THE ROLE OF SURVEYORS IN THE CONTROL OF EARTH TREMORS

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Abstract

The Role of Surveyors in the Control of Earth Tremors

The paper delves into the multifaceted role of a surveyor, who is skilled in spatial measurement, land governance, and resource planning. It also highlights the impact of various natural disasters, including earthquakes and other catastrophic events. The paper emphasizes the necessity of effective disaster risk management and the potential contribution of surveyors in this field. Incorporating application-oriented concepts, methods, and instruments, the report underscores the surveyor's aptitude in simplifying and expediting disaster management. The surveyor's capabilities in land management, geodetic engineering, geo-informatics, satellite technology, and remote sensing are crucial in disaster risk reduction. Following a disaster, the surveyor plays a pivotal role in reestablishing property boundaries and right-of-way lines. This involves locating buried markers, recreating deed descriptions, and determining roadway positions. The surveyor's expertise, often aided by Global Navigation Satellite System GNSS equipment, facilitates retracement calculations for disturbed areas. By promoting collaboration between surveyors and disaster management, this publication advocates for the integration of surveying expertise to streamline recovery efforts after catastrophic events. The abstract encapsulates the significance of surveyors in disaster response and recovery, showcasing their vital role in mitigating the aftermath of natural disasters.

Keywords: Surveyor, Earth tremor, disaster risk management, natural disasters, spatial measurement.

Introduction

A surveyor is a practical professional skilled in measuring and managing land. According to CHW Broschure (2023), “A surveyor and mapper is a skilled professional who specializes in measuring and mapping the features of land, water, and air to determine its boundaries, elevations, and topography, which are material to the development of any project.” Surveying is the practice of determining the positions of points on Earth's surface and measuring the distances, directions, angles, and elevations between them. This involves using tools like GPS (Global Positioning System), aerial photography, and ground-based instruments such as total stations and levels. Mapping is the creation of visual representations using survey data, ranging from basic two-dimensional plans to intricate three-dimensional models and geographic information systems (GIS) that combine various layers of data. Surveyors possess a professional profile that blends technical, legal, and design expertise, embodying qualities of an engineer, lawyer, and architect. This professional spectrum encompasses three main areas: surveying and mapping, cadastre and land management, and spatial planning (Enemark, 2003). Land surveys offer details about the land's topography and natural elements like trees, water bodies, and slopes, crucial for environmental assessments and planning. They help identify potential hazards like flooding or landslides, guiding decisions on land use and development (CHW Broschure, 2023).

Earth tremors are small, short movements of the earth's surface caused by forces like earthquakes. Collins English Dictionary (2023) describes it as "a relatively small or short-lived movement of the earth's surface caused by the same forces that produce earthquakes." Natural disasters, such as earthquakes, hurricanes, tornadoes, and floods, have caused destruction for centuries. This publication discusses various deadly disasters and presents concepts for effective disaster risk management. It emphasizes that surveyors, with their skills in land management and technology, can play a crucial role in simplifying and expediting disaster management. After disasters, surveyors help find existing land lines, using tools like GNSS for accurate measurements and calculations.

The occurrence of seismic events, commonly referred to as earthquakes, is a phenomenon characterized by the abrupt shaking of the Earth's surface. This geological manifestation results from the sudden release of energy within the Earth's lithosphere, leading to the generation of seismic waves. These waves, which traverse the Earth's rocks, exhibit a spectrum of magnitudes, ranging from imperceptible tremors to violent upheavals with the capacity to cause widespread destruction, including the displacement of individuals and the devastation of entire urban centers (Wikipedia, 2019).

Defined as any sudden shaking of the ground induced by the passage of seismic waves through Earth's rocks, earthquakes represent a complex interplay of geological forces. Seismic waves are produced when stored energy within Earth's crust undergoes a sudden release, typically occurring during the fracture and slip of rock masses straining against each other. The primary geological locales for such occurrences are along geologic faults, defined as narrow zones where rock masses undergo movement in relation to one another. Notably, these fault lines align predominantly at the peripheries of the substantial tectonic plates constituting Earth's crust, forming major fault lines that traverse the global landscape (Bruce, 2019).

The title is a compelling and relevant topic that touches upon the intersection of geophysics, environmental science, and surveying practices. It provides an opportunity to explore the pivotal role surveyors play in mitigating the impact of seismic events, contributing to both disaster preparedness and response efforts. The paper explores various aspects such as the use of geospatial technology, structural vulnerability assessment, urban planning considerations, and the collaboration between surveyors and other professionals in the field of earthquake engineering. Overall the paper aligns with contemporary concerns related to natural disasters and the role of surveyors (geospatial professionals) in promoting resilience and safety.

