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A profile function to predict surface subsidence for down-cut slicing panels into inclined coal seam of the Barapukuria coal mine, Bangladesh

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A B S T R A C T

Mining-induced subsidence, a typical consequence of underground mining, can cause environmental and structural problems in the mine area. Predicting surface subsidence for inclined and deep seams has been less emphasized than horizontal seams, mainly due to the complexities of extracting such coal seams. The prediction of surface subsidence and the dynamics of subsidence in down-cut slicing panels is more complex and crucial in practice. This study presents a novel profile function method for forecasting surface subsidence resulting from downward slicing panels in the inclined coal seam mining of the Barapukuria coal mine. The calculated maximum subsidence depth is 10.23 meters whereas the measured maximum water depth of the subsided lake of the Barapukuria coal mine is 10.5 meters. The results indicate a strong correlation between the predicted and the measured values.

1. Introduction

There are five discovered coal basins in the northwestern portion of the country. Most of the discovered coal basins in Bangladesh are characterized as thick to ultra-thick and multi-layered coal seams. The Barapukuria is the only coal-producing mine in the country among the all-discovered coal basins. In the Barapukuria coal basin, there are six coal seams, with coal seam VI being the ultra-thick seam, averaging 36 meters in thickness, and suitable for mining. The coal extraction process at the mine utilizes the longwall caving mining method.

In the longwall caving method, a continuous downward movement of the overburden strata is observed during and after the extraction of the resources from the ground. The downward movement of the subsurface strata developed a subsidence trough on the surface leading to various damages to the environment and physical structure of the society. A precise and validated subsidence prediction model is unavoidable to protect and mitigate the environment and structures from upcoming damages. The geometric shape of a subsidence trough varies based on the inclination of the coal seam. It (subsidence trough) is symmetric for a horizontal coal seam and asymmetric while the coal seam is inclined (**Figure 1**). The location of the peak subsidence point (S_{max}) resulting from inclined and deep coal seam mining moves towards the dipping side of the panel, as depicted in **Figure 2** [1, 2].

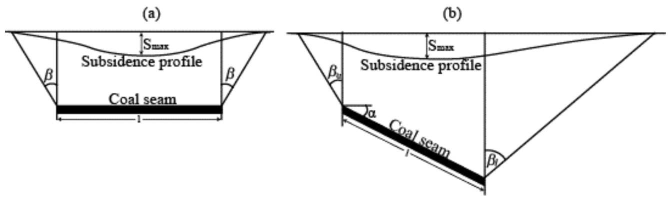

Figure 1. Subsidence profile and subsidence trough geometric shape for (a) horizontal and (b) inclined seams

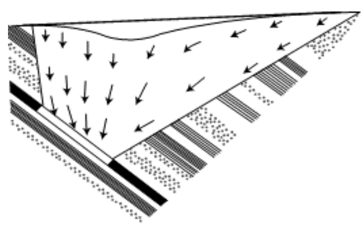

Figure 2. Movements of overburden rock layers in inclined deep seam mining [1].

A static subsidence is the final product of a subsidence trough that persists long after the completion of the mining operation while a dynamic or progressive subsidence forms during face movement. In longwall coal mining, creep subsidence typically occurs over a relatively short time frame (4 to 12 months) and amounts to 3% to 4% of maximum subsidence. This duration decreases even more with shallower depths [2]. In longwall coal extraction, subsidence is inevitable and continues for several months to several years after completing mining activities. Moreover, the thickness of the coal seam cover influences the surface subsidence duration. It is also observed that the thicker the coal seam cover, the longer the duration of surface subsidence, which is contingent upon individual characteristics such as the depth of excavation, the thickness of the extracted coal seam, and the behavior of surrounding rock masses.

Subsidence troughs can be characterized as subcritical, critical, and supercritical depending upon the width-to-depth ratio (W/H) of an opening. In the subcritical stage, while the opening width is less than 1.2x depth, subsidence is in dynamic conditions and does not reach its maximum possible subsidence (S_{max}). On the other hand, when the opening width is equal to its depth, the subsidence trough reaches its maximum value called the critical stage. Afterward, the maximum subsidence (S_{max}) does not increase on further development of the opening; rather, it spreads horizontally across an area. [1, 2].

A surface subsidence model is essential to study problems related to rock movement. An asymmetric subsidence trough is developed while mining an inclined seam, and the trough extends along the dip of rock occurrence. Moreover, the subsidence angle is greater on the inclined side of the mine working [3]. The Barapukuria coal basin is characterized by gentle to steep dipping seams. At the same time, the maximum dip is observed at the central part and the slope angle increases to the eastern side of the basin.

