15 Aug 2008, 11:00am - 12:30pm

Land Subsidence in Tehran District, Iran

Said Ghorbanbeigi
Power & Water University of Technology (PWUT),Tehran, Iran

Jafar Naji Hamodi
Power & Water University of Technology (PWUT), Tehran, Iran

6th International Conference on
Case Histories in Geotechnical Engineering, Arlington, VA, August 11-16, 2008

LAND SUBSIDENCE IN TEHRAN DISTRICT, IRAN

Said Ghorbanbeigi
Power & Water University of Technology (PWUT)
Tehran, IRAN 16765-1719

Jafar Naji hamodi
Power & Water University of Technology (PWUT)
Tehran, IRAN 16765-1719

ABSTRACT

Land subsidence is a worldwide phenomenon, where there is a sudden sinking or gradual downward settling of the earth's surface with little or no horizontal motion. In Iran, this phenomenon is noticed to take place in many areas among which are Meshhed, Kerman, Tehran, Hamedan and others. In some of the above areas, water well installations seem to rise into the air, or some times to produce fissures in the soil and/or showing sinkhole in carbonated rocks. Land subsidence could causes damages in surface and subsurface installations. UNISCO was concerning with this worldwide phenomenon and tried to study it in different parts of the world through groups of work by using GPS, SAR and InSAR techniques that uses radar satellite image. The Iranian authorities in cooperation with others were interesting to see the extension and reasons for Tehran's land subsidence by using the new InSAR techniques, which assured later on the existence of 2 profiles (namely NE-SW profile 1 and N-S profile 3) in a V shape in SW Tehran with 15 cm and 16 cm Land subsidence respectively. The subsidence is mainly due to depletion of aquifer (i.e. water level drop), which causes aquifer compaction.

INTRODUCTION

Land subsidence is a worldwide phenomenon, where there is a sudden sinking or a gradual down ward settling of the earth's surface with little or no horizontal motion. This land subsidence dues to many factors among which is over pumping and declining in water table of ground water, compaction of unconsolidated or new sediments, tectonic movement (i.e. earthquake, plate movement and others).
IHP of UNISCO has reported land subsidence in the USA since 1990. Moreover, UNISCO started to study this phenomenon worldwide through a group of work in different parts of the world by using GPS, SAR and InSAR.
In Iran, this phenomenon is noticed to take place in Meshhed, Rafsinjan, Kerman, Hamadan (Kabodder Ahan Valley), Faminin and Tehran(Maain Abad and Waramin Valleys). Similar cases were also reported in Arak, Nahawand, Khumain, Kolbaigan, Natanz, Yazd and Aber Kuh. In some of the above areas water well casing seems to rise into the air or showing to be sticking out of the land surface (Fig. 1), or sometimes produces fissures in the soils and/ or showing as sinkhole in carbonated rocks that damage canals, water networks, gas pipelines, oil pipelines and dams.
Topography of the area is also changed that affected flood regime and water recharging into ground aquifers. This phenomenon becomes distinct physically and sometimes dramatically visible.
Different authorities in Iran were concerning about this phenomenon. Therefore, they seeked help (from Oxford and Cambridge Universities) to study and explore the reasons and extend of it in Tehran District by using InSAR and GIS tools.

Fig. 1: Water well installation seems to rise in the air due to land subsidence

.

TECTONIC OF THE AREA

Tehran-Waramin valleys are located on the south side of Elburz Mountains that are N of Iran extended from Korasan till Atherbaijan, which is a part of ALP-HAMALAIA active and young mountains.

Elburz Mountains were formed from a processes of faulting and mountains movements due to Arabic Plate movement (towards N of Iran) and collapsing with Eurasian Plate. Therefore, the layers in the area and their structures were not uniform (except in Eocene Era), where Hezar Derahe formations were formed in Tehran-Karaj area.
Hezar Derahe formations are divided into Hezar Derahe alluvial (sediment A), inhomogeneous alluvial sediment of N Tehran (Bn), where it is silt in Kehrizig sediment (Bs) and in Tehran alluvial (sediment C).

LAND SUBSIDENCE IN IRAN AND OTHER COUNTRIES

Moreover, land subsidence was reported in other countries, some of which is shown in table 1.

Table 1:Land Subsidence in Iran and Other Countries

No	Period year	Place	Depth of subsidence, mm	Using water purposes
1	1 971- 1 981	Zarand,Iran	8 000	Agriculture
2	1 971- 1 981	Rafsanjan ,Iran	7 500	Agriculture
3	1 971- 1 981	Kashoyiah,Iran	7 000	Agriculture
4	1 971- 1 981	Kerman area,Iran	6 500	Agriculture
5	1 971- 1 981	Sierjan,Iran	6 000	Agriculture
6	1 930-1 973	Venz-Italy	150	Drinking+Industry
7	1 865-1 931	London,England	180	Drinking+Industry
8	-	Tiaba	1 000	Drinking+Industry
9	1 928-1 943	Tokoyo-Ozako	3 000- 4 000	Drinking+Industry
10	-	Huston-Bay Town	2 700	Drinking+Industry
11	1 938-1 969	Mexico City	8 000	Drinking+Industry
12	1 947-1 948	Arizon-USA	2 300	Irrigation
13	-	California-Santa-Clara	4 000	Irrigation
14	-	California-Sanjwan	8 500	Irrigation
15	-	New Zealand-Wayrocki	4 000	Hot Spring
16	-	Willington	+ 9 000	Hot Spring

