Applications of Geophysical Methods in Tunnel and Oil Exploration

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Abstract. Geophysical studies can be utilized adequately to decide the land, hydro geographical and geotechnical properties of the ground mass in which the designing development is occurring. The investigation must be given to the contractor to ensure the information related to soil or to predict the type of equipment to be used and to estimate productivity and cost. This article examined how integrated geophysical methods were carried out for the determination of the degree of fracturing and rigidity of rock mass. Data were collected from different case studies in which comparison is there between different types of methods suited for different type of evaluations. In this paper, methods involved for the explorations are seismic refraction method, electrical resistivity method, magnetic and gravity method for oil explorations. The authors found that gravity and magnetic are best suited methods for the oil sand exploration and because of the high acceptance of designing a lot latest applications expected in future. The techniques used in these methods are relatively cheap and fast finding in comparison to other methods.

KEYWORDS: - Electrical resistivity tomography, seismic refraction, Magnetic, gravity

1. INTRODUCTION
Geotechnical investigations for tunnels are to a great extent fruitful luckily disregarding the innate vulnerability and danger. For both the choice of the general corridor and the specific alignment of a tunnel venture, geotechnical data can be basic. In the recent years, TSP, transient electromagnetic strategy (TEM), ground penetrating radar (GPR), infrared detection, Land-sonar, and different innovations have been utilized in the tunnel construction for different purposes such as cutting edge, topographical estimation. Wide rules and a general viewpoint are given for the arranging and directing. Geotechnical data is required during the planning of any tunnel project so the owner and designer can have more noteworthy opportunity in their determination of arrangement and development strategies and hence the more prominent likely cost investment funds. Geophysical studies can be utilized adequately to decide the
land, hydro geographical and geotechnical properties of the ground mass in which the designing development is occurring. The tunnel plan and geotechnical groups need to adapt to some considerable however not feasible difficulties controlled by underground. Topography typically influences each choice made in planning and development of a tunnel from the second a tunnel is imagined. Geography gives balanced methods for associating specific tunneling conditions, kinds of ground, and case histories. It can give a comprehensive understanding of likely issues just as their answers. The investigation must be given to the contractor to ensure the information related to soil or to predict the type of equipment to be used and to estimate productivity and cost. While working in tunnels, natural hollows and other underground projects more often than not designers are working with restricted and disgraceful data. Designing geophysics is an effective method for subsurface investigation to fill in the data holes and give a complementary source data of subsurface conditions. Geophysical tests are indirect method for investigation for example magnetism, electrical resistivity, density, elasticity, or a blend of these is utilized as a guide in the development of subsurface data. Mechanical progressions and advancement of convenient computerized information procurement instrument frameworks have expanded the versatility in assessing underground conditions and site characterization. The subsurface geophysical exams are useful towards minimization and optimizing association of the conventional direct investigation techniques, helping in quickened and efficient advancement of the underground development projects.

The investigation likewise assume a vital part in quality checks of construction and non-destructive wellbeing checks during entire life pattern of tunnels, natural hollows and other underground activities. Geophysical techniques give costly and economical methods for enhancing data got by direct exploratory methods, such as borings, test pits and in situ testing; recognizing local anomalies that probably won't be distinguished by different techniques for investigation. Geophysical testing can likewise get stiffness and dynamic properties which are needed for mathematical investigation[1], [2]. Sub-surface imaging by methods for geophysical overview is a useful asset for site evaluation and planning which verifiably has been under-used world-over.. Advances in preparing and imaging programming have made it conceivable to recognize, show, and interpret little topographical highlights with incredible exactness. In the event that a territory plans to fabricate tunnel, it needs to do geographical and designing review to find out topographical structure foundation initially. At that point the developers can realize whether exists adverse elements, for example, seam, ore body, broken width and the hydrological geological features. So tunnel planning can stay away from some terrible topographical wonder. Indeed, even the tunnel put into utilization, some exceptional constructions are as yet in the long cycle of moderate turn of events, representing a likely danger to tunnel designing. Basic geophysical techniques in tunnel overview varies from the single characteristic mineral investigation, it needs to make point by point layer for earth surface and to investigate some particular objective destinations, which are probably going to be caves, springs, or might be blames and breaks [3]–[6].

The practical applications of this study includes that there are numerous geophysical prospecting techniques which can be utilized in tunnel exploration, the most well-known strategies including seismic investigation and high-density resistivity methods and the ground penetrating radar method. Geophysical methods are proved to be effective in tunnels survey by ensuring safety and stability of tunnel[7], [8].

2. LITERATURE REVIEW

2.1 Seismic refraction method
In the Seismic refraction method seismic wave have different velocities for different type of soil and rocks. When these waves cross the boundary between two different types of soils refraction is there.

The radiating shock waves are detected by number of geophones which are installed at known intervals on ground along a line of produced shock waves.

The significance of implementing geophysical methods in addition to geological and geotechnical investigation procedures is increasing[9]. The primary objective is to accomplish an accurate and active model of the subsurface in a very short span of time. The standard use of engineering geophysical techniques will increase in the subsequent years. Because of increasing demand of geo-physics designing at construction site, a lot more extensive application of geophysical examinations is expected in future.