Maximum coal has been extracted from the northern district of the Barapukuria coal mine. 20 panels to date have developed and produced coal from the northern district of the mine. The coal is being extracted slices-wise from top to bottom (1st slice at the top and 4th slice at the bottom). Although the mine offers economic advantages, it also presents environmental concerns, notably in the aspect of land subsidence [4-7]. Many research works have been carried out on the Barapukuria underground coal mine. For instance, Islam [8] conducted research on remedial measures of subsidence and modeling for strength assessment of backfill materials to reduce surface subsidence. Islam & Shinjo [9-10] focused on mining-induced fault reactivation and stress distribution with a displacement surrounding the entry roadway for igneous intrusion as well as to study possible sources of gas emission from the seam, Islam et al. [11] analyzed the complications of the multi-slice longwall mining, Islam [12] performed another research on the orientation of maximum horizontal stress, Islam and Kamruzzaman [13] conducted a further study on geochemical and techno-environmental behavior of Gondwana coals, furthermore, Islam and Islam [14] pointed on the water inrush hazard of the coal mine. Islam and Hayashi [15] conducted an exploratory study when the subsidence began. However, the focus of the study was on coal bed methane rather than surface subsidence. Wide-ranging research work was performed by Howladar [16, 4] and Howladar and Hasan [17], focusing on the impact on water and the environment. Hossain et al. [18] analyzed the subsidence trend and annual rate of subsidence and subsurface condition.

It's worth mentioning that all these studies concentrated on assessing the effects of subsidence on water and the nearby environment, neglecting to address the geotechnical-geomechanical issues and the influence function that closely relates to the dynamism of subsidence. Apart from that the subsided lake at Barapukuria has been created for coal extraction from a series of multi-slice panels. This study targeted to fill this gap by analyzing the subsidence trough using the profile function parameters considering an inclined coal seam.

2. Geologic Setting of Barapukuria Coal Mine

2.1. Central District

Commercial coal extraction was started from the Barapukuria coal mine (BCM) in 2006 and the first coal face is 1101 located in the upper part of the southern district. The research work focused on the central district of the mine where all the panels are in a north-south alignment and retreat commenced in the north-to-south direction (**Figure 3**).

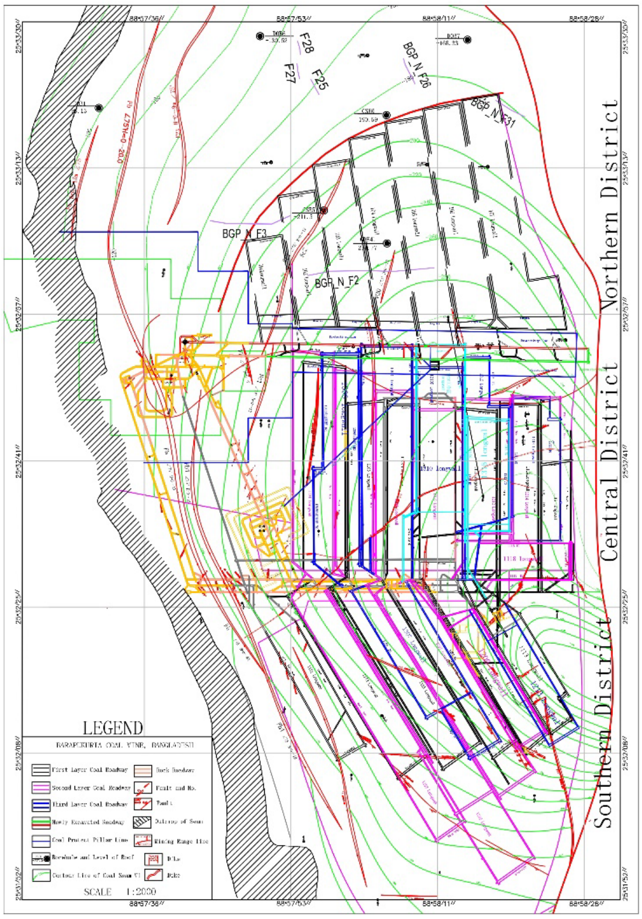

Figure 3. Coal seam VI contour with panels layout of Barapukuria coal mine.

2.2. Geology of Barapukuria Coal Mine

The BCM which covers approximately 6.68 km^2 forms asymmetrical coal deposits where deeper coal deposits at the central part and shallower depth at both edges (north-south). Longwall and Longwall Top Coal Caving (LTCC) mining systems following a descending slicing path have been applied to extract the coal. The asymmetrical syncline basin has been developed with various boundary and intra-basinal faults [19-20]. Most of the faults have a similar N-S direction (**Figure 4a**). The substantial deposition observed in the coal basin could be attributed to concurrent subsidence on the down-thrown side of a significant fault in the Archaean basement, which delineates the eastern boundary of the coal basin. (**Figure 4b-d**). In the seismic interpretation of the Barapukuria basin, a total of 37 faults have been identified [19] that affect the Gondwana Sequence. The locations and orientations of the

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faults within the basin influence the formation of a half-graben, resulting in increased deposition thickness towards the east and southeast of the basin [19, 20].

