Abstract

Landslide is a natural phenomenon which is occur due to either by manmade or due to natural factors. Landslide occurrences in hillside development areas play an important role to modify the landslide. Hillside cutting and levelling for habitation and development of areas is an example of manmade activity which is a reason for land sliding in that area. Natural factors such as heavy rainfall, flood in river, etc., are the examples of natural factors. So for that purpose for understanding their technical aspects we undertake investigation in Mulshi Tehsil at Tamhini Ghat. There are six landslide occurred in Tamhini Ghat in this year (2016). In our investigation and survey, we collect rock and soil sample from site in which we will done various tests for investigating their properties. In our survey with our guides, we take GPS reading means latitude, longitude and elevation of those points and also understood the geological and geomorphologic characteristics of rock and soil. The first stage of our project is to preliminary survey and collecting geological information of site and in second stage the collection of sample of each point and testing soil and rock sample and their results can be compare to ASTM. After testing we decide this specific area is prone to landslide. If the area is prone to landslide we suggest the remedial measures to competent authority.
I. INTRODUCTION

In our modern life safety of human and properties from various natural and manmade activities becomes difficult, in which landslide ranks seventh by which rate of death and injuries are very much. “Landslide is the rapid displacement of rocks, residual soil or sediments adjoining a slope and centre of gravity of moving mass advances in a downward and outward direction."Landslide occurrence is due to significant change in shear strength and shear stress of soil laid. When shear stress is more than shear strength of soil mass then landslide is usually happen. A landslide occurs when the part of natural slope unable to support its own weight due to natural or manmade reasons. For example, soil strata on a slippery surface below it or toe of the slope cut by manmade activity, can become heavy with prolonged heavy rain fall and may slide down due to the increasing weight of the soil strata. India is one of the fastest developing countries in the world. The rate of development in India is very much fast. Housing development and road development are increased and also cost of landslide increasing day by day hence, population turns to buy inexpensive land. Also for road development to connect one city to another hillside cutting is done and this tends to weakness in soil strength. The landslide occurrence speed depends on the slope of the hill cliff. The mass of moving soil material or stone can destroy the property along its path of movement and cause death to people and living hood. Generally, landslide occurs in the low slope gradient ground too. Increasing the demand of infrastructure and cheap residence has caused the development on hill. Mulshi Tehsil region is having heavy and prolonged rainfall and most prone area to landslide and till not studied by the landslide point of view by any national and international researchers. Every year there is news in newspaper about Tamhini Ghat about landslide. Tamhini Ghat is having highest chances to be in the landslide activity. During our visit the landslide incidents was present in complex manner. The geological survey of India carried out the study of landslide hazards which is divided into two types such as:

i.) Studies before disaster:

ii.) Studies after disaster:

Studies before disaster:

Generally in pre disasters studies we try to forecast possible landslide duration by studying environmental and geological conditions of the area. GSI use Landslide hazard zonation mapping technique on the various scales. In below given photo shown the landslide zones in India. GSI divide all part of India in five zones such as very high hazard zone, high hazard zone, moderately hazard zone, low hazard zone and very low hazard zone. By which Maharashtra comes under low or moderately hazard zone.

Studies after disaster:

Studies after disaster are done various national and international agencies if it is massive landslide and in which they go through detail investigation and analysis of landslides and after that they may suggests and remedial measures. Himalaya region, Western Ghat, Vindyas and Nilgiri is the most prone region to landslide in India.
II. STUDY AREA

We selected area for study is Tamhini Ghat which in comes under western Ghat region. There latitude and longitude are given in table. There are six landslide occurred in between this latitude and longitude. Their average elevation is about 150-200 feet and their length various according their speed and area. The lithology is also different at different six sites commonly deeply weathered, moderately weathered compact basalt are found at various places. At some places spheroidal weathering block jointing is also found. Soils are reddish brown in color and rich in sandy sediment and it is fine to course in size. There is development road in this area which is further connects to Konkan region. Here some past landslide which is occurs in India are listed below:

