ENVIRONMENTAL AND STABILITY MONITORING FOR MINES USING UNCERTAIN DATA USING ANDROID - AN APPRIASAL

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ABSTRACT

This paper presents overview of monitoring of different environmental parameters and stability of slope in the mines areas through android. Emphasis is made on urgent requirement of application of trans-disciplinary research and study the mine environmental conditions including online monitoring of mine atmosphere and mine equipment by application of wireless sensor networks and IoT devices for improved safety. Through Android smart phone, environmental monitoring parameters can be transmitted along with other parameters such as slope movements by suitable sensors. This data may be useful for taking safety measures based on the real-time data in opencast mines. If the Environmental parameter values for a particular region are high, then alert message can also be broadcasted through Android.

INTRODUCTION

Environment play an important role in regulating air and climate. Good environment is necessary for proper physical and mental health too. Technological development and industrialization have the adverse effect on the environmental parameters. Due to human activities, the three basic things air, water and land are polluted. Thus monitoring the environmental parameters is essential. The air of the atmosphere is a mixture of several gases and its composition is practically constant over the whole surface of the earth. Because air is mixture and not a chemical substance, the components can be separated. There are four fundamental sources of hazardous gas in mining applications ; Gasses from Blasting, Methane from Coal Beds, Vehicle Exhaust, and Penetrating into Stagnant Water. Fig 1 shows different type of sensors for environmental monitoring. Blasting generates toxic and harmful gases. These harmful gasses include carbon monoxide and nitrogen dioxide. As a result of the utilization of oxygen in any such impact, oxygen deficiency might likewise be an outcome. Profoundly flammable methane (CH4) or firedamp, as it is brought in numerous coal-fields, is framed in the last phases of coal arrangement, and due to the profundities and weights, it gets to be imbedded in the coal. As unearthingis made, methane gas is freed into the air. Gas is transmitted from the purpose of unearthing, as well as from the coal being transported to the surface. Vehicles are also generated various toxic and poisonous gases. These poisonous gases are an after effect of the operation of burning motors. Pockets of stagnant water can contain a lot of hydrogen sulphide (H₂S) coming out essentially due to the breakdown of pyrites.

Fig 1: Different type of sensors for environmental monitoring

Due to various issues related to environmental pollution by mining activity in underground and opencast mines, it is required to continuously monitor the gases parameters and broadcast the data in real time to
take appropriate action by the concerned for improved safety of the mines. Data can be monitored at the base station and critical data can be broadcast to different uses through android. Along with environmental parameters, the data related to stability of mines can also be generated through appropriate sensors, and can be communicated through android to concerned officials for taking necessary action. Many investigations on various aspects of mining including slope stability monitoring in opencast mines, atmosphere monitoring in mines, strata behavior monitoring etc through various types of sensors over three decades were conducted by the second author[1-6]. Geomining conditions of a typical opencast chromites mine along with the data on slope stability generated through conventional approaches such as total station is presented below.

GEOMINING CONDITIONS - OPENCAST CHROMITE MINE

Ostapal Chromite mine is located in the Sukinda valley in Odisha state. A waste dump has been created adjacent to the northern boundary of the ostapal Chromite mines lease wherein the excavated overburden mass of the ostapal quarry is being dumped. Fig.2 shows Present condition of the workings on June 9, 2017. Maximum height of dump in North and South dumps are about 87 m, and 41 m, respectively. Maximum number of decks in North and South dumps is 6, and 3, respectively. Maximum Deck height in North and South dumps are about 17m, and 15m, respectively. The mine is in subtropical climate. The average annual rainfall is about 1200mm, of which 95% precipitation is during the rainy season (June to September), which results in quick run off from the dump area due to sloping topography. There is no perennial source or channel of water near the dump. The length of the dump is about 680m and width varies from 280 to 350m. The current dump height is about 78m with overall slope angle varying from 20 to 33° to the horizontal. The waste dump is benched ranging from 5 to 30m heights. The overburden dump consists of mainly hard and friable laterite, green serpentinite, chart and soft friable brown serpentinite, nickeliferous limonite, C O B tailings and boulders of the hard quartzite. The average cohesion as reported by the mine authorities was 0.49kg/cm, the average friction angle of 30 degrees and the unit weight of the sample 1.8t/m. Figure 2 represents Plan view of the mine along with dumps. Figure 3 and 4 detailed Plan view of the South and North dumps, respectively.

