Current State of Darawat Dam Irrigation Network and Measures for its Rehabilitation

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***Abstract*: The emerging water scarcity in Pakistan caught attention of authorities as it demands construction of new dams and storage reservoirs for water saving. In order to address the said issue, a new dam named as Darawat Dam was constructed in 2013 in the vicinity of District Jamshoro few kilometers off Indus highway for water storage and Irrigation purposes. Unfortunately, the dam is unable to provide its services for Irrigation to related lands up to the desired extent. This research is therefore aimed to study the irrigation network and to bring out the reasons for its inactivity. The data was collected with the help of concerned authorities and the recommendations like implementation of Drip Irrigation System, provision of wind/solar turbines to uplift the subsurface water to meet agricultural water requirements, prohibition of human use of canal for washing and waste disposal, providing awareness and trainings to local farmers, optimized water allocation and crop pattern and improvement in embankment crest were proposed to enhance the Irrigation capacity of Darawat Dam.**

***Keywords*: Water Scarcity, Darawat Dam, Irrigation, Drip Irrigation System, Rehabilitation, Irrigation Network.**

I. INTRODUCTION

One of the principles behind life on earth is that 71% of Earth’s surface is secured with water. Water is likewise accessible beneath arrive surface and as water vapor noticeable all around. There is plentiful amount of water on the earth however just around 0.3% is even usable by people. The other 99.7% is in the seas, soils, icecaps and skimming in the climate. In addition, a great part of 0.3% that is useable is unattainable. A large portion of the water utilized by people originates from waterways. The water accessible ashore surface is alluded to as surface water. The real extent of new water is really discovered underground as soil dampness and in aquifers. [1] Watered farming is an essential division of financial advancement of nation making direct utilization of characteristic assets. Water is one of the rarest and the most valuable sources on Earth. Pakistan is a farming nation and its line relies upon water system. With an immense Indus bowl water system framework, nobody can ignore its standard and key significance. More than 90% of nation's agribusiness, which is a noteworthy piece of GDP, is subject to water system framework [2]. Just like other developing countries, Pakistan is also facing water scarcity that is very much alarming for the household, irrigation and commercial purpose of water usage. The nations per capita water accessibility has dropped from more than 5 300 cubic meters in the 1950s to around 1 000 cubic meters now which is the shortage benchmark [3]. Keeping these facts in consideration, Darawat Dam is a concrete gravity dam constructed crosswise over Nai River Baran in district Jamshoro. It is situated at a separation of around 70 km west of Hyderabad and 135 km north east of Karachi. It is available from M-9 Karachi-Hyderabad motorway. The development of the dam began in June 2010 and the undertaking was finished in August 2014. The dam has a stature of 46 meters. The store zone falls in Jamshoro district. The direction region of dam falls in district Thatta. It is a capacity dam with no power age. Darawat dam project is joint endeavor JV of national development consultant’s NDC and techno consultant international finished its practicality ponder in 2008. The task was executed by water and power development authority (WAPDA) and administered by M/S National Development Consultants and m/s cameos joint venture the financing for development of dam was finished by government of Pakistan [4].
Further features of Darawat Dam are tabulated as under:

Table. 1: Salient Features of Darawat Dam

Dam	
Type	Concrete Gravity Dam
Maximum Height	44 m (144.32 ft)
Total Length of Top of Main Dam	306 m (1,004 ft)
Top Width	20 ft
High Flood Level	RL 119.86 m (393 ft)
Top Level of Dam	RL 121.00 m (397 ft)
Life	50 Years

II. STUDY AREA

Dam Site is about 70 Km West of Hyderabad and 135 Km North East of Karachi. Which is accessible from Karachi–Hyderabad Superhighway. Dam is located across Nai Baran near Jhangri Village in Jamshoro District. Reservoir Area falls in Jamshoro District, while Dam body lies at inter district boundary of Jamshoro and Thatta Districts. Command Area lies in Thatta District.

