IMPROVEMENT OF WATER GATES WITH COMPOSITE MATERIAL IN CIMANUK IRRIGATION AREA, GARUT,WEST JAVA

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Abstract

One of the operational giudelines of the System of Rice Intensification (SRI) is intermittent water supply in order to maintain water level around the soil surface. This requirement needs more frequent operation of water gates and it becomes another heavy workload faced by farmers. However, most of the water gates are made of metal materials which are easily corosive, broken and lost. Cimanuk Irrigation Area which is located in Garut, West Java faces a serious problem in water allocation and distribution because many of the gates were broken and lost. The objective of the study is to design water gates made of lighter materials which were also capable for applying automated irrigation. Mixtures of materials were conducted composed of concrete and glass fibre with varied treatments such as normal concrete (NC), fibre-concrete with 1 kg of fibre Woven Roving (FC1), FC2, FC3, fibre-concrete with 1 sheet Woven Roving in the midle of sample, and fibre-concrete with 1 sheet WR in the bottom. Furthermore, materials for fibreglass gate were used Chopped Strand Mat and WR with resin. Material testings were conducted according to the Japanese Industrial Standard for Concrete. The weight of a full fiberglass gate with its dimension of 150 cm x 54 cm x 0.8 cm is 6.4 kg. It has a flexural strength about 200 kg/cm^2 (for deplection of 10 mm) with thickness of sample 12 mm. While, the fibre-concrete has a maximum result of the FCB treatment with flexural strength 72 kg/cm^2 and its dimension is 75 cm x 56 cm x 3 cm and 35 kg of weigth. Gate operation can be done manually as well as mechanically. These gates have been in operation in four diversion structures at Cimanuk Irrigation Area. Two of them were used fibreglass gates and the others were fibre-concrete. Evaluation for further improvement is still underway.

Keywords: Irrigation, water gate, fiberglass, fibre-concrete.

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Summary and Conclusion

Cimanuk Irrigation Area (CIA) which is located in Garut, West Java faces a serious problem in water allocation and distribution because many of the gates were broken and lost. Most of the existing water gates in Indonesia was made of iron or/and wood. Both materials are relatively easy to rusted, damaged, or decayed and also attractive to be stolen. The objective of the study is to design water gates made of lighter materials which were also capable for applying automated irrigation. Mixtures of materials were conducted composed of concrete and glass fibre with varied treatments such as normal concrete (NC), fibre-concrete with 1 kg of fibre Woven Roving (FC1), FC2, FC3, fibre-concrete with 1 sheet Woven Roving in the midle of sample, and fibre-concrete with 1 sheet WR in the bottom. Furthermore, materials for fibreglass gate were used Chopped Strand Mat and WR with resin. Material testings were conducted according to the Japanese Industrial Standard for Concrete.

Present condition of water gate facility performance shows percentage of delivery performance ratio are 21% in adequate supply, and others were excessive and inadequate condition. There are 31 gates totally, which are only 41.9% in good condition, and the others were light and heavily damage condition. Based on survey result, they needs several gates to substitute the broken gates, so water delivery in CIA could be done well.

One the main objectives using glass fiber in concrete is the increase of its tensile and flexural strength for holding out the hydrostatic pressure from the water in channel irrigation. Test results that increasing fiber content was decrease the tensile and flexural strength for FC1, FC2, FC3 treatments. FCB and FCM treatments have different result for flexural strength than others. The flexural strength of these samples were higher than normal condition about 82.1% and 25.6% respectively. The weight of these samples were more light than the control sample about 6.6% and 5.6%. The FCB is the best result from this research which the flexural strength 72 kg/cm^2. So it will be applied to make an irrigation gate with dimension 75 cm x 56 cm x 3 cm and weigth of 35 kg. The Fiberglass gate was designed with dimension 150 cm x 54 cm x 0.8 cm (height x width x thick). The weight of gate about 6.4 kg (width of 50 cm) and 4.5 kg (width of 30 cm) and flexural strength about 200 kg/cm^2 for thick of sampel 12mm. It was enough for use 8 – 10 mm of thickness for making a fiberglass gate with maximum height of water 50 cm and effectif span 50 cm.

