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Scrutiny of feasibility of implementation for underground dam in the margin of desert for land farming (Case study, Kerman (Ravar) underground dam)

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ABSTRACT

Agricultural droughts are droughts that affect the crop production or the ecology of a region. Ravar city that is located in margin of desert and the north of Kerman province is one of these areas. Due to the existence of enough underground water that entrance to desert and high evaporation to improving agricultural and cultivar activities, it needed to study the construction of underground dam in Ravar area. Therefore in order to (sake) controlling the subsurface flow that entrance to desert in west of Ravar city that is arid for cultivar agriculture, a site in the margin of desert in space of ten kilometers in the north of Kerman province (Ravar city) has selected and the needed studies has done in several step. At first the physiographic, hydrology, climatology, social economics and engineering geology study has done and the result shows the need of supplementary study. In second the geophysics study has done for Assessment of alluvial thickness and bed rock depths. in the third step the geotechnics activities for Assessment of exact depth of bed rock ,ground water table and sampling for field and laboratory testing in order to (sake) Assessment of physical and mechanical specifics. In fourth step the pumpage test has done Assessment of hydrodynamics coefficient such as (T and S). At finally the design and executive of subsurface dam with the modern methods has done and the result of monitoring shows than the dam has constructed very successfully with positive effects to ground water flows.

Key words: Underground dam, Subsurface flow, Collecting well, Ravar city, Desert, Land farming

INTRODUCTION

A drought is considered a period of abnormally dry weather that causes serious hydrological imbalance in the area. Drought is an insidious hazard of nature. It is often referred to as a "creeping phenomenon" and its impacts vary from region to region. Drought can therefore be difficult for people to understand. In the most general sense, drought originates from a deficiency of precipitation over an extended period of time--usually a season or more--resulting in a water shortage for some activity, group, or environmental sector. Its impacts result from the interplay between the natural event (less precipitation than expected) and the

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demand people place on water supply, and human activities can exacerbate the impacts of drought. Because drought cannot be viewed solely as a physical phenomenon, it is usually defined both conceptually and operationally. Kerman province has a long border with desert and verge to the desert's pit there are a sequence of High Mountain that have some deal suitable main annual rainfall and in some case that mountain has covered by snow (Aminizadeh, M.R. 1998). The condition of morphology and topography causes that the surface and subsurface flows drain toward the desert. Therefore the fresh water throughout its path toward the desert becomes briny, unfavorable and useless. The characteristic of Ravar listed in table 1. The aim of this research is the control of subsurface flow in margin of desert by construction of subsurface dam before the water become salin and unfavorable. The Mianroud river in north of Kerman province is one of the important drainage of fresh subsurface flow toward the desert. In this research the needed scientific scrutinies has done for feasibility the construction of underground dam on Mianroud River to improving sub arias agricultural activities.

Definitions

Underground dam is introduced in different ways such as; sand storage dam, groundwater dam, subsurface dam, subsurface cutoff walls and barriers (Nilson, A. 2003) subsurface dam is a facility that store ground water in the pores of strata (Ishida.S, ET all, 2003). Subsurface dams are an easy-to-build and economical means to generate, use and process new water cycles in rural areas (Thomas.E, .1988). Underground dam in comparison with the surface dams has many advantages as shown in figure 1 (Eiichi, et al, 2003).