Causes of Earth Tremors

Earthquakes occur when there is a sudden release of energy within specific areas of the Earth's rocks. This energy release can be triggered by various factors such as elastic strain, gravity, chemical reactions, or the movement of massive bodies. Among these, the most significant cause is the release of elastic strain because it is the only type of energy that can accumulate in sufficient quantities to result in major disturbances in the Earth. Earthquakes associated with the release of elastic strain are specifically known as tectonic earthquakes (Bruce, 2019). In simpler terms, when rocks in the Earth experience stress, they store energy. When this stress is released, it causes the ground to shake, leading to an earthquake. Elastic strain, which is like the stretching of a rubber band, is particularly crucial because it can store a lot of energy. Bruce's explanation helps us understand that the most powerful and impactful earthquakes, known as tectonic earthquakes, are primarily caused by the release of this stored elastic strain. This insight is essential for grasping the natural processes that contribute to earthquakes, especially those occurring along tectonic plate boundaries.

On the Earth's surface, seismic events become apparent through ground shaking and displacement. Additionally, earthquakes can instigate landslides and, on rare occasions, induce volcanic activity. In instances where a substantial earthquake's epicenter is situated offshore, it has the potential to displace the seabed significantly, consequently giving rise to a tsunami. A tsunami is a series of ocean waves with extremely long wavelengths and high energy, typically caused by an underwater disturbance such as an earthquake, volcanic eruption, or landslide. These waves can travel across entire ocean basins and, upon reaching shallower coastal areas, increase in height and potentially cause devastating inundation across vast distances and deliver powerful surges of water onto coastal communities and infrastructure. This is where surveyors significantly come in, especially by creating accurate topographic maps and coastal surveys, installation and maintenance of early warning systems, precise geodetic surveys in the use of GPS technology, structural vulnerability assessment, etc. (FIG Publication, 2015).

The seismic events with the highest destructive potential manifest at the boundaries of tectonic plates, immense lithospheric slabs that traverse the Earth's surface, covering both continents and oceanic regions. These plates, comprising approximately a dozen major components, rest atop the semi-fluid asthenosphere beneath the Earth's crust. Tectonic plates exhibit perpetual motion, driven by convective currents in the underlying mantle. As these plates move, stress accumulates along their edges due to the interaction of various forces. The stress buildup is a consequence of the dynamic processes at plate boundaries, where these massive slabs interact. This interaction can take various forms, including subduction, convergence, or lateral sliding. Regardless of the specific boundary type, the continuous movement results in the gradual accumulation of stress within the Earth's crust. When the stress along the edges of tectonic plates surpasses a critical threshold, it induces a rupture, leading to the release of accumulated energy in the form of seismic waves, which we perceive as earthquakes. This process is fundamental to our understanding of earthquake mechanics, and the recognition of the tectonic plate dynamics provides insights into the locations and characteristics of seismic events, (Metcalfe, 2019)

Positive Aspects of Earth Tremors

According to Santra (2017), Earth tremors offer certain environmental benefits. Firstly, they contribute to the uplifting of land surfaces, providing favorable conditions for vegetation growth by enhancing sunlight exposure and nutrient distribution. This natural process aids in fostering a more conducive environment for plant life. Additionally, earth tremors play a positive role in soil dynamics, facilitating aeration and the even distribution of essential minerals. This results in the creation of fertile soil, promoting healthier ecosystems. Furthermore, seismic activities provide valuable insights into the geological processes shaping the Earth. Surveyors and environmental scientists find these events essential for understanding the Earth's dynamics, including tectonic plate movements and seismic interactions. Additionally, seismic activities may influence geological formations, potentially impacting the accessibility of subsurface resources such as fossil fuels. Overall, earth tremors play a multifaceted role in shaping and sustaining the environmental landscape.

Negative Aspects of Earth Tremors

The aftermath of earth tremors presents significant challenges, particularly in terms of hazards and risks. Fires are a common consequence of seismic events that are intensified by the rupture of gas and water mains (FM Global, 2015). This not only contributes to immediate hazards but also hinders firefighting efforts. Ground shaking is another characteristic effect of earthquakes that poses threats to infrastructure, buildings, and human safety. Surveyors often assess the impact of ground shaking on structures, helping to identify vulnerable areas and improve building resilience. Another consequence is ground rupture. This occurs when movement along a fault breaks the Earth's surface (Hays, 1981). This can damage critical infrastructure like pipelines and roads, leading to disruptions and potential environmental damage. Landslides, triggered by seismic events, threaten stability on slopes, potentially causing damage to structures, roads, and natural habitats. Additionally, tsunamis generated by underwater seismic activity pose grave threats to coastal regions, requiring meticulous monitoring and early warning systems. In areas with unconsolidated ground, liquefaction and subsidence present additional risks, impacting infrastructure stability and posing challenges for surveyors engaged in land assessment and planning.