Gate operation can be done manually as well as mechanically. These gates have been in operation in four diversion structures at Cimanuk Irrigation Area. Two of them were used fibreglass gates and the others were fibre-concrete. Evaluation for further improvement is still underway. The results of the investigations show that the gate material construction can be changed by fibre-concrete with addition of a sheet of woven roving (a glass fiber) inside and fiberglass. To ease operation the gate, a mechanical lifting device systems was used for vertical (up and down) lifting, especially for the fibre-concrete gate. But for fiberglass gate, used a manual or by hand. So, performance of water delivery can improve with this new gate.

Keywords: Irrigation, water gate, fiberglass, fibre-concrete, delivery performance ratio.

INTRODUCTION

Performance of irrigated agriculture needs to be improved in order to provide additional foods for a growing and more affluent population. However, some constrains are faced such as water scarcity and consequently competition for scarce water resources. This is happened in almost all irrigation schemes in Indonesia, includes Cimanuk Irrigation systems, West, Java.

Cimanuk Irrigation Area (CIA) which is located in Garut, West Java, faces a serious problem in water allocation namely broken and lost of irrigation gates. All of the gates are made from steel which is easily corosive (Figure 1). Irrigation structures are technological artefacts which have to be operated by human beings. Thus, the water division structure (water gate) should be operated by man easily and safely. But in the field, many problems are found, for example, many gates can not be operated,because they are broken, and lost. Therefore, some solutions are needed to address the problem of water allocation and distribution to existing on-farm canals. .

This research aims at solving these problems. In improving performance of water delivery in water division structure, two steps were undertaken.First, performance evaluation of water gate (existing); and second, design of water gate with alternative material, such as composite material (i.e. fibre concrete and fibreglass).

Figure 1. the Existing Condition of Division Structure

MATERIALS AND METHODS

Monitoring of Delivery Performance Ratio

Data were collected on the irrigation demands for the time period, to come and at the end of this time period the supply allocated is compared with planned allocation. The value of performance ranges for delivery performance ration (DPR) based on Bos et al (2004) that showed in Table 1.

$$\textbf{DPR} = \frac{Actual\ Suppled\ Discharge}{Target\ Discharge} \qquad /1/$$

Table 1. Performance Ranges for Delivery Performance Ratio

DPR Value	Water Supply Category
>1.15	Excessive
0.90 – 1.15	Adequate Supply
< 0.90	Inadequate Supply

Monitoring was held in July, 2009. Some parameters were measured and calculated, such as irrigation discharge, irrigation area cammanded by each of water division structure, dimension of water gate, water height, and physical condtion of water gates. DPR value was calculated to provide the information about changes in quality of service to water users (a trend in time) and quantifies the uniformity and equity of water delivery (the spatial distribution).

Designing of Water Gate

The determination of the compresive strength and the splitting tensile strength was after JIS Method (JIS A 1108-1963, Reaffirmed 1967 and JIS A 1113-1964, Reaffirmed 1968). The compresive strength of all manufactured mixtures were determined by means of 3 cubes with a length of the edges of 150 mm at an age of 7 and 28 days. The flexural strength of the fibre-concretes was determined according to the Japan Internatonal Standard for Concrete (JIS A 1106-1964, Reaffirmed 1968) with dimensions 530 mm x 150 mm x 30 mm (length x width x thick), it was only tested of 28 days and calculate the flexural strength by :

$$\sigma_b = \frac{P\,L}{b\,d^2}\,x1000 \qquad /2/$$

where, σ_b (bending strength, kg/cm^2), P (maximum load from machine, ton), L (the length of span, cm), b (width of sample, cm), d (depth of sample, cm).

Concrete Mix Proportions

The cement used for these investigations was a portland cement, as a fine agregate with a distribution from 2 mm to below was employed. The density of fine agregate (sand) was 2.61 gr/cm^3 with fine mudulus 1.50. All of mixture were designed based on National Indonesian Standard, SNI-03-2914-1992 (for waterproof concrete) with a rasio cement and sand 1 : 2, and slump test was about 12 cm. The detailed of mix proportion are shown in Table 2.