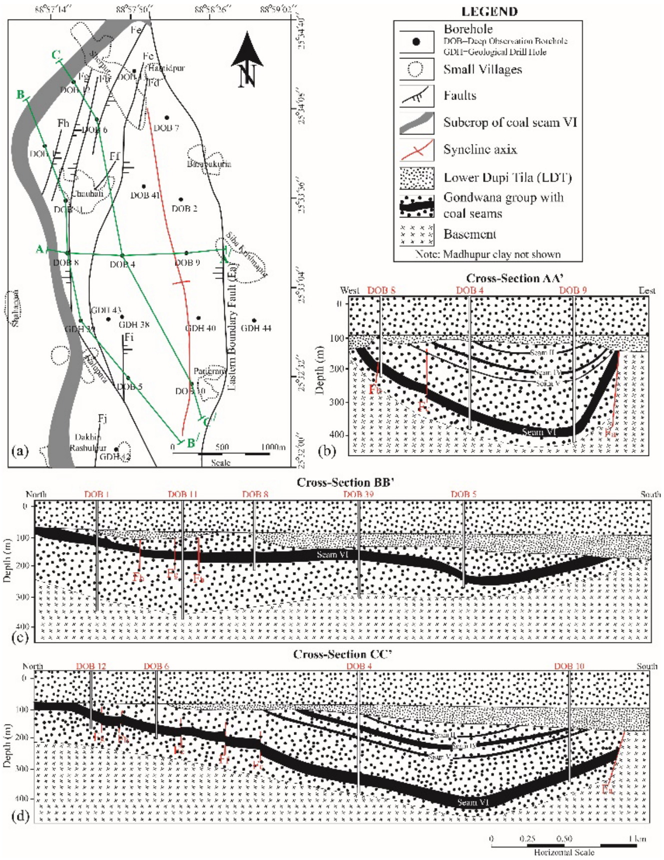

Figure 4. Major faults, stratigraphy, and coal seams distribution of Barapukuria basin (After Wardell Amstrong [19]).

2.2. Stratigraphic Units of Barapukuria Coal Mine

The geologic sequences of a basin primarily dictate the actual extent of surface subsidence. In the BCM, the stratigraphic sequence is correlated into four major formations based on age and lithological characteristics [19]. The stratigraphic units of the basin from the top are called Madhupur Clay, Dupi Tila (Upper and Lower), Gondwana Group, and Pre-Cambrian Archaean Basement (**Figure 5**). At Barapukuria, the immediate roof of the coal panels consists of Permian Gondwana Coal and Sandstone, which experiences subsidence and reaches the surface through the lower and upper Dupi Tila and Madhupur Clay layers. Here, Seam VI is mined, and the extracted panels left around 18m of coal at the top. Consequently, coal acts as the immediate roof before the sandstone layer in this scenario.

The Gondwana Group comprises coal (Seam I-V), sandstone, siltstone, shale, and numerous carbonaceous-argillaceous thin laminations. The lower Dupi Tila is a narrow impermeable layer that is not uniformly distributed across the basin, while the basin is overlain by a thick layer known as the upper Dupi Tila. The upper Dupi Tila is recognized as a formation containing water in the Barapukuria basin region.

3. Methodology

Different approaches are available for predicting subsidence troughs in both horizontal and inclined seams mining. These methods encompass theoretical and graphical techniques, physical and numerical modeling, as well as profiling and influence functions [2]. Subsidence prediction methodologies fall into categories such as empirical methods, physical models, and numerical methods [1, 22, 23].

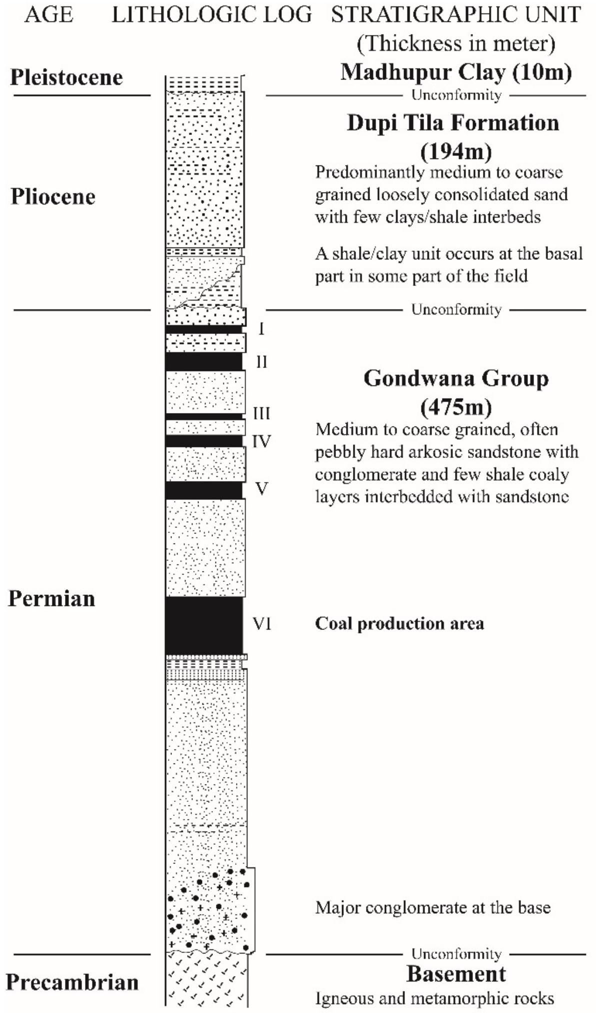

Figure 5. Summary litho-log with major stratigraphic units of Barapukuria basin (after Imam [21])

3.1. Subsidence Prediction Methods

Empirical methods rely heavily on field measurements, whereas profile functions utilize mathematical functions that involve curve fitting to the measured values. By establishing this mathematical function using real field data, it becomes feasible to predict ongoing surface subsidence in a particular mining area [1, 2]. Asadi, Shahriar, and Goshtasbi [24], and Asadi et al. [25] have proposed a new profile function that formed from the sum of two negative exponential functions for the inclined deep seam.

