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# RECLAMATION OF SUBSIDED LAND FOR RESIDENTIAL COLONY AT SAMLESHWARI OPEN CAST PROJECT, MAHANADI COALFIELDS LIMITED

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खनन के फलस्वरूप धंसी हुई भूमि को प्राय: अप्रयुक्त ही छोड़ दिया जाता है। इस आलेख में महानदी कोलफील्ड्स लिमिटेड की समलेश्वरी खुली खदान क्षेत्र में अवशिष्ट धंसान का अध्ययन किया गया है और अप्रयुक्त छोड़ दी गई भूमि के स्थायित्व का वैज्ञानिक आकलन कर निवासीय कॉलोनी के निर्माण में इसके समुचित उपयोग पर चर्चा की गई है।

## INTRODUCTION

An area of about 0.39 square kilometer got subsided due to underground mining. The collieries in this region are very old where the mines were developed by caving system, which subsided the surface topography. The terrain or the surface was mainly undulated lands having small trees and thorny bushes. The position of open cast mines of Samleshwari project is within 2 km. from the area of study.

## GEOLOGY

The seam dips 1 in 20 due S 84° 30' W. All the four overlying seams arc virgin in the area. There is a thick layer of sandstone (39.33 m), which is 38% of the overburden. The overburden mainly consists of sandstone, shale, coal and subsoil. The place is situated in Orissa, near Brajrajnagar railway station.

## PHYSICAL DETAILS OF THE AREA AND MINING HISTORY

Rampur Bottom coal seam was extracted from May 1946 to September 1975. Subsidence took place over the goaved out panels but the relevant records were not available. To assess the possibility of residual subsidence observations were conducted by taking spot levels at points from September 1990 to January 1991. The measurement indicated 0 to 15 mm of vertical surface movement, may be due to swelling of topsoil. Hence it was assumed that there were no possibilities of any further subsidence. Therefore, it was proposed to construct quarters in the area.

The Rampur Bottom coal seam extraction thickness varied from 1.65 m to 2.20 m. The depth of the workings was ranging from 80 m to 112 m. The bord and pillar developed panels in this area were extracted by conventional caving method. The other overlying seams are virgin in the area.

## ASSESSMENT OF SUBSIDENCE POTENTIAL

Several caved goaves lie underneath and in the vicinity of the area under review (Fig. 1) No record was available for assessing the percentage of extraction in the goaved out panels as well as no subsidence record.

As per Table I, width-depth ratio range from 0.82 to 1.88 in the existing geo-mining condition of coal seam and the composition of rocks in the overburden, the critical width-depth ratio is likely to be 1.4 to 1.6 and the non-effective width-depth ratio vary from 0.4 to 0.6 in single

