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AN OVERVIEW OF SLOPE STABILITY ANALYSIS METHODS AND THEIR SUITABILITY FOR DIFFERENT TERRAIN TYPES IN MAHARASHTRA

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ABSTRACT

The field of slope stability analysis has seen rapid growth in geotechnical engineering due to the increased significance of providing safe and economical slopes, especially after several catastrophic slope failures. The aim of slope stability analysis is to identify potential slope failure mechanisms, predict the stability of slopes under various conditions, and recommend appropriate measures to prevent slope failure. This paper provides a comprehensive review of slope stability analysis with a focus on the Maharashtra region. Slope stability analysis is critical in assessing the stability of slopes in geotechnical engineering, particularly in hilly terrains where the risk of landslides is high. The research findings reveal that the suitability of slope stability analysis methods varies depending on the terrain type and slope conditions in the Maharashtra region. The paper provides a valuable reference for engineers and researchers working on slope stability analysis and management in hilly terrains in the Maharashtra region.

Keywords: Landslides disaster, Landslide mitigation, slope stability analysis, Maharashtra, geotechnical engineering, terrain types.

1. INTRODUCTION

In geology and civil engineering, a slope refers to a surface that forms an angle with the horizontal plane. It is essentially a change in elevation or height over a horizontal distance. Slopes can be natural or man-made, and can range from gentle inclines to steep mountainsides. Slopes can be found in various forms such as hills, mountains, cliffs, dunes, and embankments. Slope failure, also known as landslides, refers to the movement of soil, rock, and other debris down a slope under the influence of gravity. Slope failure occurs when the forces driving the movement of the slope exceed the forces resisting the movement, causing the slope to collapse or slide downhill. Slope failure can occur due to various reasons such as heavy rainfall, earthquakes, poor slope design or construction, and changes in soil conditions. Slope failures can cause significant damage to infrastructure and property, and can also pose a threat to human life. Therefore, it is important to conduct slope stability analysis and take appropriate measures to prevent slope failure in areas prone to instability. Slope stability analysis is an important aspect of geotechnical engineering, which is concerned with the stability and safety of slopes to ensure safe construction practices.

2. LITERATURE REVIEW

To reduce the risk of landslides, various mitigation and prevention measures have been proposed and implemented in India. In this paper, we discussed some of the commonly used landslide mitigation and prevention measures in India, their effectiveness, and their limitations.

2.1 Chu, J et al. 2005-, published the artical "International Conference on Geotechnical Engineering for Disaster Mitigation and Rehabilitation". It was released by World Scientific in 2005 with the intention of addressing the crucial geotechnical engineering concerns related to catastrophe recovery and mitigation. Understanding and controlling the geotechnical impact of natural disasters like earthquakes, landslides, and floods depend significantly on the science of geotechnical engineering. Geotechnical risks, risk analysis, disaster management tactics, and geotechnical interventions for post-disaster recovery are just a few of the topics addressed in this reserch on disaster mitigation and rehabilitation. Researchers, engineers, and industry professionals can explore creative solutions to geotechnical problems in disaster-prone locations and exchange information and experiences at the conference. For experts in geotechnical engineering, catastrophe management, urban planning, and related fields, the book is an invaluable resource. It provides useful information, case studies, and technological developments that aid in the creation of successful plans for reducing and remediating geotechnical risks.

