CHAPTER – 7
ADDITIONAL STUDIES

7.1 DISASTER MANAGEMENT AND RISK ASSESSMENT

Mining and allied activities are associated with several potential hazards to both the employees and the public at large. A worker in a mine should be able to work under conditions, which are adequately safe and healthy. At the same time the environmental conditions should be such as not to impair his working efficiency. This is possible only when there is adequate safety in underground mines. Hence mine safety is one of the most essential aspects of any working mine. Indeed safety of the mine and the employees is taken care of by the Mines Act 1952.

(A) IDENTIFICATION OF HAZARDS

There are various factors, which can create disaster in coalmine industry. These hazards are as follows:

(a) Mine gases
(b) Mine fires and spontaneous heating
(c) Explosion in the mine
(d) Coal bumps
(e) Subsidence
(f) Inundation

(a) Mine Gases

The following gases are found in underground coalmines:

i) Carbon monoxide (CO)
ii) Carbon-dioxide (CO_2)
iii) Methane (CH_4)
iv) Hydrogen Sulphide (H_2S)
v) Sulphur dioxide (SO_2)

The production of these noxious and inflammable gases beyond tolerable limits in underground mines creates environmental hazards. The factors, which are responsible for the production of these noxious and inflammable gases, are as follows:

i) Blasting
ii) Underground fire

iii) Spontaneous combustion
iv) Coal dust and firdamp explosion
v) Decay of timber
vi) Bacterial action
vii) Slow oxidation of coal and
viii) Distillation of coal
ix) Exhalation by man

(b) Mine Fire and Spontaneous Heating:

The various factors governing mine fire and spontaneous heating in underground mines are as follows:

i) Chemical composition of coal
ii) Friability
iii) Presence of iron pyrite
iv) Nature of adjoining strata
v) Depth of the seam
vi) Thickness of the seam and
vii) Geological disturbances

(c) Explosion in Mines

An explosion is a sudden process of combustion of great intensity accompanied by spontaneous release of large amount of heat energy and in which the original gas or solid substance like coal dust is instantaneously converted into gaseous products. An explosion is invariably accompanied by violence on a large scale. Explosions in coal mines are due to (1) firedamp and/or 2) coal dust. Firedamp has been the cause of explosion in coal mines due to methane in dangerous proportion with the result that in every mine adequate steps should be taken to prevent a firedamp explosion. Possible causes of explosion can be attributed to the following factors: 1) Flames Naked lights, damaged flame safety lamps and contrabands, 2) Heated surface – overheated lamp gauges, electrically heated wires, heated rock surface, incandescent coal, overheated broken blocks, un-lubricated haulage rollers, rope friction, conveyor troughs rubbing against its support, 3) Sparks – Electric sparks and arcs, static sparks from compressed air pipes, friction sparks from iron pyrites, friction spark from light metal alloys, and 4) Explosives – Resulting into flame and hot gases, compressive wave set up by explosives, especially in a break adjacent to the shot hole, incandescent particles ejecting from the shot hole, incompletely detonated explosives, etc.

(d) Coal bumps

A rockburst or bump in coal mine is a sudden and violent failure or collapse of the rock in situ under stresses greater than it can normally withstand and on a scale sufficient to cause material damage to endanger the safety of the workers.

(e) Subsidence

Subsidence is an important aspect of underground mining activity. Underground mining operations can give rise to undesirable effect, such as, 1) Damage to surface installations, like buildings, railways, roads, pipelines for water supply, power line, etc., 2) produce fractures in another coal seam, immediately above the one being currently exploited, 3) cause fractures, on the surface, which may in turn cause flooding of the underground working by drawing water from the sources on the surface. 4) Cause damage to other mining installations, and as well 5) affect roots of the vegetation.

(f) Inundation

An inundation is an irruption of water from workings of the same mine or of an adjoining mine or from surface water bodies.