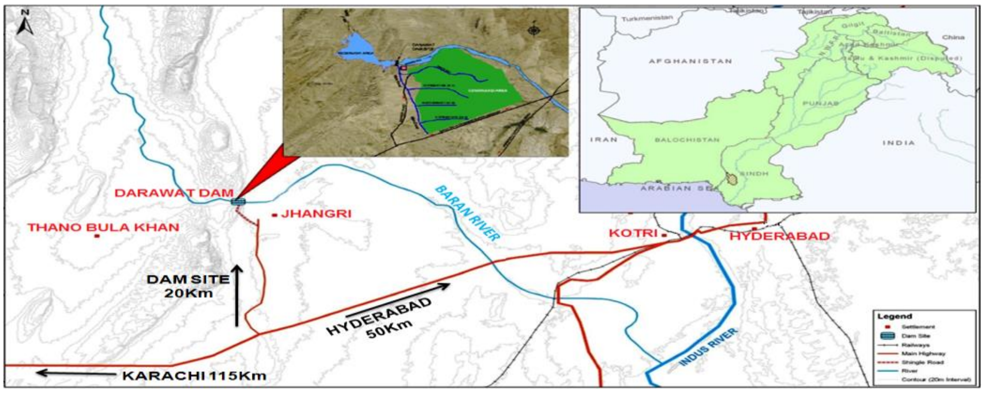

Fig. 1: Dam Site Approach Plan

III. METHODOLOGY

It is a theoretical study based on data collected from Darawat dam monitory team. Two types of researches have been done in this study (primary and secondary), in the early stage past citations and literature were studied in order to get clear idea of the project which is known as secondary data and then some objectives were set out for research. Moving forward, a reconnaissance survey was conducted in order to obtain the preliminary information regarding the dam and its command area including location, accessibility to dam, sources of related data etc. The data was also collected from Darawat dam section of Wapda Office, Hyderabad. A meeting was arranged with the XEN Darawat Dam and the field was visited afterwards. On the site, field measurements were recorded in detail including the dam, outlet works, canal irrigation system, and the newly laid pressurized pipeline. The detailed study revealed some major problems and recommendations were given to overcome them.

IV. IRRIGATION NETWORK

The command area of Darawat Dam comes out to be 25,000 acres which will be irrigated at 200% cropping intensity through a network of concrete lined main canal, distributaries and a minor. Water flowing from the outlet control structure will be led to lined canal. The permanent components of the irrigation system include lined main canal, 3 distributaries and 1 minor canal.

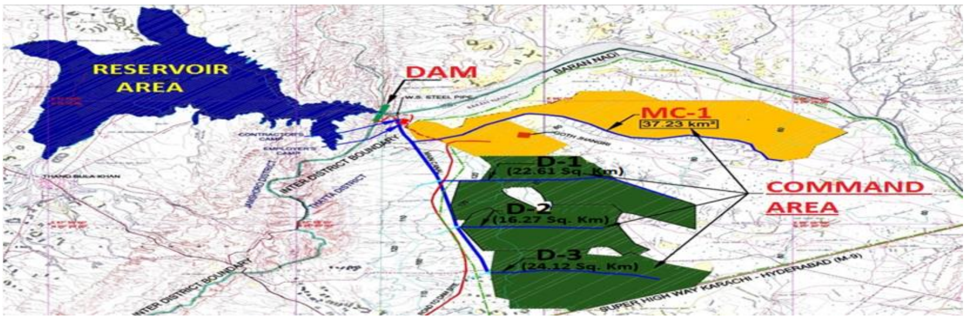

Fig. 2: Layout of Irrigation Network

A. Irrigation Conduit

The irrigation conduit of diameter 1.4m is designed to operate under full reservoir pressure. The irrigation conduit includes water evacuation facilities that allow for dewatering of the entire conduit within a period of 6 hours without damage to the upstream stop logs, trash racks or conduit structure. The conduit is designed to pass the required flow at any reservoir level above EL. 104 m (344 ft.) and will withstand all internal and external loadings associated with operation of the Project including hydraulic loadings imposed during dewatering and pressure transient surcharge up to 20% resulting from any future hydro power installation on the outlet. For this the Contractor will install a Y branch at the end of the irrigation conduit for any future power installation. The cut and over conduit are placed on the most competent portion of the dam foundation. Conduit is placed on the bed rock foundation for safety against settlement. Adequate projecting collars is provided to reduce the seepage along the conduit. The collar is capable to increase the seepage path by least 25%.

Fig. 3: Irrigation Conduit at Darawt Dam

B. Outlet Stilling Basin

For the irrigation system Impact Type USBR Basin VI has been designed. The stilling basin is an impact-type energy dissipater, contained in a relatively small box like structure, which requires no tail water for successful performance. Although the emphasis in this discussion is placed on use with pipe outlets, the entrance structure may be modified for use with an open channel entrance. Generalized design rules and procedures as given in USBR "Hydraulic Design of Silting Basins and Energy Dissipaters" are presented to allow determining the proper basin size and all critical dimensions for a range of discharges up to 9.6 cumec (339 cusec) and velocities up to about 9.14 m/s (30 feet per second). The efficiency of the basin in accomplishing energy losses is greater than a hydraulic jump of the same Froude number.

