STRATEGY FOR REHABILITATION AND STRENGTHENING OF DAM - A CASE STUDY OF TEMGHAR DAM

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ABSTRACT

Dams contribute to development of civilization and help in meeting drinking water, irrigation and hydropower requirement and also for protection from catastrophic floods. To serve these purpose successfully throughout life span of dam, these dams needs proper maintenance and repairs to be done. The study represents strategy for rehabilitation of Temghar dam. Temghar dam has been constructed across Mutha River near Pune district of Maharashtra during the period March 1997- May 2010. Temghar dam is located on upstream of Khadakwasla dam, from where drinking water is supplied to Pune city and also severs for irrigation. Construction of temghar dam was completed in year 2010. Leakages in dam were observed from the time of construction in increasing trend with increase in reservoir storage level. Since Temghar dam was located on u/s of Khadakwasla dam, which was located on u/s of Pune city, it had high hazard potential in case of any mishap. So there was need for immediate action to be taken to reduce leakages and to look for safety of dam. Water Resources Department immediately started taking action for repair work of dam and started Grouting of dam body. Repair work of temghar dam mainly includes Grouting of dam body and polypropylene fibre reinforcement shotcrete treatment to U/S side of dam. In year 2016 to 2019, 65% of Grouting work is completed and in season 2018-19, 10 % of shotcrete work is completed. As a result of this repair work of dam Water Resources Department got success in reducing 90% of leakage to Temghar Dam.

1. INTRODUCTION

1.1 About Temghar Dam

Temghar dam has been constructed across Mutha River near Pune district of Maharashtra during the period March 1997-May 2010. Temghar project mainly caters to Domestic water supply to Pune city and irrigation of 1000 Ha agriculture land through K.T. weirs. Hydro power is also contemplated at the foot of the dam. The total utilization of 3.708 T.M.C. is planned for this project which is accommodated within 599 T.M.C. of Krishna water allocated to Maharashtra.

Temghar dam is a stone masonry dam with 5 m thick colgrout masonry (1:3) septum on u/s face, at bottom of thickness 3 m and on downstream side as a triangular toe from foundation up to RL 667 m where the stresses were more than 120 T/m2. Total length of the dam is 1075 m and maximum height is 86.6 m. It comprises 72 m long spillway portion in the centre from RD 528 to 600 m and non overflow portion on either flank. The dam top RL is 711.40m and Full Reservoir Level is at RL 706.50 m. Gross capacity at FRL is 108 Mcum i.e. 3.71 TMC.

1.2 Salient Feature

Sr. No	Particulars	Details
1.	source/Name of River	Mutha River
2.	Location: a) State b) Region c) District d) taluka e) Village f) Toposheet No. g) Latitude h) Longitude	 Maharashtra Western Maharashtra Pune Mulshi Temghar 47 F/7, 47 F/11 18o 27’ 0” (N) 73o 32’ 0” (E)
3	Controlling Levels 1. River Bed Level 2. M.D.D.L. 3. F.S.L. 4. H.F.L. 5. T.B.L.	In Mtr 641.56 661.40 706.50 710.12 711.40
4.	Command Area(on d/s of dam to back water of Khadakwasla Project) 1.Gross command area 2.Culturable command area 3.Irrigable command area	 2000 Ha./4940 Acres 1600 Ha./3952 Acres 1000 Ha./2470Acres

2. ISSUES: DELAY IN CONSTRUCTION, ARTIFICIAL SAND, POOR QUALITY, LEAKAGE, DENSITY ETC.

The construction of Temghar Dam was started in March 1997. As per schedule, construction period was 44 months and work was expected to be completed by November 2000. However due to increase in quantities and cropping up of extra items during execution extension for completion was granted. The construction of dam was going in full swing from March 1997 to December 2001. However work was totally stopped by the forest department in January 2002 due to the 4.5 ha of forest land coming under submergence. After receiving the due permission from forest department, construction was again restarted in April 2009 and completed in 2010.

The upstream septum of 5m width is provided of colgrout masonry to prevent leakage. Also on downstream colgrout masonry zone is provided at toe portion up to RL 667m. From the leakage and visual inspection, it is evident that particularly left flank portion and half of the central gorge portion work has been executed very badly. Upstream surface undulations and uneven slopes speak of bad workmanship. Cement slurry accumulated on upstream surface, percolated from the shuttering for colgrout masonry reveals that cement grout is not able to occupy the space between the stones due to improper packing between the stages of masonry. Large cavities show the improper laying of stones, single drum mixer was used instead of double drum mixer which is not able to create colloidal state of the mix. Also use of improper grading of artificial sand used seems to be responsible for forming inhomogeneous masonry. Crushed sand was used for construction of colgrout masonry. Due to angular surfaces in the crushed sand together with high fineness modulus of the sand might have resulted in non colloidal state of colgrout slurry during construction and may have caused segregation of sand and cement. This may be one of the reasons for inadequate strength of colgrout mortar and high seepage. Leakages in Temghar dam were observed at the time of construction which increased with increase in reservoir storage level.