STABILITY ANALYSIS VIS-A-VIS NUMERICAL MODELING

The stability analysis was done by FLAC SLOPE software, considering three vertical cross sections AA’, BB’, CC’ and one horizontal section HH’ for South dump. The factor of safety estimated for the above sections is found to be more than 1.2 indicating stability of dumps. FOS attained for three vertical Sections 2800E, 2900E, 3000E and one horizontal section 3300N the above sections as 1.42, 1.28, 1.15 and 1.47, respectively. The stability analyses were done to determine the slope stability condition of the existing dump with the slope profile shown in the sections. The results of the analyses are presented in the Table 1. Figure 3 shows plan view of the south dump along the AA’, while the result of numerical model
with FOS of 6.81 indicating stability of dump is represented in Figure 6. Figure 4 shows the Section of the North dump along the 3000E. Figure 5 shows the Simulation output of the North dump along the 3000E Section using FLAC with FOS of 1.15 indicating stability of dump.

Table.1. Stability analyses of various sections of north and south dump

<table>
<thead>
<tr>
<th>DUMP</th>
<th>SECTION</th>
<th>Factor of safety (FOS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SOUTH</td>
<td>A-A’</td>
<td>6.81</td>
</tr>
<tr>
<td></td>
<td>B-B’</td>
<td>1.41</td>
</tr>
<tr>
<td></td>
<td>C-C’</td>
<td>2.49</td>
</tr>
<tr>
<td></td>
<td>H-H’</td>
<td>2.67</td>
</tr>
<tr>
<td>NORTH</td>
<td>2800E</td>
<td>1.42</td>
</tr>
<tr>
<td></td>
<td>2900E</td>
<td>1.28</td>
</tr>
<tr>
<td></td>
<td>3000E</td>
<td>1.15</td>
</tr>
<tr>
<td></td>
<td>3300N</td>
<td>1.47</td>
</tr>
</tbody>
</table>

The FOS achieved for the three vertical Sections 2800E, 2900E, 3000E and one horizontal section 3300N for the North dump was 1.42, 1.28, 1.15 and 1.47, respectively indicating the stability of dumps in drained condition of slopes. Similarly, the FOS reached for the three vertical Sections AA’, BB’, CC’ and one horizontal section H-H’ for the North dump was 6.81, 1.41, 2.49, and 2.67, respectively indicating the stability of dumps in drained condition of slopes. In saturated condition of slope, there is a possibility of
reduction of FOS, which may lead to failure of slope, and hence proper drainage is highly solicited. As the FOS for the vertical Section 3000E for the North dump was 1.15, efforts may be made to regrade the dump, accordingly to minimize the any scope of further reduction of FOS.

Fig 5: Simulation of the North dump along the 3000E Section using FLAC Slope

The existing external dump with its profile is likely to be safe in drained condition with good drainage in and around the dump. The dump mass must be maintained in drained condition. Water entry must be checked from entering in to the toe of the dump to avoid inundation of the dump to be providing suitable and effective drainage. Attention must be paid to avoid of rain / surface water in the slope by providing suitable and effective drainage in and around the dump. It should be taken up well before the onset of monsoon.

SLOPE STABILITY ANALYSIS VIS-A-VIS OBSERVATIONS BY TOTAL STATION

Dump slopes has been monitored with total station and monitoring stations fixed at an interval of 20 to 50 m on the dumps at a distance of about 1m from the crest of the dump slope (Fig 6). The monitoring stations are located at 25m to 50m interval in the zone of interest and on different levels of the dump. Stability of 31 monitoring stations was installed at south dump and 120 stations in the north dump. Some of the monitoring stations i.e.2/1,7/1 and 10/1 in south is relocated since the formation of bench in progress. Thirty one monitoring stations are installed and considered for the analysis of stability of south dump. 120 monitoring stations are installed in North dump and 25 monitoring stations along the cross section 3300N were considered for the analysis of the North Dump. These stations are DM – 6, DM – 7, DM - 8, DM - 9, DM – 12, DM - 13/1, DM - 14/1 , DM - 15/1, DM - 25/0, DM - 27/1, 25/1, 25/5, 25/6, 25/7/1, 25/9/2, 25/10/2, 25/11/1, 25/13, 25/14, 25/15/1, 25/37, 25/38/1, 25/50. The Monitoring stations are surveyed with reference to the base station associated with a reference station. The movement of each station is calculated with comparison to the initial reading. Table 2. Shows the maximum changes in horizontal distance during January 2017 to May 2017 in South Dump.