2.2 Inagaki &Sadohara, (2006)-The essay examines the value of slope management planning as a successful approach to preventing landslip tragedies in metropolitan environments. The authors stress that because of a variety of circumstances, including steep slopes, intense rainfall, and human activity, metropolitan areas are particularly prone to landslides.The study emphasises the necessity of thorough slope management planning that uses a multidisciplinary approach. The three primary stages the authors suggest for managing slopes are hazard assessment, vulnerability assessment, and risk assessment. Based on geological and topographical considerations, hazard assessment entails locating locations that may be prone to landslides. Evaluation of landslip susceptibility is a key component of vulnerability assessment. To calculate the total risk level, the hazard and vulnerability analyses are combined.The essay emphasises the significance of data collection and monitoring methods for successful slope management planning. The authors advise gathering information on slope stability, rainfall patterns, and ground movements using cutting-edge technology, including remote sensing, geographic information systems (GIS), and ground-based monitoring systems. Accurate hazard and risk assessments depend on this information.The research also emphasises the necessity of stakeholder participation in slope management planning. Better risk assessment and execution of suitable mitigation strategies might result from including local people, government organisations, and specialists in the decision-making process.As a critical tactic for preventing landslip tragedies in urban settings, the article's conclusion highlights the significance of slope management planning. Urban areas may better prepare for and reduce the dangers associated with landslides by putting into practise a systematic strategy that incorporates hazard, vulnerability, and risk assessments, sophisticated data collection techniques, and stakeholder participation.

2.3 Popescu &Sasahara, (2009)- the study addresses several technical tactics and safeguards against landslip catastrophes. The authors stress how crucial it is to implement efficient mitigation strategies to lessen the danger and effects of landslides, which pose serious risks to infrastructure and human life.Beginning with an overview of landslip dangers and their root causes, the study emphasises the necessity for all-encompassing solutions to this problem. The article then goes into detail on the many engineering strategies that may be used to lessen landslip tragedies. These actions fall into one of three categories: landslip mitigation, landslip control, or both.Measures to prevent or lessen the occurrence of landslides are the main goal of these programmes. They include methods for enhancing slope stability through plant cover as well as slope reinforcement methods like soil nailing or reinforcement with retaining structures. To reduce landslip risk in sensitive locations, the authors also touch on the significance of sound land-use planning and zoning laws.Measures to prevent landslides are designed to slow their progression and lessen their effects. This entails building protective structures like retaining walls and barriers to divert or intercept landslip debris and installing drainage systems to lessen water penetration and pore pressure.Mitigation strategies for landslides concentrate on lessening their effects. They comprise early warning systems, emergency action plans, and the creation of evacuation plans. In order to adopt efficient mitigation strategies, the authors stress the significance of community involvement and public knowledge.The report concludes by emphasising the need for engineering solutions in landslip catastrophe prevention. It is possible to reduce the hazards associated with landslides and ensure the security of infrastructure and populations by combining preventive, control, and mitigation techniques. For politicians, engineers, and academics working on landslip risk reduction and catastrophe management initiatives, the study's findings offer useful insights.

2.4 The article wrote by Vasistha- H. B., Rawat, and Soni, P. is "Hazards Mitigation through Application of Bioengineering Measures in Landslip Areas" It was released in 2011 and focuses on using bioengineering techniques to reduce risks in landslide-prone locations. The paper offers significant insights into the application of nature-based solutions for landslip mitigation, even if the publishing date is not stated. Particularly in areas with steep slopes and unstable terrain, landslides pose serious dangers to infrastructure, human life, and the environment. The potential of bioengineering techniques as a successful strategy to reduce the risks of landslides is highlighted in this article. To stabilise slopes, stop erosion, and strengthen soil, bioengineering uses live plant materials and ecological methods. The authors examine numerous bioengineering strategies, including the installation of biomats, root reinforcement, and vegetative slope stabilisation. They go through the benefits of these actions, such as their sustainability over the long run, affordability, and eco-friendliness. The efficacy of bioengineering interventions is ensured by the article's emphasis on site-specific concerns and wise plant species selection.

2.5 Fowze, J. S. M.- et al., wrote the paper "Rain-triggered landslide hazards and mitigation measures in Thailand: From research to practise". In 2012, it published in the journal Geotextiles and Geomembranes. The project focuses on assessing the risks of landslides caused by rain in Thailand and putting such risks under control via the application of research-based mitigation strategies. Landslides are known to occur commonly in Thailand, especially during the rainy season. In order to reduce the effects on infrastructure and communities, this article discusses the necessity of effective landslide hazard assessment and mitigation techniques. In order to assess slope stability and identify high-risk regions, the authors offer a thorough assessment that includes field research, laboratory experiments, and numerical modelling. The research's conclusions highlight the impact of several elements, including soil properties, topography, and rainfall patterns, on rainfall-induced landslides. The paper emphasises the importance of these elements in order to create site-specific mitigation strategies. The writers discuss a number of mitigation approaches, such as drainage systems, slope stabilisation methods, and early warning systems, that can be used to reduce landslip risks.