Following table shows how leakage increased year by year.

Sr. No	Year of Construction	Max. total seepage in lps	Remarks
1	June 2000	--	
2	2001-02	72	
3	2002-03	58	
4	2003-04	47	
5	2004-05	68	
6	2005-06	90	
7	2006-07	395	
8	2007-08	430	
9	2008-09	524	
10	2009-10	508	Construction upto FRL

11	2010-11	526	
12	2011-12	602	Grouting done in 2012
13	2012-13	307	Leakages observed after Grouting done in 2012
14	2013-14	402	Leakages observed in monsoon season of 2013
15	2014-15	385	
16	2015-16	1174	
17	2016-17	2581	
18	2017-18	1039	Leakage reduced from 2587 to 1039 lps after grouting of 2000 M.T. grout
19	2018-19	413.80	Leakage reduced from 2587 lps to 413.80 lps around 80 % after grouting of 18000 M.T.
20	2018-19	265.80	Leakage reduced from 413.80 lps to 265.80 lps around 90 % after grouting of 25430M.T. and 4210 Sqm (About 10%) of Shotcrete

3. POTENTIAL HAZARD

Temghar dam is located on upstream of Khadakwasla dam, from where drinking water is supplied to Pune city by a pipe line and lake water is also released into Khadakwasla RB canal to irrigate drought prone area in the East. Water stored in Temghar dam is planned to be released back into the river for its use from Khadakwasla dam. Since Temghar dam was located on u/s of Khadakwasla dam, which was located on u/s of Pune city, it had high hazard potential in case of any mishap. Leakages from masonry induce leaching of free lime in cement rendering loss of strength of masonry and also loss of water and creating fear amongst the people residing on downstream.

4. REHABILITATION & STRENGTHENING STRATEGY

4.1 Findings of Ranade Committee Report:

To suggest the remedial measures for this leakages Government of Maharashtra decided to constitute an Expert committee for study and recommendations. So Temghar Dam Expert Committee (TDEC) was constituted vide Executive Director, Maharashtra Krishna Valley Development Corporation, Pune's order no.1901 of 2014 issued under no.6549, date 27.8.2014 to examine causes of seepage through Temghar Dam and exploring possible measures to reduce it and to access structural stability of dam as well as to suggest the remedial measures for its rehabilitation.

Temghar Dam Expert Committee (TDEC) studied behavior of the Temghar dam by carrying out field inspection and reviewed record related to dam construction & quality control aspects. TDEC held discussions with the present site officials to know developments in seepage from the dam and seepage control measures tried by them. It was observed that most of the seepage was coming out in the form of jets at many places from dam body on the LB. In that comparison, seepage from gorge and RB was much less. Seepage was also coming from some monolith joints and foundation drains. TDEC felt need to improve the crude unscientific methods of measurement of seepage followed by the field officers at site. It was felt necessary to find out percentage of dissolved salts from seepage water & lake water, to know loss of dissolved solids from dam masonry. Appropriate suggestions were given to the project staff in that matter. Study of 'Tomography' was carried out for the assessment of presence of saturated zones in the dam masonry on LB. Some in-situ masonry samples also were tested for its density and crushing strength and finally TDEC has given their opinion about remedial measures to reduce seepage.

4.1.1 *Short term remedial measures*.

- U/s surface treatment
- Dam Body grouting
- Foundation curtain grouting
- Cleaning of porous block
- Repairing monolith joint

4.1.2 *Long term measures*

- Strengthening by post tensioning cables
- Strengthening by Earth backing
- Providing additional drainage gallery
- Masonry or concrete backing
- Buttressing

4.2 Repair Work-important Items

Short term measures such as grouting, providing Shotcrete treatment to upstream face of dam, completing remaining curtain grouting and dam body grouting, Rimming / drilling of porous drains to improve their functioning etc. are needed to be addressed immediately.

Considering severity of the problem and hazard potential of the dam it is planned to adopt immediate short term measure before coming monsoon to plug excessive leakages which may lead to potential danger of piping and Long term measures are planned to provide complete solution for leakages as well as strengthening of the dam.

