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Comparative Operation and Maintenance Cost Study of Shaft Over the RCC ESRin Rural Water Supply Scheme

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Abstract: Reinforced Cement Concrete (RCC) Elevated Service Reservoirs (ESRs) are widely utilized in rural water supply systems for water storage and distribution. However, their implementation in rural areas presents various challenges, including high initial costs, extended construction durations, difficulties in maintenance and repairs, concerns regarding structural stability, issues with land acquisition, water leakage, and susceptibility to natural disasters. The primary objective of this study is to examine the challenges encountered in operating rural water supply schemes, explore the use of shafts as an alternative to RCC ESRs in such schemes, conduct a cost analysis comparing shafts and RCC ESRs, and evaluate their performance and lifecycle through case studies. Therefore, the aim of this study is to reduce the overall cost of water supply projects, shorten the project completion time, and minimize future operational and maintenance expenses.
Keywords: RCC, Maintenance, ESR, SHAFT

I. INTRODUCTION

A. RCC ESR

In India's rural water supply schemes, a Reinforced Cement Concrete (RCC) Elevated Storage Reservoir (ESR) serves a vital function in enabling efficient water distribution to rural communities. This type of storage tank is constructed above ground on an elevated platform, allowing water to be stored at a height for gravity-driven distribution to households and other areas.

Fig. 1 RCC ESR

B. SHAFT

The Shaft is a hydraulic isolation structure that operates on the same hydraulic principle as a Break Pressure Tank (BPT). Its advantages are evaluated through two case studies conducted in Maharashtra, India. The effect of incorporating the Shaft into the Water Transmission Network (WTN) is analysed using energy grade lines, energy performance indicators, and life cycle energy costs. Besides lowering energy consumption, the case studies demonstrate that strategically placing the Shaft within the WTN can also enhance the system's carrying capacity.

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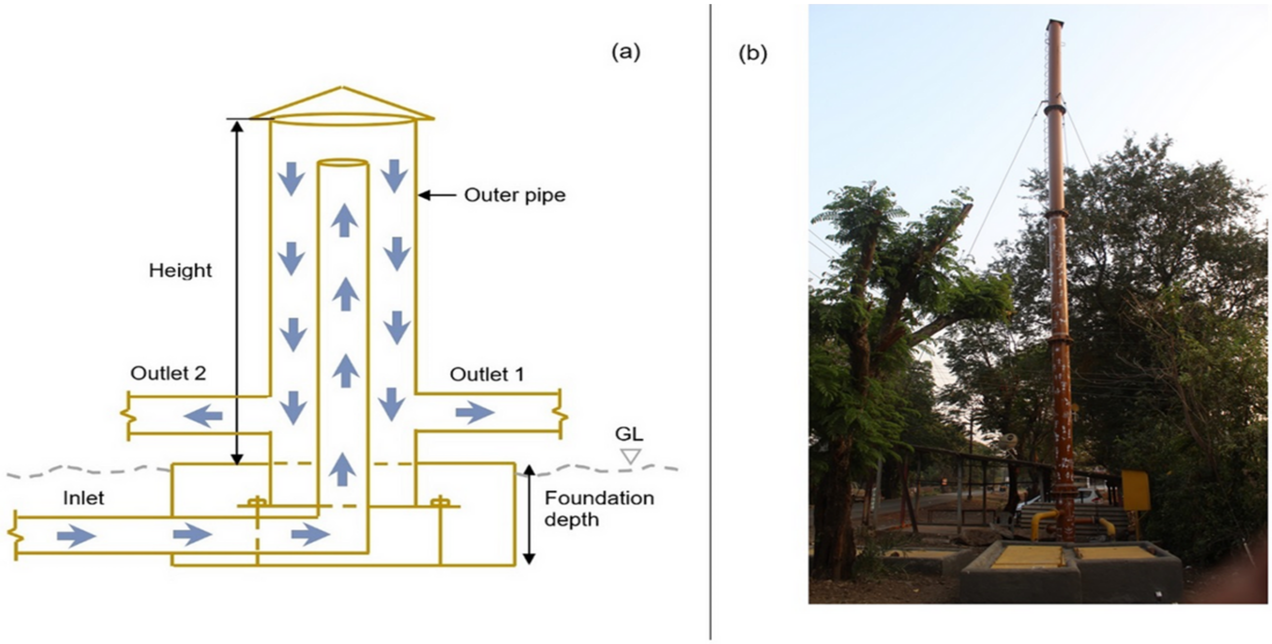

