

EARTH MOVEMENT IN ETHIOPIA:

This article is in reference to the recent earth failure or “sinkhole” under the main road south of Sheshemenie, Ethiopia. Per the report by the Ethiopian National Disaster Risk Management Commission, dated April-May, 2016 (Meazia 2008), it measured 50 meters (165 feet) wide and 50 meters deep, which would be equivalent to approximately 16 floors of a building (See pictures below). The sinkhole is said to continue east, towards the rift valley. The paper will discuss the general geologic conditions of the area, possible reasons of the movement and some viable engineering solutions. The intention is not to address all historical earthquake data and damages that might have occurred in Ethiopia, but to inform and remind the public of the earth shaking that is occurring, so the country can better prepare and minimize any future fatalities or economic devastations.

I also would like to invite Ethiopian professionals and their peers to come together and create professional associations so they can participate in disaster prevention and provide emergency engineering solutions for any current and future disasters.

Human beings have long feared earthquakes and have struggled to understand the underlying causes. The ancient Chinese believed it is the trembling of the great dragon who lived in the bowels of the earth and shook the mountains and plains when irritated. The Japanese were convinced it is furious shaking of Namazu, the giant catfish who dwelled in the ooze. Since then, science has revealed it to be the effect of a rebalancing of forces arising from the collision of continuously moving plates of layered rock that float from the earth's molten interior. This is the theory of continental drift and plate tectonics, which asserts that, about 200 million years ago, all continents were connected together as a super-continent called Pangaea before they rifted apart to form the present-day continents. (Earthquake Prediction by Haroun Tazieff 1914)

Rifting is a geologic term that describes the process that occurs when land sinks between two parallel faults. The East Africa Rift System (EARS) runs southerly, from the Afar Triple Junction in the Afar Depression of Ethiopia, through eastern Africa ending in Mozambique. It is an active continental rift zone in the area. The rifting is presumably caused by The Somalian Plate and the Nubian Plate pulling away from each other and away from the Arabian Plate to the north. The Afar Triple Junction is where the three plates meet. Geologists believe that the stretching process associated with the rift formation is often preceded by volcanic eruptions and if it continues, the thinning crust will eventually drop below sea level as has happened in the Red Sea and Gulf of Aden. In this process of rifting, large earthquakes rumble across the landscape as huge blocks of crust drop down along these diverging faults. (Chorowicz, Jean 2005).

The effects of earthquakes are measured by intensity. Intensity scales measure the effects of ground shaking based on tabulation of felt reports of ground and damages to buildings, and geological movements. In the USA, the Modified Mercalli Intensity scale

grades the observed effects into twelve classes ranging from I, ground motion not felt by anyone, to XII, indicating total damage.

In the 80s in Ethiopia, The Ethiopian Building Construction Authority (EBCA), in par with professors at Addis Ababa University, was tasked to prepare “Ethiopian Standard Code of Practice” (ESCP 1983) that included seismic research and develop case histories in order to generate the intensity map of Ethiopia. The group assessed the different areas, rating and assigning intensity numbers to places that experienced equal or very similar damages. Finally, points with equal numbers of intensity on the Ethiopian map were connected to form isoseismic contour lines. Such intensity maps are crude, but have great value in estimating the potential seismic damage in a given area and may also indicate the effect of underlying irregular rock layers and surficial soil on the intensity of shaking.

In 2009, a minor sinkhole had occurred within the same asphalt concrete roadway, around Zeway area, where there was an opening, few inches wide, running perpendicular to the road. This opening ran continuously along the west side of the roadway, increasing in size and depth, barely missing a tukul (Gojo) of one of the local farmers. Easterly, the sinkhole had extended a long distance towards the Rift Valley. The soil was mostly saturated, fine to medium silty sand. I was in Addis Ababa then, and had the opportunity to visit the site along with other engineers.

Sinkholes may be caused due to the collapse of underneath structures such as culverts, pipes or by the settling of land surface without appreciable horizontal movement. It could occur because of withdrawal of ground water, shock waves from earthquakes, or sudden excessive rain saturating the area. When seismic shear waves from an earthquake pass through loose, saturated granular soil layer, they distort the structure and cause void spaces that could eventually collapse. The collapse of underground shallow tunnels in ancient lava flows can also cause ground subsidence. (The Changing Earth by Jon Erickson).

According to the world earthquake tracking, in courtesy of the United States Geological Survey (USGS) National Earthquake Information Center, PDE data, there have been recently registered tremors in east Africa. These tremors were measured in Magnitude (M) scale, also known as the Richter Scale. It is based on seismograph measurement of ground vibration and indirectly measures the energy released at the focus of the earthquake as determined by measuring the heights of the waves (amplitude) produced. In Ethiopia, towns like Metahara, Sheshemene, Were Ilu, Asaita, Adigrat, Mekelle, Maichew, Debresina, Debreberhan, Butajira, Kolito, Abomsa, Zeway, Kemise, Gewane, Ginir, and Wenji were hit by earthquakes with magnitudes varying from 4.2 to 6.5M, in dates ranging from few months to 110 years ago.

