Production enhancement with dragline planning with real time topography

Sandhu Maninder Singh, Avchar Akhil, Kumar Mritunjay*, Pandey Deepak Chandra and Choudhary Sanjay
1. Sir Padampat Singhania University, Udaipur, INDIA
2. National Institute of Technology, Surathkal, Mangalore, INDIA
3. Datamine Software's Limited, Udaipur, INDIA
*mritunjay.247mn002@nitk.edu.in

Abstract
The seamless fusion of dragline planning with real-time topography is explored to boost production in surface mining. In coal mining, draglines play a crucial role as primary stripping tools and their uninterrupted operation is essential for cost-effective productivity. The transition from shovel to dragline mining in large-scale coal mining projects, underscores the significance of these machines. The study underscores the importance of precise dragline design to ensure reliability and predictability, minimizing disruptions during repairs and component replacements.

The proposed method integrates real-time topography data, introducing an innovative aspect to dragline planning. Utilizing advanced technologies such as Datamine (MineScape software), this integration enables dynamic adjustments in dragline operations based on evolving topographical conditions. The research highlights the potential of this integrated approach in enhancing production by facilitating proactive decision-making, minimizing downtime and overall improving mining efficiency.

Keywords*:* Dragline, mine machinery, point cloud data, topography, swing angle, re-handling.

Introduction

Surface mining operations deploy robust machinery called draglines, purpose-built on-site for strip mining, specifically designed for extracting overburden and coal. These machines boast the distinction of being the largest mobile land apparatus ever constructed[1]. Comprising of a substantial bucket suspended from a boom using wire ropes, a dragline's movement is meticulously controlled by ropes and chains[2]. Electric motors drive the hoist rope, while the drag rope facilitates the horizontal maneuvering of the bucket assembly. Despite their immense capabilities, draglines operate at a maximum speed of only a few meters per minute, necessitating disassembly for longer distances[3].

Due to their remarkable reach, draglines are infrequently relocated, given their efficiency in covering expansive areas from a single position[4]. The design of strip panels, equipping a specific unit with one operator's room on the desired side or with two on both sides and the management's strategy in coal loading operation largely affect the frequency and the length of long deadheading periods, during which the unit is unproductive[5].

These machines exhibit peak efficiency when excavating material beneath their base level, although they can also function above themselves, albeit with reduced efficiency[6,7]. It is crucial to emphasize that draglines are not designed for loading piled-up material like shovels. Nevertheless, their widespread preference in many mining operations stems from their reliability and notably low waste removal costs[8-11].

Through this technology, we can assess our needs and acquire real-time topography data, facilitating precise operational instructions and bolstering our draglines' productivity[12-14]. This approach aids in determining optimal bench height and width, ultimately leading to higher coal production targets. Recognizing the imperative is to swiftly remove substantial overburden volumes. Draglines have been identified as the most fitting equipment for such demanding tasks.

Software used in Coal Mining Industry

Mining planning uses conventional methods which take a lot of time in data compilation, plotting, interpolation and interpretation. Nowadays, we are using mining software products for mine planning accuracy[15]. The analysed data were used to generate the grids and meshes of the surface using Datamine software (MineScape) and the same was analysed with the field data to know how much accuracy level there is between the model created by Datamine software and actual mine planning and with this, we found how much loss we must face due to not working according to planning. The methodology can be summarized as:

a) Collection of exploration data.
b) Importing the same to the software grid file used to create seams by using bore hole data and LAS by using point cloud data taken by the drone to create topography.
c) Solid 3D structure of the orebody and topography (mesh).
d) Geotactic analysis of the exploration data generating waste and ore block model and then combining them to make a single resource mode. Create mesh, then create strips.
e) With strips split into blocks. Blocks are excavated with a dragline.
f) Used for scheduling.

https://doi.org/10.25303/185da1260132

Material and Methods

Using MineScape dragline, engineers can efficiently and rapidly delineate and evaluate dragline excavation methods on authentic pit models. This software offers a diverse array of features for precise simulation and assessment of different material movement approaches, including cast blasting and production dozing as shown in figure 1.

Operation cycle of dragline

Positioning and Preparation: The dragline is positioned over the excavation area. The empty bucket is properly positioned and prepared for the loading process.