Table 1: Landslides in India

<table>
<thead>
<tr>
<th>Date</th>
<th>Place of landslide</th>
<th>Remarks/ Reason</th>
</tr>
</thead>
<tbody>
<tr>
<td>6th Sept. 2007</td>
<td>Village Baram/ Sia Ladhar, Dharchula Pithorgarh district, Uttarakhand.</td>
<td>A landslide due to excessive rainfall 15 fatalities and loss of livestock.</td>
</tr>
<tr>
<td>14th Sept. 2008</td>
<td>Parampure District, Arunachal Pradesh</td>
<td>17 peoples were killed due to landslide preceeded by heavy rainfall</td>
</tr>
<tr>
<td>16th June 2013</td>
<td>Kedarnath, Uttarakhand</td>
<td>Cloud bursting took place and more than 5700 causalities takes place</td>
</tr>
<tr>
<td>30th July 2014</td>
<td>Malin, Pune, Maharashtra</td>
<td>More than 200 people died in the tragedy.</td>
</tr>
<tr>
<td>26th July 2015</td>
<td>Sakinaka, Mumbai, Maharashtra</td>
<td>104 people were died.</td>
</tr>
</tbody>
</table>
Table 2 : Topographical and geological information of study area

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Location</th>
<th>Lat-Long</th>
<th>Type of movement</th>
<th>H</th>
<th>L</th>
<th>Nature of slope</th>
<th>Lithology</th>
<th>Vegetation</th>
<th>Nature of soil and rate of erosion</th>
</tr>
</thead>
<tbody>
<tr>
<td>01.</td>
<td>100 m before the Tamhini village square, near bridge along stream no. 01.</td>
<td>N18°23'866&quot;, E74°00'896&quot;</td>
<td>Subsidence</td>
<td>70 feet</td>
<td>200 feet</td>
<td>Vertical 85°-95°</td>
<td>Deeply weathered compact basalt followed by moderately weathered compact basalt underlain by columnar jointed compact basalt.</td>
<td>Moderate to dense</td>
<td>Fine to coarse High erosion</td>
</tr>
<tr>
<td>02.</td>
<td>After the Tamhini village along stream no.3, 100 m before the Vijaimata temple in Tamhini.</td>
<td>N18°27'167&quot;, E73°26'066&quot;</td>
<td>Subsidence</td>
<td>50 feet</td>
<td>180 feet</td>
<td>50°-80° very steep</td>
<td>Spheroidal weathering followed by deeply weathered upper section rest on compact basalt</td>
<td>Moderate to dense</td>
<td>Reddish brown High erosion</td>
</tr>
<tr>
<td>03.</td>
<td>In front of Siddha-Bhairavnath temple in Tamhini Ghat</td>
<td>N18°28'400&quot;, E73°26'565&quot;</td>
<td>Subsidence</td>
<td>55 feet</td>
<td>70 feet</td>
<td>85°-95°</td>
<td>Spheroidal weathered compact basalt followed by red tachylitic basalt followed by spheroidal weathering followed by deeply weathered soil.</td>
<td>Moderate to scanty</td>
<td>Reddish High erosion</td>
</tr>
<tr>
<td>04.</td>
<td>At the second turn at the downstream of Tamhini Ghat downstream region</td>
<td>N18°23'383&quot;, E73°23'394&quot;</td>
<td>Landslide</td>
<td>80 feet</td>
<td>150 feet</td>
<td>Steep slope 65°-75°</td>
<td>Compact phosphoric basalt followed by compact basalt followed by deeply weathered soil.</td>
<td>Moderate to scanty (at places trees are up-rooted and collapse down)</td>
<td>Reddish Very high erosion</td>
</tr>
<tr>
<td>No.</td>
<td>Description</td>
<td>Coordinates</td>
<td>Measurements</td>
<td>Soil Conditions</td>
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<tr>
<td>05</td>
<td>Left side sharp turn from the Konkan to Tamhini</td>
<td>N 18°24'32.68&quot;</td>
<td>55 feet</td>
<td>Block jointed compact basalt soil followed by spheroidal weathering compact basalt followed by deeply weathered compact basalt followed by reddish thick soil.</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>E 73°24'200&quot;</td>
<td>200 feet</td>
<td>Moderate to scanty</td>
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<tr>
<td>06</td>
<td>At the downstream of Khind (cliff) at the beginning of Tamhini Ghat, Hothar Phata 100 m downstream.</td>
<td>N 18°23'95.6&quot;</td>
<td>110 feet</td>
<td>Block jointed compact basalt soil followed by spheroidal weathering compact basalt followed by deeply weathered compact basalt followed by compact soil followed by loose soil.</td>
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<tr>
<td></td>
<td></td>
<td>E 73°23'106&quot;</td>
<td>100 feet</td>
<td>Moderate to scanty</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Vertical 80°-85° vertical slope. Base 90° vertical</td>
<td>Moderate to scanty</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Block jointed compact basalt soil followed by spheroidal weathering compact basalt followed by deeply weathered compact basalt followed by compact soil followed by loose soil.</td>
<td>Reddish brown rich in talc and cobalt and sandy sediment. High erosion</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Image No. 1 Existing landslide in Tamhini Ghat

