

Assessment of suitable Location for Construction of groundwater dams

Leila Sharifi¹, Mohamad Karami²

¹ Department of Civil Engineering, Abadan Branch, Islamic Azad University, Abadan, Iran

² Department of Civil Engineering, Dehloran Branch, Islamic Azad University, Dehloran, Iran

* Corresponding author. Leila Sharifi

Abstract: Crisis of maintaining, supplying and optimal operating and conservation of natural water resources is one of the largest hydrological problems in the country. In fact groundwater is part of surface water that either reaches to the surface naturally through springs or is extracted from groundwater tables (aquifers) by well, infiltration gallery etc. These waters are one of important sources of supplying drinking water and agriculture water that does not need treatment. Scientific and practical designing and planning for obtaining and feeding groundwater network can prevent destruction of these sources and stabilize them without causing any environmental damages. Our country, as one of regions with low water level and nearly hot and dry climate, needs protection of groundwater resources and construction of groundwater dams, including infiltration galleries, traditional aquifers and flumes, can help optimal operation of water, protection of groundwater and prevention of draught in agriculture sector.

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Introduction

In many areas of our country, intensive changes occur in surface waters and winter seethe of water of rivers and streams decreases in summer and seasonal and permanent streams become dry paths, which causes intensive low water and economic and social problems. Considering weather fluctuations and climatic changes in some seasons of year in various areas, using watershed projects, water resource management and optimal operation of these natural sources by applied approaches is evaluated. An important step for solving problems of hot and dry climates is construction of groundwater dams in suitable points. Therefore, given the situation of groundwater tables, an appropriate method for obtaining stable productivity and development of agriculture is reclamation and regeneration of natural resources in the mentioned points.

In dry and hot areas, groundwater always has great importance due to low precipitation levels and its resultant run-off and high level of evaporation in these points.

From past till now, due to low water problems in arid areas, man has considered extraction of water from underground layers and has directed water to farmlands for drinking and agricultural purposes using well, infiltration gallery and modern method of groundwater dam construction.

In arid and semi-arid areas with considerable potential for development of agriculture, increasing production, reforestation and reclamation of pastures, water is the most important for this development and in some seasons, floods cause much damage and destruction. Therefore, one of the most essential aims

of this study is to examine groundwater dams, suitable place for them and their importance in agriculture, drinking water and development.

Groundwater Dam Definition

Groundwater dams are hydraulic structures that block natural flow of groundwater and store water underground. Groundwater dam is structurally different from normal dams and its height does not exceed river level. An underground reservoir is created by excavation of river bed and filling it with impermeable material and soils and creating impermeable layers against flow.

History of Groundwater Dams in Iran and World

History of using groundwater dams in Iran and all over the world dates back to old civilizations. For example, groundwater dams in Sardina Island were constructed in Roman era. In 1983, groundwater dams were constructed in bed of Boelivi River in small scale to prevent draught (World Water, 1984).

In China, using groundwater dams along with other grand plans of water supply for stable development of rural areas in various scales and compatible with environmental conditions of each area was performed successfully. In Safavieh era in Iran, in order to increase water of mother well Kanat Vozoran in Meime, Isfahan, water of other kanats were deviated to it. But, now groundwater dams are used in most points of the world due to their benefits compared to surface dams.

Groundwater Dams Implemented in Iran

In Iran, where precipitations average does not exceed 240 to 250 mm, groundwater reservoirs are limited and rainfall distribution is unequal at country level. History of groundwater dams construction in Iran dates back to 1370 which was performed in Kahnooj, Kermaan, by Jihad-e-Sazandegi Ministry in order to supply urban drinking water. This dam, which was constructed at 4% slope with clay core and 40 m width and 12 m height, had 1000 m³ storage volume. Other works done include:

Koohrez, Damghaan, which was constructed in two phases: 1) from bottom to height of 4 m in form of brick wall with tar cover, and 2) other parts of wall to the ground level with compact clay.

Toye-Davar groundwater dam, which is constructed with stone and mortar to 5 meters depth and rest of it is made of concrete. For protection of isogam layer, a 20 cm brick wall was built and gravel material was used inside dam reservoir.

Dams currently under construction include dams in Makoo, Azabayejan-e- Gharbe and Kharanegh in yazd. One of the odests dams of world is constructed in Meime Isfahan and near Kashan. This groundwater dam is 9 meters high and able to store nearly 270,000 m³ water for usage in irrigation and draught periods. There are some other dams under construction in the country now including groundwater dam Kharanegh in Ardakan, Yazd. Several groundwater dams have been operated recently. In other countries, including Thailand, Tanzania, China, Japan and Brazil, there are some constructed dams which are mentioned below.

Purpose of Groundwater Dam Design

Intensive reduction of water level in some points has caused water level to reduce over 100 meters. One goal of groundwater dams is to collect groundwater and prevent it from being wasted and being mixed with saline water, and this way, level of groundwater can be elevated again which is performed in four areas:

Drinking water supply

- 1- Water resources management (such as blocking some springs or infiltration galleries and directing their water toward main spring or mother well)
- 2- Preventing saline water from extending into groundwater, such as coasts and salt plains
- 3- Environmental such as diffusion of pollution or nuclear radiations and their adverse effects on groundwater

Groundwater dams have some benefits compared to surface dams, including:

- Much lower construction cost
- Dam is nearer to consumption point
- Prevention of water reduction due to surface evaporation
- Water of groundwater dams is cleaner due to disinfection of microbes and viruses that usually exist in waters behind dams.
- Distribution of surface water by channels is more expensive.
- Construction technology is much simpler.