Loading: The bucket is lowered to the ground and the dragline's hoist system is engaged to fill the bucket with material (overburden or coal).

Swinging: The filled bucket is lifted and swung horizontally over to the designated dumping area (spoil pile). The swinging motion occurs simultaneously with the lifting operation.

Dumping: The material is dumped onto the spoil pile at the designated location.

Returning: The empty bucket is then swung back to the excavation area. Simultaneously, the bucket is lowered and positioned for the next loading cycle.

Enter 0.69023 in the first base productivity field. Units will set to the current volume units (1000 Cu Metres). The table 1 shows the specifications of dragline under various capacities.

Table 1
Specification of dragline parameters

	Draglines			
	15/90	**20/90**	**24/96**	**33/72**
Tail room	12	25.00	26.99	18.9
Setback	12	11.50	10.00	9.63
Tail height	1.5	1.40	3.14	3.14
Tub diameter	14	14.50	15.25	15.3
Foot height	6	6.00	8.00	5.8
Dig depth	42.5	42.50	54.00	46.2
Reach (from centre pin)	83	83.00	88.00	72.5
Boom angle	30	32.00	30.00	38
Dump height	37.3	38.50	38.20	40.6
Dump clearance	15.2	15.20	16.80	16
Sheave diameter	2	2.00	2.00	2.51
Point height	53.7	53.70	53.90	56.6
Base productivity M3/hour	300	410.00	690.23	899

Table 2
Shows the material specification wise the data required for the dragline planning.

Field	Value	Value	Value	Comment
Specification Name	PRETYPE	COALTYPE	DRAGTYPE	Name of the material specification file.
Swell Factor	1.3	1.3	1.3	Swell applied to material when dumping. Previously swelled blasted material will be reset to this value when dumped.
Display Definition	CYAN	GREY	SIENNA	Controls the appearance of the material in CAD.
Blast Swell	1.1	1.1	1.1	Swell applied to material when blasting.
Material Type	Prestrip	Coal	Dragline	Name that appears when selecting material type.
Repose Angle	38.0	38.0	38.0	Angle of repose for material and used for designing dumps.
Dig ability	1	1	1	Productivity control based on material type. A value of 1 will not affect dragline productivity.
Stand Angle	45	65.0	65.0	Maximum angle of disturbed dump material. Used to trigger a warning.

