Journal of Positive School Psychology http://journalppw.com
2022, Vol. 6, No. 5, 4635–4639

A Study on Horizontal Displacement & Strain over Longwall Mine

Chitti Ravi Kiran [1]*, Prof. A K Mishra[2], Dr. M S Venkataramayya [3]

[1] Research Scholar, Dept. of Mining Engineering, IIT ISM Dhanbad - 826004, India.
[2] Head (Mining) & Professor, Dept. of Mining Engineering, IIT ISM Dhanbad, India.
[3] Professor, Dept. of Mining Engineering, MREC Hyderabad –500100, India.
E.Mail : [1] chittiravikiran@gmail.com

Abstract

Strain is an essential component associated with Surface subsidence. Predicting strain due to underground mining is one the difficult concept. In this paper, the subsidence over mechanized Longwall located in the south of India is predicted with the help of ANSYS software. The predictions from the numerical model are compared with field data and validated.
Keywords— Subsidence – Horizontal Displacement- Horizontal Strain

INTRODUCTION

Experience shows that accurate prediction of the mine subsidence process and its effects are the keys to designing and implementing effective control measures to reduce the severity of the subsidence disturbances and the subsequent consequences (Peng, 1984). The accuracy of the subsidence prediction method depends on the employed mathematical models, empirical formulae & Numerical analysis for subsidence parameters deduced from field works (Brauner G, 1974, NCB 1976)

Subsidence on the mine surface has two important components: a) vertical Displacement b) Horizontal Displacement. Normally the vertical measurements displacements are easy to measure with conventional surveying equipment. Similarly, the horizontal displacement & strain can be measured with conventional equipment(S Tanadanand., etal 1991), but they require more accurate studies. In this paper, surface subsidence has been observed using ANSYS software.

Subsidence survey over underground coal mine is a very important topic to assess the damage to the structures, rivers, roads, forests, water bodies, etc.; Different countries have stipulated guidelines to accesses the damage due to subsidence. Various researchers have utilized different techniques to predict subsidence and damage (Chrzanowski, 1998). In India, subsidence prediction studies should be conducted to obtain forest clearance for all underground mining projects. In this study, subsidence (displacement), horizontal strain values, their impact on forests & surfaces, and mitigation should be mentioned. The maximum permissible limit for horizontal (Tensile) strain is 20mm/m. (MOEF& CC, 2019). The Ministry of Environment, Forestry & Climate Control of the Government of India has framed guidelines for exemption from payment of NPV. For underground mining, the NPV exemptions are as follows:

S.No	Surface Strain Predicted by the 3D subsidence prediction model	NPV
1	Up to 5mm/m	Nil
2	5mm/m to 10mm/m	10% of the Normal rate of NPV
3	10mm/m to 15mm/m	25 % of the Normal rate of NPV
4	15mm/m to 20mm/m	50 % of Normal Rate of NPV
5	More than 20mm/m	Normal Rate of NPV

Table 1 Exemptions for NPV of mines (MOEF& CC, 2019)

Site discussion

The Longwall Mine considered here is located in southern India. It is a multi seam coal block having four major working seams. At present, coal seam I of this mine was worked at a depth of 413m having a thickness of 6.74m. Two Longwall panels are extracted with 250m in width, 2350m long, and having a working height of 3.2m from the bottom of the seam. Coal seam II is at a depth 0f 438m from the surface. The area above seam I was composed of coal, shale & clay. The Intraburden distance between the I Seam & II Seam is around 18m & it is filled with Sandstone. The mechanical properties of the rocks are as given in Table.1

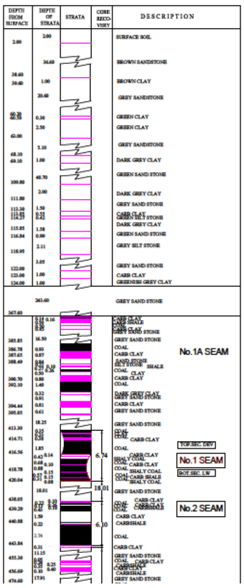

Figure 1 Lithology of the mine

Rock strata	Density ρ(kg/m3)	Elastic modulus *E cm* (GPA)	Poisson's ratio	Cohesion C (MPa)	Friction angle Φ	Dilation angle Δ
Clay	1100	1.278	0.35	0.811	27^0	18^0
Coal	1500	1.535	0.35	1.00	31^0	21^0
Sand stone	2147	5.132	0.28	1.461	38^0	19^0

Table 1 Mechanical Properties of Rock used in modeling (After Sreenivasa Rao et al., 2016)

Model Preparation:

In this study, a three-dimensional element model has been developed, having a length (X-axis) and width (Z-axis) of 3000m and 1000m each and a depth (Y-axis) of 500m. The dimension of the Longwall panel is considered to be having a length of 2350m and a width of 250m. The working height of the Longwall panel is 3.2 m. The mechanical properties of the material are taken from table 2. After the generation of the model and assigning material properties, it is meshed, as shown in figure 2

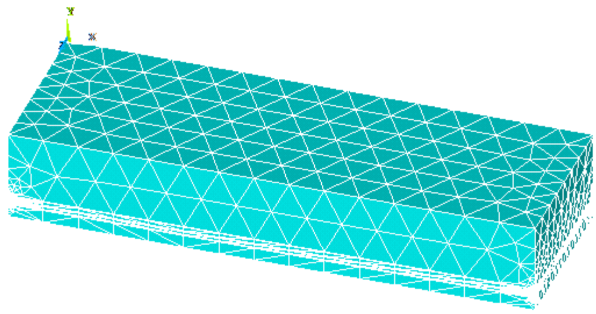

Figure 2 Meshing of Model

After the model is meshed, as shown in figure 2, contact & target element command are applied, and then loads are applied. The loads applied to the model are as follows: a) the bottom of the model is constrained for vertical displacement (U_y), b) The sides along the panel length are constrained in the Z direction, c) The sides along the width of the Panel are constrained in the X direction and d) the acceleration due to gravity is applied in the Y direction (Kiran C R et.al 2022)

Results and Discussion

The result obtained from numerical modeling consists of vertical displacement, horizontal displacement, etc., as shown in Figure 3 below. In this study, vertical displacement and horizontal displacements are considered.

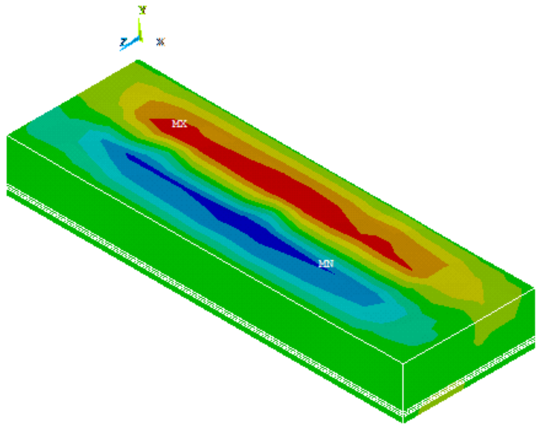

Figure 3 Horizontal Displacement predicted in the model.

The horizontal displacement predicted after extraction of Panel I was 3.1cm at the initial edge point of the width and 3.2cm at the other edge point of the width, as shown in figure 4. The displacement values are predicted to be zero at the center of the Panel. The horizontal strain is predicted after the extraction of Panel I; the maximum tensile (+ve) strain is around 2mm/m, and the maximum compressive strain (-ve) is 3mm/m. The compressive strain is observed within the excavation zone while the tensile strain is on both sides of the excavation

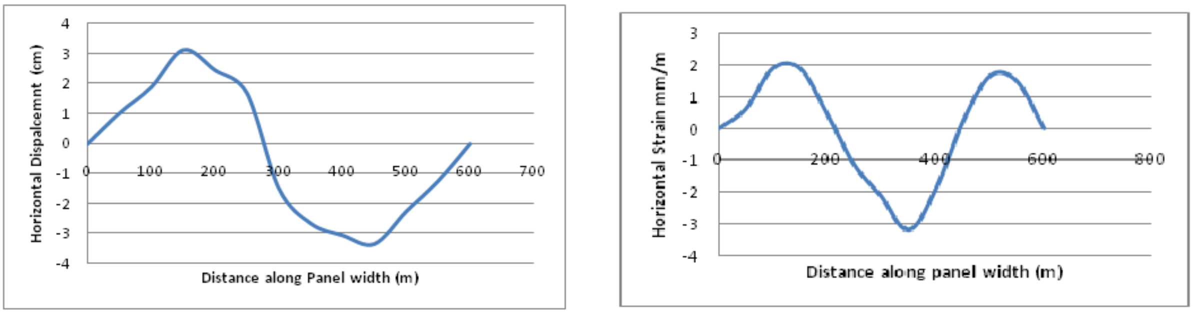

Figure 4 Horizontal Displacement and Horizontal strain predicted from the model after extraction of Panel I of Seam I

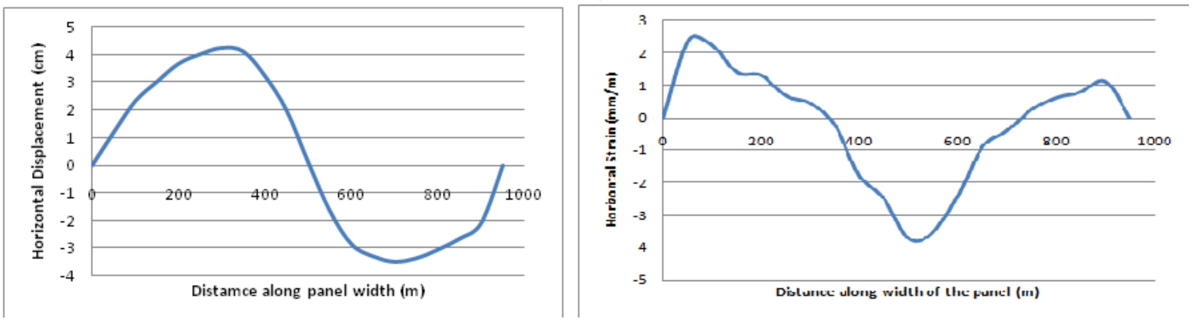

Figure 5 Horizontal Displacement and Horizontal Strain predicted from the model after extraction of Panel II of Seam I

The horizontal displacement after extraction of panel II was the crest of the profile was 4.2cm and the trough of the profile was 3.53cm on the other edge of the width. The horizontal strain predicted after extraction of Panel I & Panel II is as follows. The maximum tensile strain (+ve) is 4.2mm/m, while the maximum compressive strain is 3.8 mm/m.

S. No	Panel /Seam	Tensile Strain	Compressive Strain
1	Panel I Seam I	2mm/m	3mm/m
2	Panel II Seam I	4.2mm/m	3.8mm/m

Table 3 Horizontal Strain predicted after extraction of Seam I

As shown in figure.6, the maximum vertical displacement predicted after extraction of Panel II is 1.438m. The displacement observed on Panel I after the extraction of Panel II was 1.438m. As per the field data, the vertical displacement of Panel I after extraction of Panel II was 1.402m, the variation between the field data to the predicted data is about 97% (A Nurnic, 2012). The vertical displacement observed on panel II was 1.262m, and the field data of the corresponding Panel was 1.296m.

Therefore the variation is about 97% (A Nurnic, 2012).

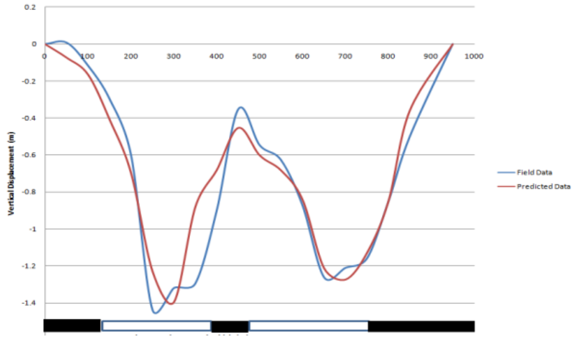

Figure 6 Vertical Displacement predicted and field data after extraction of Panel II of Seam I

S. No.	Panel/ Seam	Vertical Displacement	Type
1	Panel I Seam I	1.438	Predicted
2	Panel I Seam I	1.402	Field Data
3	Panel II Seam I	1.262	Predicted
4	Panel II Seam I	1.296	Field Data

Table 4 Vertical Displacement predicted and field data after extraction of Panel II

The horizontal displacement after extraction of Panel I in was the crest of the profile is 5.2 cm and the trough of the profile is 5.6cm on the other edge of the width. The horizontal strain predicted after extraction of Panel I in seam II is as follows. The maximum tensile strain (+ve) is 5.2mm/m, while the maximum compressive strain is 5.8mm/m.

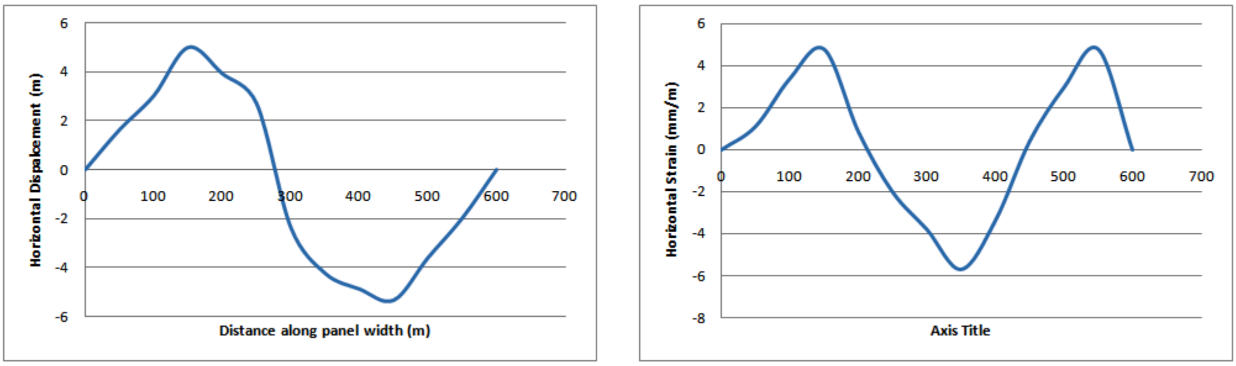

Figure 5 Horizontal Displacement and Horizontal Strain predicted from the model after extraction of Panel I of Seam II.

