International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 05 Issue: 01 | Jan-2018 www.irjet.net p-ISSN: 2395-0072

Needle Type Gates to be Fixed on Waste Weir of Dam

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Abstract - *Water flowing from catchment area to streams or rivers has the ability to scour channel bed, to carry particles and to deposit materials. This phenomenon of sediment transport can affect substantially the design of reservoirs. Many cases have been recorded where reservoir siltation rendered water storage structures useless in less than 25 years. Sedimentation problems were observed predominantly with small to medium size reservoirs. The cost of removing and throwing silt out of submergence area is nearly equivalent to the cost of construction of a new reservoir. Removal of silt is also not feasible due to tremendous quantity. So to fulfill requirements, additional water storage is required. For that we have introduce "Needle Type Gates To Be Fixed on Waste Weir of Dam". With adoption of this idea, we can increase the additional water storage by up to 20 percent of capacity of dam. We find it the cheapest method to improve the capacity of dam.*

Key Words: **Silting, desilting, Needle, Gate, Waste weir, Reservoir capacity.**

1.INTRODUCTION

Water flowing from catchment area to streams or rivers has the ability to scour channel bed, to carry particles and to deposit materials. This phenomenon of sediment transport can affect substantially the design of reservoirs. Many cases have been recorded where reservoir siltation rendered water storage structures useless in less than 25 years. Sedimentation problems were observed predominantly with small to medium size reservoirs[1].

The rate of sedimentation in 1,105 reservoirs with a capacity of less than 1.235 x 104m3 was approximately 3.5 % a year. In the case of medium-sized reservoirs, the annual storage loss was 2.7 % per annum and the medium rate of sedimentation was 1.5 %. For reservoirs with a storage capacity of more than 1.235 x 109 m3, the rate of sedimentation was only 0.16 % per annum, with the mean rate coming out at 0.11 % a year [2].

This means after about 20-25 years the reservoir losses it's about 20% of capacity. Thus it is inevitable to release excess inflow during monsoon which flow as unused down stream reaching nearby sea resulting grate loss in water wealth [3].

To catch this excess water we introduce needle gates on waste weir (W.W.) of dam. For this work we have divided dams in to two categories. 1 Gated and 2 Non Gated Dams. Our area of interest is in non gated dams.

There is a scope of storing water in the same reservoir. As any dam is designed for its High Flood Level(HFL) but actually stores water up to Full Reservoir Level(FRL). So we can store water above FRL and below HFL. Now days a practice of controlling water flow over W.W. by using sandbags barrier is becoming popular[4]. But leakage from sandbags increased rapidly with increase of the outside water level[5].

So to store water between FRL and HFL we introduce "Needle Type Gates To Be Fixed On Waste Weir of Dam".

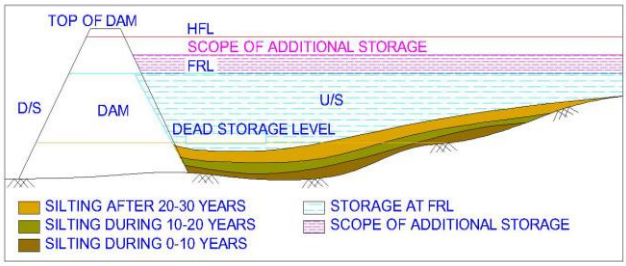

Figure-1: Scope of Water Storage Level

Government acquires land up to HFL. But the actual land submerged is up to FRL. So there is no problem of designed strength and land acquisition for submergence area.

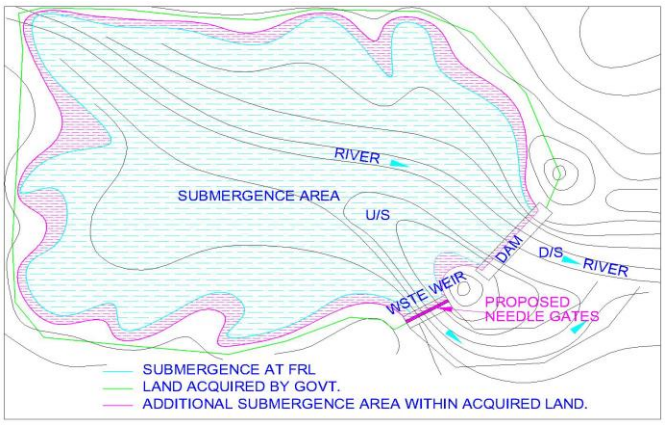

Figure-2: Additional submergence area within acquired land.