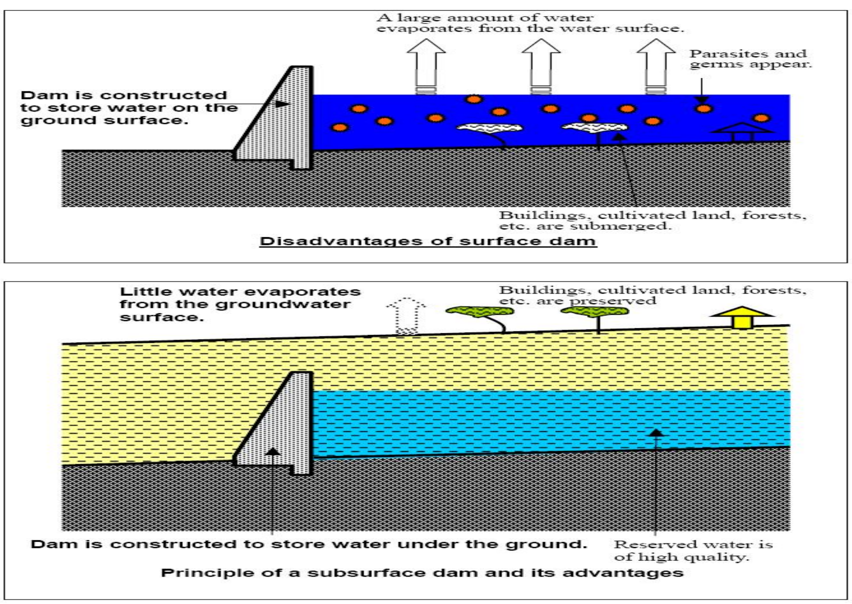


Fig 1. the advantages of underground dam in comparison with the surface dams

Methodology

By considering that constructing an underground dam has not a considerable background in Iran and now is passing its beginning stages such as surveying, designing and constructing, so they are new projects. There is no a vast guideline for performance and constructing of underground dams. Therefore, the goal of the present study is assessment of underground dam construction mechanism. The trend of Scrutinizes for underground dam construction consisted of the followings: Site selection: because the aim of this research was the feasibility underground dam construction in the margin of Kerman desert hence the extensive part of desert that the surface and subsurface flows were entrains to the desert was investigated and at finally the Minored river site due to suitable condition selected for construction of underground dam. The manual drillings for calculating and evaluating the volume of passing undersurface flow from the valley of underground dam constructed place. The machinery drillings for improvising the observing boreholes that the fluctaion of underground water level is doing by them after the dam constructed. Pumpage test for calculating the hydrodynamic coefficients of dam reservoir Performed. Desk and field studies for verifying the proposed dam site are as follows:

Physiography, climatology and hydrological studies

Some of physiographic characteristics of the Ravar underground dam are shown in table 1. In base of the Domarten method and with consideration of the coefficient that result from this method (I=9.14) the watershed basin is located in dry climate. Also (in addition) in base of the Ambergeh method and with consideration of the coefficient that result from this method (Q=29.83) the watershed basin is located in semi dry and cold climate.

Annual run off of watershed basin

The main annual runfall in watershed basin is about 197mm. the total annual run fall is about 339 milion cubic meters. the quantity(amount) of evaporation is about 271 million cubic meters and the volume of runoff(based on contain method) is about 17and the quantity of infiltration is about 50 million cubic meters .therefore the content of subsurface flow is about 1 million cubic meters.

Population, employment and income

In the past has been about 8 village in confined of Main Rood river with the population about 600 persons but at present for the reason of drought and the migration of people, about 170 person are resident in Mianroud area .the job (employment) of people is stockbreeding (husbandry) and farming. About 100 hectare of cultivate land is in Rotation cultivation (fallow land) and after the constructing of underground dam can be planted.

Investigations of engineering geology

The location of Ravar underground dam is on Mianroud seasonal and torrential river. The valley is narrow and deep and its width is about 70 meters. This valley has formed by common action of faulting and weathering. The geological formation in base and two sides of valley are formed by layered sedimentary rocks .this formations contained the compacted unit of white to gray shale and marls and causes the base and two sides of valley become impermeable and shutting the water. Therefore there is not the feasibility for desertion and escape of water. The result of excavation and electrical sounding shows that the depth of bed rock in location of axis subsurface dam is about 11 meters.

Risk analysis and determination of base design earthquake

Today there are two method for assessment of design earthquake, deterministic and probabilistic methods .in this study we have used the deterministic method and appointment the risk analysis with use of seismicity potential of active faults. The horizontal acceleration of earthquake calculated about 0.10g by use of Kuhbanan and Nayband faults.