Table 2. Treatments of the Fibre-Concrete for the Investigations on the Mechanical Properties

Code	**Treatment Variatons**	**Fiber content (kg/m^3)**	**Testing**
NC	Normal concrete	0	C, S, B
FC1	Fiber-concrete 18mm, dose 1 kg	1	C, S, B
FC2	Fiber-concrete 18mm, dose 2 kg	2	C, S, B
FC3	Fiber-concrete 18mm, dose 3 kg	3	C, S, B
FCM	Concrete+ Roving in the middle	1 sheet (450 gr/m^2)	B
FCB	Concrete+ Roving in the bottom	1 sheet (450 gr/m^2)	B

Note : C (Compressive strength); S (Splitting Tensile Strength); and B (Bending Strength)

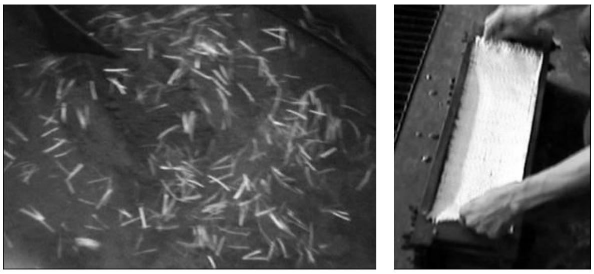


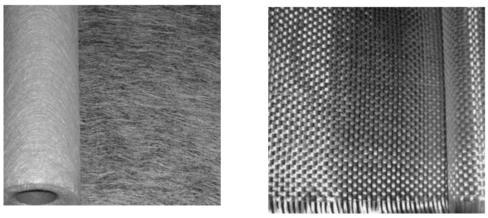
Figure 2. Mixing glass fibre with sand and a of WR in the bottom of sample.

Fibreglass

For fibreglass, sample was made by two kind of glass fibre (Figure 3), i.e. chopped strand mat (CSM)and woven roving (WR). For making polymer, used a YUKALAC Polyester Resin (157 BQTN EX-Series) and Hardener. In Table 3 shows the specifications of material properties.

Table 3. Material Propeties for Making a Fiberglass

Material	Specific Gravity (gr/cm3)	Notes
Unsaturated Polyester Resin (157 BQTN-EX Series)	1.10	viscosity : 4.5 -5.0 poise
Mepoxe (Catalyst)	1.13	at 20 C
Chopped Strand Mat (Type)	1.35	weight : 450 gr/m^2
Woven Roving	1.50	weight : 615 gr/m^2



Chopped strand Mat *Woven Roving*

Figure 3. Chopped Strand Mat and Woven Roving Glass Fiber

Dimensions of samples made for testing a flexural strength was 65 cm x 15 cm x 1.2 cm. Testing was done with Universal Testing Machine instrument with type of weight 2.5 and 1 ton for fibre-concrete and fiberglass. Flexural strength was calculated with Equation 2.

RESULTS AND DISCUSSIONS

Condition and Performance Water Gates in CIA, Garut

Table 4 showed the summary of condition of Cimanuk Irrigation Area (CIA). Based on the matrix problem, there were a critical condition for allocating irrigation water on canal farm and human resources to operates the gates.

Table 4. The Problem of Cimanuk Irrigation Area, Garut.

Component	Existing Condition	Problems
Availability of water	Intake discharge (80%) from Cimanuk Dam (1990 up to 2007) Qmin = 1,539 l/s Qmax = 15,282 l/s[5]	Availability of water is enough to afford the needs of CIA, but CIA has an interconnection facility with others irrigation area in the below. So, it is need a saving water and efficient in water uses, especially in drought season.
Irrigation schedulling	Watering gives in rotation system. It start from 06.00 AM until 02.00 PM every day.	Rotation systems did not optimum work, because almost a half of the gates did not work well and limited of human resources for operating the gates
Water Gate facility	There are 24 gates in a main channel of CIA. Where, there is only a 41.9% that can opearate well, and the others was broken and lost. All of the gates made from stell (Figure 1)	Water exploitation performance was decrease.
Irrigation Exploitation Performance	The Value of Delivery Performance Ratio (DPR) shown an exesive water about 45.8%, 33.3% inadequate supply, and other was adequate supply (see Table 5)	On the farm have an exesive and inadequate supply water in the same periode of planting, specially in the downstream farm. These affected the yield result of paddy field.
Human Reources (Irrigation Gate Operator)	There are six operators. Every man operates 5 – 6 gates that a length between divison structure about 0.5 – 1 km.	Three operators will be retired in 5 years later. So, it will become a new problem in the future, especially for operating the gates.