This paper describes the structure of gates, its design, implementation, operation, results and benefits.

2.NEEDLE TYPE GATES TO BE FIXED ON WASTE WEIR

The main consideration of adopting needle gate is that government acquires land for submergence is up to HFL of reservoir. So the height of needle gates should be less than HFL. We adopt the formula for height of needle gate

Height of Needle Gate < = (HFL - FRL) / 2 . .... (1)

The Dam is always designed taking HFL in to account. So water level up to HFL does not damage the. So no any extra design check is required for dam.

2.1 Open and Closed Position

The concept of fixing such Needle Type Gates on W.W. is in such way that when there is a forecast of heavy rainfall in the rainy season the needle gates are in the open position and when flood water passes from W.W. and river flow comes to normal then the needle gates are to be in closed position.

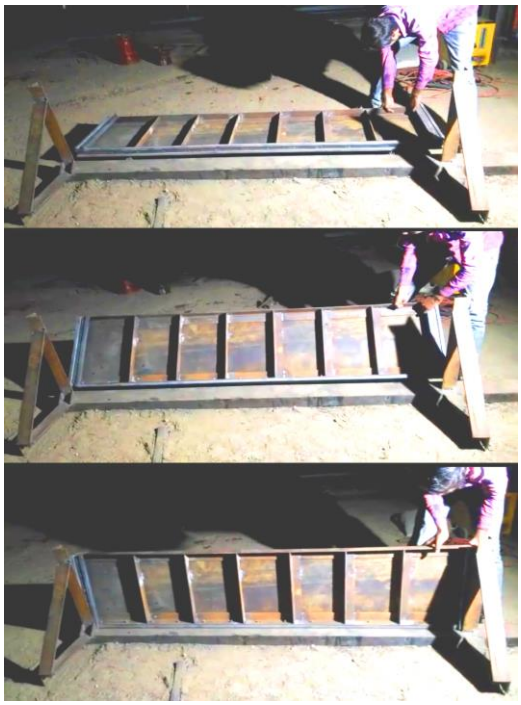

Figure-3: 1st slide shows Open position, 2nd slide shows operating position, 3rd slide shows Close position.

2.1 Features of Needle Gates

1. The gates are to be hinged. So antitheft.
2. The gates are to be made of MS. Hence strong enough.
3. Single man can operate it. So operating cost is very less.
4. The rubber sill can be provided to make gate leak proof.
5. Nut bolt arrangement is provided to lock the gates in its both positions.
6. Proper coating is applied to avoid corrosion and rusting.

2.3 Area Capacity Curve

From the figure 4 it can be seen that as elevation increases the rate of increment in area of contour and storage capacity increases rapidly. So as we go higher and higher, we get more and more storage. This purpose is solved by Needle Type Gates to be Fixed on W.W. of dam.

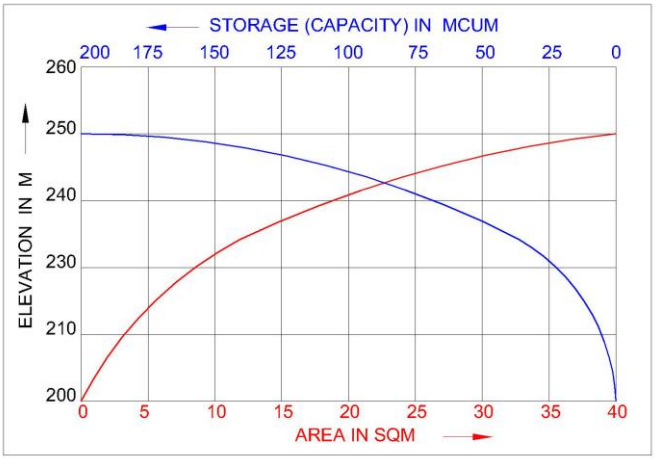

Figure-4: Area Capacity Curve against Elevation.[6]

The volume of storage water between successive contours is calculated by cone formula which is

$$V = H/3 \{A1 + A2 + \sqrt{A1\ A2}\} \text{ cum. ..... (2)}$$

Where

V Volume between two successive contour lines having areas A1 and A2 in sqm.

H Vertical interval in meter between these two successive contour lines.

The reservoir capacity is generally given in Million Cubic Meter (MCM).