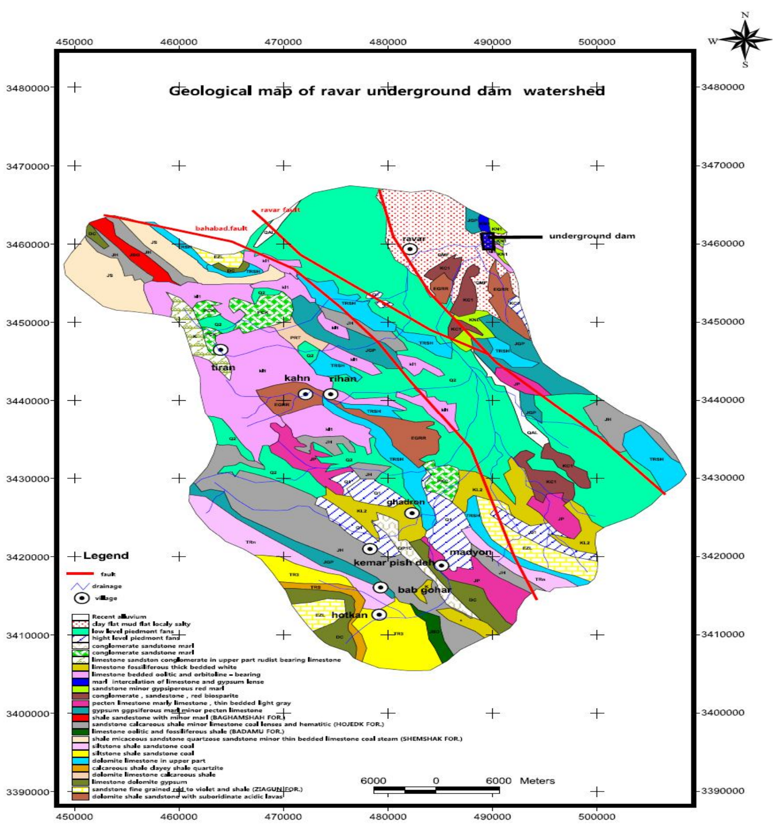


Fig 2. Geological map of Ravar underground dam watershed

Ground water

Because the aim of this research is prevention of water that enters to desert, it is very important to determine the volume of subsurface flow that entrance to dsesrt. Because, using the available water resources and developing the scientific and new methods, for using the potential water resources which are sometimes out of access, are so necessary (Lea, *et al* 2005). Therefore we obtained the physical and hydro dynamical properties of alluvium for the calculation of subsurface flow.

Measurement of subsurface discharge in location of dam axis

In space of 800 meters above the axis dam two piezometric well with space of 50 meter has been Excavated in stream bed. Then the hydraulic conductivity calculated by Leogeon and laboratory tests .furthermore the subsurface discharge determined by Darcy method as follow.

$$Q = KAi = 3.2\times10^{-4}\,m/\sec\times190\times10\times\frac{25.09-24.41}{50} = 8.3\,lit/\sec$$

$$i = \frac{h}{L} = \frac{25.09-24.41}{50} = 0.0136$$

$$i = haydraulic\text{–}gradient$$

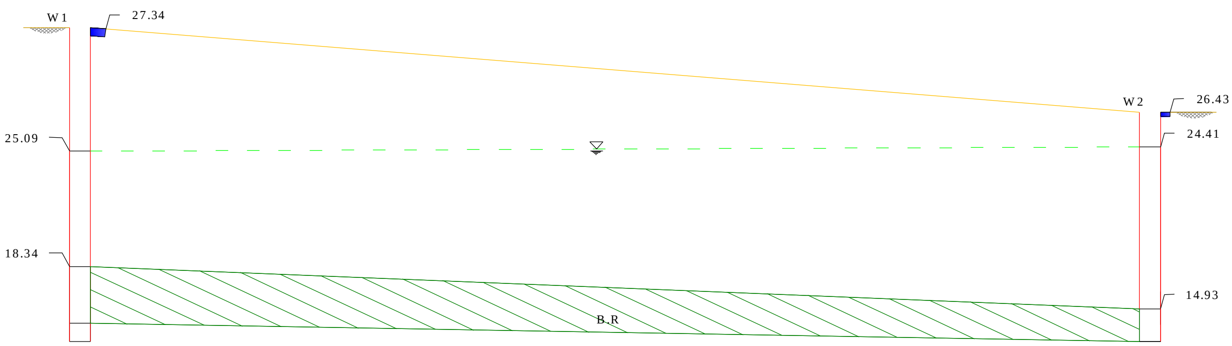


Fig 4. Peizomter numbers 1 and 2 and the calculation method of hydraulic gradient.

The mean value of subsurface discharge that calculated is about 8.3 liter per second .but the discharge of dam after construction is 12-14 liter per second. Measurement of hydrodynamic coefficient in Mianroud River (in location of dam axis). To sake calculate the hydrodynamic coefficient (storage coefficient and transitivity) a borehole excavated by hand for doing the pumpage test. During the pump age with 12 liter per second the drawdown in the borehole were recorded at different time. Therefore with use of Theis method and recovery test the hydrodynamic coefficient were calculated.

