Situational Analysis of Egypt – Issues through The Seismic Oceanography

Marwan El-Sheikh

Schlumberger D&I DSS A&I, Qatar

Abstract

Given the huge and quick expansion of major investments in national projects, as well as the fact that, despite Egypt's generally low earthquake frequency, it has historically experienced devastating earthquake effects, the study of seismic activity and seismic risk evaluation for Egypt are of utmost importance. According to seismic oceanography, Egypt may be the cause of considerable earthquakes, particularly those that occur near the Gulf of Aqaba, the Dead Sea Transform, and the triple junction point in the northern Red Sea, And the Dahshur region. Seismic hazard research for Egypt started decades ago with the goal of forecasting the earth's motion's parameters at various geographic scales; With the purpose of eliminating flaws in future assessments of seismic risks, the researcher employed the descriptive analytical approach to review earlier studies that handled with this subject in order to analyse the situation in Egypt - issues through seismic oceanography.

1. Introduction

Acoustic oceanography, or seismic oceanography, is the study of the physical characteristics and dynamics of the ocean using sound waves. It offers visual representations of variations in seawater salinity and temperature. Seismic oceanography employs sound waves with lower frequency than 500 Hz, in contrast to the majority of oceanographic acoustic imaging techniques, which use sound waves with rates higher than 10,000 Hz. Seismic oceanography is unique in its ability to generate extremely detailed views of oceanographic structure that span horizontal distances of hundreds of kilometres and that reach from the ocean's surface to the seabed thanks to the use of low-frequency sound (Holbrook, et al., 2003).

To decrease the impact of earthquakes, particularly in nations near tectonic plate boundaries, earthquake prediction systems should be established. The pre-seismic events along dangerous fault zones can be effectively monitored using satellite remote sensing systems. A considerable association between pre-seismic signals and impending earthquakes has been found by numerous statistical studies using major earthquakes and a variety of analytical techniques (Bouchon, et al., 2013).

The mathematical understanding of the seismic risk for Egypt is crucial for the country's future socioeconomic development as well as the protection of its current infrastructure. Both historical and modern earthquakes in Egypt were researched by Maamoun and Ibrahim (1978) and Maamoun et al. (1980), along with the answers to various shocks' focal mechanisms. The Red Sea-Gulf of Suez seismic zone and the Egypt-Mediterranean coastal zone were the two main seismic zones they found in and around Egypt.

2. Research aim

We had to learn to live with earthquakes because they are natural disasters that have an impact on property and human life. We also had to take the required precautions to limit their devastating consequences as much as necessary. up to the risk's magnitude. As a result, the current study's objective is to provide earlier research in order to conduct a situational analysis of Egypt's problems using seismic oceanography.

3. Theoretical framework

Because to their immediate, observable effects on people, society, and technical facilities, earthquakes are among the most damaging and dangerous natural events. A magnitude 9 and 5 earthquake struck Egypt on October 12, 1992, causing significant property damage and loss of life. These losses could have been avoided or lessened if there had been adequate scientific research and public knowledge of the seismic threat (Fergany, et al., 2009). As a result, it was required to conduct a study using seismic oceanography to describe the development, velocities, and directions of these earthquakes through the interpretation of prior research.

This kind of research is offered in this work to look into the features of earthquake sources and how they relate to the local tectonic setting. Southwest of Cairo, the site of the Dahshur earthquake that struck on October 12, 1992, was chosen for this investigation. Because of the region's seismic activity in the past and present, it was selected. The historical seismic activity of northern Egypt and the study area was evaluated using the results of prior research in this area in order to perform this research.

The orientation of the Nile and its delta, the path of the Nile and its delta, and lastly the path of the Mediterranean Sea are the dominant and seismic activity impactful influences on northern Egypt and the study area, and this is supported by latest seismic recordings of these dynamics, which were made by the network The National Seismological Institute of the National Institute (Omar, et al., 2013).

In order to determine the nature of the site around these earthquakes, this study attempts to investigate the properties of the earthquake reservoir, its orientations, including its pace. Two earthquakes that had a Richter value of at least 4 were found in the research region, according to the National Seismic Network. When the event earthquakes in the study region were regarded, it was discovered that there were 135 of them. Of these earthquakes, pretty obvious earthquakes with good polarization were chosen, and 27 of them were counted and recorded in enough local stations to allow for the study of the mechanics of the earthquake's specializations (Thenhaus, et al., 1993).