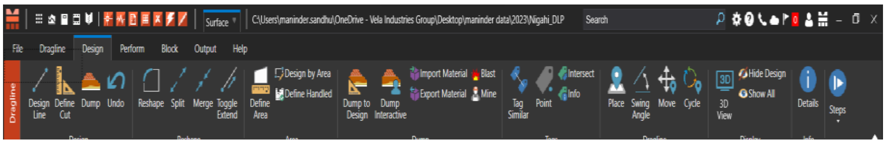


Figure 1: Tools using for during dragline planning

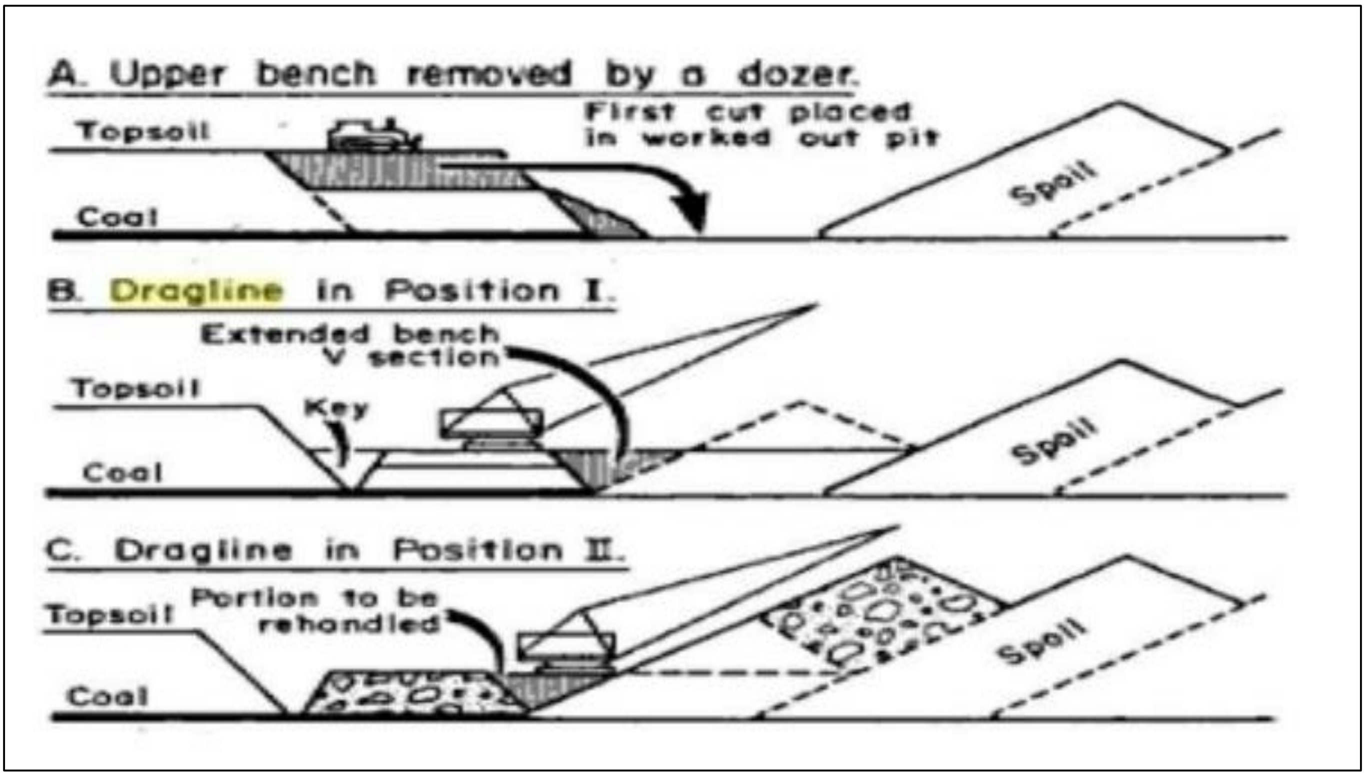


Figure 2: Extended bench method

Dragline stripping methods

1. The dragline initiates the stripping cycle by creating a trench known as the key cut, along the recently formed highwall. The distance covered from the prior key cut location to the new one is termed as the dig out length.

2. The key cut serves the purpose of preserving the panel width and ensuring a consistent highwall. Without this key cut, each subsequent dig out would lead to a narrowing of the panel width, as the dragline would lack control over the bucket when digging against an open face. The material from the key cut is deposited at the bottom of the mined-out pit away from the coal and adjacent to the previous spoil pile.

3. Upon completing the key cut, the dragline is relocated to a new position to finalize the excavation of the dig out, known as the production cut. The material excavated is cast onto the key cut spoil. Once the dig out is finished, the dragline is shifted to the next position, marking the commencement of the subsequent stripping cycle (next dig out).

Factor effecting dragline stripping methods are as follows:

1. Full Key Cut vs. Layer Cut
2. Dragline Panel Width
3. Bench Height
4. Dig out Length.

Dragline Extended bench method

1. When the depth of overburden or the width of the mining panel surpasses the dragline's capacity to sidecast the material away from the coal, a burden bridge can be established, effectively elongating the dragline's reach. This bridge extends the working bench of the dragline, either by material naturally cascading down the spoil bank or by the direct placement of material using the dragline. Clearing the bridge material from the coal's top requires rehandling as shown in figure 2.

2. The extended bench systems exhibit versatility in adapting to various pit configurations. In this approach, the dragline shapes its operational bench by cutting material from the upper section of the bench, creating a bridge. The dragline then transits to the bridge to clear it from the top of the coal. The primary dragline is responsible for stripping overburden, depositing it into the previously excavated panel. This material is then levelled, either by tractor-dozers or a secondary dragline, to establish the bench for the secondary dragline. The secondary dragline initiates material extraction near the highwall before moving onto the bridge to handle the rehandled material.

3. In a dual dragline system, the operation speed of one machine is contingent on the pace established by the other. Consequently, mine planning needs to account for their individual capacities when determining assigned digging depths. The primary dragline is responsible for excavating overburden up to the upper boundary of the initial coal seam as shown in figure 3.