2.6 Miele, P., et al. 2021-, wrote the article "Temporal efficiencies of soil bioengineering techniques to mitigate geo-hydrological risks". In 2021, it appeared in the journal Ecological Engineering. The main objective of the study is to assess the temporal effectiveness of soil bioengineering methods in reducing geo-hydrological hazards. The sustainable management of landscapes is severely hampered by geo-hydrological concerns including erosion and slope instability. Techniques for soil bioengineering provide environmentally friendly approaches that make use of living plant materials for erosion prevention and slope stabilization. This article looks at how various methods function over time while taking into account how beneficial they are to the environment. The authors conducted field investigations and monitored certain places where soil bioengineering techniques were used. By examining the plant growth, soil stabilization, and erosion management over time, they evaluated the temporal effectiveness of the approaches. The study provides information on the effectiveness, longevity, and upkeep needs of several soil bioengineering techniques. The results demonstrate the temporal efficacy of several approaches, including vegetative reinforcement, live crib walls, and brush stacking. For successful implementation, the essay emphasizes the significance of choosing the right plant species, comprehending their development dynamics, and taking into account the site-specific circumstances. Additionally, it covers the ecological advantages of soil bioengineering, such as increased biodiversity and ecosystem services.

2.7 Susanti et al., (2021)-, the research focuses on landslip catastrophe mitigation techniques in Indonesia's Banjarnegara Regency. The area's mountainous topography and heavy rains make it prone to landslides. The authors' goal is to offer information on practical ways to lessen the effect of landslides on nearby populations. Field surveys, data gathering, and analysis are all components of the research approach. The authors list a number of causes for landslides, such as geological variables, rainfall patterns, land use, and human activities. The study suggests appropriate mitigation measures based on an awareness of these aspects. The significance of landslip early warning systems is emphasised throughout the text. In order to identify slope instability and foresee probable landslides, it recommends using monitoring tools including inclinometers, piezometers, and rainfall gauges. In order to improve readiness and response to landslides, the research also emphasises the necessity of community participation and awareness programmes. For policymakers and local authorities to create successful disaster management strategies, the study's findings offer invaluable insights. To reduce the danger of landslides, the authors advise establishing land-use planning and zoning rules. They also stress the significance of using sustainable land management techniques to stabilise slopes and stop soil erosion, such as terracing and replanting.Overall, the study advances knowledge of landslide mitigation techniques in Banjarnegara Regency and provides a useful foundation for future research and real-world interventions in other landslide-prone regions.

2.8 Salimah, (2021), In the Satui area of Tanah Bumbu, South Kalimantan, the paper discusses the crucial problem of landslip mitigation. In order to reduce the danger of landslides in the region, the research will analyse slope stability and provide practical solutions. The author begins by addressing the importance of landslip dangers, emphasising their destructive character and the potential risks they bring to infrastructure and human life. The Satui area, which is known for its mountainous topography and has already seen multiple landslides, is the subject of the investigation. Salimah intends to find problematic regions and create effective mitigation solutions by doing a slope stability analysis. Field research, geotechnical testing, and numerical modelling are just a few of the techniques the study uses to evaluate slope stability. In order to identify the variables causing slope instability, the author collects information on the soil qualities, groundwater conditions, and geological parameters. The author determines important locations vulnerable to landslides and evaluates the stability of various slopes with the use of advanced modelling tools. Salimah makes many mitigating suggestions to improve slope stability in light of the findings. These include engineering fixes like vegetation management, surface water management, and slope reinforcement. The author also stresses the value of early warning systems and community readiness to reduce the effects of prospective landslides. In conclusion, the writer's work offers insightful information about slope stability analysis and landslip mitigation in the Satui region. In order to reduce the danger of landslides and safeguard the community and infrastructure in Tanah Bumbu, South Kalimantan, local authorities, engineers, and policymakers can make use of the results and suggestions.