Measurement of S and T with Theis method

At first the result of pumpage test has drawn on a graph that named pumpage curve then with overlaying the pumpage curve to type curve a point like A were selected on the graph and the needed s parameters like u , w(u) , r^2/t and s obtained from the graph, and at finally with use of following formula the value of S and T calculated(Todd,D.K. 1980) .

$$u = 10^{-2}$$

$$w(u) = 1.0$$

$$\frac{r^2}{t} = 5.0 \times 10^{-4} m^2 / \sec$$

$$s = 0.40 m$$

$$s = \frac{Q}{4\pi T} w(u) \Rightarrow T = \frac{Q}{4\pi s} w(u)$$

$$T = \frac{0.012}{4 \times 3.14 \times 0.4} \times 1.0 = 2.5.0 \times 10^{-3} m^2 / \sec$$

$$S = \frac{4Tu}{r^2/t} = \frac{4 \times 2.5 \times 10^{-3} \times 1 \times 10^{-2}}{5.0 \times 10^{-4}} = 0.20$$

$$s = \frac{Q}{4\pi T} = w(u)$$

$$u = \frac{r^2 . S}{4tT}$$

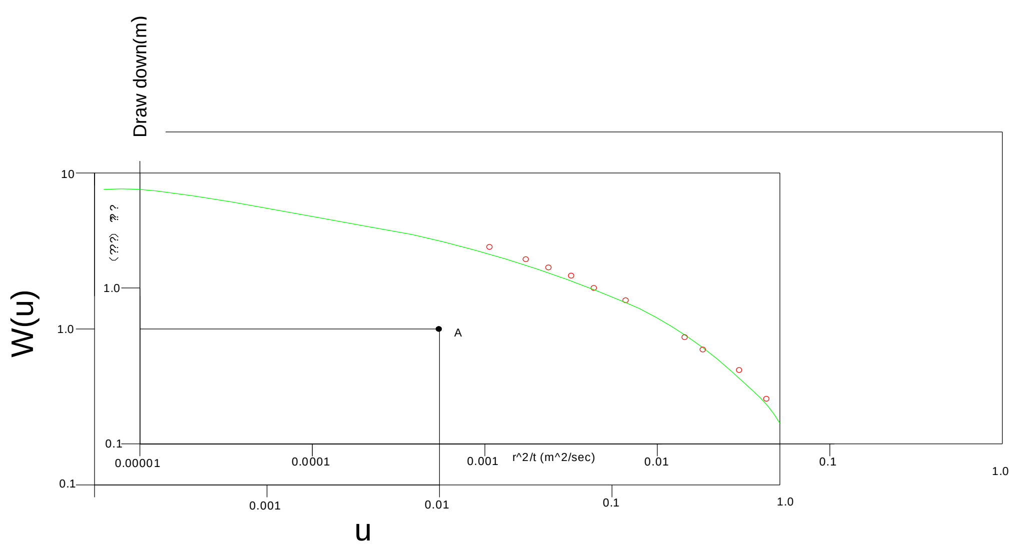
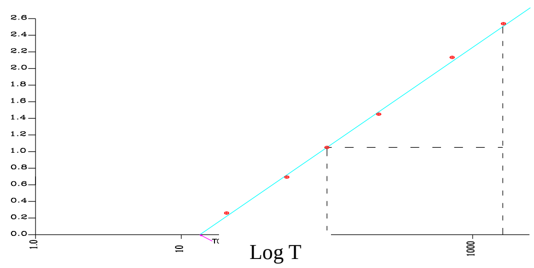


Fig 5 . overlaying the pumpage curve to type curve

Measurement of S and T with drawdown versus time logarithm

In this method the value of time logarithm draw versus the drawdown and the slope of produced line that named "m" measured. Then the transmissivity calculate as follow.