Fig. 4: Stilling Basin at Darawat Dam

C. Main/Major Canal

The main canal takes it water from the stilling basin. The main canal has length of 11.929 Km and design capacity of 4.42 Cumec or 156 Cusecs. It is concrete lined throughout its length. Manning's Roughness Coefficient is adopted to be 0.018. Trapezoidal Shape with 1:1 side slope has been adopted. The design elements are tabulated as under:

Table. 2: Design Elements of Main Canal

Main Canal	Discharge (Cumec)	B [m]	D [m]	A [m]	Pw [m]	$R^{2/3}$	$S^{1/2}$	V [m/sec]
0000-1757	4.420	2.00	1.34	5.3734	6.8314	0.8521	0.0173205	0.82
1757-4800	2.778	1.50	1.00	3.000	5.1055	0.7015	0.02	0.82
4800-5871	1.781	1.00	0.93	2.227	4.3531	0.6396	0.0223606	0.80
5871-7400	1.781	1.00	0.63	1.225	3.2714	0.5195	0.05	1.45
7400-8333	1.781	1.00	0.89	2.078	4.2089	0.6246	0.0244948	0.85
8333-11929	1.064	0.80	0.84	1.3776	3.1758	0.5730	0.0244948	0.78

D. Aqueduct

An aqueduct is introduced in the run of main canal to allow the free flow of flood water in the rainy season which will come at a high velocity because of nearby high mountain peaks. The width of aqueduct is 3 ft and the length of one slab is 15 ft, total 12 slabs are used. The aqueduct will prevent the scouring of the soil on the sides of main canal.

Fig. 5: Measurement of Length and Width of Aqueduct

E. Minor Canal (MC-1)

The minor canal has the length of 14.6 Km and has the discharge capacity of 1.642 Cumec or 58 Cusecs. It takes water from the main canal. Minor canal is concrete lined through its length. Trapezoidal Shape with 1:1 side slope has been adopted. The design elements are tabulated as under:

Table. 3: Design Elements of Main Canal

MC-1	Discharge (Cumec)	B [m]	D [m]	A [m]	Pw [m]	$R^{2/3}$	$S^{1/2}$	V [m/sec]
0000-1700	1.642	1.00	0.56	0.8736	2.5839	0.4853	0.0707106	1.90
1700-4578	1.393	0.90	0.73	1.1899	2.9647	0.5441	0.0387298	1.17
4578-5103	1.132	1.50	0.69	1.035	2.88	0.5054	0.0387298	1.13
5103-7700	1.132	0.80	0.69	1.0281	2.7516	0.5187	0.0387298	1.11
7700-9800	0.832	0.70	0.57	0.7239	2.0121	0.5058	0.0447213	1.15
9800-12300	0.488	0.60	0.46	0.4876	1.9010	0.4036	0.0447213	1.00
12300-14600	0.252	0.40	0.41	0.3321	1.5596	0.3565	0.0387298	0.77

F. Distributary-1

The distributary-1 has the length of 8.52 Km and has the discharge capacity of 0.997 Cumec or 35 Cusecs. It takes water from the main canal. It is concrete lined through its length. Trapezoidal Shape with 1:1 side slope has been adopted. The design elements are tabulated as under:

Table. 4: Design Elements of Distributary-1

Distributary-1	Discharge (Cumec)	B [m]	D [m]	A [m]	Pw [m]	$R^{2/3}$	$S^{1/2}$	V [m/sec]
0000-1100	0.997	0.50	0.85	1.148	2.904	0.5386	0.0223606	0.71
1100-2200	0.838	0.60	0.60	0.72	1.45	0.6271	0.0447213	1.15
2200-3400	0.670	0.60	0.54	0.616	2.127	0.4377	0.0447213	1.15
3400-4100	0.514	0.50	0.50	0.5	1.914	0.4086	0.0447213	1.02
4100-6000	0.372	0.40	0.54	0.508	1.927	0.4111	0.0316227	0.72
6000-8520	0.183	0.35	0.40	0.3	1.481	0.3449	0.0316227	0.61

G. Distributary-2

The distributary-2 has the length of 5.0 Km and has the discharge capacity of 0.717 Cumec or 25 Cusecs. It takes water from the main canal. It is concrete lined through its length. Trapezoidal Shape with 1:1 side slope has been adopted. The design elements are given below in table.