2.4 Hydraulics and Design

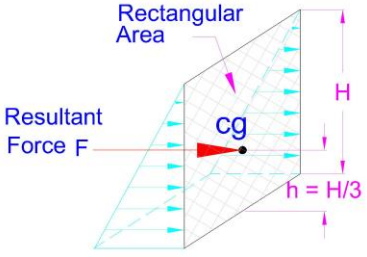

Figure-5: Pressure Prism for Vertical Rectangular Area.[7]

1. Area of gate A = L x H sqm.
2. Total depth of water = Height of gate = H m
3. The position of cg of water prism on the vertical gate is at 1/3 of height of water H from bottom (hinges). Hence h = 1/3 x H m
4. Specific gravity of water is assumed as 1000 Kg/cum and g is gravitational acceleration = 9.81
5. So pressure on rectangular gate
   P = Density of water x g x h
   = 1000 x 9.81 x h N/sqm or Pa
6. The force applied on the rectangular gate F = P . A
   F = (1000 x 9.81 x 1/3 x H) . (L x H) N
7. Consider lowest grade MS material for needle gates which is Fe215 Whose yield strength is 215 MPa
8. Take factor of safety 10 which can cover all types of stresses i.e. tensile, compressive, bending, vibrating, impacting, buckling, fatigue etc. stresses.
9. So the strength of MS material (Fe215) used for needle gates is…

Design Strength = Yield Strength / Factor of Safety
Design Strength = 21.5 x 106 N / sqm

3.IMPLEMENTATION

The Needle Type Gates are implemented at Virkhel Minor Irrigation Tank at village Virkhel, Taluka Sakri, District Dhule in Maharashtra State, India. It is geographically located at 200 52' 35.17" N and 740 03' 36.88" E [8]. It can be located on Toposheet No. 46 L/1 [9].

Year of completion of project is 1972. The FRL is 671.00 m. HFL is 672.00 m. Type of W.W. is channel type. Length of W.W. is 88 m. Total water utilization of dam is 0.83 MCM. The catchment area is 14.90 sqkm. Irrigated area is 198 Ha. These are some salient features of Virkhel M.I. Tank. [10]

As the age of project is about 45 years, as expected the silt is accumulated in the dam and the capacity of dam is reduced by 20% (0.166 MCM). So to restore the capacity, irrigation department has decided to fix needle type gates on its W.W.

As per the formula (1) the height of needle gate is 0.5 m. Consider width of single needle gate is 2.1 m. So the numbers of needle gates provided are say 42 nos.

3.1 Fabrication details

Gate frame structure consists of 150x75x10 MS channel. 75x75x10 vertical MS angles are welded to channel. To sustain water pressure, supports of inclined toe shoe MS angles are welded to vertical angles. The gates are joined to gate frame structure by MS hinges. They are fixed in open position during flood and after river comes to its normal flow they are fixed in close position. In this position water is stopped to flow over the W.W. and the level of water storage increased to height of gates which is 0.5 m. This extra height produces additional storage. Nut bolt arrangement is provided to lock the gates in both open and closed position. See figure 6.

All this MS structure is to be fixed onto the top of W.W. So about 0.3 m thickness of top of W.W. is to be dismantled and new R.C.C. work of same thickness with gated structure is carried out. See figure 7.