$m=0.35$ $T=0.012*2.3/(12.56*0.35)=0.006m^2/sec$



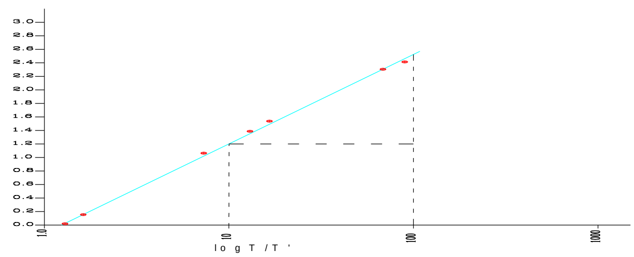


Fig 6. drawdown versus time logarithm chart. **Fig 7.** drawdown versus time ratio logarithm chart

Furthermore we can determine the intersection between produced lines with time logarithm axis that named "t_0". Then the storage coefficient calculate as follow (Raghunath, H.M. 1987)

$r=1m$ $t_0=22$ $S=2.25*T*t_0/r^2 \rightarrow S=2.25*0.006*22/1=0.29 \rightarrow S=0.29$

Estimation of storage volume in Radar underground dam reservoir

The gradient of river bed is 1.8 percent; elevation of curtain (membrane) of water shut is 8 meter and means weight of river bed is 190 meter. The **recess** (repercussion) of water **in** alluvium reservoir is about 410 meters and the mean value of storage coefficient is about 0.25, therefore the storage volume calculates as follow. → Storage volume=$410*0.25*190*4.0=77900m^3$

Geophysics

Geophysics sanding has performed in four run to identify the best section for construction of subsurface dam. The third section has best condition and altogether 35 electrical sounding done around this section with Ab=100 .after comment (paraphrase) of data the geoelectical profile drown and confirmed (ratification) by comparison of electrical sounding with the profile of borehole that excavated by hand.

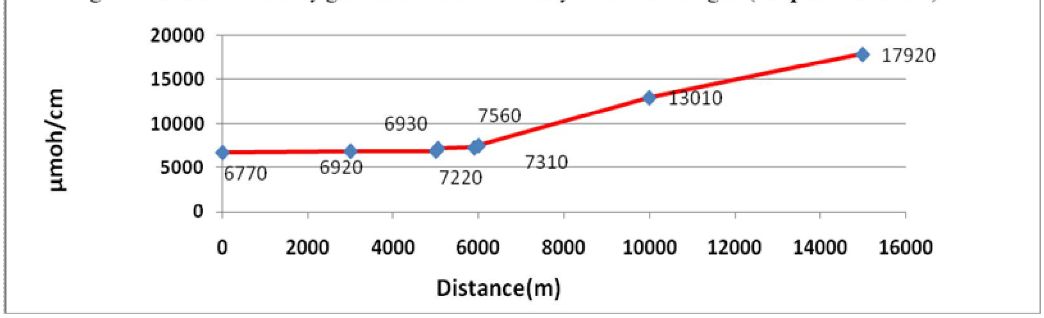


fig 8 schema of salinity gradient from Ravar city to desert margin (in space of 15 km)

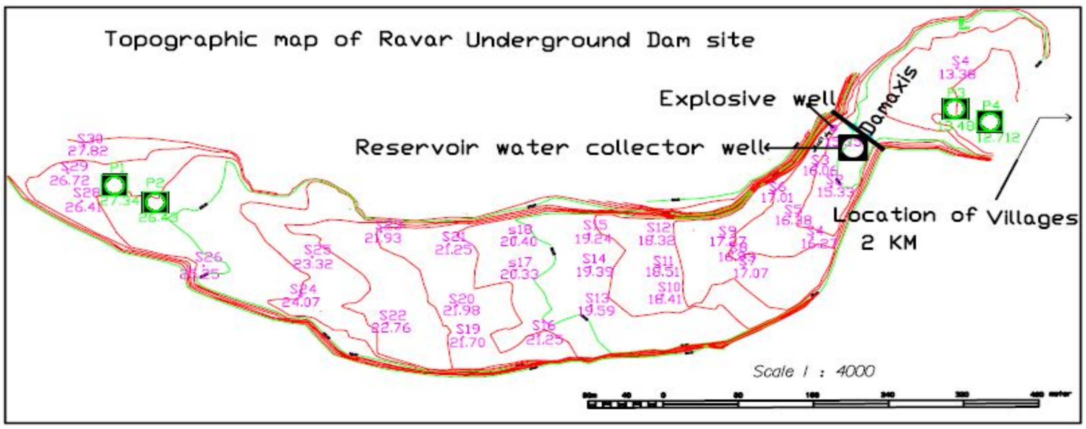


Fig 9 Fig 3 shows the situation of dam axis, piezometers (P_1, P2, P3, and P4), dam's reservoir water collecting well and geoelecterical sounding.