The profiling function method enables satisfactory results for an inclined subsidence trough. Based on the assumption of two types of soil movement, a prediction method is devised for inclined and steeply dipping seams. The first type occurs perpendicular to stratification as a result of bending and fracturing of layers, while the second type happens parallel to stratification due to shear and slip. The profiling function is a combination of three exponential functions [26]. The influence function methods are usually applied to predict surface subsidence for flat, inclined, and steeply dipping seams with different geometries of mining operations, ranging from rectangular to irregular-shaped polygonal [27, 28].

3.2 Subsidence Model

The asymmetrical subsidence trough has ascending and descending parts. The ascending section spans from the onset of subsidence at the panel to the maximum subsidence point. On the other hand, the descending section extends from the maximum subsidence point to the zero value (**Figure 6**).

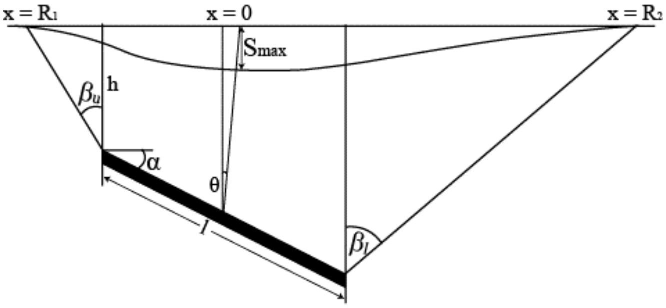

Figure 6. Parameters of the model [24]

Asadi et. al developed the following profiling function to predict subsidence in both parts of the subsidence trough:

$$S(x) = S_{max}\left[ce^{-f\left(\frac{-x}{R_1}\right)^g} + de^{-p\left(\frac{x}{R_2}\right)^q}\right] \quad (1)$$

Where S(x) = Subsidence measuring point x,

x = The distance from the point of maximum subsidence of the trough movement (in this case, where the point corresponding to S_{max} is considered the coordinate origin with x=0; negative and positive values of x denote the ascending and descending part of seam respectively),

f, g, p and q = The experimentally obtained constants.

The further parameters for subsidence mechanisms are calculated as follows:

$$S_{max} = macos\alpha \quad (2)$$

$$R_1 = htg\beta_u + 0.5lcos\alpha + (h + 0.5lsin\alpha)tg\theta \quad (3)$$

Or

$$R_1 = htan(\beta_u) + 0.5lcos(\alpha) + \big(h + 0.5lsin(\alpha)\big)\tan(\theta) \quad (3a)$$

$$R_2 = 0.5lcos\alpha - (h + 0.5lsin\alpha)tg\theta + (h + lsin\alpha)tg\beta_l \quad (4)$$

Or

$$R_2 = 0.5lcos(\alpha) - (h + 0.5l\sin(\alpha))\tan(\theta) + \big(h + lsin(\alpha)\big)\tan(\beta_l) \quad (4a)$$

$$c = -0.5[\text{sing}(x) - 1] \quad (5)$$

$$d = 0.5[\text{sing}(x) + 1] \quad (6)$$

Where, m = The thickness of the seam,

a = The subsidence factor,

α = The seam dipping angle,

R_1 and R_2 = The distances from the maximum subsidence point to the zero subsidence point on both the ascending and descending sections of the trough respectively,

h = The mine working depth on the panel ascending side,

β_u & β_l = The limit angles on the panel's ascending and descending sides respectively,

l = The working panel width,

θ = The trough angle,

c and d = The coefficients [While x<0 c=1, d=0;
while x=0 c=0.5, d=0.5
while x>0 c=0, d=1]

4. Subsidence dynamics and profile function

The subsidence is a dynamic process depending on the extraction rate. Developing from the goaf the upward deformation movement reached the surface which created a subsidence trough. The curve of a subsidence trough is being considered by the subsidence prediction method called profile function. The coal seam VI of the Barapukuria coal mine dips to the middle-eastern side of the basin (Figure 3). Consequently, all the panels of the central district are dipping to the west-southern direction. The profile function coefficient of the Negin coal mine [25] is used in the calculation as the characteristics of the stratigraphic column over the panel of the Barapukuria coal mine are similar. A series of panels and slices perform coal extraction from the Barapukuria coal mine. A single subsidence trough and goaf is considered adding coal extraction thickness of all the individual slices and panels. In that case, there are two panels (1204 & 1104) at panel 1204; three panels (1306, 1206 & 1106) at panel 1306; three panels (1308, 1208 & 1108) at panel 1308; four panels (1310, 1210, 1210D & 1110) at panel 1310; four panels (1412, 1312, 1212 & 1112) at panel 1412; three panels (1314, 1214 & 1114) at panel 1314; and one panel at 1116. The series of panels have been developed and extracted coal from all those panels to meet the production target of the mine.

Various charts and graphs are developed for specific conditions and geometrical shapes in the empirical method. Sometimes these resources can quantify subsidence amounts. Among all, the National Coal Board (NCB) has proposed one of the most well-known graphs for subsidence prediction. For instance, **Figure 7a-b** illustrates a graph for predicting surface subsidence in horizontal panels.

