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REVIEW OF ALL SUBSIDENCE IN THE EAST AND SOUTH CENTRAL UNITED STATES OF AMERICA

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Subsidence is a hazardous phenomenon that occurs like a gradual settling or sudden sinking of Earth's surface due to subsurface movements of underground materials. Subsidence is one of the biggest global problems. It has occurred for many times in the United States of America. It causes a lot of different damages. Sometimes, it is really difficult to make up the damages; But Sometimes It is not possible. So, subsidence and its implications are considered two important issues which must be known and studied before they accomplish. Considering the situation, subsidence can have different amounts of depth and width. A subsidence with big measurements indicates a bigger attention. This article is about all subsidence have occurred in the East and South Central United States of America. It is really necessary to study about different kinds of hazards and their effects on the world. In that case, the number of hazards will be decreased or they won't be accomplished anyway.

Keywords – Subsidence, the United States of America, damage, cause, measurement

Introduction

Land subsidence is a natural phenomenon which is like a gradual settling or sudden sinking of the earth's surface. Actually, if subsurface materials start moving, the earth's surface will be settled or sunk [USGS, 2017]. Mainly because of human effects, the causes of subsidence are depressuring of underground reservoirs, extraction of petroleum riverine damming [Thomas L. Holzer, 1988], loss of freshwater inflow and extensive land use changes [Mohammad E. Al Mukaimi et al, 2018]. But some of its reasons are completely common and natural, such as inundation or increased flooding (caused by loss of land elevation), withdrawal of fluids (groundwater, petroleum or geothermal) or resources [Thomas L. Holzer, 1988], anaerobic decomposition, wind erosion and shrinkage or dissolution of soil [Priyanka Sharma et al, 2016].

The main causes of land subsidence in California are mostly linked to groundwater withdrawal. Among the areas in this state, there are just a few regions meeting land subsidence due to any reasons but groundwater withdrawal. In this article, all subsidence of South Central United States of America, almost all of them (excluding California), have been introduced.

In the early 1900s, the first land subsidence, due to extraction of oil, water or gas, occurred and it has continued up to 20th century, due to groundwater pumpage. Houston area includes the patterns of this kind of subsidence [U.S. Geological Survey Circular 1182, 1999].

Subsidence is a global problem. In the United States of America, more than 17,000 square miles in 45 States have been directly influenced by subsidence [National Research Council, 1991]. Some of the main causes of land subsidence are visible in the tables.

Sometimes rich soils in organic carbon are drained for agriculture or other purposes. At this time, land subsidence may occur. There are many other factors that cause land subsidence, too. All of these factors have been mentioned in table 01 [Devin Galloway, 1999].

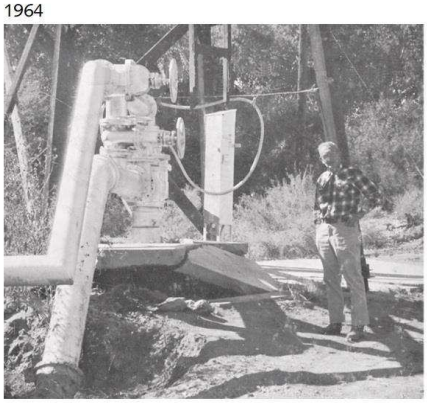

Fig. 1. A protruding well- west of downtown, Las Vegas (before subsiding, 1964)

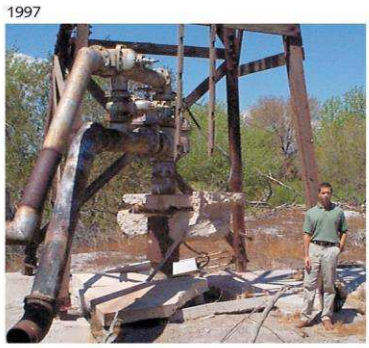

Fig. 2. A protruding well- west of downtown, Las Vegas (after subsiding, 1997)

In the tables below, subsidence all over the United States of America (excluding California) and some of their important features have been introduced; such as occurrence time, subsidence measurement (depth and width), their causes and damages.

Table 1

Subsidence in Texas and details

Location		Period	Measurement	Reason(s)	Damage(s)	Scholar/Author
Houston, Galveston	Near Addicks	1973-96	2.5 ft.	Decline of ground water pumping	Increase of frequency and severity of flooding	Kasmarek and others
Hueco Bolson	near downtown, El Paso	1953-81 1981-93	0.82 ft.	Drawdown of ground-water	-	Emery Balasz, National Geodetic Survey, written commun., 1994

Table 2

Subsidence in Virginia and details

Location		Period	Measurement	Reason(s)	Damage(s)	Scholar/Author
Chesapeake Bay	The Southern region	Since 1940s	Max: 1.02 ft.	Aquifer system compaction caused by groundwater withdrawals and glacial isotactic adjustment	Can increase flooding Alter wetland and coastal ecosystems Damage infrastructure and historical sites	Cahoon and others, 2009
Hampton	The roads	1940-71	0.28 ft.	Soil compaction High rate of relative sea level rise	More than half the relative sea level rise	Whitney Katchmark, Principal Water Resources Engineer Nov, 2014
		2006-11	0.061 ft.			
Franklin	The city	1979-96	0.078 ft.	Soil compaction		
Suffolk	The city	1982-96	0.164 ft.			