In 1961, a major earthquake with 6.1 magnitude had hit the Kara Kore area and heavily damaged the town called Majete, claiming a lot of lives.

The above information indicates that most of Ethiopia lies in seismically active zones with varying intensities. It is of great concern that any future vibrations could potentially demolish buildings, roads, bridges, dams, and other infrastructures. The proximity of these movements to Addis Ababa is of utmost concern as it is the most populated city, housing many high rise buildings and other structures. The fact that the Fulwoha (hot spring) passes through the city is also an indication that the city is not spared of its active location.

Knowing what has occurred so far, leads to the next step that needs to be done to keep residents safe and protect their economy and booming development. The following are suggestions that need to be implemented:

1. Though drought, flooding, and food shortage are frequent disasters, Ethiopia should prepare for any seismic disaster. There should be more periodic programs on the media to make the population aware of the condition of the rifting, any tremors, and discussions with experts in and outside Ethiopia.
2. Mitigation plan should be addressed.
3. More studies should be conducted and monitoring devices installed to better identify the earthquake zones. The current map should also be evaluated for any changes.
4. Preliminary studies based on available geologic, geotechnical and environmental reports should be compiled as reference for any future comparison of the progress of the site conditions.
5. Site assessment and geologic and seismic mapping should be done. Preliminary subsurface explorations like boreholes, test pits with backhoes, and some geophysical explorations should be conducted. Soils and rock materials should be logged and soil profiles plotted to better identify possible fault lines and their locations in the area. The current sinkhole, would greatly benefit from this as the area should be explored for any other cavities, and fault lines before placing any permanent infrastructure.
6. Ground water levels can be identified from the boreholes and tested for mineral contents to detect any potential volcanic activities or the influence of the existing.
7. The Ethiopian government or the states should budget or solicit international funds for these studies to be conducted in most seismic prone areas. This is especially advantageous for Addis Ababa and the major highly populated cities and towns.

8. Design engineers should adhere to design standards. There are inexpensive ways of addressing earthquake loads without affecting the budget much. Structures can be designed flexible to withstand the movement or rigid by tying beams with columns and columns with foundations.
9. Construction inspectors must work closely with the contractor, and design engineers to make sure foundation types, depths, concrete strengths, reinforcements and all other materials were used per the design. When I was working for EBCA, design engineers used to approve all the important stages of construction before any soil and concrete backfill can be performed. Soil and concrete samples were taken to Building College lab for testing. Daily site activities were reported. Final building occupancy inspection and evaluation used to be performed in the presence of the contractor by all engineers who were involved in plan reviews before acceptance of work. However, in those days, we mostly had government projects to deal with. Now that many projects are going on at the same time, it may be overwhelming for the cities and state inspectors to enforce the necessary regulations. Here in the USA, where I worked for many years, private consultants can be hired to do the County design and inspection jobs if approved ahead of time. Pre-screened consultants are tasked to work on the project but always oversighted by the county engineers. Ethiopia can implement similar solution.
10. Retrofit existing structures that are identified to cause major damages during an earthquake. Roads, bridges, airports, railroads, dams, schools and hospitals are major structures that are crucial to be prioritized. Help cannot be reached and without drinking water people cannot survive long.
- ~~11.~~ Outside institutions can be invited for training of personnel in monitoring and installing seismographs and other devices to narrow down the prediction and exchange of ideas with the engineers at home. There are many highly educated expert Ethiopians all over the USA and the world who can contribute if encouraged and/or invited. Engineers in Ethiopia may be doing their best but will still need to work together with other professionals to “Raise the Bar” in quality products.

For the purpose, I would like to invite all professionals abroad to create professional association(s). The mission is to establish non-profit, non-political organization to provide value to its members and partners, provide tools for lifelong learning, promote professionalism, and serve the public. Engineering knowledge and competency can be achieved through publications, educational web and live seminars, conferences and workshops. Periodic site reviews and safety evaluations of standing structures can be arranged.

The associations can easily approach foreign donors and other experts to participate in any endeavor that needs to be taken. Once Ethiopian Professional Associations are established, other associations such as the American Society of Civil Engineers

(ASCE), Association of American State Geologists (AASG), the USGS, National Society of Professional Engineers (NSPE), and other experts everywhere can be approached.

The Ethiopian government will have to participate in providing transportation and other minor accommodations so a group can travel there periodically and evaluate existing structures for any potential failures and provide immediate and long range solutions. Other non-Ethiopian retired experts may be willing to participate and contribute towards this noble cause. The cheapest and yet vital solutions can be accomplished through this method. Awareness outside Ethiopia may bring additional funds for necessary studies of the EARS.

We all can learn from each other. Irrespective of political affiliations, development and the safety of the people should not be negotiated or compromised. Governments come and go but the country and the people will always be there. I was involved in many major projects during the Derge era. That government is gone, but the Ethiopian people are benefiting from the projects. We should all be concerned about the people. The bottom line is the safety of the nation and its 90 million people.

For any comments, and suggestions, please e-mail me at lmazfesseha326@gmail.com.





The existing asphalt concrete roadway is gone.





Note from an eye witness who saw the collapse of the road from the crack (above).



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