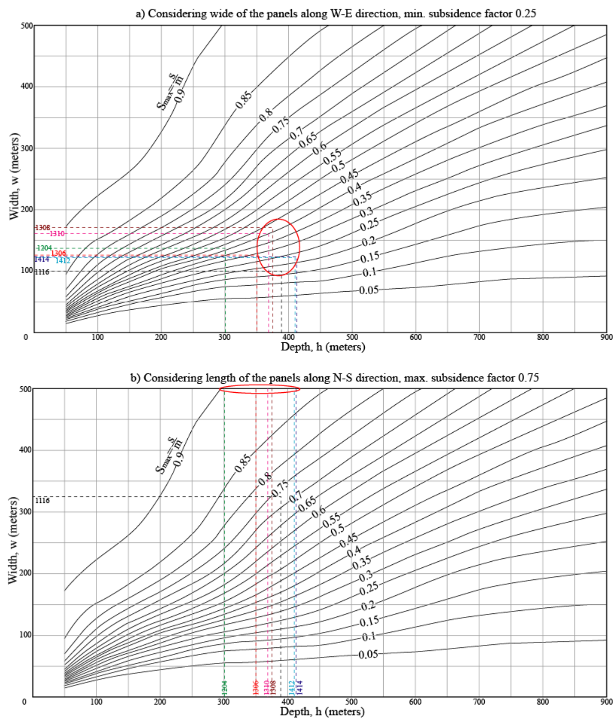

Figure 7. Subsidence factor for the northern portion of the Barapukuria coal mine (After NCB [22])

Subsidence is a continuous process that started while starting coal extraction. To quantify the profile function, a series of profile functions must be considered. The study has considered two profile function curves for each panel position. The first one is along the west-east direction while using the width of the panels and the second one is along the north-south direction while using the length of the panels to develop the profile function curves. The newly developed profile function of the Barapukuria coal mine depends on all the mining and profile function parameters of the west-direction oriented panels listed in Table 1 & Table 2 and the profile functions are shown in Table 3.

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Table 1. Mining operation parameters for W-E oriented central district panels of BCM.

Panels	Mining operation parameters, symbol						
	Coal extraction height, m	Subsidence factor, a	Maximum Subsidence, S_{max}	Mine depth, h	Width of working, l	Critical width-to-depth ratio (W/H)	Angle of seam, α
1204	06 m.	0.25/0.75	1.49/4.47	302 m.	138 m.	0.457	7°
1306	09 m.	0.25/0.75	2.22/6.67	350 m.	126 m.	0.360	9°
1308	12 m.	0.25/0.75	2.96/8.89	375 m.	171 m.	0.456	9°
1310	11 m.	0.25/0.75	2.7/8.1	368 m.	161 m.	0.437	11°
1412	14 m.	0.25/0.75	3.46/10.37	410 m.	122 m.	0.297	10°
1314	13 m.	0.25/0.75	3.2/9.6	413 m.	124.5 m.	0.301	7°
1116	03 m.	0.25/0.75	0.74/2.26	389 m.	100 m.	0.257	7°

Table 2. Profile function parameters for W-E oriented central district panels of BCM.

Panels	Profile function parameters, symbol				
	Angle of draw of ascending side, β_u	Angle of draw of descending side, β_l	Angle of trough, θ	Distance from max. subsidence to ascending side, R_1	Distance from max. subsidence to descending side, R_2
1204	38°	52°	3°	320.6 m.	463.1 m.
1306	43°	57°	3.5°	410.6 m.	609.5 m.
1308	45°	59°	4°	486.6 m.	725.9 m.
1310	46°	62°	4.5°	490.3 m.	798.7 m.
1412	46°	60°	4°	514 m.	777.5 m.
1314	46°	60°	3°	511.5 m.	781.4 m.
1116	46°	56°	3°	473.2 m.	623.7 m.

Table 3. Newly developed profile functions for west-east oriented panels of central districts of the Barapukuria coal mine.

Panels	Considered maximum subsidence	Profile functions
1204	S_{max}=1.49 or 4.47	$S(x) = -S_{max}\left[ce^{-8.8\left(\frac{-x}{320.6}\right)^{2.17}} + de^{-7.4\left(\frac{x}{463.1}\right)^{2.11}}\right]$
1306	S_{max}=2.22 or 6.67	$S(x) = -S_{max}\left[ce^{-8.8\left(\frac{-x}{410.6}\right)^{2.17}} + de^{-7.4\left(\frac{x}{609.5}\right)^{2.11}}\right]$
1308	S_{max}=2.96 or 8.89	$S(x) = -S_{max}\left[ce^{-8.8\left(\frac{-x}{486.6}\right)^{2.17}} + de^{-7.4\left(\frac{x}{725.9}\right)^{2.11}}\right]$
1310	S_{max}=2.7 or 8.1	$S(x) = -S_{max}\left[ce^{-8.8\left(\frac{-x}{490.3}\right)^{2.17}} + de^{-7.4\left(\frac{x}{798.7}\right)^{2.11}}\right]$
1412	S_{max}=3.46 or 10.37	$S(x) = -S_{max}\left[ce^{-8.8\left(\frac{-x}{514}\right)^{2.17}} + de^{-7.4\left(\frac{x}{777.5}\right)^{2.11}}\right]$
1314	S_{max}=3.2 or 9.6	$S(x) = -S_{max}\left[ce^{-8.8\left(\frac{-x}{511.5}\right)^{2.17}} + de^{-7.4\left(\frac{x}{781.4}\right)^{2.11}}\right]$
1116	S_{max}=0.74 or 2.26	$S(x) = -S_{max}\left[ce^{-8.8\left(\frac{-x}{473.2}\right)^{2.17}} + de^{-7.4\left(\frac{x}{623.7}\right)^{2.11}}\right]$