(B) DISASTER MANAGEMENT IN MINING INDUSTRY

(a) Measures taken to avoid mine gases are as follows:

- The quantity of inflammable gas given out in each ventilation district will be determined at least once in a month and similarly borehole samples once in a quarter.
- The quantity of air sent into each district will be such as to keep the percentage of inflammable gases in the district return airway below a percentage of 0.75 to 1.25 at any place in the mine.
- The state of atmosphere near the stopping will be continuously monitored by flame safety lamps, air sampling and analysis.
- There should be strict adherence to provisions of CMR 1957,with regards to gas emission.
- All workings will be ventilated by a suitable mechanical ventilator installed on the surface.
- Approved types of stone dust barriers will be provided at the specified places.
- Adequate quantity of air will be coarsed to all the working faces as stipulated in the CMR 1957 and air samples will be collected at regular intervals frequently collected of the roof of the working faces and analysed timely for the presence of CH_4 and other gases.

(b) Measures to Avoid Fires in the Underground Mine are as under:

- Check the workers, before they proceed to underground, for matchbox, lighters and other contrabands,
- Do not allow burning of fire inside the mine and also within 15m of an incline/pit,
- Avoid welding of headgear pulley or the headgear frame unless adequate timely precautions are taken,

- Avoid welding in underground repair shops without adequate precautions.
- Restrict the storage of inflammable and combustible material like oil, grease, timber etc.
- Remove all woodcuttings as also oily and greasy cotton wastes out of the mine.
- Install the electrical cables and equipment with due care and maintain them properly with regular inspections.
- Use only approved safety lamps, which should be taken underground in locked condition.
- Machinery to be used underground should be meticulously assembled and properly operated so as to ascertain that during use it does not cause any dangerous sparks or for that matter generate any hot surface.
- Brake blocks of underground machinery like haulage engines, locomotives, etc., should be adjusted periodically to avoid their overheating and
- Avoid at any cost accumulation of dangerous static electric charges on the equipment using air by earthing.

(c) Measures to prevent explosions are as under:

(i) Fire damp explosion:

- ➢ For avoiding dangerous accumulation of firedamp it must rest below the lower limit of explosibility.
- ➢ Avoiding sources of ignition, which may cause the firedamp accumulation to explode.
- ➢ Proper ventilation of the mine is the keynote to prevent dangerous build-up of firedamp.
- ➢ Besides this, regular inspection of places where firedamp may accumulate is very essential in addition to making provision of proper ventilation.
- ➢ The motors, switchgears and transformers should always be provided with flameproof enclosures.

(ii) Coal dust explosion:

- ➢ Reducing the formation of coal dust in the working faces, haulage roads etc.
- ➢ Preventing its spread.
- ➢ Rendering the coal dust harmless by wetting it with water or mixing the same with inert stone dust.
- ➢ Making provision of stone dust barriers or water barriers.
- ➢ Water spraying at loading points, transfer points as also over the loaded coal tubs help in reducing the dissemination of coal dust and
- ➢ Dust at the transfer points should be collected with free use of dust extractor.

(d) Measures to counter effects of Bursts are as follows:

- Distressing of coal and the surrounding strata.
- Avoiding concentration of abutment loading near the working places.
- By discarding the random selective extraction.

(e) Measures to Avoid Subsidence:

- Long faces: Long faces or longer width of panel are to be preferred to reduce the number of rib-sides, where differential movements occur resulting in high subsidence.

  In this mine inbuilt care has been taken while laying the long panels with 250 meter wide faces to arrive at uniform subsidence with minimum damage to surface features.
- Harmonic extraction: In this method the working in two or more seams are so advanced simultaneously as to cancel the strains caused by another seam at a different level, resulting in a bare minimum subsidence on the surface.
- Splitting of faces: To control the subsidence due to traveling strains the longwall faces or working in a panel are split into two units, which are so advanced in steps with a fixed interval in between, such that the strains induced by the two faces or units have a tendency to cancel each other.

(f) Measures to avoid Inundation:

- Working place approached within a distance of 60m of any other working (likely to contain accumulation of water) shall not be extended further unless it is examined physically and found to be free from accumulation of water.
- Whenever seepage of water is noticed at any place of working, such working shall be immediately stopped. The height of such working shall not extend 2.4m and at least one borehole near the center of working place shall be maintained with sufficient number of flank holes. The boreholes drilled above and below the workings at intervals of not more than 5m. Such boreholes constantly maintained 3m in advance of the working.
- The panels have been laid to be extracted from rise to dip. This ensures self drainage of the panels and thereby no water would be accumulated in the goaf.