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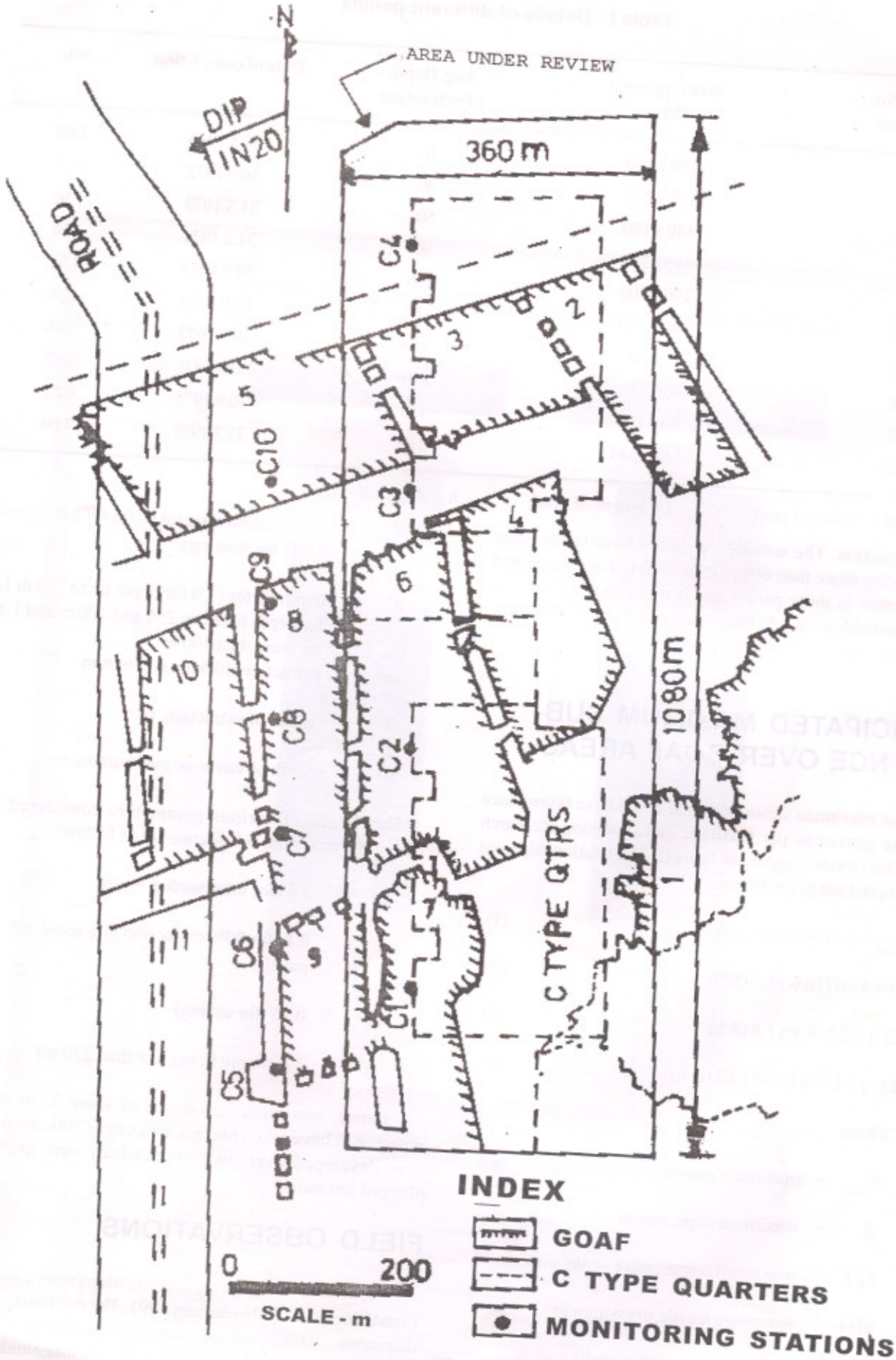


Fig. 1 : Plan showing area under review over goaved out region with "C" type quarters

Table I : Details of different panels

| Panel No. (w x l) $m^2$ | Size (approx.) (h) m | Avg. Depth of extraction | Date of completion | w/h |
|---|---|---|---|---|
| 1 | 150 x 180 | 80 | 31.5.1946 | 1.88 |
| 2 | 100 x 270 | 80 | 30.9.1972 | 1.25 |
| 3 | 140 x 180 | 90 | 31.3.1972 | 1.56 |
| 4 | 140 x 280 | 90 | 31.3.1973 | 1.56 |
| 5 | 170 x 300 | 110 | 30.9.1971 | 1.54 |
| 6 | 150 x 380 | 110 | 30.9.1974 | 1.36 |
| 7 | 95 x 340 | 110 | 30.9.1973 | 0.86 |
| 8 | 90 x 350 | 110 | 30.6.1975 | 0.82 |
| 9 | 90 x 150 | 110 | 30.9.1975 | 0.82 |
| 10 | 120 x 240 | 110 | 31.3.1973 | 1.09 |

w = width of goaf, l = length of goaf, h = depth of cover

seam extraction. The subsidence should have taken place (considering more than 60% extraction) during the period of extraction in these panels and it was expected that the residual subsidence might have taken place about 1000 days after the completion of extraction.