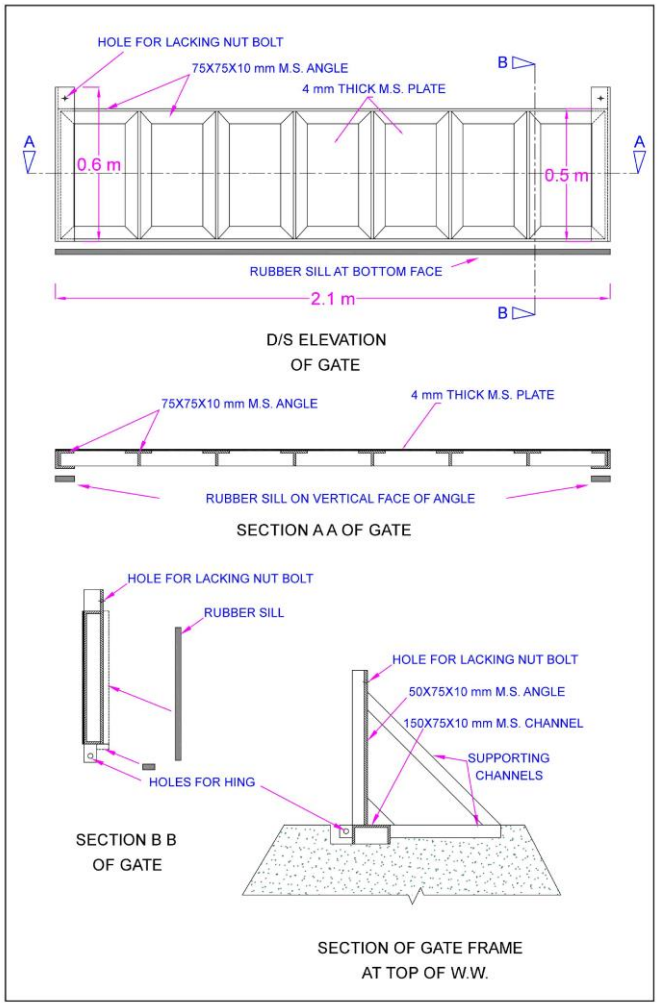

Figure-6: MS Needle Gate Detailed Drawing.

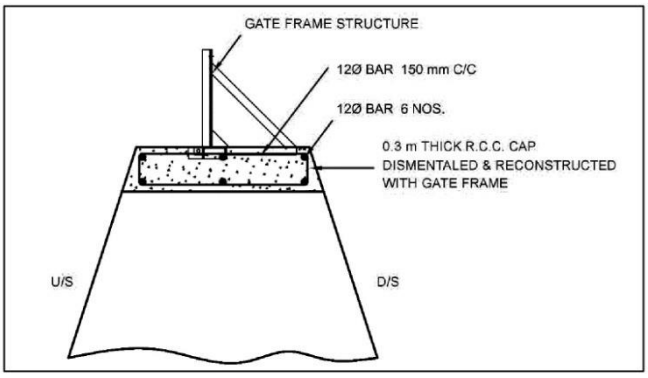

Figure-7: R.C.C. Work to be carried out on the top of W.W.

As size of needle gate is L = 2.1 m & H = 0.5 m

The area of one gate = 2.1 x 0.5 = 1.05 sqm

Hence the strength of one gate is = Design strength x area

= 21.5 x 106 x 1.05 = 22.575 x 10^6 N

Thus a gate can sustain force of water up to 22.575x10^6 N

Now the actual force of water on each gate is

F = (1000 x 9.81 x 1/3 x H) . (L x H) N
= (1000 x 9.81 x 0.5 / 3) x (2.1 x 0.5) = 1.5891 x 10^6

Hence actual force of water on each gate is say 1.6 x 10^6 N which is very less than the force that can sustain by the gate which is 22.575 x 10^6 N

Hence the design is safe and we can use this type of gate.

3.2 Estimate

1. The rates adopted as per Irrigation Department C.S.R. year 13 – 14 and B&C D.S.R. year 15 -16.

2. The work will be executed as per specifications and instructions given by Executive Engineer, Dhule Irrigation Division, Dhule

3. All technical sanctions, administrative approvals, departmental estimate, allocation of work order to contractor and execution of work is carried out under the supervision of Irrigation Sub Division No. 1, Sakri.

4. The estimated cost of complete work is Rs. 999939/- [10]. Say Rs 100000/-

Figure-8: Work in progress.

Figure-9: Completed work

Figure-10: Water storage created by Needle Type Gates at Virkhel M.I.Tank, Taluka Sakri, District Dhule.

4.RESULTS

Sr. No.	R.L. in m	Area in sqm	Contents In MCUM	Successive Contents In MCUM	Remark
1	659	0	0	0	
2	660	1920	0.0006	0.0006	
3	661	10960	0.0082	0.0088	
4	662	18400	0.0145	0.0234	
5	662.2	23717			SILL
6	663	29960	0.0239	0.0473	
7	664	47600	0.0384	0.0857	
8	665	59120	0.0533	0.1390	
9	666	70240	0.0646	0.2036	
10	667	88560	0.0792	0.2828	
11	668	107520	0.0979	0.3807	
12	669	127120	0.1172	0.4979	
13	670	151320	0.1390	0.6369	
14	671	179800	0.1654	0.8023	F.R.L.
15	**671.5**	**249800**	**0.1070**	**0.9093**	**Gate Top**
16	672	310720	0.1950	0.9974	

Table-1: Content Table of Virkhel M. I. Tank [10].