Seismic methodology is dependent on the variation in the rock i-e velocity and density changes with locations whereas the electrical reaction depends upon the electrical resistivity of the rock material[10]. According to this paper, an assessment of both seismic refraction and electrical imaging is used to locate a tunnel. Although there is a fact that the difference in seismic velocity and electrical resistivity between the tunnel and its encompassing material[11] can be large, still tunnels are difficult to detect. The trouble fundamentally emerges due to the spatial resolution of these method is less or depends on the order of the size of tunnels.

Geophysical techniques are non-destructive strategies that are progressively being utilized in engineering practice work. The principle reason lies in the economical and time saving when contrasted with conventional methods, mainly borehole explorations. However geophysical methods (seismic refraction method) are still used in combination with borehole techniques. By this technique a wider range of image is obtained. Many research works and practical applications are already done in the previous years; geophysical methods are actualized in the field of underground engineering.

### 3. Electrical resistivity methods

1. This method is based on the fact that the different type of soils offers different resistance to the flow of an electrical current.
2. The resistance of flow of current is determined by measurement of resistivity(p)
3. The potential difference (E) between the two inner electrodes is then measured by the given equation:

\[ P = 2 \pi D \frac{E}{I} \]  

where \( D \) = Electrode spacing

A geophysical method explorations which includes (SRT) seismic refraction tomography for planning 'P' waves was completed in San Juan Province, Sierra Santa Clara and Argentina in July’09[13][14]. The reason for the geophysical study was to predict the degree of breaking and the rigidity nature of the rock mass by which a 290 m long tunnel was constructed crossing the mountain almost perpendicular to the hub thereof, at around 100 m depth from the summit. This is the first occasion when it has been done in Argentina, bearing the depth of examination in addition to hard geographical conditions and refraction tomography at the top of the priority list.

The application of electrical resistivity imaging method in the field of civil engineering and environmental issues has been demonstrated in few case studies in Korea. The electrical resistivity
surface method helps us to plan the topographical features of a structure in large region for a very short span of time[10], [15]. The outcome was an effective excavation of the tunnel. Secondly, electrical resistivity tomography (ERT) was adopted in an exploration tunnel site to analyze the brine water movement after the infusion in a test borehole. The pathway of the groundwater stream was imagined with the couple of low conductivity zones.

4. **Gravity And Magnetic Geophysical Methods in Oil Exploration**
   1. Gravity and magnetic strategies are a fundamental piece of oil investigation. They don't supplant with seismic method or maybe, they add to it. In spite of being relatively low-resolution, they have some big advantages. These geophysical techniques inactively measure natural variation in the earth gravity and magnetic fields over a mapping region and afterward attempt to relate these varieties to geologic conditions in the subsurface. Without a controlled source.
   2. A geophysical irregularity is measured with the difference between the observed geophysical field value and the value that would be observed at a similar area if the Earth were more uniform.
   3. On comparison with seismic method, gravity and magnetic strategies are most appropriate for analyzing steep discontinuities, for example, faults. Seismic strategies, conversely, are best for identifying vertical rock variation and low-angle discontinuities, for example, layer boundaries.
   4. Gravity and magnetic methods, which are explained in this article, are very trendy in both mineral and oil investigation.

Gravity and magnetic investigation, also called as" investigation is used to give geoscientists a indirect method to "see" underneath the Earth's surface by detecting actual properties of rocks (density and polarization, separately). Gravity and magnetic investigation can help to find minerals, faults, geothermal or oil assets, and ground-water supplies. The objective of this study is that potential fields are to give a superior investigation of the subsurface topography[16]. The techniques are moderately cheap, non-invasive and nondestructive ecologically.

In the investigation carried out by, he occurrence and the structural settings of Agbabu area sand deposits were examined due to the economic significance of bitumen as a readily accessible elective source of energy[17]. The examination was completed with the use of organised geophysical methods of magnetic and electrical resistance (VES and dipole). The explanation of forward modeling of the surface magnetic shows the existence of slight dyke and fault, and the nature of the subsurface photography.

It is inferred that gravity method is the best and economical strategy in uncovering unexposed and deep situated structures, focusing on and represents oil and gas-bearing sedimentary basins, and finding fundamental part of structures inside productive basin in beginning phase of investigation in China[18]. Now It has become basic and prime geophysical method innovation in investigation for conventional oil and gas, and in particular for unconventional oil and gas recently.

5. **CONCLUSION**

It is concluded after the review of literatures, Geophysical refraction methods was a important apparatus for evaluating rock rigidity, subsurface parameters and also it will combine with other techniques for the evolution of accurate result in a short period of time. Gravity and magnetic method are the best suited and economical for the exploration of oil assets, minerals, faults and geothermal over comparison to seismic methods and also very
trendy methods these times. Electrical resistivity method is best suited for the observation of subsurface parameters even at low conductivity soil is there.

6. LIMITATIONS AND SCOPE FOR FUTURE STUDIES

The limitations of the present investigation are that there is no specific geophysical exploration method that can solve all the problems. So, for every problem we need integrated geophysical prospecting methods. Future scope is expected to vary from expansion of existing use of technologies to the introduction of entirely new techniques. At a beginning phase of site investigation it is very well might be valuable to attempt a reconnaissance geophysical survey to distinguish zones of the site which should be additionally explored utilizing obtrusive techniques.

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