Table 2. Maximum Changes Observed in Horizontal distance during the January 2017 to May 2017 in South Dump.

<table>
<thead>
<tr>
<th>Station No</th>
<th>Maximum Changes in Horizontal Distance (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>January</td>
</tr>
<tr>
<td>01</td>
<td>0.046</td>
</tr>
<tr>
<td>02/1</td>
<td>0.052</td>
</tr>
<tr>
<td>03</td>
<td>0.051</td>
</tr>
</tbody>
</table>
In view of many limitations of the conventional monitoring systems for various geotechnical parameters to understand stability, it is proposed to implement various type of sensors for stability monitoring as well as climatic conditions in the mines and communicate the data through android to the concerned officials. Many investigators conducted studies on various types of sensors and wireless sensor systems [6-7]. Scope of application of android for the above purpose is discussed below:

**SCOPE OF APPLICATION OF ANDROID**

Android is the most widely used mobile OS developed by Google. Designed primarily for touch screen mobile devices such as smart phones and tablet computers. Founded in Palo Alto of California in 2003. The android is an open source operating system means that it’s free and anyone can use it. Android is a Linux based operating system. The hardware that supports android software is based on ARM architecture platform. The android development supports with the full java programming language. Android operating systems are named after desserts. Google put different versions of sugary names in alphabetical order. Android9 Pie, 16th version of Android harnesses the power of artificial intelligence. Android8 Oreo, 15th version of android, includes notification grouping, picture in picture support for video etc. Fig 7 shows various Android operating systems named after desserts.
**Android architecture**

1. **Linux Kernel**: The Linux Kernel provides a level of abstraction between the device hardware and the upper layers of the Android's software stack (Fig 8).
2. **Library**: Android library includes the application framework libraries in addition to those that facilitate user interface building, graphics drawing, and database access.
3. **Application framework**: The Application Framework layer provides many higher level services to applications in the form of Java classes.
4. **Android runtime**: This section provides a key component called Dalvik Virtual Machine which is a kind of Java Virtual Machine specially designed and optimized for Android.
5. **Runtime applications**: Each Android application runs as a process directly on the Linux kernel. In fact, each application running on an Android device does so within its own instance of the

Fig 9 represents Environmental parameters (temperature, humidity) measured by various sensors. Fig 10 illustrates the possibility of an alert message broadcasted through smartphones.
METHOD OF ENVIRONMENTAL MONITORING

Environmental monitoring consists of 4 phases.
1. Measurement phase
2. Transmission phase
3. Computation phase
4. Broadcast Phase

Measurement Phase
In the Measurement phase, Environmental parameters of a particular location are measured by different sensors. Different environmental parameters are temperature, humidity, CO₂, CO, pressure etc.

Transmission phase
The measured sensors data values from a particular location should be transmitted to the base station for computation. This transmission can be done by two methods.
(a) Through Bluetooth network available through smart phone.
(b) Through Vehicular ad-hoc network (VANET)

Computation Phase
In the Computation phase, the uncertainty environmental parameters are handled at the base station. Current parameters values can be compared with different stable threshold values. If the current values are more than different threshold values, then appropriate message can be broadcasted through Android.

Broadcast Phase
If during computation phase, environmental parameters are found to be high, then an alert message can be broadcasted through smart phones.

Role of Android in Environmental monitoring

Different Android apps are designed to fight with climate change. Some examples are Modeling; Community Erosion from Climate Change, Minnesota Solar Suitability Analysis, Every DropLA etc. Flood forecast information can be provided to a person in a particular area through Android App. Different Android apps are designed to provide rain forecast information. Flood forecast information can be provided to a person in a particular area through Android App.
With meticulous application of the above system of gas monitoring and slope stability monitoring in opencast mining conditions, real time data can be provided to the concerned officials for taking appropriate decisions by the mining officials.

CONCLUSION

Thus through Android smart phone, environmental monitoring parameters can be transmitted along with other parameters such as slope movements by suitable sensors. This data may be useful for taking safety measures based on the real-time data in opencast mines. If the Environmental parameter values for a particular region are high, then alert message can also be broadcasted through Android. In view of recent disasters due to slope failures in India (Involving 23 fatalities at ECL mines in December 2016), and many issues of mine gases in underground and opencast mines, there is an urgent requirement of application of trans-disciplinary research and study the mine environmental conditions including online monitoring of mine atmosphere and mine equipment by application of wireless sensor networks and IoT devices for improved safety.

REFERENCES