It was required to research and select the best geological model for the study area. They are four models, and each one has undergone testing. The fourth paradigm was discovered to have the lowest error; therefore, it was selected to test the mechanics of seismic events for the 27 earthquakes that were pre-selected. This study was compared to earlier studies, and it was established that there is consistency between them. The earthquakes were separated into two groups, and it was discovered that the predominant tendency in the area is northwest-southeast. The first group, as we said before, is consistent with existing research, whereas the second group follows a north-south axis (Moustafa, Sayed, 1992).

18 km south of Cairo, Egypt, a 5.3 on the Richter scale earthquake called the Dahshur struck. The primary event was associated with a number of 4.3 magnitude aftershocks in

the weeks that followed. Many Egyptian cities were affected by the earthquake, which took place in a region that had not lately been subject to seismic activity. Numerous structures and monuments suffered significant damage or fell down. There has been very little non-structural damage to contemporary concrete constructions. Generally speaking, modest earthquake activity was seen in Egypt. Only for reinforced concrete structures, earthquake precautions were first added to the Egyptian Code of Practice in 1989. The earthquake made it abundantly evident that an assessment and restoration programme were required immediately to reduce seismic dangers in existing structures. Additionally, the lessons acquired from the incident must be incorporated into future planning and preparation measures for earthquakes (El-Sayed, et al., 1998).

Seismic activity continues north along the Suez Fault and covers the northern portion of the Eastern Desert in additional to the Dahshur region. This seismic movement, which stretches across Cairo and Alexandria in the northwest and the Mediterranean Sea, is the most significant phenomenon in Egypt. The Red Sea rift, in addition to several seismically active with northwest directions parallel to the Red Sea and Gulf of Suez direction and their extension towards the eastern Mediterranean, are credited with the activity of this trend. Seismic activity grows as northeast direction problems cross the expanding zone and the northwest fault system as they travel south over the Red Sea, demonstrating that both of the region's third tectonic orientations are active (Abdel Rahaman, et al., 2008).

The seismicity data shows two distinct NW-SE trends in the Gulf of Suez region following the establishment of the Hurghada seismic network in 1994 near the northern part of the Red Sea. The first one is roughly 125 km long and travels through the southern entrance of the Gulf of Suez, with Gubal Island serving as the focal point of most of its activity. According to Daggett et al. (1986), this activity was assigned to the same source location as the significant earthquake that occurred on March 31, 1969.

Along the Sinai Peninsula's southwesterly border, the second movement is identified. The two movements' events might be connected to the faults that divide the Gulf of Suez depression from the Precambrian peaks in southern Sinai. Due to the opening of the Red Sea, addition in the Gulf of Suez, and left lateral strike-slip motion in the Gulf of Aqaba, Daggett et al. (1986) connected the high rate of seismicity at the southern end of the Gulf of Suez to crustal movements between the Arabian and African Plates and Sinai sub plate. The Eastern Desert's Gulf of Suez and its northern extension are where the epicenters of low to moderate seismic activity are concentrated (Abou Elenean and Hussien, 2008).

Egypt's seismic oceanography aided in the installation of seismic cables in earthquake-prone regions across the Republic. These systems' primary goal is to keep an eye on seismic activity in both the northern and southern halves. There was a dearth of seismic data in southern or northern Egypt prior to the construction of these networks. As a result, a positive reply with an extensive seismic risk evaluation factor for the southern and northern parts of Egypt became accessible response systems monitoring from these networks from 1982 to the present (Deif, et al.,2011).

It is crucial for the nation to be able to forecast the magnitude of seismic activity that should be anticipated from big earthquakes in the upcoming for the evaluation and mitigation of earthquake risk to be successful. In order to identify these places and reduce the risk of earthquakes there, numerous geophysical and geotechnical investigations have been carried out in various regions across the Republic. The results of these analyses are crucial for planning land uses, building earthquake-resistant structures, and solving issues related to the construction of different civil engineering projects (Arfa, et al., 2015).

There are several different geophysical techniques that can be used to characterise subsurface soils. Every technique has its own advantages over other techniques as well as limits. The choice of a certain approach for site characterization is seldom clear-cut. The choice of a particular approach is influenced by a variety of elements, including the goal and scope of the study, the accessibility of resources (equipment and personnel with the necessary skills), the type of analysis to be conducted, the type of soil, etc. The geophysical and geotechnical site investigations needed to reduce earthquake risk (seismic micro zonation) are distinct from regular site examinations. Additionally, dynamic site description from the standpoint of earthquake loading is necessary for micro zonation research. Therefore, it is crucial to adequately organize site studies using the right geotechnical and geophysical techniques (Basheer, 2008).