FIG. 2 CROSS-SECTION OF A SHAFT (A) SHAFT AT SAPHALE, PALGHAR, MAHARASHTRA, INDIA (B) ,

II. LITERATURE REVIEW

A. kumar Sinha, and P. Kalbar et al.[1] In this literature paper we studied the application of Shaft in WTN has operational benefits like minimizing the effect of waterhammer, thus reducing the operation and maintenance cost of the pipelines. Also, Shaft reduces the extra static head over the pipeline, improving the performance of the system. The Shaft acts as a hydraulic isolation structure, separating the hydraulics of the upstream and downstream network. The hydraulic separation, helps in conversion of the RWPM into RWGM. Overall, use of Shaft at appropriate location in the WTN will substantially improve the efficiency of the system.

P. F. Boulos, B. W. Karney, D. J. Woodet al.[2]In this literature paper we studied the hydraulic transient, also called pressure surge or water hammer, is the means by which a change in steady-state flow and pressure is achieved. When conditions in a water distribution networkchanged, such as by closing a pump or a valve or starting a pump, a series of pressure waves generated. These disturbances prop-of sound within the medium until gate with the velocity of sour dissipated down to the level of the new steady state by the action of some form of damping orfriction.

P. Kalbar and P. Gokhaleet al.[3]In this literature paper we studied the the design and operational practice of water supply schemes (WSSs) in India is discussed in the context of the prevailing performance of the systems. Issues such as the tremendous gap in design and operation, unskilled manpower, and unmanageably large operation zones are identified as the main causes of the failure of WSSs in India.

P. N. Gokhale, A. K. Ghorpade et al. [4] In this literature paper we studied the there is a need to create a WSS that delivers water with good pressure with expected liters per capita per day, and there should not be inequality in the distribution. Several solutions such as multi-outlet tanks, shafts, manifolds, and masterpiece introduced in this paper can help alleviate the current situation.

III. METHODOLOGY

Limala is a village situated in Purna Taluka of Parbhani District in the state of Maharashtra, India. It is part of the Marathwada region and falls under the Aurangabad Division. The village is located about 31 kilometers east of the district headquarters, Parbhani, and approximately 512 kilometers from the state capital, Mumbai. The Pin code of Limala is 431402, and its postal head office is located in Parbhani. The village is bordered by Palam and Loha Talukas to the south, Basmat Taluka to the north, and Parbhani Taluka to the west.

As part of the Bharat Nirman scheme, a percolation well was constructed approximately 2.1 km from the village, near a local nala. This well currently holds 1,30,000 liters of water. Additionally, a 30,000-liter capacity RCC Elevated Storage Reservoir (ESR) with a staging height of 12.0 meters was completed in 2009.

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The existing RCC ESR with a capacity of 30,000 liters is no longer sufficient to meet the water demand of the current population. Based on this, an additional RCC ESR with a capacity of 46,000 liters is required to fulfill the projected demand for the next 30 years, assuming a per person requirement of 55 liters per day. Moreover, the current percolation well is also inadequate, so a new percolation well with an estimated yield of 1,50,000 liters is proposed. However, there is no available open space near the existing ESR for constructing a new one. To address this issue, based on case studies, the application of a water distribution shaft can be used to effectively distribute water to the supply lines.This study presents a comparative analysis of RCC ESR and shaft systems, focusing on their applications, limitations, cost-effectiveness, future scope, and other relevant aspects.