Figure 3: Two Dragline working parllel and creating extended bench

MineScape software for calculating rehandling percentages and hours required for removed overburden

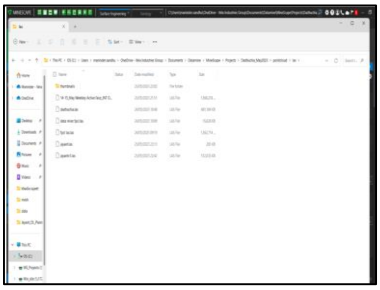
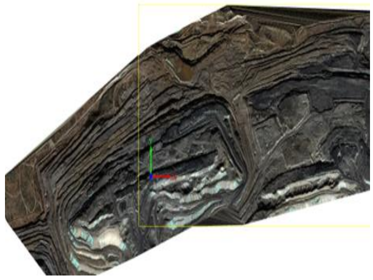
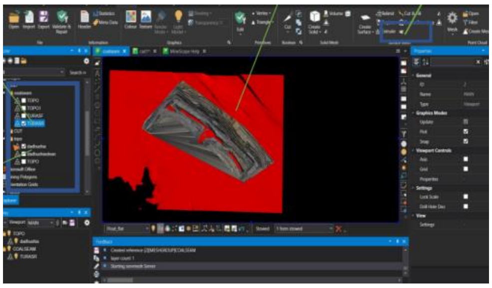
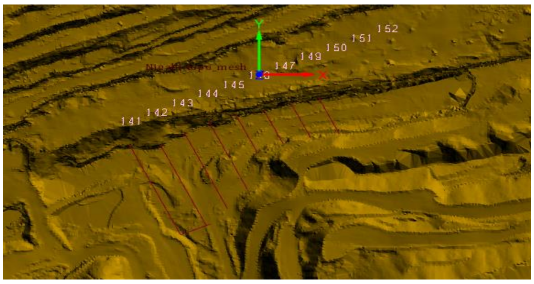
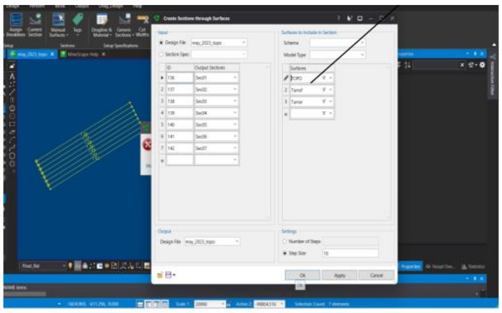
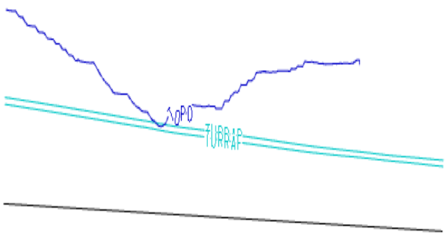
 **Importing Las file**	 **Topography taken by drone survey**
 **Intersect Topography and Grid surface for creating breakline**	 **Creating sections (we are taking section 50m distance)`**
 **Assign surface which we are using to extracted coal**	 **Creating surface(topo,turra top,down)**

Figure 4: Steps in minescape for creating topography and rehandling overburdern

Steps performed for creating balance diagram

a) Strip or Bench plans are created by dividing a strip or bench into sections of specific width as shown in figure 5.

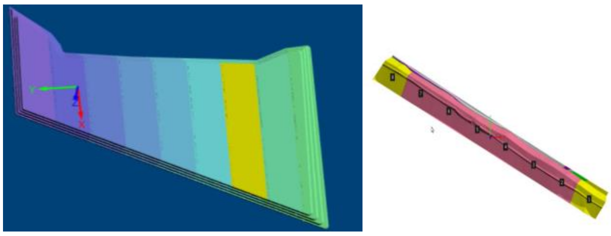


Figure 5: Strip plan and Bench splits into blocks

b) For each of these sections, block and spoil movement is defined in terms of Key Cut, Box Cut etc. and optimized to achieve minimum rehandling.

c) Block and spoil movement from sections can be meshed to see block and spoil movement in plan create block plans showing digging and dumping sequence.

d) After Key Cut removal process using Copy topo tool will give an output of the same and that can be farther meshed and then by using Just-in-Time DTM tool topography, it can be updated with this patch as shown in figure 7.

e) Creates strip or bench plan (s) (plan view and cross sections) show blocks and spoil movement with key information marked. Excavation replay includes lowering bucket, scooping material, lifting of bucket, swinging to dump position, dumping and swing back based on dragline productivity. Swing angles determined from design and reported as output are shown in fig. 7.

