuan Diskusi. Pengelolaan Daerah Aliran Sungai. DITSI. Jakarta.
[38] Suripin, 2004. Pelestarian Sumber Daya Tanah dan Air. Penerbit Andi. Yogyakarta.
[39] Soewarno. 1995. Hidrologi Aplikasi Metode Statistik Untuk Analisa Data. Bandung Nova.
[40] Sosrodarsono dan Takeda, 1980. Hidrologi Untuk Pengairan. Jakarta: PT Pradnya Paramitra.
[41] Sri Harto, 1993. Analisa Hidrologi. Jakarta, PT Gramedia Pustaka Utama.
[42] Viessman, W., J. W. Knapp, G. L. Lewis, and T. E. Harbaugh. 1972. Introduction to Hydrology, Harper & Row Publishers, New York.
[43] Walpole, R.E., Myers, R.H., Myers, S.L., and Ye, K. 2007. Probability and Statistics for Engineers and Scientists. Eighth Edition. London: Pearson Education.
[44] Ward, R. S. 1974. Priciples of Hydrology. Second Edition. McGraw-Hill Book Company, Limited. London.