At the same time, the mining operation and profile function parameters of the north-south oriented panels are listed in Table 4 & Table 5, and newly developed profile functions are shown in Table 6.

Table 4. Mining operation parameters for N-S oriented central district panels of BCM.

Panels	Mining operation parameters, symbol						
	Coal extraction height, m	Subsidence factor, a	Maximum Subsidence, S_{max}	Mine depth, h	Length of working, l	Critical width-to-depth ratio (L/H)	Av. Angle of seam, α
1204	06 m.	0.25/0.75	1.46/4.38	302 m.	677.5 m.	2.24	13°
1306	09 m.	0.25/0.75	2.19/6.58	350 m.	649 m.	1.85	13°
1308	12 m.	0.25/0.75	2.92/8.77	375 m.	691 m.	1.84	13°
1310	11 m.	0.25/0.75	2.68/8.04	368 m.	568 m.	1.54	13°
1412	14 m.	0.25/0.75	3.41/10.23	410 m.	592 m.	1.44	13°
1314	13 m.	0.25/0.75	3.17/9.5	413 m.	547.2 m.	1.32	13°
1116	03 m.	0.25/0.75	0.73/2.19	389 m.	325.95 m.	0.84	13°

Table 5. Profile function parameters for N-S oriented central district panels of BCM.

Panels	Profile function parameters, symbol				
	Angle of draw of ascending side, β_u	Angle of draw of descending side, β_l	Angle of trough, θ	Distance from max. subsidence to ascending side, R_1	Distance from max. subsidence to descending side, R_2
1204	33°	49°	4°	552.6 m.	826.35 m.
1306	36°	53°	4°	600 m.	944.80 m.
1308	40°	57°	4°	683 m.	1121.8 m.
1310	41°	59°	4°	626.81 m.	1071.62 m.
1412	41°	61°	4°	678.15 m.	1235 m.
1314	43°	61°	4°	684.9 m.	1200.54 m.
1116	41°	62°	4°	526.71 m.	998.53 m.

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Table 6. Newly developed profile functions for north-south oriented panels of central districts of the Barapukuria coal mine.

Panels	Considered maximum subsidence	Profile functions
1204	S_{max}=1.46 or 4.38	$S(x) = -S_{max}\left[ce^{-8.8\left(\frac{-x}{552.6}\right)^{2.17}} + de^{-7.4\left(\frac{x}{826.35}\right)^{2.11}}\right]$
1306	S_{max}=2.19 or 6.58	$S(x) = -S_{max}\left[ce^{-8.8\left(\frac{-x}{608}\right)^{2.17}} + de^{-7.4\left(\frac{x}{857.25}\right)^{2.11}}\right]$
1308	S_{max}=2.92 or 8.77	$S(x) = -S_{max}\left[ce^{-8.8\left(\frac{-x}{683.46}\right)^{2.17}} + de^{-7.4\left(\frac{x}{1122.62}\right)^{2.11}}\right]$
1310	S_{max}=2.68 or 8.04	$S(x) = -S_{max}\left[ce^{-8.8\left(\frac{-x}{677.3}\right)^{2.17}} + de^{-7.4\left(\frac{x}{1158.7}\right)^{2.11}}\right]$
1412	S_{max}=3.41 or 10.23	$S(x) = -S_{max}\left[ce^{-8.8\left(\frac{-x}{678.15}\right)^{2.17}} + de^{-7.4\left(\frac{x}{1235}\right)^{2.11}}\right]$
1314	S_{max}=3.17 or 9.5	$S(x) = -S_{max}\left[ce^{-8.8\left(\frac{-x}{684.9}\right)^{2.17}} + de^{-7.4\left(\frac{x}{1200.54}\right)^{2.11}}\right]$
1116	S_{max}=0.73 or 2.19	$S(x) = -S_{max}\left[ce^{-8.8\left(\frac{-x}{600}\right)^{2.17}} + de^{-7.4\left(\frac{x}{1132.13}\right)^{2.11}}\right]$

A subsidence curve of the west-east direction panels has been created based on the developed profile function, shown in **Figure 8**; and subsidence curves of the north-south direction have been created and shown in **Figure 9a-f**.