Results and Discussion

Once the Dragline balancing diagram is prepared the replay file of block or operations can be saved and that replay file, can be played with the help of the tools in the MineScape Do section/Do Strip on either one section or multiple sections in one go

a) Balance diagram without software: Manual AutoCAD diagram is used in all sections, so there are very high chances of errors due to undulation in the surface.

b) Balance diagram with software: Balance diagram with real time topography and with REPLAY file create make it possible to balance diagram of each section. Time taken=224.59 hours.

It is found that the swing angle time needed for manufacturing is 224.5 hours with mine planning software while with AutoCAD it is 5538 hours. Figure 10 shows the plan and actual topography of the area.

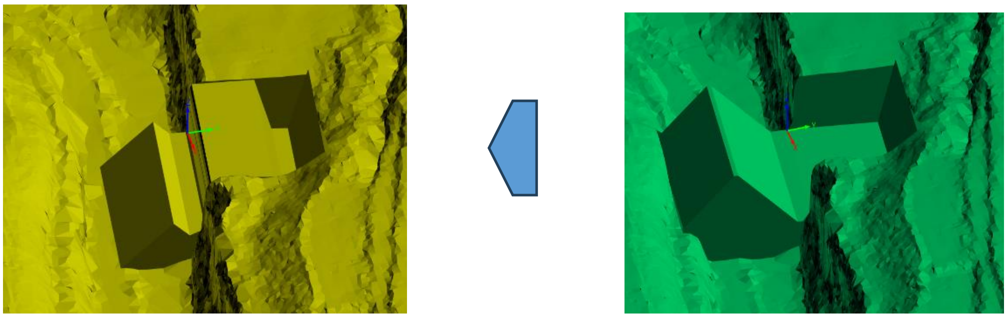


Figure 6: Profile before and after box cut

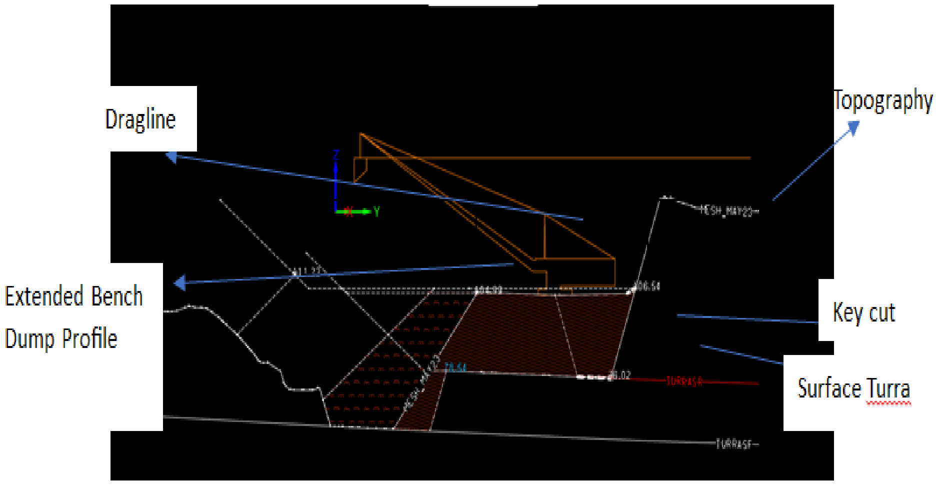


Figure 7: Dragline Dump Profile

https://doi.org/10.25303/185da1260132

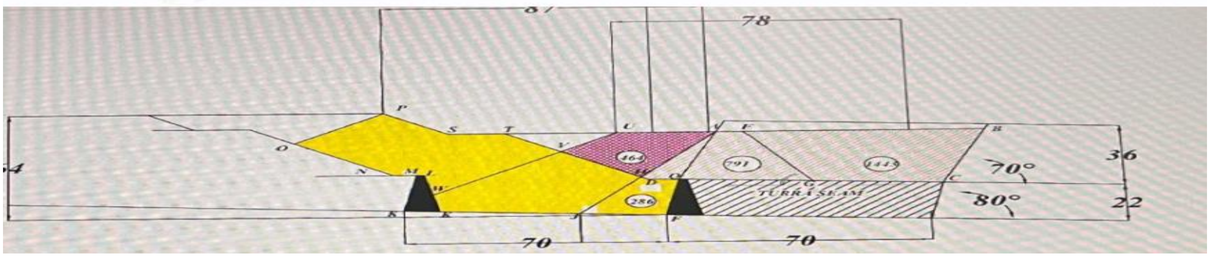


Figure 8: Balance diagram with AutoCAD

w/hours	solid	Rehandling	Composite
5538.5	1862897	656880	251677

In cubic meters.
Time taken =5538 hours

```
Block SEC02.C38
   All volumes are in 1000 Cu Metres
   Section breadth 50.00 Metres
   (No operation in use)
Step Machine          Material          Moved     Prime        Rehandle  Productivity  Swing_Angle
---------------------------------------------------------------------------------------------------
 1   33_72            DRAGTYPE          31.69     31.69     0.00     0.00%      0.88     102.19