Table. 5: Design Elements of Distributary-2

Distributary-2	Discharge (Cumec)	B [m]	D [m]	A [m]	Pw [m]	$R^{2/3}$	$S^{1/2}$	V [m/sec]
0000-1000	0.717	0.60	0.56	0.6496	2.1839	0.4455	0.0447213	1.41
1000-2400	0.519	0.50	0.51	0.5151	1.9424	0.4127	0.0447213	1.02
2400-3800	0.382	0.40	0.47	0.4089	1.7293	0.3823	0.0447213	0.95
3800-5000	0.128	0.35	0.34	0.2346	1.3116	0.3174	0.0447213	0.78

H. Distributary-3

The distributary-3 has the length of 5.9 Km and has the discharge capacity of 1.064 Cumec or 38 Cusecs. It takes water from the main canal. It is concrete lined through its length. Trapezoidal Shape with 1:1 side slope has been adopted. The design elements are given below in table.

Table. 6: Design Elements of Distibutary-3

Distributary-3	**Discharge (Cumec)**	**B [m]**	**D [m]**	**A [m]**	**Pw [m]**	$R^{2/3}$	$S^{1/2}$	**V [m/sec]**
0000-800	1.064	0.70	0.55	0.6875	2.2556	0.4529	0.0447213	1.22
800-2100	0.814	0.60	0.60	0.72	2.2970	0.4614	0.0447213	1.14
2100-3700	0.531	0.50	0.51	0.5151	1.9424	0.4127	0.0447213	1.03
3700-4400	0.274	0.10	0.40	0.2	1.2313	0.2976	0.0447213	0.87
4400-5900	0.159	0.35	0.38	0.2774	1.4248	0.3359	0.0316227	0.59

V. FINDINGS

Improper monitoring of water on the upstream side was observed. No quality measures have been adopted to stop the illegal usage of water and to prevent the contamination of stored water on the upstream side. Water is not available in the required quantity. The situation is so worse that water has never been able to overflow the spillway of the dam. The dam has never been utilized for what it was designed and constructed. To overcome that improper future climatic forecast a pressurized pipeline system was laid in the year 2017 and with its help 12000 acres of land was irrigated. The water was conveyed through pipes which irrigated 5000 acres on the upstream side and 7000 acres on the downstream side of the dam. The canal network is open and too lengthy hence it will be very difficult to take proper care of water allowed to downstream and there will be some evaporation losses which can be a big problem in such dry and water scarce region. The water application efficiency can be a bit of concern when canals will run fully as the water will be applied to the point of its application through furrow irrigation which will result in loss of water through seepage and percolation losses.

VI. CONCLUSIONS

Irrigation network consists of permanent and temporary conduits (canals and pipes) that supply water to irrigated lands from an irrigation source. An efficient irrigation system does not only reduce the losses but also satisfy the crop water requirements. This study on the Darawat Dam assesses the irrigational system and it was found that the irrigation system is best designed. The seepage and percolation losses are controlled by the canal lining with concrete as cement was easily available in that area. The main canal, minor and the distributaries are all lined to get high conveyance efficiency. Design capacities of main canal, minor and distributaries are based on the monthly crop water requirements. Water flows under gravity in whole irrigational network so there is no need to install any electrical equipment and no electricity cost is there. Steel pipeline is used to convey water to the main canal which reduces the seepage and evaporation loss and increases conveyance efficiency. The conveyance system is best designed according to the allocation to give design discharges. The irrigation network will also prove helpful in socio-economic uplift of the area. Lifestyle of local people will improve. Agricultural productivity will increase greatly in command area. Due to efficient use of water cropping intensity will improve up to 200%. The involvement of Pakistan Agricultural Research Council (PARC) will prove helpful in increasing the yield.

VII. RECOMMENDATIONS

Drip irrigation system might be the one to be recommended for irrigation in such a semi-arid region. As the top of canal and its branches is open, human use of canal for washing and waste disposal must be noticed. As the conveyance system is designed adequately, so next step is to give proper attention towards the water application efficiency. Optimized water allocation and cropping pattern must be adopted and must be monitored. A continuous knowledge exchange between farmers and resource managers is necessary identify the scope of future improvements. Partnership between water suppliers/Irrigation Department, farmers and among farmers should be developed.

REFERENCES

[1]. National Ground Water Association Report http://www.ngwa.org/Fundamentals/teachers/Pages/information-on-earth-water.aspx

[2]. Rashid, M.S (2016), “Irrigation Problems in Pakistan”, Middle East Technical University. https://www.researchgate.net/publication/299845578_Irrigation problems in Pakistan.

[3]. General Ghulam Rasool, Director Pakistan Meteorological Department, July 22, 2016. https://tribune.com.pk/story/1146784/need-dams-water-storage-capacity-drops-35/

[4]. Water and Power Devolopment Authority (WAPDA) http://www.wapda.gov.pk/index.php/darwat-dam-menu