4.3 Grouting

It was decided to go for exhaustive grouting. So from dam top to Inspection Gallery, Inspection gallery to foundation gallery, from D/s as well from U/s side the drilling and grouting work was immediately started from April 2017.

Grouting from Upstream face: Grouting the upstream colgrout septum from foundation to dam top is done by drilling 38 mm to 51 mm dia holes having depth at 3 m c/c both ways. Intermediate holes are drilled for water intake test and for grouting if necessary.

Grouting from Downstream face: Grouting of UCR masonry is done by drilling 51 mm to 75 mm dia holes with light weight hydraulic diamond drilling machines (by percussion drilling). These are mounted on continuous support systems anchored firmly on dam top with anchor fasteners for maximum depth to cover all the masonry perpendicular to the downstream slopping face of dam. Primary grouting at 6 m c/c and intermediate secondary grouting at 3 m c/c and tertiary at 1.50 m c/c is adopted.

Dam body grouting is also done from dam top to inspection gallery and from inspection gallery to foundation gallery wherever it was possible by drilling slant holes. Directional grouting it also carried out targeting maximum penetration under low pressure with reservoir empty condition. Stage grouting method is adopted. Grout pressure is given between 1.5 to 3.0 kg / cm2 and grout mix design is given by CWPRS, Pune is as below-

Sr. No.	1		2
1	Mix proportion cement+Fly ash +Silica		80:18:2
2	WC Ratio		0.65
3	Admixtures (% by weight of cementatious material)	Powder Form	2 %
		Liquid by volume	5 ml per Kg of cementatious material
		Liquid by volume	
4	Average Compressive Strength Kg/cm2	7 Days	107
		28 Days	222
5	Density (gm/cc)		1.8
6	Marsh Flow Time (Sec)		27 to 36
7	Settlement		Less than 5%

4.4 Shotcrete treatment to U/S Treatment

As per the various experiments carried out at field with help of CWPRS, it is decided to give polypropylene fibre reinforcement shotcrete treatment to upstream face of the dam. For this purpose following provisions are made for wet shotcrete treatment to upstream surface

- Clean the Upstream surface by chipping with mechanical brakers and Air, water jetting of the chipped surface & expose the masonry.
- Anchor Bars of 25 mm dia. 1.5 m length anchored at 1m x 1m distance.
- To give the strength to shotcrete layer wire mesh of 8 gauge of 100 mm x 100 mm is to be used.
- To create bond between bars and wire mesh, M.S. square plate of 100mm x 100mm size and 5mm thickness is being fixed on outer end by threading.
- Providing first layer of average 50mm thick filler shotcrete and second layer of 50mm thick shotcrete.
- Spraying 2 to 3mm thick cement slurry.

For Temghar dam reccomended shotcrete mixture is of 43 grade portland cement, fly ash, silica, admixtures, polypropylene fibre, 10 MSA coarse aggregates, fine aggregates and water.

Final mix design for Shotcrete given by CWPRS, Pune is obtained from CWPRS, Pune as follows :

Sr. No.	Constituents	Quantity of Dry ingredients in kg for one cubic meter concrete	
		First layer	Finishing coat
1	Cement	380.00	360.00
2	Fly Ash	40.00	40.00
3	Silica	20.00	20.00
4	Coarse aggregate (10mm – 4.75 mm)	471.2	254
5.	Fine aggregate (Passing 4.75 mm)	1100	1439
6.	Fibre	1.17	1.17
7.	Accelerator	4.7	4.7
8.	SPG (Super plastisizer)	4.7	4.7
9.	Water	286 (Tentatively)	294 (Tentatively)

As per the recommendation of CWPRS, Pune with reference to Manual for dam rehabilitation of large dam, CWC, January 2018, it is decided to give shotcrete joint treatment by cutting slot of joint width 50mm and depth 150 mm and fixing 12 mm thick Ethylene propylene diene monomer Geomembrane(EPDM) sheet by adhesive and aluminum strips and filling the formed hole with polyurethane material.