4. Discussion

Seismic risk assessment was conducted out utilizing the maximum likelihood estimation of Kijko and Sellevoll to provide insight into the seismic oceanography in Egypt (1990). This technique effectively integrates sporadic data for significant historical earthquakes with more reliable data for earthquakes that have just been discovered. This approach is appropriate for Egypt because the homogeneity of the earthquake data there varies with time. A collection of earlier research that contained information on significant seismic zones were examined for the current analysis. The Red Sea, the Gulf of Suez, and other bustling regions of Egypt are all included (Kijko, and Sellevoll, 1990).

Several historical and modern seismic activity in Egypt were researched by Maamoun and Ibrahim (1978) and Maamoun et al. (1980), along with the focal mechanism explanations of specific shocks. The Red Sea-Gulf of Suez seismic zone and the Egypt-Mediterranean coastal area were the 2 major seismic zones they found everywhere in Egypt. Three local zones were also proposed, including the Aqaba Qena zone, Gilf E1 Kebir-Abu Roash zone, and Gaghbub-Ryan region (Ibid).

Same study has been done in a series of papers about seismic events including in seismic oceanography. These are Ambrasis (1975, 1983), Poirier and Taher (1983), Gutenberg and Richter (1954), and (1980). 22 seismic activities with magnitudes more than seven and potential strengths greater than 4.5 were discovered overall between the years 320 and 1906. Inadequate information of the earthquake's size and location, another 10 shocks had to be disregarded. Mamoun et al. (1984) provide locations of highest damage, potential upper and lower limits of magnitudes and intensities, and also other related qualities, in their well-written description of the remaining seismic events.

The Gulf of Suez, which represents Egypt's greatest active region, is the first subarea. This area has already seen a number of seismic events with magnitudes ranging from 4.0 to 6.2. (Ismail, 1960; Al Gergawi and Al Khashab, 1968). More later, Daggett et al. (1986) reported that this region has swarms of roughly 200 seismic events once a week and an average of 25 seismic events per day with magnitudes ranging from 0.7 to 3.1. Several tectonic features, including the Red Sea seismic axis and the nearby Arabian, Sinai, and African moving zones, are linked to activity in the Gulf of Suez (Courtillot et al., 1987; Gaulier et al., 1988; Martinez and Cocheran, 1988). Maximum activity is seen when two or more tectonic factors contact with one another, as demonstrated by Kulhfinek et al. (1992a,b). In this subregion, 688 seismic activities with a magnitude greater than 3 were recorded overall between 1906 and 1987.

Conclusion

Despite these achievements, seismic oceanography has had trouble becoming a common observational technique. There are two reasons for this modest growth. First, there have been practical difficulties with data collection and trustworthy, consistent record analysis, which have hampered the field. Second, and perhaps more importantly, many physical oceanographers see the field as a curiosity with no distinct goal or practical application in science. The seismic oceanographic community must decide on the principal scientific issues that it can methodically investigate in order to advance.

References

1) Abdel Rahaman, M., Tealeb, A., Mohamed, A., Deif, A., Abou Elenean, K., El-Hadidy, M.S., 2008. Seismotectonic zones at Sinai and its surrounding. In: First Arab Conference on Astronomy and Geophysics, Helwan, Egypt, 20–22 October 2008.
2) Abou Elenean, K., 1997. Seismotectonic of Egypt in relation to the Mediterranean and Red Seas tectonics. Ph. D. Thesis. Fac. Sc. Ain Shams Univ., pp. 200.
3) Ambraseys, N. N.: 1975, Studies of historical seismicity and tectonics, Geodynamic Today, Royal Society of London.
4) Ambraseys, N. N.: 1983, A note on historical seismicity, Bull. Seisrnol. Soc. Am. 73, 1917-1920.
5) Arfa, M. (2015): Engineering seismological studies for the new Nubian habitations area in Wadi Kurkur, Aswan, M. SC thesis, Al-Azhar University.
6) Badawi, H. S.: 1991, High earthquake risk buildings in Egypt, Internet Symptoms. Geophysical Hazards in Developing Countries and their Environmental Impacts, Perugia, Italy, August 1991.
7) Basheer, A. (2008): Geophysical study on the new Qeft city, Qena, Egypt, PhD thesis, South Valley University.
8) Bouchon, M.; Durand, V.; Marsan, D.; Karabulut, H.; Schmittbuhl, J.: (2013), The long precursory phase of most large interplate earthquakes. Nat. Geosci. 6(4), 299–302.
9) Courtillot, V., Armijo, R., and Tapponnier, P.: 1987, The Sinai triple Junction revisited, Tectonophysics 141, 181-190.
10) Deif A., Hamed H., Igrahim H. A., Abou Elenean K., and El-Amin E. M. (2011): Seismic Hazard Assessment in Aswan, Egypt, Journal of Geophysics and Engineering 2011; 8: 531-548.
11) El-Sayed, Attia; Arvidsson, Ronald; Kulhánek, Ota (1998). "The 1992 Cairo earthquake: A case study of a small destructive event". Journal of Seismology. 2 (4): 293–302. doi:10.1023/A:1009717023043.
12) Fergany, Elsayed A.; Sawada, Sumio (2009). "Estimation of Ground Motion at Damaged Area During 1992 Cairo Earthquake Using Empirical Green's

