

Geotechnical Investigation of Sinkhole Occurrence in Kabudrahang Plain, Hamedan Province, Iran

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Abstract

Water resource management faces with a lot of problems in arid and semi-arid area because of water crisis and lots of problems in finding water and extracting it, traditional irrigation, climate change and recently droughts. Moreover, irrational extraction of underground water resource causes any irrecoverable damages to environment and these resources. Sinkholes could be classified as irreparable and irrecoverable disaster. For example, in order to unallowable water extraction from underground resources in Famenin and Kabudrahang plains in Hamedan province, underground water level decreases about 2.5 to 3 meters annually. Mean thickness of alluvial deposits in mentioned plains are 70 to 100 meters. Mentioned decrease in underground water level and also reservoir shortage causes sinkholes and land subsidence in those plains that the number of sinkholes is 35 and the magnitude of land subsidence is about 35 centimeters in recently two decades. In the aim of managements and making applied decisions to eliminate the occurrence of this phenomenon, correct knowledge of its occurrence mechanism and creating a local data base of sinkholes could be beneficial. In this research, geotechnical mechanism of sinkhole occurrences, in Kabudrahang plain has been encountered and finally any conclusions have been presented.

Keywords: Sinkhole; Geotechnical Investigation; Underground water table;

1-Introduction

According to UNICCO definition, subsidence is downfall or land settlement, which has occurred in different dimensions and different reasons. Usually this phenomenon could be described by perpendicular motion of land surface that has small horizontal vector. This definition doesn't contain any settlement or slip slop observations, such as landslide, because these movements are almost horizontally and also in disturbed soils, occurrence mechanism could change and be in a different manner. In general, land subsidence and sinkholes should be considered in two different categories. The first one, which belongs to general settlement of plains, could be called "land subsidence". Mentioned phenomenon has been accessed in some plains such as Kerman, Rafsanjan, Abarghoo, Yazd and Ardakan plain. Second section is related to subsidence in limited and depth zones that are sinkholes or Dolin and occurred in the regions under study. Dimensions and depth of sinkholes are different, and from the most important types of those are Kabudrahang, Famenin, Hamekasi sinkholes and other small types are Maharloo plain sinkholes in Fars province.[1]

Several factors are effective to create this phenomenon out of which solution, ice-melting, sedimentary concentration, plan slow motion and magma eruption, or human operations such

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as mining or groundwater and oil consumption can be referred. Pay attending to geological situation and already done geophysical studies in the area under investigation indicating the existence of alluvium on top of carbonate bedrock and with respect to it, it can certainly be a referent as the origin of karstic. An example of sinkholes seen in the area of kabudrahang plain has been presented in figure (1)



Figure left: An example of sinkholes seen in the area of kabudrahang plain, [right]: the largest sinkhole in our country

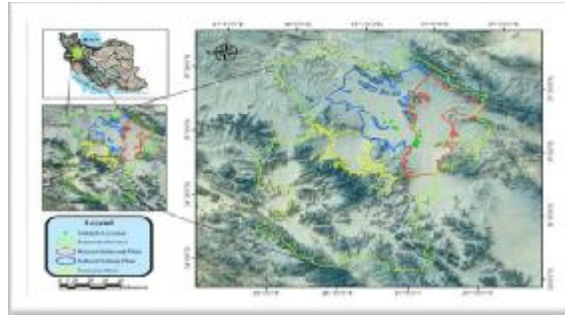
Figure (2) is related to the largest sinkhole in our country near to villages Baban and Ghozlije 5 kilometers to kabudrahang city. These sinkholes have occurred and we tried to portray them. Today in most of Iran plains, sinkholes can be seen. The plains of Tehran, Isfahan, Hamedan, Kerman, are with the largest number of sinkholes.

2-Methodology

Through the comprehensive investigation which was done during the study, and based on the information gathered at the field study stage, the exact location of sinkhole was determined and also, a map of the sinkholes was drawn having compared with the map of faults of area, It was seen that the process the sinkholes are in accordance with the young faults. In addition, by investigating the available reports of geophysical and geotechnical studies and comparing them with the nearby wells log, and geological reports of the area, the exact mechanism of sinkholes was determined. And then, having introduced the scope of study, and the sinkhole situation, first an introduction of karstic sinkholes and the study of their formation in this the area, and also the understanding of geotechnical structure around the sinkhole, some related factors will be represented. Finally the results of the present study will be discussed.

3-The Geographic situation of the study

As it has been shown in map 1, the area of the study included in Hamedan province which its situation is between $48^{\circ} 30' 00''$ and $49^{\circ} 30' 00''$ eastern hemispheroid, and $34^{\circ} 45' 00''$ and $35^{\circ} 30' 00''$ northern hemispheroid. The study area and Razan-Ghahavand area in Hamedan province possesses the largest number of sinkholes in the province.



Map 1 : The area of the study and situation of sinkholes

4- An introduction to karstic sinkhole and the study area of their formation process in the area of study.