The Roles of Surveyors in Earth Tremors' Control

In the aftermath of disasters, the affected regions are often left in disarray, with structures and infrastructure decimated. In response, surveyors are increasingly called upon to play a crucial role in search and rescue operations. Their responsibilities encompass locating and deactivating essential utilities, including electricity, gas, and water, to mitigate further risks. Moreover, surveyors provide invaluable mapping assistance for retracing potential locations of individuals amidst the rubble. Timely and accurate location information is paramount in these scenarios, and Global Navigation Satellite System (GNSS) technology, employed by surveyors, proves indispensable.

The utilization of geomatics products, whether derived from satellite imagery, aerial photography, or ground surveys, forms the bedrock for effective disaster mitigation planning.

This is particularly critical in areas prone to seismic activities resulting from crustal movements or explorations. Continuous monitoring is imperative to minimize the devastating impact of phenomena such as earthquakes, volcanoes, and landslides. The insights provided by surveyors through geospatial technologies contribute significantly to understanding, planning, and responding to the dynamic challenges posed by natural disasters.

Space geodesy techniques, employing Very Long Baseline Interferometry (VLBI), Satellite Laser Ranging (SLR), and the Global Positioning System (GPS), are instrumental in acquiring precise and repetitive measurements at carefully selected points within specific areas. This methodology aims to detect crustal movements that may lead to seismic events such as earthquakes and landslides (Onyeka, 2009). Photogrammetry emerges as a potent tool for deformation measurements concerning the location, form, and shape of expansive spatial entities like volcanoes or large-scale landslides (Altan, 2005). Its distinctive advantage lies in conducting measurements based on images of hazard-prone areas.

Encouraging the implementation of precise monitoring surveys at regular intervals is paramount, especially for massive and critical engineering structures like dams, telecommunication masts, and oil and gas infrastructures (Ehigiator-Irughe et al., 2010; Otakar & Pavel, 2004; Yunus et al., 2010). This proactive approach, including speculative diagnostic analysis of soil liquefaction potential for foundation stability (Jimoh & Ige, 2011), serves as a preventive measure against infrastructural failures. Nigeria, boasting several small and over eighteen large dams, underscores the necessity of monitoring these infrastructures post-construction and during operations. This ongoing scrutiny enables the timely detection of any behavior that could compromise the structure, potentially leading to failure. Deformation monitoring involves establishing a network of geodetic control points in areas with anticipated stability. Periodic observation of signalized targets on the structure's surface from this network allows for the assessment of deformation nature, directions, and velocities. Any detected movement prompts concern for the structural integrity of the feature. Surveyors are essential in designing, developing, and implementing measurement systems, as well as evaluating and analyzing the measured quantities. Instruments employed for this purpose include GPS, close-range photogrammetry, and classical terrestrial methods like leveling, angle, and distance measurements (Ehigiator-Irughe et al., 2010; Otakar & Pavel, 2004; Yunus et al., 2010).

The impact of an earthquake transcends its magnitude; it hinges on the contextual vulnerabilities of the affected area. An earthquake of substantial magnitude in an uninhabited region might not qualify as a disaster. Conversely, a seismic event with comparatively lower intensity, striking an urban area characterized by inadequately engineered structures ill-prepared to withstand earthquakes, has the potential to inflict significant distress and hardship (International Federation of Surveyors (FIG), 2006). This underscores the critical role of surveyors in assessing and fortifying urban infrastructure to enhance resilience against seismic risks.

While the mentioned actions contribute positively to disaster response, the pivotal role lies in land use planning to proactively diminish community vulnerability and mitigate economic repercussions linked to disaster events (Devlin, 1998). Disaster-oriented land use planning involves meticulous mapping of natural hazards' extent and impacts, forming the basis for crafting land use and building policies. Effective policies require spatial data encompassing topographic details such as land elevations, geomorphology, flood characteristics, bush fire trajectories, acid sulfate soils, degraded land, and storm surge elevations (Ireland, 2001). By mapping this data, professionals like Engineers, Architects, and Town Planners can formulate precise policies, ordinances, building codes, and control measures for population density and expansion. This strategic approach guides development in specific areas, ultimately minimizing potential losses.