## ANTICIPATED MAXIMUM SUB-SIDENCE OVER GOAF AREAS

The maximum subsidence that could have taken place over the goaves as per CMRI [Central Mining Research Institution] model is given in Table II. The relationship used in the model are given below:

$$S_{max} = 0.5\,(1+M)\,(e'.a'.h'.m') \quad (1)$$

$$G = 4.007\,(h/w)\,1.7\,(S/h) \quad (2)$$

$$E(-) = 2.2\,(h/w)\,1.8\,(S/h) \quad (3)$$

$$E(+) = 1.976\,(h/w)\,1.68\,(w/h) \quad (4)$$

Where

$S_{max}$ = maximum possible subsidence, m or mm

G = maximum slope, mm/m

E(-) = maximum compressive strain, mm/m

E(+) = maximum tensile strain, mm/m

M = rock mass factor (0.5 – 1.0)

e' = extraction percentage factor (0.5-0.95)

a' = goaf treatment factor (0.95 for caving and 0.701 for stowing)

h' = depth factor (1.0 for depth up to 250 m 1.1 for depth between 250 and 400 m and 1.15 for more than 400 m

m' = extraction thickness, m or mm

w = width of extraction, m

h = depth of cover or overburden, m

The values of various parameters considered for anticipating maximum subsidence are as follows:

M = 0.6 (for interbanded strata)

E' = 0.8 (for 80% extraction in goaved out panels)

A' = 0.95 (for caving)

H' = 1.0 (depth being less than 250 m)

Hence, maximum subsidence of about 1330 mm is expected to have taken place. Cracks upto 200 mm widths were developed over the goaves which were gradually plugged naturally.

## FIELD OBSERVATIONS

Subsidence monitoring investigations were conducted from September 1990 to January 1991. The maximum vertical displacement observed to he 20mm, which indicated both upliftment and subsidence of insignificant magnitude. This movement was mainly owing to swelling and shrinkage of

**Table II : Predicted subsidence movements in different panels**

| Panel No. | w/h | m' (m) | S (mm) | G (mm/m) | E(-) (mm/m) | E(+) (mm/m) |
|---|---|---|---|---|---|---|
| 1 | 1.88 | 2.2 | 1330 | 37 | 17 | 17 |
| 2 | 1.25 | 2.2 | 1300 | 36 | 17 | 16 |
| 3 | 1.56 | 2.2 | 1330 | 33 | 16 | 15 |
| 4 | 1.56 | 2.2 | 1330 | 33 | 16 | 15 |
| 5 | 1.54 | 2.2 | 1330 | 27 | 13 | 12 |
| 6 | 1.36 | 2.2 | 1320 | 26 | 13 | 12 |
| 7 | 0.86 | 2.2 | 840 | 17 | 8 | 8 |
| 8 | 0.82 | 2.2 | 730 | 15 | 7 | 7 |
| 9 | 0.82 | 2.2 | 730 | 15 | 7 | 7 |
| 10 | 1.09 | 2.2 | 1230 | 25 | 12 | 11 |

**Table III : Details of subsidence and strain observation in 1994**

| | REDUCED LEVEL | | | | DISTANCE | | |
|---|---|---|---|---|---|---|---|
| Monitoring Station | May 94 (m) | Oct. 94 (m) | Subsidence (m) | Stations | May 94 (m) | Oct. 94 (m) | Strain (mm/m) |
| B1 | 98.99 | 98.985 | 0.005 | C5-C6 | 7.445 | 7.445 | NIL |
| B2 | 98.965 | 98.965 | 0 | C6-C7 | 7.455 | 7.455 | NIL |
| C1 | 101.75 | 101.75 | 0 | C7-C8 | 7.37 | 7.37 | NIL |
| C2 | 101.92 | 101.915 | 0.005 | C8-C9 | 7.25 | 7.25 | NIL |
| C3 | 101.985 | 101.985 | 0 | C9-C10 | 7.565 | 7.565 | NIL |
| C4 | 102.155 | 102.155 | 0 | C8-C10 | 14.935 | 14.935 | NIL |
| C5 | 101.17 | 101.165 | 0.005 | C10-C11 | 7.415 | 7.415 | NIL |
| C6 | 101.71 | 101.71 | 0 | C11-C12 | 7.315 | 7.315 | NIL |
| C7 | 101.62 | 101.62 | 0 | C12-C13 | 7.215 | 7.215 | NIL |
| C8 | 102.02 | 102.02 | 0 | C13-C14 | 6.962 | 6.962 | NIL |
| C9 | 101.945 | 101.945 | 0 | C24-C29 | 12.045 | 12.045 | NIL |
| C10 | 102.26 | 102.26 | 0 | C5-C29 | 18.403 | 18.403 | NIL |