FIG. 3 (CASE STUDY LOCATION IN GOOGLE WARTH)

Using the available population census data from the past five decades (1971–2011), we projected the population for the next 30 years at 5-year intervals. The projections were made using the Arithmetical Increase Method, Incremental Increase Method, and Geometric Progression Method. By averaging the results from these methods, we obtained the estimated population for the corresponding years, along with the daily water demand for the 30-year period, as shown in the table below. Table No.1

TABLE NO. 1 (POPULATION FORECASTING)

POPULATION - FORECAST

Village:- LIMLA
Taluka:- PURNA
District:- PARBHANI

YEAR	POPULATION	INCREASE IN DECADE	INCREMENTAL INCREASE IN DECADE	RATE OF GROWTH PER DECADE
1971	829			
		0		0.0000
1981	808		371	
		371		0.4592
1991	1179		0	
		246		0.2087
2001	1425		0	
		169		0.1186
2011	1594			
TOTAL	5835	786	371	Rg =
AVERAGE :-	1167	197	124	0.0000

YEAR	ARITHMETICAL METHOD	INCREMENTAL INCREASE METHOD	GEOMETRIC PROGRESSION METHOD	AVERAGE OF I. I. & G. P.
2025	1870	2078	1594	1847
2040	2165	2865	1594	2208
2055	2461	3930	1594	2662

TABLE NO. 2 (DAILY DEMAND) DAILY DEMAND

Village:- LIMLA
Taluka:- PURNA
DISTRICT:- PARBHANI

	Present stage 2025	Immediate stage2040	Ultimate limited stage 2055
A) Domestic Water Demand			
1. Population (Souls)	1847	2208	2662
2. Rate of Water Supply(L.P.C.D.)	55	55	55
4. Daily Demand (Liter . per Day)	101592	121439	146387
3. Daily Demand (M.L. per Day)	0.102	0.121	0.146
B) Other Water Demand			
1. Demand for floating Population (MLD)	0	0	0
2. Instituional Demond (LTR)	0	0	0
3. Floting Population (LTR)	0	0	0
4 For Cattle	13395	13395	13395
5. Total Demond (LTR)	114987	134834	159782
6. Supply Available from exisiting sources	0	0	0
7. Net Demand Requried(5-6)	114987	134834	159782
C) Demand Considerring the Looses as Below			
1. Demand at ESR with 15% Losses in Distribuction system (MLD)	: 17248	20225	23967
Gross Demand (Liter)	: 132235	155059	183750
Gross Demand (MLD	: 0.1322	0.1551	0.1837
For Pumping Machinary/ Rising Main	Total Deamand In	=	183750 Liter

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	Water available from exisiting source is		130000		
1)	Exisitng Water	:	0.1300	0.1300	0.1300
	For Desing purpose				
2)	Gross Demand (MLD	:	0.1322	0.1551	0.1837
3)	60 % Water available from exisiting Source	:	0.0793	0.0930	0.1102
4)	40 % Water available from New Source	:	0.0529	0.0620	0.0735

To pump the water we calculated the pumping machinery for lifting the water from source to ESR/ Shaft.

DESIGN OF PUMPING MACHINARY

Village:-	LIMLA
Taluka:-	PURNA
DISTRICT:-	PARBHANI

1)	Daily demand FOR 2035	:	0.0620	MLD
2)	Pumping Hours	:	12	Hrs.
3)	Rate of pumping	:	5169	Lit/Hrs.
4)	STATIC HEAD			
a)	F.S.L. of Reservoir	:	404.10	M
b)	Lowest Suction level in the well	:	362.71	M
c)	Velocity head / Residual head	:	3	M
D)	Heance Static head	:	44.39	M
5)	FRICTIONAL HEAD			
a)	Designed discharge in MLD LPH X 24	:	0.1240	MLD
b)	Length of Main	:	2.1540	KM
c)	Diameter , Type & class of pipe	:	90.00	mm Dia. PVC 6 Kgf. / Sq.cm.
d)	Hazen williams constant	:	140	
e)	Rate of Frictional loss	:	1.48	M
f)	Total Frictional losse(b x f)	:	3.18	M
g)	Add for losses in bends/ valve etc.10 % of above f	:	0.32	M
h)	Total frictional Head (f + g)	:	3.50	M
6)	TOTAL HEAD ON PUMP	:	50.89	M