4-1- Karstic sinkholes

Karstic sinkholes can be categorized into three main classes (solution, subsidence, and collapse). The collapsible sinkholes especially the cap ones are the most problematic and causing financial damages and casualty. These sinkholes are formed only in an area having adhesive soil on the top of karstic carbonate. It is important to mention that in this formation there must be several channels in the depth of karstic formations which can transfer water. This condition leads to increase the speed of water vertically and horizontal as a result, the transferred sediment of the cavities is created on the border between soil and carbonate. And by the cavity getting larger, the cavity ceiling strength decreases, and consequently it collapses suddenly. Human being by these activities specially by dropping the level of aquifer or by concentrating runoff causes the collapsible cap sinkhole to happen faster. By geological and karstic hydrogeologic studies, one can identify areas with the possibility of sinkholes by paying attention to the vast area of the karstic formation in the Zagros mountain range; the number of dangerous sinkholes is low in Iran due to the geological features of the Zagros.[3]

4-2- The study of the formation process of sinkholes in the area

In the manifestation of karsts in the studied area has provided the right condition to create the main reason for creating sinkholes in the sediment of alluvium of upper surface during hundreds or thousands of years. The collapse of the ceiling the karsts activities cavities in the mass of carbonate bedrock which is mainly created by the solution erosion during the process, makes the parts separate and creates many cavities that these points of creating sinkhole and finally the movement and transfer of the alluvium covering materials to the deeper areas and their washing-away by the lateral currants happen. Generally, the development of cavities in the alluvium and the soil transfer into those cavities in the bedrock happens in two ways of vertical and lateral. The effective factors in vertical transfer are: the adhesiveness persistence, wetness, the size of forming materials, and finally the size of cavities and cracks in the bedrock. The effective factors in lateral are as follows: the speed of water in the horizontal channels of the bedrock and the size of the collapsible materials of the model of process of buried sinkhole formation. These factors show the mechanism of sinkhole formation in two ways: the homogeneous and non-homogeneous alluvium mass.[2]

5-The understanding of geotechnical formation of earth around the sinkhole

By drilling an exploration well About 4 inches to 115 meters through rotary technique with the random sampling without using drilling mud in 15 meters distance to the edge of Jahan abad sinkhole in formation plain, the geotechnical conditions of the area was investigated. The kind of subsurface soil up to 93 meters down includes the diversity of fine grains which have passive such as silty clay (CL) and clay silt (ML) and also silty clay sand layers (SC/SM), they are according to unified ranking. The silty clays usually have average plasticity and also their common liquid limit is between %31.2 and %47.2. The bed rock at 93 meters down includes calcareous Breccias with tiny cavities which are 109 to 119 meters with relatively large cavities. The level of groundwater at 109.5 meter down indicates the mass of alluvium of unsaturated covering with blow-up of sand materials (collapse of piling of materials from deep horizon of cavities in the bedrock).[4]

6-Conclusions

Based on investigations, measurements and field studies, it can be shown that:

6-1- solution cavities, water channels, faults and cracks system in milestone bedrock and irregular water pumping that has in those is the major factor for sinkhole occurrence in the area. It is important to mention that any factors such as sand washing-away, wells gas out and very speed decrease groundwater table affect in speed up sinkhole occurrence

6-2-it can be mentioned that the major factor of carbonate solution is carbon dioxide with hydrothermal, penomality and atmospheric origin that solution in groundwater, that dioxide with atmospheric region approaches mero-karst and carbon dioxide with internal region approaches holo-karst

6-3- Paying attention to done studies about Hamedan sinkholes it was ignored the importance and majority factor and has been the claim that there aren't effective faults in sinkhole occurrence and just very high harvesting of ground water and sinkholes dispersal aren't in accordance with special trend. But paying attention to studies, the sinkholes situation is systematic and the major factor is three groups that occur in tertiary. These faults has been oligomiusen carbonate karstification that it is the preliminary and importance factor of sinkhole occur or generally can have been this claim that sinkholes dispersal in accordance with faults trend. The achievement of the integration map of subsidence sinkhole scattered plains Hamedan obtained tectonic Sitemap_So that the dispersion around sinkhole in existing faults are plain.

6-4-One important factor in expediting the creation of natural phenomena and the Earth Summit created sinkhole groundwater table change and eventually disassemble stable balance between vertical stress and inhibitory forces in the crust of soil mass is, The famenin and Kabudrahang plains also provided the model surface of a reduction in groundwater level during the past two decades with the increased utilization is and Effect of soil covering the rock bed column in expediting the process of creating this phenomenon can be identified as follows:

6.4.1- Loss Buoyant Support in the ceiling cavities in the bedrock mass that already have water storage and eventually created tension changes in soil mass

6.4.2- Vertical speed flow of underground water level depth in alluvial mass due to increased hydraulic gradient along the vertical pressure change due to piesometric

6.4.3- Increasing range of water level eventually changes the water level of underground bedrock surface and drainage through to complete the mass to the upper alluvial

6.4.4- Phenomenon created to make feeding easier to create vertical and establishing vertical flow surface to a depth of penetration to achieve seamless system and gaps and cavities in the rock mass bed

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