4.5 Current Status of Temporary repair measures

Work of grouting started in April 2017 and Work of shotcrete is statred in April 2019. Before that leakage observed was 2587 lps and now in 2019 leakage observed are 265.80 lps. Monolith wise quantity of grouting and Shotcrete executed upto June 2019 is as shown in below table-

Monolith No.	Executed quantity of grouting (MT)	Executed quantity of Shotcrete (Sqm)
1 to 13	14885.80	3075.00
14 to 17	8898.64	1135.00
18 to 27	1645.85	0.00
Total	25430.29	4210.00

Uptill now about 65% of grouting and 10 % shotcrete work is completed and with this work about 90 % of the leakages are reduced. As per the Temghar Dam Expert Committee (TDEC) out of five short term recommendations grouting and Shotcrete that is also in a partial quantities are executed. But with this about 90% of leakages has come down. After the execution of all grouting and shotcrete work as well as remaining measures like Vertical porous hole cleaning, Curtain grouting, repairing monolith joint etc. it can be say that leakage will be reduced within the permissible limits.

4.6 Test and quality control

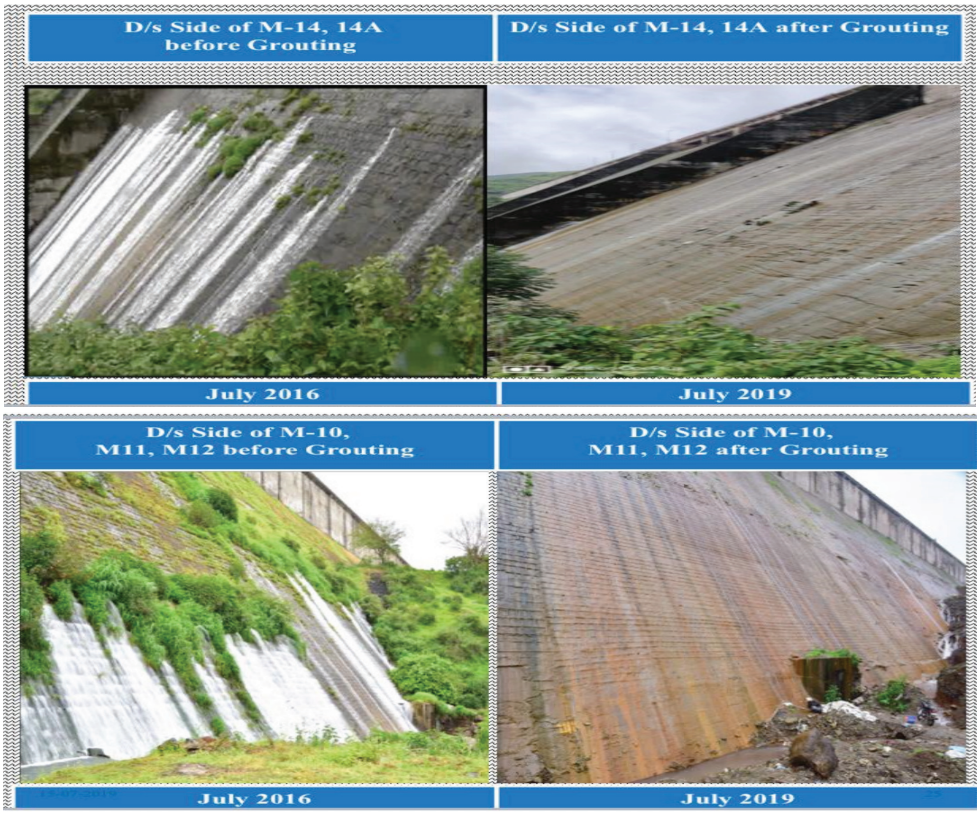
To maintain the quality of work there are various teste conducted on the grout, which includes marsh cone test, settlement, pH value, strength and Temperature. To check the flow time marsh cone test is carried out and the permissible flow time should be between 28 to 30 sec. permissible pH value of grout should be between11to13. For assessing colloidal stage of slurry settlement test is taken where in settlement should be below 5 %. Standardize formats are maintained at site in which periodical reports (weekly, fortnightly, monthly and seasonal) about physical progress, cement consumption, mixer registers, field tests, laboratory tests etc. are recorded by engineers at different levels.

5. CONCLUSION

At the end of season 2019 (June 2019) about 65% of grouting and 10% of shotcrete work is completed and the leakages are curtailed to 90%. It is planned to complete whole work in coming year & by the end of June-2020 whole work along with all measures is expected to be completed. It is also planned to check the density of post grouting masonry by Nuclear bore hole logging and also test the weak zones by Tomography. After these results it is planned to go for permanent measures like concrete backing of dam as suggested by Temghar Dam Expert Committee.

Below figure shows comparison of leakage to Temghar Dam before starting repair work in July 2016 and after completing about 65% of grouting and 10% of shotcrete work at the end of July 2019.

Picture 1 : Leakage Comparison before and after repair work.



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