**Table IV : Details of subsidence and strain observation in 1997**

| | REDUCED LEVEL | | | | DISTANCE | | |
|---|---|---|---|---|---|---|---|
| Monitoring Station | May 94 (m) | Oct. 94 (m) | Subsidence (m) | Stations | May 94 (m) | Oct. 94 (m) | Strain (mm/m) |
| B(3) | 98.97 | 98.97 | 0 | C5-C6 | 7.445 | 7.445 | NIL |
| B(4) | 98.94 | 98.94 | 0 | C6-C7 | 7.455 | 7.455 | NIL |
| 1 | 104.195 | 104.2 | -0.005 | C7-C8 | 7.37 | 7.37 | NIL |
| 2 | 104.2 | 104.205 | -0.005 | C8-C9 | 7.25 | 7.25 | NIL |
| C1 | 101.75 | 101.75 | 0 | C9-C10 | 7.565 | 7.565 | NIL |
| C2 | 101.92 | 101.915 | 0.005 | C8-C10 | 14.935 | 14.935 | NIL |
| C3 | 101.985 | 101.985 | 0 | C10-C11 | 7.415 | 7.415 | NIL |
| C4 | 102.155 | 102.155 | 0 | C11-C12 | 7.315 | 7.315 | NIL |
| C5 | 101.17 | 101.165 | 0.005 | C12-C13 | 7.215 | 7.215 | NIL |
| C6 | 101.71 | 101.71 | 0 | C13-C14 | 6.962 | 6.962 | NIL |
| C7 | 101.62 | 101.62 | 0 | C24-C29 | 12.045 | 12.045 | NIL |
| C8 | 102.02 | 102.02 | 0 | C5-C29 | 18.403 | 18.403 | NIL |
| C9 | 101.945 | 101.945 | 0 | | | | |
| C10 | 102.26 | 102.26 | 0 | | | | |

topsoil on surface. The field observations were conducted in May 1994 and October 1994, shown in Table III. The details of subsidence and horizontal strain recorded in July 1997 have been given in Table IV. Most of the monitoring stations were damaged in the process of making roads etc.

## DISCUSSION

The future subsidence potential of the goaves underneath and in the vicinity of the area was practically zero, hence, the constructions for building residential quarters were advised to start, taking the following precautions for extra safety:

1. Building length more than 200 m may be avoided or slots may be provided at suitable positions.

2. Building up to two storied is advisable.

3. Pillars in the developed workings underneath the area should not be splitted.

Double storied buildings were constructed in 1992. Subsidence measurements were conducted as a precautionary measure. At least two monitoring stations were anchored near each building. In January 1904, some hairline cracks were noticed at the boundary wall of "C" type quarters. Construction work was stopped due to the fear of subsidence. Subsidence observations were further carried out and no changes in reduced levels were found when compared with initial observations. It was advised that cracks were not due to subsidence. For avoiding cracks following suggestions were made:

1. Foundation should be laid carefully to avoid leaving any cavities.

2. The vibrations due to blasting in the open cast mines may cause cracks in walls, should be repaired immediately.

As per Table III, the maximum subsidence was 5 mm with no horizontal movement. As per Table IV the maximum residual subsidence was observed to be 5 mm, which is practically for a period of three years. No strain was observed. Most of the monitoring stations were damaged in the process of making roads. The above records impart clear indication that there is no further residual subsidence due to caved goaves. By June 1998, two storied buildings, community hall, school building, parks, project office, dispensary and shops etc. were constructed and the complex was named Hill Top colony. The subsidence observations were again conducted and no ground movement was observed.

## CONCLUSION

Before selecting a subsided area in mining field for residential estate, a thorough study of the ground movement at the site is desirable by establishing subsidence-monitoring stations and conducting the leveling observations at regular intervals. The field data reflects that after about 22 years of the completion of the extraction of panels, the ground over caved goaves was stable, showing no indication of residual subsidence, thereby suitable for constructing buildings. If the subsidence record is available it should be properly studied and analyzed for ascertaining no future subsidence potential in the area.

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