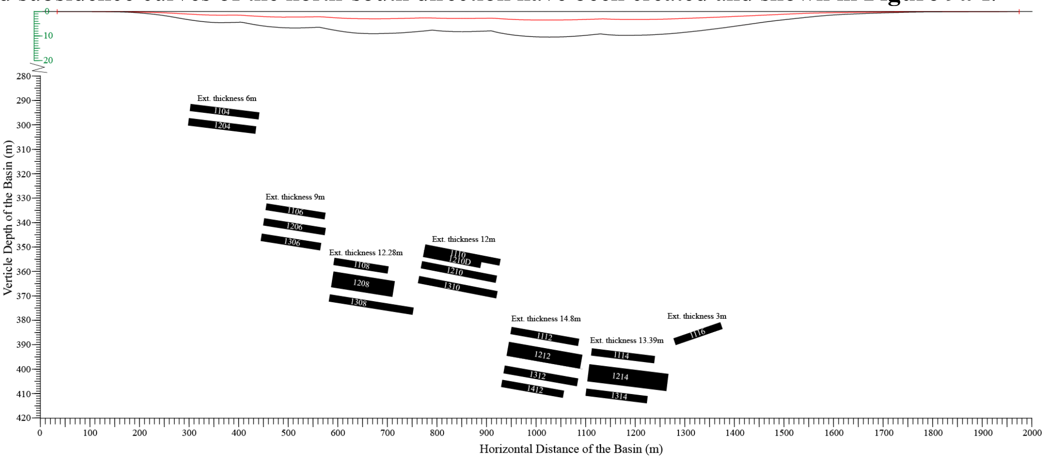
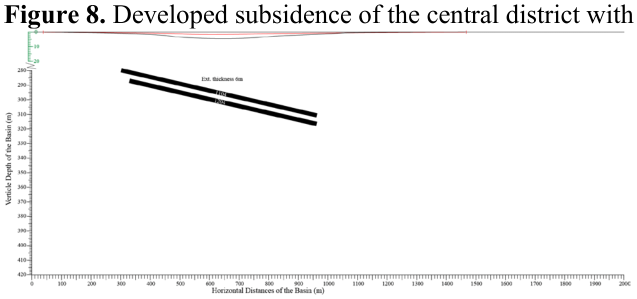
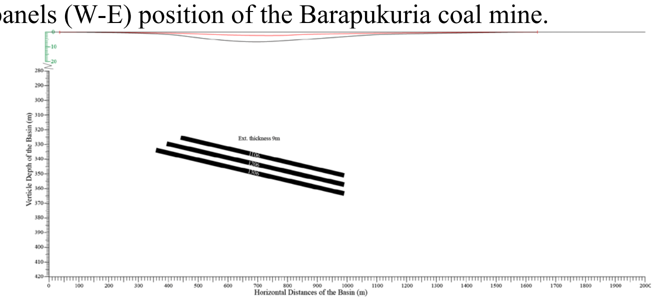


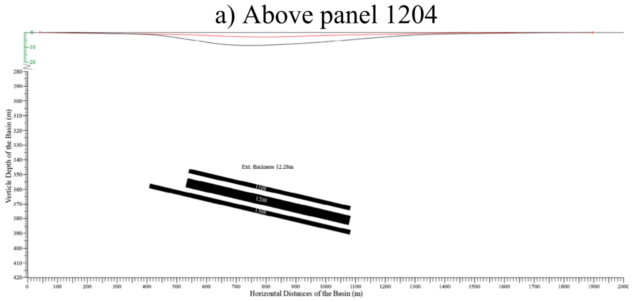
Figure 8. Developed subsidence of the central district with panels (W-E) position of the Barapukuria coal mine.



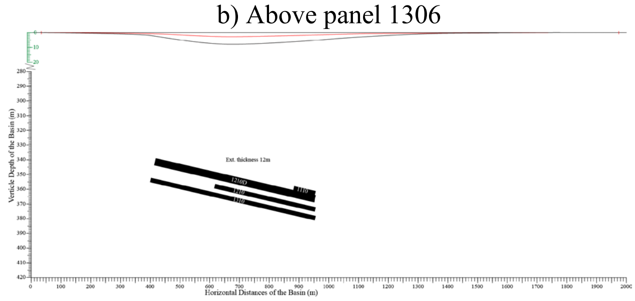
a) Above panel 1204



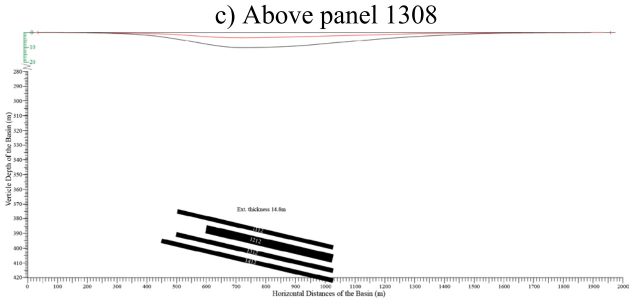
b) Above panel 1306



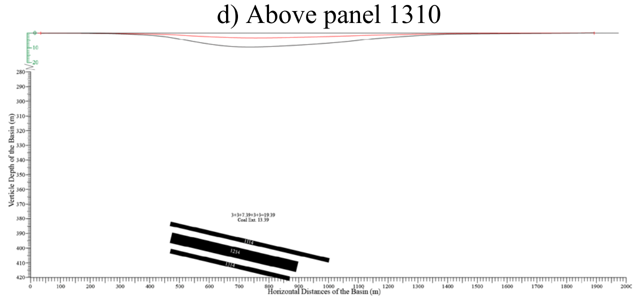
c) Above panel 1308



d) Above panel 1310



e) Above panel 1412



f) Above panel 1314

Figure 9. Developed subsidence of the central district with panels (N-S) position of the Barapukuria coal mine.