Water gate facility faces a serious problem. Table 5 showed there was almost 21% that have delivery performance ratio in adequate supply, and others were excessive and inadequate . Despite most of the gate made from steel their condition was broken and lost. Based on survey, from the total of 31 gates, there were only 41.9% in good condition, and the others were light and heavily damage condition.

[5] Based on Water Resources Agency of Bayongbong, Garut, West Java (2008)

Table 5. Allocation and Actual Supply Irrigation in CIA

Structure Code	Distance (km)	Area (ha)	Q_{plan} (l/s)	Q_{actual} (l/s)	DPR	Note
B.CMK 0	0.000	876	2622	2250	0.86	Dam
B.CMK 0/1	0.285	1	3	22.50	7.50	Offtake Struc.
B.CMK 1	0.807	2	6	24.92	4.15	Offtake Struc.
B.CMK 2	1.024	167	501	426.67	0.85	Division Struc.
B.BYB 1		*45*	*135*			*Tertier Box*
B.BYB 2		*52*	*156*			*Tertier Box*
B.BYB 3		*70*	*210*			*Tertier Box*
B.CMK 3	1.100	6	18	19.30	1.07	Offtake Struc.
B.CMK 4	2.381	5	15	43.75	2.92	Offtake Struc.
B.CMK 5	2.733	9	27	29.57	1.10	Offtake Struc.
B.CMK 6	4.640	9	27	35.48	1.31	Offtake Struc.
B.CMK 7	4.859	25	75	226.79	3.02	Offtake Struc.
B.CMK 8	5.268	16	48	68.18	1.42	Offtake Struc.
B.CMK 9	5.618	6	18	145.19	8.07	Offtake Struc.
B.CMK 10	5.905	19	57	201.93	3.54	Offtake Struc.
B.CMK 11	6.172	58	174	226.60	1.30	Offtake Struc.
B.CMK 12	6.435	13	39	36.86	0.95	Offtake Struc.
B.CMK 13	6.595	14	42	16.68	0.40	Offtake Struc.
B.CMK 14	6.745	77	231	107.26	0.46	Offtake Struc.
B.CMK 15	7.534	40	120	68.24	0.57	Offtake Struc.
B.CMK 16	6.875	144	432			Division Struc.
B.CN 1		*50*	*150*			*Terier Box*
B.CN 2		*40*	*120*			*Tertier Box*
B.CN 3		*54*	*162*			*Tertier Box*
B.CMK 17	8.163	4	12	42.61	3.55	Offtake Struc.
B.CMK 18	8.641	10	10	79.35	7.94	Offtake Struc.
B.CMK 19	8.689	101	303	271.11	0.89	Offtake Struc.
B.CMK 20	8.795	26	78	79.59	1.02	Offtake Struc.
B.CMK 21	9.500	80	240	95.24	0.40	Offtake Struc.
B.CMK 22	9.500	6	18	10.71	0.60	Offtake Struc.
B.CMK 23	9.896	31	93	90.91	0.98	Offtake Struc.
B.CMK 24	10.711	7	21	11.73	0.56	Offtake Struc.

<u>**Note :**</u> *Held in July 2009 (the 3rd Panting Date)*

Plant pattern : Paddy and Palawija (garlic, peanuts, vegetables, etc)

DPR Value (Delivery Performance Ratio Value) :

> 1.15 : excessive

0,90 - 1,15 : Adequate Supply

< 0,90 : Inadequate Supply

Planning water allocation : 3 l/s/ha

Based on survey result, they needs several gates to substitute the broken gates, so water delivery in CIA could be done well. In the below section will explain about design and application of water gates that was made with composite material, i.e. fibre-concrete and fiberglass.

Fiber-concrete Mechanical Properties

With increasing fiber content a reduction of the compressive strength can be recognized (see Figure 4). The compressive strength of normal condition (0 kg/m^3) is about 381.41 kg/cm^2 higher than the compressive strength of the fiber-concrete with 1, 2, 3 kg/cm^2. Stegmaier (2003) explained that the increase of the fibre content within the design mix leads to a reduced fraction of agregates. The specific surface of the fibers is however much bigger than the specific surface of the aggregates so that the replacement of aggregates with fibers induces a great enlargement of surface that has to be connected by the cement paste.

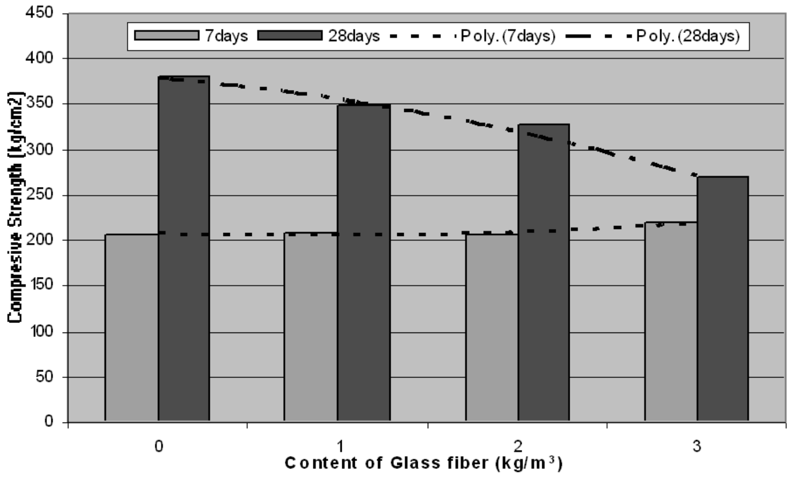


Figure 4. Compressive Strength againts Content of Glass Fiber

Also with the splitting tensile strength and the bending tensile strength. Normal concrete is higher than others treatment (content fiber 1, 2, and 3 kg/m^3). It was affected by reducing a cement paste content in sampel. However, it was seemingly that the fiber-concrete with content of a glass fiber 1 kg/m^3 higher than normal concrete (0 kg/m3) about 1.1 %.

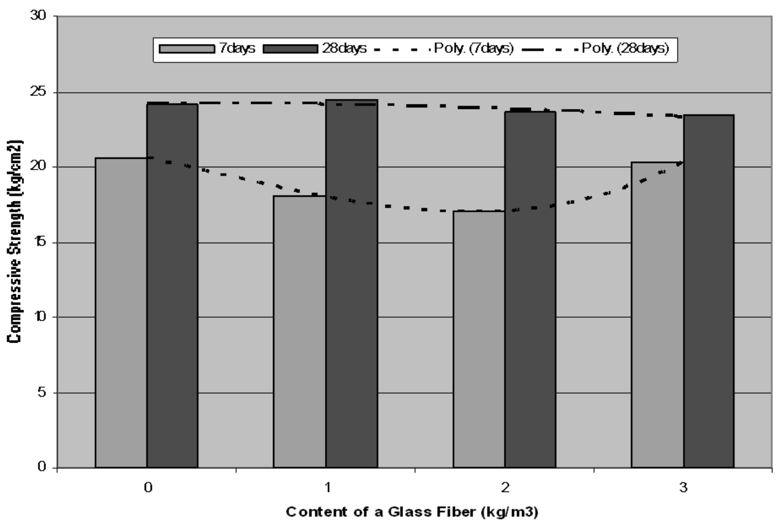


Figure 5. Tensile Strength againts Content of Glass Fiber

In fact excessive fibers decrease the sample strength. One the main objectives using fiber in concrete is the increase of its tensile and flexural strength for holding out the hydrostatic pressure from the water in channel irrigation. Test results showed (in figure 5 and 6) that increasing fiber content was decrease the tensile and flexural strength. Libre et al., (2008) states the sample compaction and homogenity are important in the final strength of the samples. Therefore, the instability of cement paste samples with higher fiber volume (length and content) which wad realized earlier in the fresh cement paste test could have probably lead to a decrease in concrete strength.

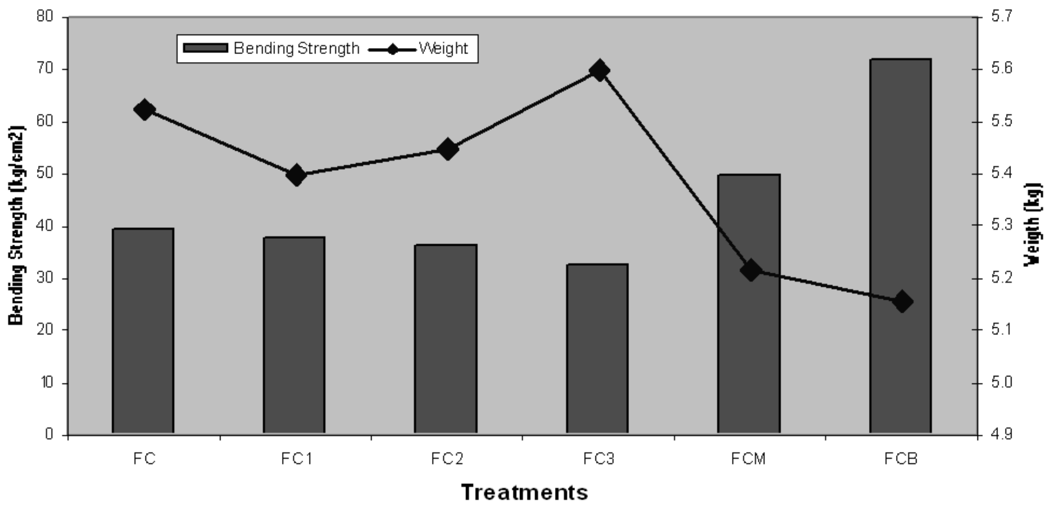


Figure 6. the Effect of Fiber Content on Bending/Flexural Strength

Furthermore, inreasing the fiber content requires more adixtures or higher water-cement ratios to maintain cement paste workability; higher water content leads to mixture instability (Libre et al., 2008). So, for the best treatment is put on a sheet of woven roving (a glass fibre) without slices into concrete both in the middle and bottom of sample. Based on the result (see in Figure 6), showed that FCB and FCM treatments have higher the flexural strength than normal condition about 82.1% and 25.6% respectively. The weight of these samples were more light than the control sample about 6.6% and 5.6%. Based on the result, the FCB is the best result from this research. So it will be applied to make an irrigation gate.

Fiberglass Mechanical Properties

Sample of fiberglass with thickness 12 mm has a flexural strength about 200 kg/cm^2 (for deplection of 10 mm, see figure 7). It was enough for using 8 - 10 mm of thickness for making a fiberglass gate with maximum height of water 50 cm and effectif span 50 cm (Figure 8). The Fiberglass gate was designed with dimension 150 cm x 54 cm x 0.8 cm (height x width x thick). The weight of gate about 6.4 kg (width of 50 cm) and 4.5 kg (width of 30 cm). flexural strength about for thick of sampel 1.2 cm.

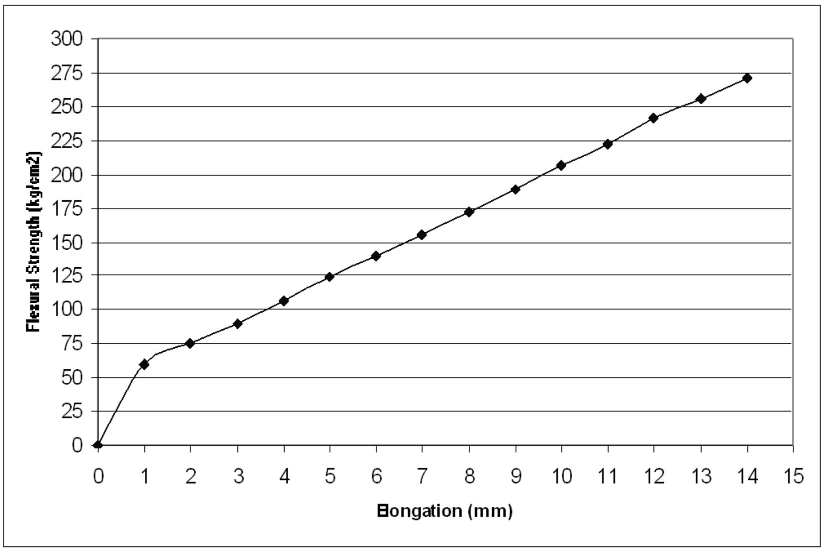


Figure 7. Flexural Strength of Fiberglass Gate Sampel (12mm)

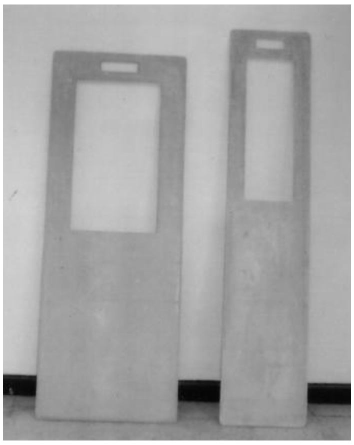


Figure 8. Model of Fiberglass Gate

Water Gate Lifting Device

Lifting device systems was made in two kind, i.e. by manual lifting (by hand) which is applied for fiberglass gate, and by mechanical device for fiber-concrete gate. Figure 9 shows the lifting gate design.

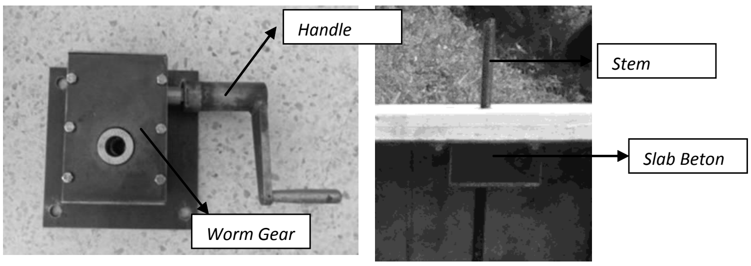


Figure 9. Lifting Device of Gate

Based on calculation of stem design, the diameter of stem used 1”. It can support loads from dead load of the gate (35 kg), mechanical system load 15 kg, and hydrostatic pressure of 50 cm water level is 56 kg or total load is 106 kg.

Mechanical system device lied below slab concrete (Figure 9) with thickness 6 cm and used one way plat system. Slab concrete used one woven roving and two steel with diameter 6mm. Handle for lifting the gate and cover for mechanical system used knock-down systems, so it would be easy for maintain the gate and to prevent the gate from the thieves.

Water Gate Application

These gates were applied on four division stucture in Cimanuk Irrigation Area, such as : B.BYB 2 (box tersier), B.CMK 5, 21, dan 22 (Offtake Structure/Secondary). On B.BYB 2 dan B.CMK 22 applied fiberglass gate and B.CMK 5 and 21 used fiber-concrete. These gates can be operated well by operator since December 2009 until now.

Figure 10. Application of Water Gate, Garut

CONCLUSION

The results of the investigatins show that the gate material construction can be changed by fibre-concrete with addition of a sheet of woven roving (a glass fiber) inside and fiberglass. To ease operation the gate, a mechanical lifting device systems was used for vertical (up and down) lifting, especially for the fibre-concrete gate. But for fiberglass gate, used a manual or by hand. So, performance of water delivery can improve with this new gate.

ACKNOWLEDGEMENTS

The authors wishes to express our appreciation to Ir. Lolly Martina Martief, M.T (Head of Irrigation Research and Development Agency) for financial support given during the production of the gates.

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