EMERGENCY PLAN: Manager having workings belowground prepares general plan of action for use in case of fire, explosion or other emergency occurs. This plan prepares under rule 199(A) of CMR 1957. The plan outlines the duties and responsibilities of each mine official and key man including telephone operators. All officials and key man thoroughly instructed in their duties to avoid contradictory orders and confusion.The emergency plan provide for mock rehearsals at regular intervals.

7.2 SOCIAL IMPACT ASSESSMENT

The study area falls under Dhanbad district.

The main occupation of the people of leasehold and adjoining area is cultivation. Besides agriculture, people are engaged in collection of fuel wood. Coal mine in this area is creating good indirect job prospects for the local people.

Quality of life

Quality of life (QOL) is one of the components to enumerate the status of socio-economic environment of a region. QOL has been determined for the study area in the core and buffer zones of project site. A number of socio-economic indicators like food, clothing, shelter, sanitation, security, environmental pollution etc. have been considered for the study. Detailed methodology and results are discussed below.

Methodology

The QOL has been determined under two categories i.e. subjective evaluation of local inhabitants and objective evaluation by an expert group incorporating the existing conditions with reference to availability and utility of available basic amenities. In the present study assessment of quality of life has been carried out with the help of a predesigned questionnaire for subjective dimension and by evaluation of existing condition (secondary data) by an expert group for objective dimension.

The population in the study area has been surveyed on the basis of proportionate stratified random sampling. The questionnaire is based on satisfaction level of each individual for the various indicators used, following a scale as:

0.1 - Highly unsatisfactory (HU)
0.3 - Not satisfactory (NS)
0.5 - Neutral (NE)
0.8 - Satisfactory (SA)
1.0 - Highly Satisfactory (HS)

Once objective measures has been obtained for each factor they are transformed to a normal scale varying from 0 to 1 (value function curve) in which 0 corresponds to the lowest or least satisfactory measures and 1 corresponds to the highest. The weights have been assigned to each factor by ranked pair wise technique by the expert group based on the secondary data and general observations.

For each objective measure, a corresponding subjective measure has been developed and obtained for each individual of the sample population, by investigation the rate of satisfaction with the objective measures for each factor. A scale of 0 to 1 scale (value function curve) has been used that 0 corresponds to the lowest level of attitudinal satisfaction. Again weights have been assigned to each factor from a total of one using ranked pair wise technique. After collecting the information the following steps has been followed to calculate the quality of life:

a) Ranking of QOL factors, i.e. income, food etc.
b) Assigned values for subjective attitude of satisfaction levels, i.e. HS, SA, NE, NS, HU has been derived.
c) Assigned weigh to all the factors by pair wise ranking technique.
d) Normalization of weights by taking the total weight as unity.
e) Frequency distribution of all the respondents to get QOL (S)
f) Adding the values and dividing by the number of respondents to get QOL(s).
QOL is then estimated using the following formulae (USEPA, 1974)

I. Objective Quality of life

Where,
$$QOLo = (\sum_{i=1}^{n}) QL_1 \times W_1$$

QOL (o) - Objective Quality of life Index.
n = Number 0f QOL factors.
L = 1, 2, ...n.
QL_1 = Satisfaction level (assigned by the expert group) for the its objective indicator out of one (L).
W_1 = Normalized weight for its factor.

II. Subjective Quality of life:

$$QOLs = 1/P \sum^{m} \sum^{P} Qlij \times WiJ$$

Where,
QOLs = Subjective QOL Index.
P = No. of respondents
J = 1, 2,..........P
m = No. of factors
I = 1, 2,...........m
QLij = Subjective quality index (Vfc) for ith factor assigned by ith respondents.
Wi = Weight of ith factor.