From above table, it is shown that the people of the world were aware of the soil subsidence phenomena about a century ago. Anyhow, it can be seen how serious this phenomena can be where there was up to 9 meter soil sinking. It can be also imagine the possibility of damages that can be exited to all installations over the surface like, buildings, dams, pipelines, canals, roads, railroads and likewise to the underground buildings and installations.

VALLEYS AND WATER RESOURCES

Valleys

The valleys under consideration are Tehran and Shehriar that are located between 35° 28’06”- 35°49’42” north Latitude and 51° 06’ 37”– 51° 33’ 13” east Longitude, the total area of which is about 8250 square kilometer, 350 square kilometer mountains (with a maximum height of 3 138 mssl at Tojal peak) and 1900 square kilometer are valleys. The average height of the valleys is 1 100 mssl. These valleys started from Elburz Mountains in the north and ended in Azad-Fisha Boyiah in the south. From east is Se Pajah, Bibi Shehrbano and from west is Karaj's aquifer.

Valleys’ Conditions

The two valleys have the following conditions:
-Average rainfalls is about 250 mm/y (less at south and more at north).
-Average relative humidity at Mehraabad airport is about 40 percent.
-Average annual temperature variations is from 10 °C in the mountains up to 17°C at Mehraabad airport.
-The average evaporation from the valleys is about 2 500 mm per year (more at south and less at north).
-The wind flows normally from west with an average of 20 kilometer per hour in winter and from SE in summer.

Water resources

Surface water

There are 7 seasonal rivers and only 2 permanent rivers, namely Khan and Karaj, from which the required water is maintained for the valleys. In the past years, part of Tehran’s water is maintained from ground water from 522 canals , with a total water production of 393 MCM . Drilling a big number of wells in the two valleys caused most of the canals to go dry once ground water level went down.

Ground water

Aquifers

There are actually 3 alluvial aquifers in Tehran - Shehrair valleys.

Aquifers description

The aquifers in Tehran-Shehriar valleys are divided into 3 aquifers namely:
-Northern aquifer: It is extended from Elburz Mountains down to Abasabad-Yusifabad of Sediment A with a little permeability, the water of which flows into the main aquifer.

-Main aquifer: It is extended from Louizan hills down to Bibi Sherbano, west (Shehrekahe Karb) and Karaj aquifer and eastward to Shehrekahe Hezar fault. The sediments of the aquifer are C and B (with an average thickness of 130 meter and decreasing towards S and E) with medium to high permeability. The aquifer layers inclined at 50 per 1 000 at N and NW while it is less than one per 1000 at middle of the aquifer. Water flows mostly from N to S (and NW to SE in the west part of the aquifer). Water recharge into aquifer consists of floods, permanent rivers, seasonal rivers, waste water and agriculture water. Transmissibility factor of the aquifer is variable between 50 m^2/d in NE, 2 000 m^2/d in W (Sherhriar valley) and 2 000 m^2/d at the middle of the aquifer. Moreover, the average storage factor varies from 1 to 3 percent (less at S and more at NE (15%).
-Perched aquifers: They consist of separated small aquifers in separated thin sediments of A and B.

Geology of the aquifers

Elburz Mountains are an old Paleocene-Eocene rock with a medium permeability that recharges the aquifers and surrender it from N. The aquifers sediments are made of above mentioned sediments (i. e. mainly quartz toward S with a high permeability) which came from weathering process of the mountains.

Geophysics of the aquifers

The geophysics of the area was carried by CGG of France by using about 300 electrical sondages (mostly with AB= 2 000 meter). Electrical resistivity of new sediments is 300 Ω -m and decreasing towards S, while the old sediments have a resistivity of 25 Ω -m. This study indicates that the aquifer thickness is mostly in N(400 meter) and NW(300 meter)(as a syncline basin) that changes to 25 meter in E , SE and SW due to uplift in basement rock.

Aquifer's water level changes

The average annual water level drop in the main aquifer is about 40 centimeter as computed from the unit hydrograph.

SATELLITE AND THEIR DATA

Data were obtained from satellite, where InSAR method, was used to study the area. InSAR stands for Interferometer Synthetic Aperture Radar. It is a remote sensing technique that uses radar satellite image. The radar satellite, among which Radar Sat, shoots constantly beams of radar waves towards the earth and record them after they bounced back off the Earth's surface.