Functions". Seismological Research Letters. 80 (1): 81–88. doi:10. 1785/gssrl.80.1.81 . ISSN 0895-0695.

13) Gaulier, J. M., Le Pichon, X., Lybris, N., Avedik, F., Geli, L., Moretti, I., Deschamps, A., and Hafez, S.: 1988, Seismic study of the crust of the northern Red Sea and Gulf of Suez, Teetonophysics 153, 55-88.

14) Gergawi, A. and Khashab, A.: 1968, Seismicity of U.A.R., Helwan Observatory Bull. No. 76.

15) Gutenberg, B. and Richter, C. F.: 1954, Seismicity of the Earth, Princeton University Press New Jersey.

16) Holbrook, S. W; Páramo, P.; Pearse, S; Schmitt, R. W. (2003). "Thermohaline Fine Structure in an Oceanographic Front from Seismic Reflection Profiling". Science. 301 (5634): 821–824.

17) Ismail, A.: 1960, Near and local earthquake of Helwan (1903-1950), Helwan Observatory, Bull. No. 49.

18) Kijko, A. and Sellevoll, M. A.: 1990, Estimation of the earthquake hazard parameters from incomplete data files, Natural Hazards 3, 1-13.

19) Kulhnek, O., Korrat, I., and E1-Sayed, A.: 1992b, Recent seismic activity and general tectonic situation in the Red Sea, published abstract, tenth symposium on Quaternary and development in Egypt, E1-Mansoura University Geology Department, 18 April 1992.

20) Maamoun, M. and Ibrahim, E. M.: 1978, Tectonic activity in Egypt as indicated by earthquakes, Bull. HIAG, No. 170.

21) Maamoun, M., Allam, A., Megahed, A., and Abu E1-Atta, A.: 1980, Neotectonic and seismic regionalization of Egypt, Bull llSEE 18, 27-39.

22) Martinez, F. and Cocheran, J. R.: 1988, Structure and tectonic of the northern Red Sea: Catching a continental margin between rifting and drifting, Tectonophysics 150, 1-32.

23) Moustafa, Sayed S.R.; Takenaka, Hiroshi (2009). "Stochastic ground motion simulation of the 12 October 1992 Dahshour earthquake". Acta Geophysica. 57 (3): 636–656. doi:10.2478/s11600-009-0012-y. ISSN 1895-7455. Retrieved 11 October 2020.

24) Omar, Khaled; Attia, Mohsen; Fergany, El Sayed; Hassoup, Awad; Elkhashab, Hussein (2013). "Modeling of strong ground motion during the 1992 Cairo earthquake in the urban area northern Greater of Cairo, Egypt". NRIAG Journal of Astronomy and Geophysics. 2 (1): 166–174. doi:10.1016/j.nrjag.2013.06.019.
25) P.DaggettP.MorganF.BoulousS.HenninA.El-SherifA.El-SayedN.BastaY.Melek, 1986, Seismicity and active tectonics of the Egyptian Red Sea margin and the northern Red SeaTectonophysics1251986313324.
26) Poirier, J. P. and Taher, M.: 1980, Historical Seismicity in the near and Middle East north Africa and Spain from Arabic documents (VIIth- XVIIth Century), Bull Seismol. Soc. Am. 70, 185-201.
27) Thenhaus, P.C.; Celebi, M.; Sharp, R.V. (1993). "The October 12, 1992, Dahshur, Egypt, Earthquake". Earthquakes & Volcanoes (USGS). 24 (1): 27–41. Retrieved 11 October 2020.