III. Quality of life:

$$\frac{QOL(s)+QOL(o)}{2}$$

Quality of life Factor List:

- Health
- Nutrition
- Housing
- Education
- Employment and working conditions

- Clothing
- Energy
- Transportation
- Communication
- Water supply and sanitation
- Environment and pollution
- Recreation
- Social security
- Human rights

The Quality of life in the core zone is good to very good while the inhabitants in the buffer zone lead miserable life leading to poor quality of life.

Results and Discussions

The results of QOL analysis is given in **Table 7.1** and gist of observations are highlighted in the remarks column. It can be observed that QOL index is varied from 0.721 to 0.792. QOL index in most of the villages of the study area is satisfactory (SA) as per the scale discussed in the methodology. Water supply, sanitation, re creation, employment, education are good in the area. It is observed that all the basic amenities are found improved before the mining. Additional support from government level is required in these aspects and implementation of various schemes like watershed management programme, wasteland development programme and other societal mission programme are required to further enhance the standard of living.

Table 7.1: Results of QOL Analysis

S. N.	Village	QOL index	Remarks
1	Suriyadih	0.776	
2	Udalbani	0.792	There is good basic facilities in most of the villages i.e regular power supply, good employment, availability of higher secondary education institution etc. So the overall quality of life is satisfactory. Earning of people is still depends on agriculture and cash crops, local employment & employment in the coal mines etc.
3	Renduadih	0.721	
4	Tetulmari	0.739	
5	Kapuria	0.782	
6	Parasia	0.763	
7	Sijua	0.759	
8	Bhelatand	0.781	
9	Debgram	0.729	
10	Kanchanpur	0.735	
11	Darangabh	0.767	

7.3 MITIGATIVE MEASURES FOR SOCIO-ECONOMIC IMPACTS

The Project is having a positive impact on the socio-economic environment. It is evident from the past history of TISCO that it is putting on continuous efforts and instrumental in enhancing the living conditions of the mining and surrounding communities. Similarly the activities of the local population will bring in additional indirect employment opportunities and will also bring in the medical and communication facilities within their reach. A common central township is already established on non-coal bearing area with facilities like dispensary, schools, recreation clubs, well-lighted internal roads, drinking water supply, sewerage system and dustbins etc.

TATASTEEL RURAL DEVELOPMENT SOCIETY (TSRDS) towards fulfilling its objective for improving social and Economic Status of the Community has been doing commendable job. TSRDS at Jharia Division works in three areas namely Sustainable Livelihood, Health and Hygiene and Empowerment.

7.3.1 Employment and business promotion

The direct employment has been given to 860 persons. Also indirect employment will be generated to a large number of local populations for various activities like coal transport, coal handling and green belt development etc.

7.3.2 Educational facilities

Colliery maintains a primary school in the colliery premises. Tata Steel patronizes a few high schools, both English medium and Hindi medium in the area. Apart from these, management provides school bus to local schools and also for attending schools and colleges in and around Dhanbad.

7.3.3 Medical Facilities

A well-equipped dispensary with two general physicians and nurses is maintained at Bhelatand Colliery. The dispensary is mainly for rendering first aid and day-to-day medical assistance. For specialised treatment, patients are referred to Tata Central Hospital (TCH), located at Jamadoba. TCH has strength of 23 doctors, 65 staff and 32 nurses and it is equipped with specialised equipments. The next higher level of medical facility is available at Tata Main Hospital (TMH), Jamsedpur. In addition to these, patients are referred to Vellore, Mumbai, New Delhi, etc. for the specialised treatment.

7.3.4 Welfare Amenities

The surrounding villages are also benefited from the welfare amenities as listed below:

- Provision of protected drinking water supply
- Provision of library, school, post-office, banks etc,
- Conducting of medical camps for checkup of different diseases and their prevention
- Provision of roads
- Green belt development to improve the ecology
- Sports and Cultural Activities
- Employment & Livelihood Generation
- Women Health and Child Development

7.4. HYDRO-GEOLOGICAL ENVIRONMENT

The hydro geological environ of the area within 10km radius buffer zone from the edge of Bhelatand as per MoEF guidelines has been studied with the object of estimating the current gross ground water draft, net surplus water availability and the impact of the Bhelatand Project on ground water environ of the area. For this purpose, the groundwater potentiality of the study area has been estimated as per Ground Water Resource Estimation Committee-1997 methodology.