7) B.H.P. REQURIED

$$\frac{5169 \quad x \quad 50.89 \quad x \quad 1.20}{75 \quad x \quad 3600 \quad x \quad 0.60} = 1.95 \text{ Bhp}$$

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= 1.95 Bhp

8) Total H.P. Proposed = 5.00 Bhp

9) Provide duplicate set of submerssible pumps capable of 5169 lit./ hours against total head 50.89 M be driven by 5.00 H.P. electrical motardirectely coupled to it.on pump will be in operation and one will be stand by .

Required RCC ESR Design.

Village:- LIMLA
Taluka:- PURNA

DISTRICT:- PARBHANI

CAPICITY OF STORAGE RESERVOIR

1)	Total requriment of water per day	:	155059	Litrs
2)	Distribution of water twice per day	:	77529	Litrs
3)	ExisitingE.S.R.Capicity	:	30000	Litrs.
4)	Proposed E.S.R.	:	46000	Litrs.

By using the construction cost, Electricity Requires etc. of the sub work such as RCC ESR & Shaft We can calculate the overall Maintenance and Repair cost of the project as shown in table below.

TABLE NO. 3 (M & R SHAFT)

YEAR	2025	2030	2035	2040	2045	2050
	SHAFT					
Daily Demand (MLD)	0.053	0.056	0.059	0.062	0.066	0.069
Time in Hrs.	3.306	3.480	3.670	3.876	4.099	4.338
5.0 HP Motor Discharge	16000	16000	16000	16000	16000	16000
3.73 Electric Units in One Hour.	Electric Consumption (Operating Cost)					

Daily (1)	12.00	13.00	14.00	14.00	15.00	16.00
Annualy (365)	4380	4745	5110	5110	5475	5840
Unit Rate (5 Rs.)	5	5	5	5	5	5
Amount (Rs.)	21900	23725	25550	25550	27375	29200
	Installation Cost					
			Pumping	176283	Rs.	
			Shaft	119604	Rs.	

TABLE NO. 4 (M & R RCC ESR)

YEAR	2025	2030	2035	2040	2045	2050
	ESR (46,000 Lits.)					
Daily Demand (MLD)	0.053	0.056	0.059	0.062	0.066	0.069
Time in Hrs.	3.306	3.480	3.670	3.876	4.099	4.338
5.0 HP Motor Discharge	16000	16000	16000	16000	16000	16000
3.73 Electric Units in One Hour.	Electric Consumption (Operating Cost)					
Daily (1)	12.00	13.00	14.00	14.00	15.00	16.00
Annualy (365)	4380	4745	5110	5110	5475	5840
Unit Rate (5 Rs.)	5	5	5	5	5	5
Amount (Rs.)	21900	23725	25550	25550	27375	29200
	Installation Cost					
	Pumping	176283		Rs.		
	ESR	1403655		Rs.		
Total Cost	=	1733238		(21900+23725+25550+25550+23775+29200+176283+1403655)= 1733238		
Difference	=	1284051		Rs.		

O and M Cost Reduction in % over the sump instead of construction of RCC ESR	=	74.08	%

IV. CONCLUSIONS

The study done over here is related to comparative study for use of SHAFT over the RCC ESR in Rural water supply scheme. The observations and remark shows that the maintenance cost of Shaft/BPT over the RCC ESR will be reduced upto (74.08 %). The use of RCC ESR or SHAFT will be used as per site condition, soil bearing capacity of soil, availability of skilled labors, pipe type will be used, budget etc.

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