2.9 The authors of the article- "Modelling the impact of landslides on geosynthetic-reinforced barrier using DEM-FDM analyses" are S. Cuomo,et al. 2022, In 2022, it was printed in the Materials Science and Engineering Conference Series of the IOP. In this work, Discrete Element Method (DEM) and Finite Difference Method (FDM) are coupled to predict the effects of landslides on geosynthetic-reinforced barriers. In geotechnical engineering, geosynthetic-reinforced barriers are frequently employed for slope stabilisation and erosion control. In order to evaluate the performance and behaviour of such barriers under landslip situations, precise numerical models are required, as is discussed in this study. By combining DEM, which replicates the behaviour of individual particles, with FDM, which models the continuous medium, the authors suggest a revolutionary strategy. The researchers examine how geosynthetic-reinforced barriers respond to various landslip scenarios using DEM-FDM studies. They assess the barrier's efficacy in avoiding or minimising slope failure by taking into account variables including slope inclination, landslip characteristics, and barrier geometry. The work sheds light on the patterns of deformation, the distribution of stress, and the causes of failure connected to the interaction between landslides and geosynthetic-reinforced barriers.

2.10 Ma, S., Jia, and Liu,- X. wrote a paper "Effect of the Wall-Back Inclination Angle on the Inertial Loading Distribution along Gravity-Retaining Walls: An Experimental Study on the Shaking Table Test". In 2022, it was published in Advances in Civil Engineering. The primary objective of the study is to conduct a shaking table test to examine how the wall-back inclination angle affects the distribution of inertial loads along gravity-retaining walls. In civil engineering projects, gravity-retaining walls are essential for stabilizing slopes and provide structural support. In order to better understand how wall-back inclination angles affect how inertial loads are distributed during seismic occurrences, this paper explores the issue. To determine how gravity-retaining walls might react to movements caused by an earthquake, the scientists conducted a number of tests using a shaking table. The analysis looks at various wall-back inclination degrees and assesses the inertial loading distribution that results along the walls. The researchers examine the effects of inclination angles on the distribution of forces, moments, and shear stresses inside the walls through rigorous measurements and analysis. The results offer light on the significance of wall-back inclination angles in their structural performance and shed light on how gravity-retaining walls behave under seismic circumstances. The study that is discussed in the paper advances earthquake design methods for gravity-retaining walls. The results demonstrate how important it is to take into account the wall-back inclination angle as a design factor to enhance the effectiveness and structural integrity of such walls during seismic occurrences. For engineers and scientists working on gravity-retaining wall design and analysis, the experimental investigation offers useful information that can help create stronger, more effective structures.

3. GAP ANALYSIS

After reviewing the literature on landslide mitigation and prevention measures in India, several research gaps have been identified. Firstly, while there are several studies on the effectiveness of individual measures such as slope stabilization techniques, early warning systems, and vegetation management, there is a lack of comprehensive studies that compare the effectiveness of these measures in different contexts. Such studies could help policymakers and practitioners make informed decisions on the most appropriate measures for specific areas. Secondly, there is a need for more research on the economic and social feasibility of landslide mitigation measures. Many of the measures discussed in the literature review, such as slope stabilization techniques and retaining structures, can be costly and may not be feasible in low-income areas. Research could focus on identifying cost-effective measures that are suitable for different socio-economic contexts. Thirdly, there is a lack of studies on the long-term sustainability of landslide mitigation measures. While many measures have been found to be effective in the short-term, their long-term sustainability is uncertain. Research could focus on assessing the durability of measures such as vegetation management and slope stabilization techniques and identifying the factors that contribute to their long-term effectiveness. There is a need for more research on the impact of climate change on landslides in India. With climate change projected to increase the frequency and intensity of extreme weather events such as heavy rainfall, landslides are likely to become more frequent and severe in the future. Research could focus on identifying the areas most at risk of landslides due to climate change and developing appropriate adaptation measures. Overall, further research in these areas could help improve the effectiveness, feasibility, and sustainability of landslide mitigation and prevention measures in India.