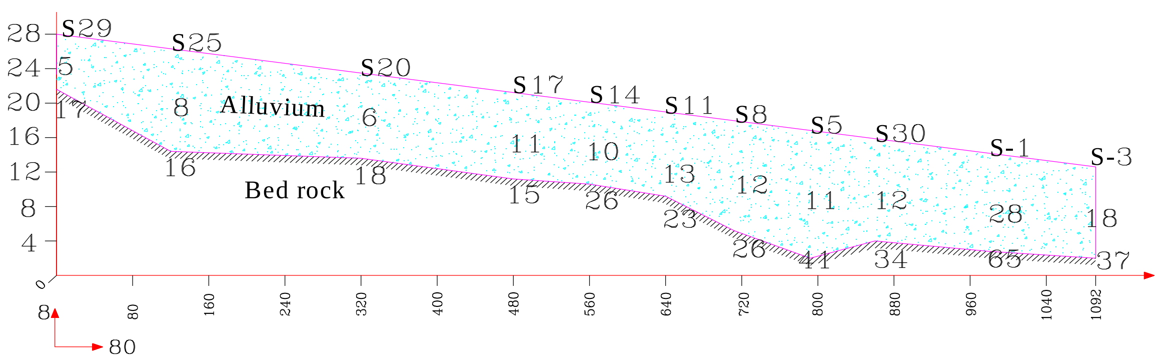


Fig 10. An instance of geoelecterical sections

Scrutiny of water quality

To obtain the trend of salinity in space of Radar city to desert margine, we get 8 sample of Water (3 samples from surface and 5 sample of subsurface water) and test them in the laboratory. The result shows that the salinity gradient is very violent (intensive), such that the salinity at border of desert is three times related to Radar city (in distance of about 15 kilometer).

Geotechnical scrutinizes

It is essential that a dam should be constricted in strongest available strata free from fissure (Gupta, et, al, 1987). Therefore to identify the geotechnical specification of alluviume, determination of bed rock depth, investigation of material quality that needed for dam construction and calibrating the electrical sounding 7 borehole (3 borehole by hand and 4 by excavator machine) excavated in river bed. To identify the geotechnical specification of alluviume ,determination of bed rock depth , investigation of material quality than needed for dam construction and calibrating the electrical sounding 7 borehole (3 borehole by hand and 4 by excavator machine) excavated in river bed. We have done the pumping test in one of the borehole that excavated by hand for determination of hydrodynamics coefficient(S, T) in alluviume. Distinguish the depth of bed rock and thickness of alluvium four borehole drilled by excavator machine. Furthermore we done the field and laboratory test for obtained hydraulic conductivity (leoferan method in alluvium and leogeon in bed rock), SPT and RQD.

Geotechnical scrutinizes to confirmation material construction

Because of the use of local and disposal materials cause thrift in cost (expenditure) and time therefore field inspection and sampling from the nearest fine material done. Then the samples tested for distinguish the grain size, Waterberg’s limit, hydraulic conductivity (constant and falling head) and chemical quality. The result show that the fine material in vicinity of site were suitable for construction of shut water membrane.

Design of Radar underground dam:

Design of Radar underground dam is unique (individual) such that water collector system completely developed and the quick drainage get easy to obtain to collector well. The Transmission system of water is gravitational and is very commodious. In this system the water that has been stored in dam reservoir after entrance to collector well, transmit by a double tube to the farm. At the end of tube has installed a valve to control and store the water while there is no need to use it.

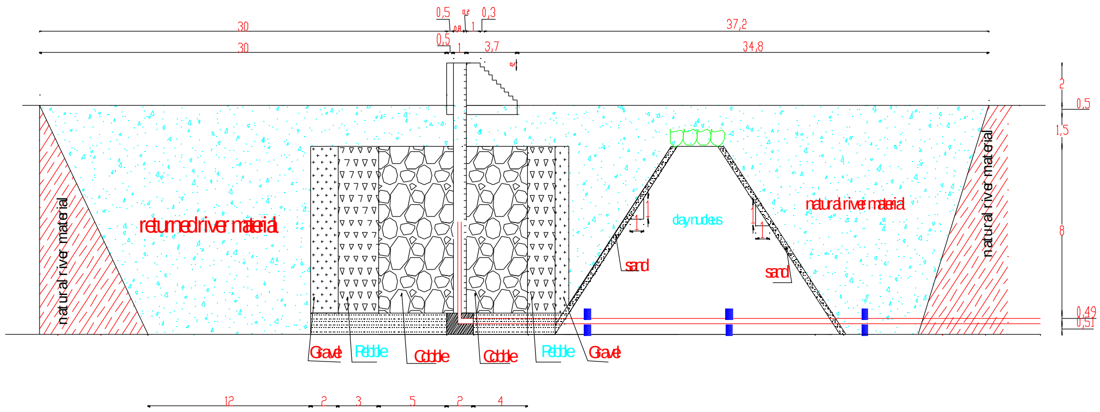


Fig 11. executive section of Radar underground dam implementation.