Map No.2 Satellite map of study area

Dr. Pandurang D. Sable, Sagar M. Gawande, Laxmikant P. Bangar, Pavan B. Wanare, Amit T. Sagar :: Landslide investigation in Mulshi Tehsil - A case study of Tamhini Ghat
III. METHODOLOGY
Our methodology of this project is to preliminary survey for obtaining various geological data such as latitude and longitude. The field work and survey identify and notify the landslide activities such scars, remedial measures and vulnerable zone has been conducted in study area. We took latitude and longitude for location purpose by using standard GPS instrument. Study map has been generated through elsewhere software. The surveys are used to classify to differentiate the mitigation level of action and interpret further. In further stage we collected sample for testing it in lab and their results can be compare to ASTM, then we will decide the area prone to landslide or not.

IV. LANDSLIDES
Landslide in Tamhini Ghat is occurs due to heavy rainfall in the locality. In the Western Ghat region in Tamhini Ghat village along the road are more and continuous landslides are occurring because of manmade activity and natural activity, the soil loosen its strength of creep day by day due to weight of soil which will slide down.

V. REMEDIAL MEASURES
Remedial measures are provided according their hazards to population. There are various way to provide measures such as one can provide vegetation for increasing density of soil along slope, pitching of stone on slope, retaining wall along hill side road sectors, net bolting techniques, closed conduit trenches, bunds, etc., are the remedial measures.

VI. CONCLUSION
Conclusion of our project after studying various parameters and investigating the sites we measurably found that anthropogenic and natural phenomenon are the reason for landslides in Tamhini Ghat. Heavy rainfall in July to August of 2016 is found main reason. There is need to aware people about landslide before they built their residence in such places. For the purpose of acquiring land, cutting of hill should be minimized or if there is possible by proper engineering method should be adopted.

VII. ACKNOWLEDGEMENT
This study is a part of investigating the reason of landslides in Tamhini Ghat and further providing remedial measures to minimize the landslide if necessary. The authors are also grateful to Dr. S. B. Thakare of ABMSP’S “Anantrao Pawar College of Engineering and Research, Pune” for his moral supports. The authors are grateful to Dr. P. D. Sable, Prof. in Deccan College of Post Graduate and Research Institute, Yerwada, Pune and Prof. S. M. Gawande Head of Civil Engineering Department at Anantrao Pawar College of Engineering and Research, Parvati, Pune for their supports and valuable guidance in our paper. Last but not the least authors are grateful to management staff, college staff members, Peons, etc for their supports in our project.
VIII. REFERENCES


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