7.5 SUBSIDENCE PREDICTION

The effect of subsidence on the various surface features due to the proposed mining operations has been studied by CMRI, Dhanbad.After considering the geomining parameters it has been proposed to extract the panels by longwall mining with an estimated life of 30 years.

7.5.1 Method of mining

Longwall retreating with caving is chosen as the principal method of mining in all the above seams. The panels are also designed to a width of 250m and lengths of 2-3 km.

7.5.2 Geotechnical parameters for subsidence prediction

Subsidence parameters

Subsidence parameters	
Subsidence factor S_{max}	0.69 (for caving)
Non-effective width to depth ratio (NEW)	0.5
Angle of draw	25^{o}
Percentage of extraction	100 % (for Longwall mining)

A Non-effective width to depth ratio (NEW) of 0.5 has been taken for the subsidence calculations, which is the average value found from various coalfields in the country, which also holds good for Coal mines operated by Tisco The subsidence factor of 0.69 is also the national average (references).

7.5.3 Subsidence prediction technique

The subsidence prediction technique employed for the study involves three dimensional influence function method for multi-seam and multiple panel extractions. Of all the different tools available for subsidence modelling, the influence function method with suitable modifications appears to be a powerful method for complete subsidence prediction for all shapes of extraction panels.

This method, in its classical form, consists of laying a surface grid of square elements overlapping the panel up to the draw limits. An asymmetric influence zone, subdivided into a sufficient number of rings and sectors, gives the subsidence at the grid point, which is the sum of the weighting factors of all the sectors falling within the extracted area. The weighting factors are derived from an asymmetric influence function of bell shape covering the influence zone. The classical method, however, requires some modifications to suit the observed subsidence behavior from various Indian coalfields for inclined seams.

7.5.4 Modification of the Method

The following influence function was found to be suitable while simulating surface subsidence. Where R is the radius of the influence circle and r is the distance of each sector from the center of the influence zone (P).

$$K_z = \frac{0.5352}{R^2}\left(1+\cos\frac{\pi \cdot r}{R}\right)$$

The conventional method as described gives rise to much higher subsidence at the edges of a panel. Besides the correction to the influence function for panel edges, another correction required was to account for the asymmetry of the subsidence trough, which is invariably found in Indian conditions. The point of maximum subsidence always occurs closer to the start line of the panel.

The correction function (weighting function) has been suitably designed as

$$W_z = 0.5\tanh\left(\frac{5d_b}{1.5NEW\,H} - 2.4\right) + 0.5$$

where d_b is the distance of the extraction element to the nearest boundary of the extracted area, NEW is the non-effective width to depth ratio and H is the depth of cover.

The correction function for asymmetry has been designed as follows

$$Q_z = 0.9 - 0.1\tanh\left[0.5\left(d - 0.4d_{\max}\right)\right]$$

where d is the distance of the extraction element centroid from the starting face line and d_{max} is the distance between starting and ending face line.

We thus have the modified influence function using the above two equations as

$$dV_z^{/} = Q_z W_z dV_z$$

7.5.5 Variation of depth with seam inclination

The depth at which the coal seams lie varies from place-to-place due to seam inclination and change in surface RLs. To accommodate these variations, the influence function method has been suitably modified to interpolate the depth from borehole data at each grid point location.

The development of this numerical subsidence prediction technique has been presented in details in references, Sheorey et al. (2000) and Anon (1998). The subsidence prediction software SUBSOFT incorporates the above technique of three dimensional subsidence estimation. The basic input parameters required for the software include the geometry of the extraction panels at each stage of subsidence prediction, details of overlying goafs, depth, angle of draw, subsidence factor, height of extraction, percentage of extraction and the sequence of mining. With these inputs, the software is capable of predicting subsidence, horizontal displacements, strains and slope at each grid point on the surface.