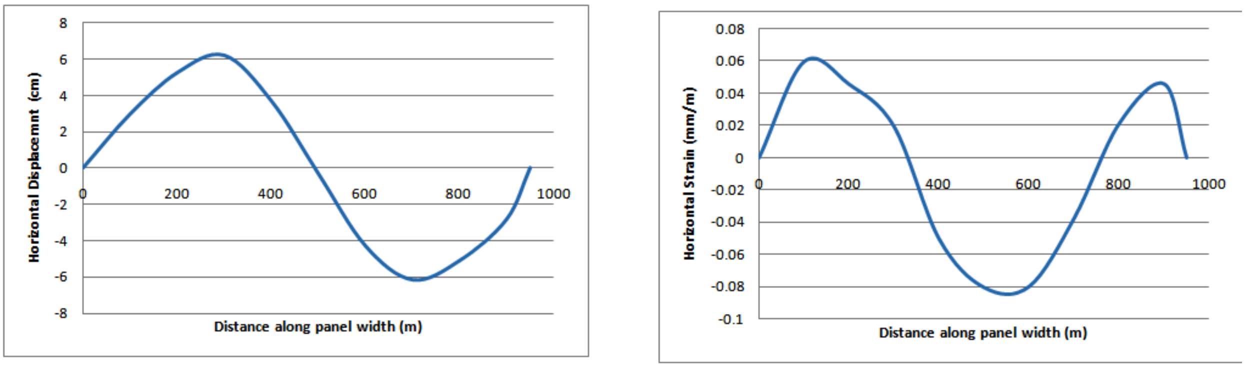

Figure 6 Horizontal Displacement and Horizontal Strain predicted from the model after extraction of Panel II of Seam II.

The horizontal displacement after extraction of panel II was the crest of the profile was 6.19cm and the trough of the profile was 6.17 cm on the other edge of the width. The horizontal strain predicted after extraction of Panel I & Panel II in Seam II is as follows. The maximum tensile strain (+ve) is 6mm/m, while the maximum compressive strain is 8mm/m.

S. No	Panel /Seam	Tensile Strain	Compressive Strain
1	Panel I Seam I	5.2mm/m	5.8mm/m
2	Panel II Seam II	6mm/m	8mm/m

Table 5 Horizontal Strain predicted after extraction of Seam II

Conclusion

Subsidence associated with Longwall mining is a problem causing damage to structures and posing severe environmental problems. The horizontal strain is predicted using Finite element analysis.

a) This study proposes the subsidence prediction technique using ANSYS software.
b) The vertical displacement predicted from the model is compared with the field data and an accuracy of 97 -98% is achieved. The results generated are validated.
c) The horizontal strain values are around 2 - 4mm/m which are well within permissible limits while extracting Seam I, which is well within the limit.
d) The horizontal strain values are around 6 - 8mm/m permissible limits while extracting Seam II, which exceeds the standard limit & is placed in the 10% deduction Range.

Acknowledgment

The authors would like to thank the management of SCCL for allowing them to visit the mine and collect the data.

References

1. A. Nuric, et al., (2012) "Numerical Modelling and Computer Simulation of Ground Movement Above Underground Mine," International Journal of Geological and Environmental Engineering, Vol:6, No:9, pp 579-587
2. Brauner, G.(1973) "Subsidence due to underground mining. I. Theory and practices in predicting surface deformation," (in two parts), USDI Bur. of Mines.IC8571
3. Chrzanowski, A.S., and Forrester, D. J.(1998), "100 years of ground subsidence studies" proceedings (CDROM) of the 100th CIM Annual General Meeting Montreal, Canada.
4. Chitti Ravi Kiran, A K Mishra, M S Venkataramayya (2022), " A Study of Subsidence over Longwall Panel – Prediction and Calibration, Journal for Mines, Metals & Fuels, Vol. 70 (2), pp 60-63
5. Handbook of Forest Conservation Act, 1980 & Forest Conservation Rules 2003, (Guidelines and clarifications), Ministry of Environment, Forest and Climate Change, Government of India, 2019, PP 55, 77
6. National Coal Board. "Subsidence Engineering Handbooks," London 2nd Edition. 1975.
7. Peng, S.S., and Chiang, H., "Longwall Mining," John Wiley & Sons, Inc. New York, 1984.
8. Sathit Tandanand and Larry R Powell (1991), "Determining Horizontal Displacement and strains due to Subsidence, Report of Investigation 9358
9. Sreenivasa Rao Islavath, Deb D and Hemant Kumar., (2016) Numerical analysis of a longwall mining cycle and development of a composite longwall index, Int J Rock Mech Min Sci, 89, 43-54.