Design of Groundwater Dams

Suitable Location

First step in construction of groundwater dams is locating. Since groundwater dams can't be constructed in every place, the best location must be considered for construction according to characteristics and climate of the region. In order to locate suitable areas for construction of groundwater dams in the desired area, decision making support system has been used. This support system has been used in three phases. In the first phase, unsuitable areas for dam construction are identified using elimination measures and suitable site for construction of groundwater dams is determined. In the second step of decision making in each site, the most suitable canyon for groundwater dam construction is specified. In the third step, axes identified in the second step are compared to each other using hierarchical analysis method and by considering evaluation measures. Finally, the most suitable axes are identified for closer evaluations.

Groundwater dams is many arid and semi-arid areas of the world have been paid attention in recent years for development of groundwater resources and prevention of water waste. Design implementation method is similar to sealing system of surface dams' foundations. The most important parameters in determination of water height on groundwater dams are discharge, dam height, initial hydrostatic level, hydraulic conductivity coefficient of aquifer, dam thickness and slope of aquifer bottom.

The location should have following climatic conditions:

It should have arid or semi-arid climate.

Rainfall should be low or irregular or occur in seasons when it is not needed.

Since groundwater dams should have more storage volume and less leakage by least cost, they are usually constructed with 3 to 4 meters height in a location where ground slope is less than 5%. This characteristic is seen in uniform and narrow rivers or valleys.

In some cases, suitable natural conditions act like a groundwater dam and blocking effect of natural

barriers (such as protrusion of bed impervious layer) can play a significant role in locating and saving costs.

In addition to the above topographic conditions, ground should have the following characteristics too:

- Impervious bed with low distance from surface
- Highly porous ground layers with sufficient thickness for storage of more water.
- In tables with fine grained material, there is usually enough water inside soil void space but possibility of its operation is limited due to the risk of discharge reduction.
- Least distance to consumption area
- The stored water will not be polluted due to human activities.
- Salt level of soil and annual precipitation should be examined. Presence of salt layers causes stored waters to become saline. Although recent researches in Adelaide, Australia, have shown that slow flow of fresh water limits its mixing with saline groundwater, evaluation of annual precipitation is important for maintain sufficient flow and preventing dam from being endangered.

Dam Construction

First step in dam construction is digging a ditch perpendicular to drain path or river bed, which is performed by human force due to low depth of implementation operation. In dry sand alluviums with low cohesion and sand areas, trenches walls can collapse due to instability of slopes, which makes digging problematic. Nevertheless, sand alluviums are suitable sites for dam construction because groundwater level is seen in them easily and they keep water level low by pumping. Time of groundwater dam construction is usually at the end of dry season when groundwater level is low and implementation operation is done easily. Materials used in dam construction are determined according to three parameters: 1) borrow material in area, 2) consumed costs, and 3) ease of performing work. However, various building materials are used in dam construction and only sealing dam walls is needed.

Types of Dams in Terms of Construction and Placement on the Ground

1 – Natural

Impervious layers, as mentioned before, consist of stone or clay and water movement is slowed or stops in contact with them. These layers, like earth surface, have low and high points that result from fault motion, volcanoes, crustal motions etc. When groundwater encounters a high impervious layer during moving on earth slope, it stops moving and

accumulates behind the impervious layer that acts as a groundwater dam.

2 – Artificial

These are man-made dams which are divided into two groups buried and semi-buried: a) buried: 1) near ground surface, 2) deep in earth.

Types of Dams in terms of Material:

In the following, two types of material used in dam construction are mentioned:

Compact clay:

Using clay is a common method that does not need skilful human force. Clay is placed in low thickness layers and then is compressed. Because of groundwater flow, there is a possibility of clay surface corrosion. Therefore, plastic plates are used for protection of walls. Trench filling operation is performed by compressive tools and with suitable humidity. If groundwater storage reduces in dry season, crack can develop in dam. Thus, by constructing wall with suitable thickness in order to keep moisture in core area, this can be prevented even in long dry periods.

Plastic or bituminized plates:

In this method, a plastic core is used for sealing whose plastic type is usually poly ethylene and in terms of material costs, is the lowest cost method. In using this method, it should be considered that materials such as mud must be used for covering two sides of the plate to prevent holes formed by sharp stones. Also, for protection against effects of contraction and expansion, temperature changes should be evaluated. If a hole is created in the plate, it can be patched with another plastic plate by a suitable cohesive material.

Water Extraction

Water extraction operation is performed by two methods: gravitational and well drilling. If operation point of people is downstream of dam and topographic conditions are present, water can be extracted from reservoirs gravitationally. In this method, water is extracted through a pipe which is on dam body and directs water gravitation force to downstream. The well which extracts water from groundwater dams is inside the reservoir and is drilled near rivers in order to prevent it from being degraded by floods (operation by well).

Conclusions

Groundwater dams can be a cost effective method for using groundwater due to their low cost, easy construction method, clean water storage and

many other benefits they have compared to surface dams and due to arid and semi-arid climate of Iran. Groundwater dam is constructed preferentially on an impervious layer to create larger volume of water. Groundwater dams can also be constructed on rivers without impervious layers, but they may store less water. Therefore, suitable locations for construction of groundwater dams are determined by interpretation of natural processes of region such as alluvial fans, valley of narrow seasonal rivers and lands with less than 8% slope.

It is expected that construction of groundwater dams will be paid more attention in our country.

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