SUMMARY

Surface mining operation often results in removal of huge quantities of waste material and subsequently dumping it outside quarry areas or back-filling in the excavated areas as the case may be. In recent years the unprecedented increase in the rate of accumulation of waste dumps has been a great environmental concern because this leads to more frequent large/small dump failures. General increase in environmental awareness has given rise to concern about safe and economic design of waste dump both during mining and following mine closure. On the one hand, stable slopes are essential for safety of men and machine and on the other hand vast amount of land and money can be saved by optimising slope geometry of dump. It is therefore, a technical and economic necessity that the most efficient compromise be achieved, in the light of these two conflicting requirement; by optimising the slope that is steep enough to be economically acceptable and flat enough to be safe.

The primary objective of the present investigation is to elucidate, through a fairly extensive numerical evaluation programme, the influence of face/slope angle on its stable height under varying geo-technical, geological and hydro-geological parameters for a particular range of factor of safety. The intention has been to produce design graphs and tables covering wide range of each controlling parameter for the mine planners and operators to select optimum slope geometry of waste dumps. This investigation has been done for high risk zone and low risk zone which are defined below:- (A) High risk zone - Dump is situated in such a situation in which failure will lead to loss of life and severe damage to property. Factor of safety in this case is taken as 1.3 to 1.35. (B) Low risk zone - Dump is situated in such a situation in which failure will lead to no loss of life and moderate damage of property. Factor of safety in this case is taken as 1.15 to 1.20.

KEY WORDS: Slope Stability, Waste Management, Opencast Mining, Surface Mining, Reclamation, Environment, Ground Control in Mining, Mine Planning, Dump Slope Stability, Geo-technical Engineering, Engineering Geology, Mining Engineering, Civil Engineering, Soil Mechanics, Pit Slope Stability, Geo-textile Engineering.
1.0 INTRODUCTION

India has reached the forefront of world coal scene, ranks 4th in the total coal production largely due to production from opencast coal mines which contributes 75% of country's total coal production. Opencast coal mining operation results in removal of huge quantities of waste material and subsequently dumping it outside quarry areas or back-filling in the excavated areas, as the case may be. In recent years the unprecedented increase in the rate of accumulation of waste dumps has been a great environmental concern because this leads to more frequent large/small dump failures.

In Indian scenario, the emphasis on opencast mining in the recent past heightened the concern for environment because of land degradation and rehabilitation of people affected by mining. Land rendered biologically unproductive will increase over the years, as more and more areas come under opencast mining and even larger areas are required to accommodate external overburden dumps. Another factor is the effect of mining in the forest areas. Fairly large tracts of forest land in Singrauli, North Karanpura, Ib valley, Talcher, Korba and Wardha valley coalfields under Coal India Ltd. will be affected as a result of large scale opencast mining in these areas. Reclamation and restoration of mined out and dumped areas will have to be further increased and adequate compensatory afforestation will need to be undertaken.

In international scenario, the most tragic incident of spoil heap failure which brought the problem of stability to the public attention occurred at Aberfan, South Wales in 1966 in which 144 people (mostly children between age 7 to 10 years) were buried under colliery waste. The number of fatalities in this single disaster exceeded the death caused by natural slide in U.K during previous centuries.

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of dump. It is, therefore, a technical and economic necessity that the most efficient compromise be achieved in the light of these two conflicting requirements by optimising the slope i.e. steep enough to be economically acceptable and flat enough to be safe.

2.0 OBJECTIVE

The primary objective of the present investigation is to elucidate, through a fairly extensive numerical evaluation programme, the influence of face/slope angle on its stable height under varying geo-technical, geological and hydro-geological parameters for a particular range of factor of safety. The intention has been to produce design graphs and tables covering wide range of each controlling parameter for the mine planners and operators to select optimum slope geometry of waste dumps. This investigation has been done for high risk zone and low risk zone which are defined below:

(A) High risk zone - Dump is situated in such a situation in which failure will lead to loss of life and severe damage to property. Factor of safety in this case is taken as 1.3 to 1.35.
(B) Low risk zone - Dump is situated in such a situation in which failure will lead to no loss of life and moderate damage to property. Factor of safety in this case is taken as 1.15 to 1.20.

Factor of safety adopted in this investigation are selected after going through all the available literature on factor of safety recommended by National Coal Board, U.K, Mines branch, Canada, 1972 and British Columbia Mine waste rock pile research committee, 1991.

3.0 CRITERIA FOR THE SELECTION OF RANGE OF VALUES OF VARIOUS PARAMETERS

The selected range of values of input and output parameters considered in this investigation are discussed here.
3.1 Output parameters

The results have been presented for slope heights of 15 to 90 M at 10 M intervals corresponding to face angle in the range of 20 to 45 degrees. These ranges have been selected considering geometry (i.e. height and face angle) of all the existing and planned dumps in various large opencast projects under Coal India Ltd. Dump height above 90m is not considered as more than 90m high dump should be analysed as two or three dumps, one dump standing above another dump - each dump representing different geometrical characteristics. The lower limit of dump heights and face angles has been restricted to 15 M and 20 degrees respectively, mostly on the consideration of scarcity of land required for dump formation. The upper limit of face angle has been restricted based on the facts of the difficulty in negotiating such steep slope of loose O.B dump by heavy earth moving machines as like - dragline and dumper.

3.2 Input parameters

The values of all the parameters have been selected with an aim to cover the entire practical range, as far as possible, considering all the geotechnical, geological, hydro geological and mining data of various planned and existing opencast projects represented from all over the world. The range of values of all the input parameters considered in this investigation are presented in Table below (Figs 3.5 & 3.6).

DETAILS OF PARAMETRIC VARIATIONS INVESTIGATED

<table>
<thead>
<tr>
<th>PARAMETERS</th>
<th>VARIABLES</th>
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<tr>
<td><strong>OUTPUT PARAMETERS</strong></td>
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<tr>
<td><strong>A. Slope Geometry</strong></td>
<td></td>
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<tr>
<td>1. Dump Height(H)</td>
<td>15 to 90m at 5m intervals</td>
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<tr>
<td>2. Face Angle(β)</td>
<td>20, to 45 degrees at 2 degrees intervals</td>
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