STABILITY ANALYSIS OF INTERNAL DRAGLINE DUMP SLOPE USING NUMERICAL MODELLING

Thesis submitted in partial fulfilment for the

Award of Degree

Doctor of Philosophy

by

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16151004 **2023**

CHAPTER 7

Conclusion and Future Scope of work

7.1 Conclusions

The dragline dumps are formed by broken overburden material. There are several geometrical and geotechnical parameters which can affect the stability of dragline dump slopes. The increasing demand of coal has put pressure on the operational opencast mines which has increased the depth of working. Increasing depth has forced engineers to handle huge amount of overburden material in the form of dragline dumps. Which leads to the threat of dragline dump instability. The stability of dragline dumps is mainly governed by the geotechnical properties and geometrical parameters of the dragline dump profile. A detailed stability analysis of the dragline dump slope has been performed.

Various laboratory tests have been performed to assess the geotechnical properties of the overburden material. It has been found that, geotechnical properties are highly variable throughout the mine. Therefore, Monte-Carlo simulation technique is used to incorporate the variability of geotechnical properties within the overburden material and sensitivity analysis only for the geometrical parameters have been performed to assess the crucial parameters and by using them a safety chart has been devised, which is handy in quick identification of the stability of dragline dump slope. Apart from the safety chart, A classification system has been developed to assess the stability of dragline dump slope. This classification system has been developed by performing sensitivity analysis using two factor interaction method, which is different from previous one, for geometrical as well as for geotechnical parameters and on the basis of the sensitivity index a rating has been assigned to all the parameters. Based on the overall rating of a dragline dump slope its stability can be assessed. The simulation results that have been found in safety chart and classification is used for further analysis using machine learning tools; artificial neural network and multiple regression analysis, which has validated the accuracy of simulation results and thus has confirmed the accuracy of safety chart as well as classification system. The following important conclusions have been drawn from the stability analysis of the study:

- The geotechnical properties of the overburden material are not uniform throughout the mine. Geotechnical parameters, cohesion and friction angle of the overburden material are highly variable and their grain size also varies.
- The sensitivity analysis shows that the geometrical parameters; slope angle and height of the dragline dump which lies between the coal-rib roof and dragline sitting level and coal-rib height are the three most sensitive among all geometrical parameters only. A small variation in these can show significant impact on the stability of the dragline dump slope.
- Coal-rib width, berm width at coal-rib roof level and dragline sitting level, slope angle and height of the bench above the dragline sitting level are the medium sensitive parameters; a small change in these parameters will have a negligible impact on the stability of dump slope, but a greater change in these parameters may cause instability.
- Strata dipping is the least sensitive among all geometrical parameters, and there will be a negligible impact on the stability of the dump at any change within its defined range in the study.
- A safety chart has been proposed for the identification of instability in dragline dump based on the combination of dragline slope profiles. The primary purpose of formulating this kind of chart is to assist investigators during the preliminary

investigation, thereby helping them in focusing more on the vulnerable slopes. The stability chart is divided into three regions - safe, vulnerable or fail based on the behavior of slope profiles.

- The chart also gives the idea about how to optimize the combination of the parameters coal-rib height, slope angle and height of the bench from the coal-rib roof to dragline sitting level, to maximize the amount of overburden material with ensured safety of the dragline dump.
- According to the sensitivity analysis using two factor interaction method, friction angle from the strength parameters and two geometrical parameters, slope angle and height of the dragline dump which lies between the coal-rib roof and dragline sitting level are the three topmost sensitive among all the parameters with the sensitivity index of 0.72, - 0.52, and - 0.28, respectively.
- The least significant parameters are Dip angle, Berm width at the coal-rib roof level, and Coal-rib width with the sensitivity index - 0.03, 0.07, and 0.09, respectively.
- Based on the sensitivity analysis, rating for individual parameters is obtained wherein the friction angle has the maximum rating of 28 and Dip has the minimum rating of 1 (this rating is only applicable for the range that has been chosen for the particular parameter within the system).
- The sum of the individual rating of the parameters is used to obtain the stability status for the investigated slope, which ranges from highly unstable to very safe.
- The developed classification system will be handy in the quick estimation of the stability of the dump slopes. If the stability status of the dump slope is vulnerable, the slope profile needs to be redesigned. This system helps in the pre-estimation

of geometrical parameters to design a safe dragline dump profile for a particular strength parameter and the thickness of coal.

- The performance of artificial neural network and multiple regression analysis models were compared with factor of safety values acquired from the numerically simulated results. These models can be used for the prediction of factor of safety as a function of coal-rib height, slope angle and height of the dragline dump which lies between the coal-rib roof and dragline sitting level, has conferred satisfactory results with coefficient of determination value 0.9996, 0.9972, 9769 and 0.9156, for ANN1, ANN2, MRA1 and MRA2, respectively.
- To examine the prediction accuracy of multiple regression analysis and artificial neural network models, several performance indicators such as root mean square error, variance accounted for and variation of residual error are used. The root mean square error for ANN1, ANN2, MRA1 and MRA2 models are 0.003784, 0.014746, 0.020894 and 0.057335, respectively and the variance accounted for values are 99.9214, 99.3288, 97.6940 and 91.5854, respectively.
- The analysis of residual error shows the variation of the predicted values from the simulation results for the MRA1 and ANN1 models, which ranges from - 0.53 to + 0.54 and - 0.020 to + 0.015, respectively and for MRA2 and ANN2 models ranges from -0.133 to +0.219 and -0.065 to +0.136, thus confirms artificial neural network has lower variation of residual error.
- Based on these performance indicators, it has been observed that the artificial neural network model has a higher prediction accuracy than multiple regression analysis. The level of accuracy attained by both the machine learning tools have proved that artificial neural network architecture is a handy tool in estimating the safe dragline dump slope profile.

7.2 Future Scope of work

1. The idea of proposed safety chart and the classification system for the stability of dragline dumps can be a guiding road for solving stability problems of other types of dump slopes.
2. More tests can be done by collecting samples from the mines other than Singrauli coalfield to increase the applicability range of the chart as well as to improve the reliability of the numerical simulation.
3. Weight of the dragline machine can also be considered in the numerical simulation in order to detailed and macro stability analysis of the dragline dump.