Table 3

Subsidence in Idaho and details

Location		Period	Measurement	Reason(s)	Damage(s)	Scholar/Author
Raft River valley	3.5 miles north of Malta	1934-74	2.5 ft.	Decline of water level, the trend of earth fissure	Fissures	Lofgren, 1975

Table 4

Subsidence in New Jersey and details

Location		Period	Measurement	Reason(s)	Damage(s)	Scholar/Author
Atlantic area	Southern New Jersey	1972-94	0.08 ft.	elastic consolidation of the aquifers	Prediction of land loss ad tidal flooding	H. Sun 7 D. Grandstaff 7 R.Shagam
Coastal area (Delaware bay)	Maine to South Carolina	during the last 4000 years	22 ft.	-	-	Belknap, 1975; Belknap and Kraft, 1977; Hall et al., 2013; Leorri et al., 2011
	Cape May		20.34 ft.	-	-	Kopp, 2013

Table 5

Subsidence in Pennsylvania and details

Location		Period	Measurement	Reason(s)	Damage(s)	Scholar/Author
Philadelphia	Border with New Jersey	during the last 4000 years	19.68 ft.	-	-	Kopp, 2013

Table 6

Subsidence in Arizona and details

Location		Period	Measurement	Reason(s)	Damage(s)	Scholar/Author
Eloy	Near Eloy	1940-77	12.5 ft. 625 mi^2	Ground water level declines of more than 300 feet	Collapsing roads, Broken pipes, Damaged canals, Loss of agricultural land, Disrupted drainage, Contaminated groundwater aquifer, Sudden discharge of ponded water, Human injury or death\	Robinson and Peterson, 1962
		Oct 1988-Feb 1989	0.16 ft.			
	South of Ely	1985	15 ft.			Carl C. Winikka, Arizona Department of Transportation, 1985
Phoenix	Northeast Phoenix	1962-82	5 ft.			Laney and others, 1978
	West of Phoenix	1992	18 ft.			Schumann, 1995 Carpenter 1999
	Between Phoenix and Tucson	1952-77	7 ft. 100 mi^2	may be attributable to urban groundwater use	damage and disruption may be expected from extensive subsidence	Arizona geological survey, 1993
Salt River Valley	Near Queen Creek	1977	3 ft. 230 mi^2	water-level decline	Earth fissures, impacted roads, a power generation facility, and a railway localized flooding A change in the gradient of a sewer line, storm drain, or aqueduct can interrupt flow causing it to slow, clog, overflow or reverse	ALSG, 2007
	Western part of the Valley		3 ft. 140 mi^2			Poland, 1981
	Eastern part of the Valley	1965-82	5 ft.			Pewe and Larson, 1982
Pinal	Stanfield	1977	11.8 ft. 425 mi^2			Laney et al., 1978
Aguila and Wenden	Harquahala plain	-	0.6 ft.			Holzer, 1980; Strange, 1983; Schumann and Cripe, 1986
Cochise County	Willcox	1937-45	5 ft.			
		2006- now	2.41 ft.			
	San Simon valley	1952-80	1.3 ft.	lowering of the groundwater	Earth fissures have formed and continue to grow in the Bowie-San Simon area	Strange, 1983
	Bowie		5.8 ft.			

Table 7

Subsidence in New Mexico and details

Location		Period	Measurement	Reason(s)	Damage(s)	Scholar/Author
Grant County	Mimbres Basin	1910-90	1.18 ft.	Compaction of uncon solidated alluvium due to dewatering of an unconfined aquifer	Fissures	G. J. Contaldo J. E. Mueller

Table 8

Subsidence in Georgia and details

Location		Period	Measurement	Reason(s)	Damage(s)	Scholar/Author
Savannah	11 miles northwest and 12 miles west of Savannah	1933-55	0.135 ft. 130 km^2	-	-	-

Table 9

Subsidence in Louisana and details

Location		Period	Measurement	Reason(s)	Damage(s)	Scholar/Author
Baton Rouge	Industrial district	1929-65	0.165 ft. 250 mi^2	Tectonic movement, Decline in pressure due to petroleum production	Flooding Soil compacting	G. H. Davis and J. R. Rollo
	Bordering on the Mississippi River	1929-65	0.82 ft. 2 mi^2			
New Orleans	Michaud area	2009-12	0.36 ft.	Loading at land surface		
	Lower 9th Ward		0.26	Drying out and shrinkage of surficial deposits		
	Chalmette					
	Algiers					
	Old Metairie			Decline of pressure head in confined aquifer		

Table 10

Subsidence in Nevada and details

Location		Period	Measurement	Reason(s)	Damage(s)	Scholar/Author
Las Vegas valley	Las Vegas	1953-65	6 ft.	Compaction of aquifer system Ground failures	Surface fissures Damage of wells, homes, roads, and water lines	Bell, 91a; Bell and Price, 1991 Mindling, 1971; Bell, 1981, 1997; Bell and Price, 1993
	Northwestern part of the valley	1963-87	5 ft.			
	Central and southern		2.5 ft.	Permanent reduction of storage capacity of aquifer system		

Conclusions

Subsidence is an unrecognized problem. To solve this big problem, a lot of information and studies are needed. This problematic phenomenon is a type of hazard and all kinds of hazards must be known and studied first and then controlled by experts. So, to prevent land subsidence from exceeding, it is necessary to study last hazards and their exact details. In that case, the numbers of hazards will be eminently decreased.

Considering the table above, in the United States of America, the land subsidence usually occurs in eastern, western or even south central United States of America. Thus, these regions are more important to care. On the other hand, the measurements are not close to each other and damages are not similar. This issue alerts anyone to be prepared for any kinds of subsidence with any details.

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