Subsidence and location

By analyzing the satellite radar pictures by InSAR method, it was able to allocate land subsidence in SW Tehran and S Waramin valleys. Software (ROI-Pac) with digital height model help in allocating these subsidences. However, the accuracy of the analyzed data base was determined within 2 cm at different time periods of 2, 3, 4, 6, 12, and 18 months. From satellite color data and the analysis of land subsidence maps, land subsidence rates were determined at 70, 175, and 315 days, where there was no difference between the results.
InSAR satellite radar picture shows that there are two profiles (profile number one NE-SW and profile number three N-S) in V shape as in SW Tehran with 15 cm and 16 cm subsidence respectively (Fig. 2). The cross-section of the profiles are also given in the figure.

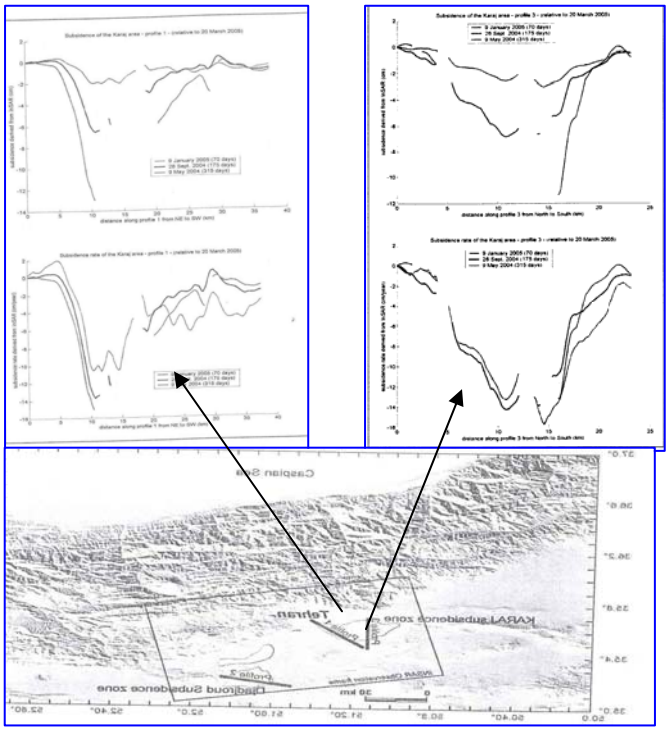

Fig 2: land subsidence and their cross- section in Tehran and Waramin Valleys

CONCLUSIONS

Following conclusions were drawn:
-InSAR data show that there is a land subsidence in southwest Tehran.
-This study shows that there is also another region in Shehriar valley(profile number two) showing land subsidence.
-The indicated area in Tehran-Waramin is V shape with an average continuous yearly subsidence of 15.5 cm.
-Land subsidence is mainly due to over production of ground water (depletion of aquifer and decreasing in aquifer water level that causes compaction of aquifer's grain.

SUGGESTIONS

Moreover, following suggestions are recommended:
-Controlling ground water production to minimize aquifer water level decreasing in order to minimize damages resulted from them.
-To prevent further land subsidence need to apply artificial water recharge into the aquifer as soon as possible.
-Applying water resources management technique to save guard the ground water aquifers and minimize damage to surface and subsurface installations.

REFERENCES

Barbarian,M., Koroishi,M., Archanek,R. [1985]. "Studying the effect of earthquake upon building structure in Tehran", National Geological Association (NGA), Report 56, Tehran, Iran.

Bidrami, M. [1978]. "Notes on quartz sedimentation around Tehran', NGA, and Tehran, Iran.

Darwishzadeh, A. [1991]. "Geology of Iran, Danish Imroz Publication", Tehran, Iran.

Najihamodi,J. [2007]. "Ground water overproduction and its geoenvironment effect in Kerman", PWUT, Tehran, Iran.

Tehran Water Association (TWA) [1968]. "Characteristics of deep and shallow water wells in Tehran", Tehran, Iran.

Ibid [1986]. "Report on pies meter wells in Tehran valleys and Khan", Tehran, Iran.

Ibid [1994]. "Report upon water balance and ground water resources of Tehran valley", Tehran, Iran.

Ibid [2001]. "Quantitative control: Tehran ground water and its effect upon overproduction", Tehran, Iran.

Ibid [1998]. "Studying and preparing quantitative and qualitative model for Tehran,Waramin and Shehriar aquifers", Mahabe Kodis co., Tehran, Iran.
Shamshaki, A. [2000]. "Hydrogeology and water balance of Waramin valley", MSc thesis, Shahid Behishti University, Tehran, Iran.

CONTACTS

Saeid Ghorbanbeigi
Jafar Najihamodi
Power Water University of Technology (PWUT)
Damawand Ave., Iranabzar Ave., Ab Ave.
Tehran, Iran
Tel: 0098 21 77313062
Fax: 0098 21 77006660
Email: s_ ghorbanbeigi@Yahoo.com
Email: s_ghorbanbeigi@ pwut.ac.ir
Email: Naji_237@ Yahoo.com
Email: naji@pwut.ac.ir
Website:www.pwut.ac.ir