4. CONCLUSION

In conclusion, landslides are a recurring natural disaster in India, particularly during the monsoon season. The effective mitigation and prevention of landslides require the implementation of a combination of measures tailored to the specific context and terrain type. The literature review has discussed some of the commonly used landslide mitigation and prevention measures in India, including slope stabilization techniques, early warning systems, land-use planning, vegetation management, drainage control, retaining structures, and education and awareness programs. These measures have been found to be effective in reducing the risk and impact of landslides in different parts of India, and their success is largely dependent on appropriate planning, design, and implementation. Therefore, further research and development are necessary to enhance the effectiveness of these measures and promote sustainable landslide management in India.

5. REFERENCES

[1] Chu, J., Phoon, K.-K., & Yong, K. Y. (Eds.). (2005). Proceedings of the International Conference on Geotechnical Engineering for Disaster Mitigation and Rehabilitation, Singapore, 12-13 December 2005. World Scientific.

[2] (Inagaki, K., &Sadohara, S. (2006). Slope Management Planning for the Mitigation of Landslide Disaster in

Urban Areas. Journal of Asian Architecture and Building Engineering, 5(1), 183–190. https://doi.org/10.3130/jaabe.5.183)

[3] (Popescu, M. E., &Sasahara, K. (2009). Engineering Measures for Landslide Disaster Mitigation. In K. Sassa& P. Canuti (Eds.), Landslides – Disaster Risk Reduction (pp. 609–631). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-540-69970-5_32)

[4] Vasistha, H. B., Rawat, A., & Soni, P. (2011). Hazards Mitigation through Application of Bioengineering Measures in Landslide Areas.

[5] Fowze, J. S. M., Bergado, D. T., Soralump, S., Voottipreux, P., & Dechasakulsom, M. (2012). Rain-triggered landslide hazards and mitigation measures in Thailand: From research to practice. Geotextiles and Geomembranes, 30, 50–64. https://doi.org/10.1016/j.geotexmem.2011.01.007

[6] Miele, P., Di Martire, D., Di Napoli, M., Guerriero, L., & Calcaterra, D. (2021). Temporal efficiencies of soil bioengineering techniques to mitigate geo-hydrological risks. Ecological Engineering, 170, 106338. https://doi.org/10.1016/j.ecoleng.2021.106338

[7] (Susanti, P. D., Miardini, A., &Harjadi, B. (2021). Disaster mitigation on lands affected by landslides in Banjarnegara Regency. IOP Conference Series: Earth and Environmental Science, 916(1), 012026. https://doi.org/10.1088/1755-1315/916/1/012026)

[8] (Salimah, A. (2021). Slope stability analysis for landslide mitigation in Satui, Tanah Bumbu, South Kalimantan. IOP Conference Series: Earth and Environmental Science, 708(1), 012022. https://doi.org/10.1088/1755-1315/708/1/012022)

[9] Cuomo, S., Camusso, M., Gambardella, P., Moretti, S., & Frigo, L. (2022). Modelling the impact of landslides on geosyntethics-reinforced barrier using DEM-FDM analyses. IOP Conference Series: Materials Science and Engineering, 1260(1), 012035. https://doi.org/10.1088/1757-899X/1260/1/012035

[10] Ma, S., Jia, H., & Liu, X. (2022). Effect of the Wall-Back Inclination Angle on the Inertial Loading Distribution along Gravity-Retaining Walls: An Experimental Study on the Shaking Table Test. Advances in Civil Engineering, 2022, 1–15. https://doi.org/10.1155/2022/8632920