 2   33_72            DRAGTYPE          79.83     79.83     0.00     0.00%      0.91      91.21
 3   33_72            DRAGTYPE          39.74     22.12    17.61    79.61%      0.84     114.78
 4   33_72            DRAGTYPE          46.20     25.72    20.48    79.61%      0.86     109.41
 5   TRUCK_SHOVEL      COALTYPE         63.26
------------------------------------------------------------------------------------
     33_72                             197.46    159.37    38.09    23.90%      0.88

   SEC02.C38
   Materials by Machine Summary
COAL        Machine                     Moved   1000 Tonnes
-------------------------------------------------------------
     TRUCK_SHOVEL                       63.26     84.14
BURDEN      Machine        Moved      Prime          Rehandle  Productivity    Hours
------------------------------------------------------------------------------------
     33_72                197.46     159.37     38.09   23.90%      0.88       224.59
     Not Handled:    1.69%             2.74
```

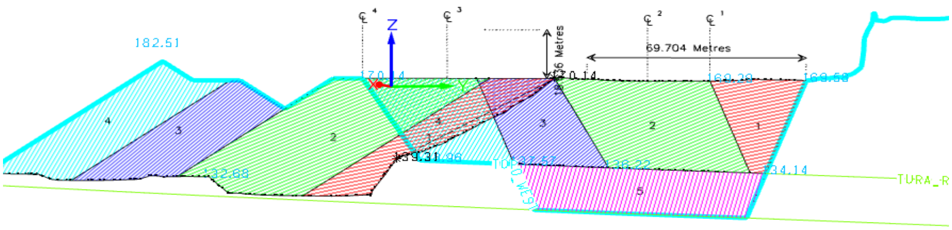


Figure 9: Balancing diagram Topography after excavation

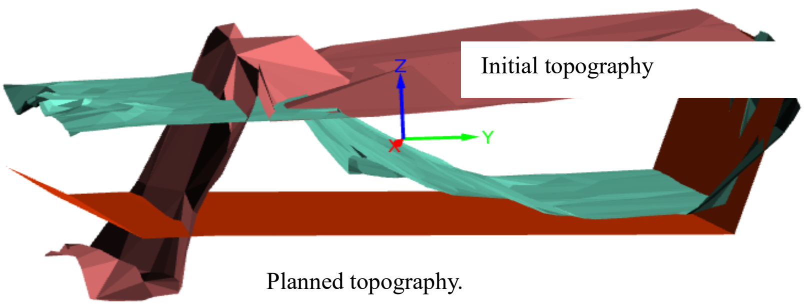


Figure 10: Plan vs actual Topography

Conclusion

From the study, following conclusion can be drawn:

1. With the help of the mine planning software, the various balancing diagrams and scenarios have been created for each block and it is easy for the operator to handle the dragline machine by these balancing diagrams and to minimize the overburden handling and should be able to manage the excessive load.