Geomatics plays a pivotal role in the comprehensive evaluation of damages, facilitating the rehabilitation of residential spaces, infrastructure, and public facilities, while concurrently diminishing future vulnerabilities in human settlements. The amalgamation of Photogrammetry, Remote Sensing, and LiDAR proves instrumental in meticulously analyzing structural damages post-failure. Leveraging advanced 3D-object reconstruction techniques, classification methods, and image detection, these technologies seamlessly integrate into deformation analysis procedures (Altan, 2005; Lee et al., 2006). This data acquisition approach equips allied professionals with an effective tool to discern whether a compromised building should undergo retrofitting or necessitate demolition.

In instances like the tragic I-35 Westbridge Collapse into the Mississippi River in Minneapolis on August 1, 2007, LiDAR, ground surveys, and aerial assessments played crucial roles in the damage assessment and structural analysis (http//www.rieglusa.com). Photogrammetry, Remote Sensing, and LiDAR, as survey methods, offer rapid data acquisition, enabling swift detection of damaged components within objects, urban areas, or residential zones. These geospatial techniques empower surveyors and related professionals to make informed decisions for efficient rehabilitation and risk mitigation.

GIS serves as a robust tool facilitating the seamless execution of data capture, organization, analysis, visualization, and dissemination. Particularly in emergency scenarios, the significance of GIS transcends the mere location of the event; it extends to encompass a spectrum of non-spatial information crucial for effective decision-making. Questions such as 'How many people are affected?,' 'What road networks are accessible?,' 'Where are the nearest hospitals located?,' and 'What is the capacity and specialization of nearby medical facilities?' demand prompt responses. The expeditious handling of such inquiries becomes feasible only when reliable spatial data are available in digital format and processed within a GIS framework (Government of India, 2004).

Spatial Data Infrastructure (SDI) emerges as a critical component, defined as the cohesive amalgamation of technologies, policies, and institutional arrangements. This infrastructure plays a pivotal role in facilitating the accessibility and availability of spatial data (Global Spatial Data Infrastructure, 2004). In emergency situations, the streamlined operation of SDI becomes imperative, ensuring swift and organized access to critical information that is indispensable for efficient response and management. The integration of GIS and SDI not only expedites the retrieval of spatial data but also enhances the comprehensive understanding of the multifaceted aspects associated with emergency situations.

Conclusion

Geomatics is pivotal in effective disaster management, particularly in controlling earth tremors by furnishing precise spatial data. Governments and communities need to prioritize building essential infrastructure to harness geomatics' capabilities, emphasizing the crucial role of Spatial Data Infrastructure (SDI) for swift emergency responses and effective data sharing. In a nutshell, the role of surveyors in earth tremor control is paramount, and the integration of geomatics is indispensable for effective disaster management. Geomatics, comprising technologies such as GIS, GPS, and LiDAR, provides accurate spatial data crucial for assessing damages, planning rescue operations, and implementing preventive measures. The establishment of Spatial Data Infrastructure (SDI) is vital for efficient responses to emergency situations, enabling the rapid sharing of spatial data among relevant organizations. The September 11 emergency response serves as a testament to the effectiveness of spatial information technologies in disaster management (Clarke, 2003). To enhance earth tremor controls, it is imperative that governments and communities invest in the necessary machinery and infrastructure to harness the full capabilities of geomatics.

Recommendations

The work on the role of surveyors in earth tremors control will make the following recommendations to the government, policy makers, stakeholders and to the entire citizenry:

Rescue maps should be produced at appropriate scales and regularly updated for emergency response management. These maps should encompass route locations, infrastructure details (hospitals, disaster management centers), potential shelter and resettlement locations, among others.

Research on route network analysis, especially in urban centers, to identify optimal routes (routes of least resistance) for rescue operations across different disaster scenarios should be conducted.

The continuity and improvement of early disaster warning systems through periodic deformation monitoring and measurements of significant engineering structures like dams and telecommunication masts has to be ensured. Sustained and mandatory deformation monitoring of areas prone to seismic activities is recommended.

The use of advanced survey technologies like GIS, GPS, LiDAR, and other recent ones should be promoted to maximize their capabilities in disaster management.

Nationwide identification and mapping of hazard-prone zones by the Federal, State, and Local Governments, as well as agencies like NEMA, should be conducted to create hazard maps and implement and enforce appropriate land use planning policies for these zones.

Moving forward, the recommendations outlined, including the production and regular updating of rescue maps, research on optimal rescue routes, sustained disaster warning systems, promotion of advanced survey technologies, and nationwide hazard mapping with stringent land use planning policies, should be diligently implemented. These measures not only contribute to the immediate response to earth tremors but also foster proactive strategies for disaster preparedness and mitigation. By prioritizing these actions, surveyors and relevant authorities can significantly enhance the resilience of communities in the face of seismic events.

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