From the above table it is observed that increase in storage due to fixing needle type gates is 0.107 MCM.

5.ANALYSIS

5.1 Cost Analysis

The cost of creating 0.107 MCM water storage with this project is about Rs. 100000/-, hence Rs. 0.107/- i.e. say 11 paise per cum of water, is the cost of needle gates.

If we decide to desitl 0.107 MCM, form dam site to dumping site having average distance 1 Km lead, the cost of work (excavation + transportation) will be about Rs. 23.03 crors.[11]

5.2 Dumping area analysis

For 0.107 MCM silt means 10.7 Ha m silt, means it requires 10.7 Ha land for dumping of 1 m thick silt. If thickness reduces then area of dumping increases, which is not feasible as well as practicable.

5.3 Water Supply Analysis

As storage created is utilized for rabi crops, so only rabi crops are considered for analysis.

Crop	Area	Base period	Depth of water	Duty	Disch-arge	Volume
	A	B	Dt	D	Q	V
	Ha	Days	m	Ha / cumecs	cumecs	Cum
				D=8.64B/ Dt	Q=A/D	V = Q x 86400
Wheat	114.58	10	0.05	1728	0.066308	5729
Onion	10.36	10	0.05	1728	0.005995	518
Gram	66.13	10	0.06	1440	0.045924	3967.8
Other	6.93	10	0.06	1440	0.004813	415.8
Total	198	10			0.123039	10630.60

Table-2: Water supply analysis.

As design discharge of main canal of dam is 0.15 cumecs [10] and discharge required for rabi crops is 0.123039 cumecs, the canal is capable to supply water.

5.4 Tax Recovery

Now as per Maharashtra government resolution dated 29 Jun 2011 in Appendix 1[12] the total tax of water supply by canal flow for rabi crops recovered is Rs.83050 for 50 watering days. The contribution of storage created by needle gates is 10 watering days means 20 % of total tax, which is Rs. 16610/-

5.5 Benefit from Rabi Crops

Now against the expenditure of Rs. 1000000/- for this project, 20% command area i.e. 39.6 Ha is again comes under irrigation. So the production of crops in this 39.6 Ha is the actual benefit of this project.

The rates of crops and expenses per Ha are collected from local farmers. So the profit with rabi crops in 39.6 Ha area which is irrigated by the needle gate project is Rs. 580325/- So the benefits ratio is 1.72.

5.6 Increase in Per Capita Income

The population of Virkhel village as per Census 2011 is 985[13].

Per Capita income from agriculture sector of Maharashtra state is Rs. 14794/-[14].

As the profit with rabi crops in 39.6 Ha is Rs. 580325/- so per capita extra income due to this project is say Rs. 589/-

Hence about 3.98% increase in per capita income for people of Virkhel village due to application of needle gates on W.W. of Virkhel M.I. Tank.

5.7 Effect on utilization (quota) of water storage allotted.

As the reservoir losses its capacity due to silting, the needle gates just restores it again. So after implementation of needle gates it does not stores actual additional water but stores the quota which is allotted to that reservoir. It prevents to flow water which is displaced by silting. So it is not an encroachment or utilization of water quota of downstream sites. So there is no need to get the water utilization certificate from Central Water Commission (CWC).

As 0.166 MCM storage capacity is lost due to silting, needle gates restores 0.107 MCM. So the water stored by needle gates is not exceeds the quota sanctioned by CWC. So there is no additional permission of CWC is required for application of needle gates.

6.CONCLUSION

So we can conclude that "Needle Type Gates to be Fixed on Waste Weir of Dam" can be adopted to all dams with having flat top W.W. particularly having problem of reduction in irrigated command area due to silt and sedimentation, in expense of very low cost and getting high benefits.

Government of Maharashtra has decided to conduct a similar project with 1 m height of needle gates, to Kanoli Medium Project in Dhule district. It is a pilot project. Government wishes to apply the project to all dams in the Maharashtra state.

ACKNOWLEDGEMENT

We are really thankful to Irrigation Sub Division No.1, Sakri District Dhule, Government of Maharashtra for made available the relevant data, without which this paper can never completed in all manner.

We also thankful to Principal Prof. P.B. Kachave, HOD Prof. N. B. Khivsara and all staff of Department of Civil Engineering, Shri Shivaji Vidya Prasarak Sansth's Bapusaheb Shivajirao Deore Polytechnic, Dhule for their valuable guidance.

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