2. Reshaping of final landforms is done for rehabilitation purposes. MineScape can quickly reshape as-built or designed surfaces to tie in with surrounding topography.

3. There is a significant reduction in the swing time with the help of the balancing diagram with software.

4. Detailed tailings deposition planning for tailings facilities allow planning for infrastructure (pipes, roads, pumps). Modelling of tailings beaches and decants pond locations leads to less pipe/pump moves and a more efficient overall tailings operation.

References

1. Avchar A., Choudhary B.S., Budi G. and Sawaiker U., Effect of rock properties on rippability of laterite in iron ore mines of Goa, *Mathematical Modelling of Engineering Problems*, **5(2)**, 108–115 **(2018)**

2. Avchar A., Choudhary B.S., Budi G. and Sawaiker U., Applicability of size-strength rippability classification system for laterite excavation in iron ore mines of Goa, *Modelling, Measurement and Control C*, **78(3)**, 378–391 **(2017)**

3. Avchar A. and Choudhary B. S., Ripper production prediction for laterite excavation in iron ore mines, *Journal of Mining Science*, **57(1)**, 66–75 **(2021)**

4. Avchar A., Pal S.K., Tripathi A.K. and Kumar G., Subsidence analysis for old abandoned board and pillar coal mines using ANSYS and Monte Carlo simulation, *Journal of Mining Science*, **59(6)**, 938–948 **(2023)**

5. Cheskidov V.I., Akishev A.N. and Sakantsev G.G., Use of draglines in mining diamond ore deposits in Yakutia, *Journal of Mining Science*, **54(4)**, 628–637 **(2018)**

6. Li Y. and Liu W., Dynamic dragline modeling for operation performance simulation and fatigue life prediction, *Engineering Failure Analysis*, **34**, 93–101 **(2013)**

7. Mohammadi M., Rai P. and Oraee S.K., A critical investigation of digging time segment of draglines in a large surface mine, *Geotechnical and Geological Engineering*, **33(4)**, 763–771 **(2015)**

8. Mohammadi M., Rai P., Singh U. and Singh S.K., Investigation of cycle time segments of dragline operation in surface coal mine: A statistical approach, *Geotechnical and Geological Engineering*, **34(6)**, 1765–1774 **(2016)**

9. Mpembe N. and Genc B., Enhancing productivity through effective spoil stability management in an open cast coal mine, *International Journal of Mining and Mineral Engineering*, **11(2)**, 134 **(2020)**

10. Pal S.K., Avchar A. and Tripathi A.K., Comparison of model study with field implementation of gravity blind backfilling method to control subsidence induced disaster in abandoned underground coal mines, *Disaster Advances*, **5(16)**, 10–18 **(2023)**

11. Pal S.K., Avchar A., Vyas A. and Tripathi A.K., Prediction of the specific energy requirement of hydraulic rock breaker based on laboratory impact hammer—A case study, *International Journal of Mining and Mineral Engineering*, **15(2)**, 237–259 **(2024)**

12. Rai P., Yadav U. and Kumar A., Productivity analysis of draglines operating in horizontal and vertical tandem mode of operation in a coal mine—A case study, *Geotechnical and Geological Engineering*, **29(4)**, 493–504 **(2011)**

13. Rai S.S., Murthy V.M.S.R., Sukesh N., Teja A.S. and Raval S., Operational efficiency of equipment system drives environmental and economic performance of surface coal mining—A sustainable development approach, *Sustainable Development*, **29(1)**, 25–44 **(2021)**

14. Seervi V., Signh N.P., Kishore N. and Verma A.K., Critical analysis of tandem dragline performance in open cast coal mines—A case study, *Journal of the Institution of Engineers (India): Series D*, **104(1)**, 391–402 **(2023)**

15. Verma R., Jaiswal A. and Avchar A., A numerical method approach for analyzing the effects of joint orientation on stability of open-stope in metalliferous mines, *Annales de Chimie - Science des Matériaux*, **43(2)**, 129–134 **(2019)**.

(Received 22nd January 2025, accepted 20th February 2025)