Conclusion

The result of geoelectrical sounding and borehole drilling shows that maximum depth of alluvium in confine of axis dam is 15m and there are the feasibility of implementation for underground dam construction. The bed rock sloped in limited of reservoir and dam axis followed by topographic gradient. The result of drilling shows that the lithology of bed rock and two side of valley formed of water shut shale and marls. The volume of water can be stored in dam reservoir is about 77900m^3. The result shows that the salinity gradient is very violent (intensive) such that in distance of Ravar city to margin of desert **(**in distance of about 15 km) value of salinity has been three times. Monitoring result shows that the Kerman (Ravar) subsurface dam has constructed very successfully and the amount of water escaping from bed rock and two side of dam is in admissible rang. Study of groundwater and the geomorphologic condition shows that the volume of dam reservoir is suitable for storage of adequate water. Situation of beneficiary villages relation to dam axis cause the transmission system execute in gravitational form. The trend of salinity shows that if the subsurface water not to control in location of Ravar underground dam it entrance to desert and become saline (briny) and useless. The final goal of this research is decreasing of affect of low precipitation in Ravar in Kerman because living organisms that require water to survive often die out. Once this happens the land then becomes barren and uninhabitable. Although in other cases the animal and plant life of the drought affected area may grow to evolve more with their dry environment. They might begin to store more water in their bodies, or be able to conserve how much water is regulated throughout their body as well.

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Table 1: Characteristic of ravar area

Water source	Total area	Land area	Highest temperature	Lowest temperature	Mean precipitation	Sea level
126	4148 m^2	30 hectare	40^0C	-14^0C	100 mm	1170m

Table 2. physiographic information of Ravar underground dam watershed

length of river (m)	mean weighted elevatio	width of equal rectangle (m)	length of equal rectangle	Area (m^2)	Perimeter(m)	form coefficient	lowest elevation (m)	highest elevation (m)	Time concentration (hr)	Drainage compaction (km^2)	Mean weighted river slope	length of basin (km)
446.8	1835.7	27.15	63.4	1720.	181.0	0.465	600	2800	6.53	0.26	3.18	60.8

Table 3. time-drawdown data for calculation of hydrodynamic coefficient

Number	time (sec)	Drawdown(m)	Number	time (m)	drawdown(m)
1	0	0	13	264.6	1.2
2	7	0.1	14	303.6	1.3
3	20.6	0.2	15	317.4	1.4
4	35.4	0.3	16	330	1.5
5	49.8	0.4	17	369.6	1.6
6	68.7	0.5	18	388.2	1.7
7	92.3	0.6	19	433.8	1.8
8	16.4	0.7	20	486	1.9
9	147.6	0.8	21	542.2	2.0
10	186.6	0.9	22	607.2	2.1
11	198.6	1.0	23	733.8	2.2
12	249.6	1.1	24	858.6	2.3

Table 4. time-residual drawdown data for calculation of hydrodynamic coefficient(recovery test)							
Number	t	t/t' (sec)	residual drawdown	Number	t	t/t' (sec)	residual drawdown (m)
1	0	0	2.4	14	122	7.5	1.1
2	9	101.9	2.3	15	131	7.0	1.0
3	15	61.12	2.2	16		6.4	0.9
4	23	39.8	2.1	17	182	5.02	0.8
5	29	31.6	2.0	18	211	4.35	0.7
6	34	27	1.9	19	278	3.7	0.6
7	44	20.8	1.8	20	270	3.4	0.5
8	53	17.3	1.7	21	321	2.85	0.4
9	62	14.7	1.6	22	366.6	2.5	0.3
10	68	13.4	1.5	23	393.6	2.32	0.2
11	74	12.4	1.4	24	453.6	2.02	0.1
12	81	11.3	1.3	25	539	1.7	0.08
13	90	10.25	1.2	26	632	1.45	.07
27	849	1.08	0.05	28	1055.	0.86	0.02