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5. Result and Discussion

An ultra-thick coal seam of the Gondwana age has been discovered in the Barapukuria coal basin. The average thickness of the coal seam VI is 36m. It is observed from the feasibility study data that the coal seam is inclined and asymmetric having shallow depth at the periphery. A north-south aligned major fault boundary has controlled the eastern boundary of the coal basin. Consequently, the thickness of coal seam VI is increased and found deeper in depth toward the eastern portion of the central district of the Barapukuria coal basin.

The subsided area observed at the Barapukuria coal mine is attributable to the extraction of coal using the longwall caving mining method. The subsidence lakes located above the coal mine are the cumulative result of a series of coal panels. In the central district of the mine, there are 7 north-south aligned panels arranged side-by-side. The longwall caving mining was planned by downward cutting, with 9 slices considered for each corresponding panel. Finally, four slices is to be operated in one panel, and three slices are to be applied in most of the panels to date (Figure 8).

The subsidence prediction for the Barapukuria Longwall mine is a special event that must be considered a cumulative function of all the panels. Moreover, the configuration (rectangular) of the panels maintained a west-east and north-south trend. Considering the panel configuration the subsidence prediction has been calculated based on the profile function. To find out the possible maximum subsidence for each panel, two subsidence factors have been considered as the lowest (0.25) and highest (0.75) limit of the maximum subsidence, shown in Tables 1 and 4.

Maximum subsidence has been calculated and the calculated subsidences are- above panel 1308 (lowest 2.92 m., highest 8.77 m.); panel 1412 (lowest 3.41 m., highest 10.23 m.), and panel 1314 (lowest 3.17 m., highest 9.5 m.). The maximum water depth (10.5 meters) of the lakes developed due to the subsidence has been measured by HawkEye DT1H Handheld depth finder. The measured values have been plotted according to coordination and correlated with the newly developed profile function data. The result obtained from the calculation using the profile function curves shows that the predicted values closely matched the measured data of panels 1308, 1412, and 1314 shown in **Figure 10**.

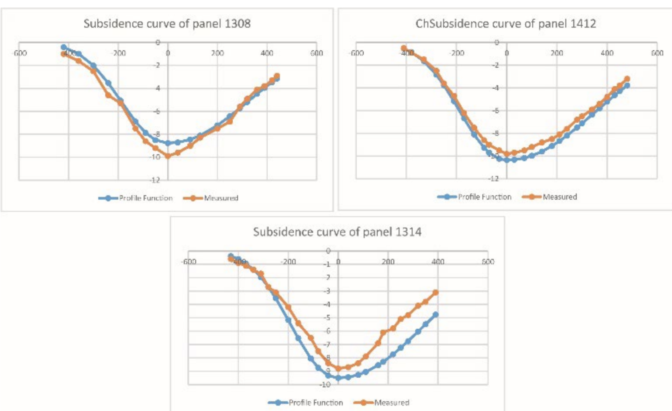

Figure 10. Correlation curves of panels 1308, 1412, and 1314.

The correlation coefficients between the predicted and observed values of the mentioned panels are 0.9875, 0.9993, and 0.9752 respectively, indicating strong agreement within the datasets.

6. Conclusion

Mining-induced land subsidence is a continually evolving process that begins post-ore extraction and extends for several years beyond the cessation of mining activities. This ongoing process results in the gradual development of the subsidence trough, influenced by factors such as the mining method, extraction rate, shape and size of extraction panels, characteristics of the immediate roof rock, and geotechnical properties of the overburden. A giant subsidence trough of around 1.25 square kilometers has been developed in the central district of the mining area. Subsidence prediction in such a complex environment is one of the toughest exercises in mining industries. In this study, the newly proposed profile functions for all the rectangular panels have been adjusted by field investigation in the Barapukuria coal mine.

Utilizing the new model, which relies on the straightforward profile function, shortens the time needed to calculate surface subsidence predictions and enhances the precision of subsidence forecasts. The proposed model demonstrates a strong correlation between measured and predicted subsidence by utilizing the measured water depth instead of directly measuring surface subsidence in the subsidence lake at the Barapukuria coal mine. The correlation coefficient ranges from 0.9752 to 0.9993, indicating a highly satisfactory level of correlation.

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Ethical Approval:

This work is an original contribution to the field and has not been published in any form or language elsewhere. The results are presented clearly and honestly, without any fabrication, falsification, or inappropriate manipulation of data (including image-based manipulation). The authors follow discipline-specific rules for data acquisition, selection, and processing.

Consent of Participate:

The submitted work is experimental work performed in the field and laboratory. No human subject or living organism/tissue is involved in this research.

Consent to Publish:

No consent to publish is to be shared.

Author Contributions

All authors contributed to the research work. Material preparation, data collection, and analysis were performed by Md. Abdul Malek. Moreover, the first draft of the manuscript was written by Md. Abdul Malek and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript