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Study of Illumination System in Open Cast Coal Mine

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Abstract: *Illumination is undoubtedly a vital aspect in mining operations. Properly designed and implemented lightning system would provide the mine workers with improved visibility and contribute to improved safety, productivity, and high level of morale. In this thesis a detailed survey has been carried out for a large-scale opencast coal mine. Survey data revealed that illumination levels at major parts of mine are below recommended levels. Detailed calculation showed that illumination cost is insignificant component of overall production cost. A little increase in production cost would bring the light level of mine up to desired standards. As per DGMS of India the mine lighting should be designed and installed with proper lamps and fixtures regarding height, orientation, spacing and reflectors or other accessories, to secure a uniform distribution of light on the work area for visual comfort and avoiding objectionable shadows, sharp contrasts of intensity, glare, light clutter (excessive groupings of light) and light pollution to prevent strain on the eyes of the workmen, work fatigue and medically defined stress. The following recommendations were proposed for consideration to improve the visual level in the workplaces.*

- *Installation of 250-Watt lamps for the roadways so that the number of poles can be reduced resulting less cost for pole installation and more free areas for movement of vehicles.*
- *Truck mounted illumination system can be used instead of fixed lighting system at the places which are vulnerable to damage caused by blasting.*
- *The cabin lighting of HEMMs can be improved by installing proper luminaries..*

Keywords: *Opencast Mining; Mine Illumination, Mine light, Surface Illumination.*

1. Introduction

Illumination is a very important factor to be understood properly and to be provided in the mines where activities are performed in the night shift. The provision of adequate illumination and the need to ensure a safe visual working environment is a challenge faced by almost all mining industries. Lighting in mines presents special problems because of the dark surroundings and low reflectance. In opencast mines where work is being carried out at night shifts, effective illumination is required to achieve production and sale operation of various machinery at different work areas.

Importance to ensure that the working environment is visually viable, in particular in opencast mining field where the additional constraints usually gain an upper hand. Generally, vision is influenced by three main lighting design parameters: -

- Illuminance level of the surface,
- Uniformity of light distribution and
- Glare from sources.

Illuminance levels on visual tasks are taken care by luminous intensity of light sources, whereas uniform distribution pattern of light depends on the technological aspects like luminaire layout, aiming angle and positioning of the light sources.

2. Literature Review

2.1 Introduction

Good lighting is very much required for safety and production. Physiological suitability of a person to his working environment is very much important from safety point of view. Certain evidence shows that only 2% are attributed to unforeseen circumstances and 88% of the mine accidents are attributed to unsafe acts. It is realized that if a task is performed in poor lighting for long time sign of strain appear in the individual and if not checked, can lead to physicalillness**.** The increased mechanization demands that the lighting should be adequate and suitable to reduce accidents. Good lighting encourages visual performance, improves quality of work, reduces the frequency of errors and prevents fatigue, and improves visual communication with the working environment. Which results in better production and efficiency.

2.2 Open cast Mining

A mine in which the coal lies near the surface and can be extracted by removing the covering layers of rock and soil. Surface mining is used when deposits of commercially useful minerals or rock are found near the surface' Called Surface Mining because mine is open to the sky where mineral of interest is being excavated to create an open-pit mine, the miners must determine the information of the ore that is underground. This is done through drilling of probe holes in the ground, then plotting each hole location on a map. The information gained through the holes with provide an idea of the vertical extent of the ore's body. This vertical information is then used to pit tentative locations of the benches that will occur in the mine.

3. Experimental and Methodology

3.1 Introduction

For critical and optimized lighting designs mathematical modeling in a computer is required. Based on the positions and mounting heights of the fixtures and their photometric characteristics,the proposed lighting layout can be checked for uniformity and quantity of illumination. For larger projects lighting design software can be used. Advanced programs can include the effect of light from luminaires, allowing further optimization of the operating cost of the lighting installation. Computer modeling of outdoor flood lighting usually proceeds directly from photometric data. The total luminous energy of a lamp is divided into small solid angular regions. Each region is extended to the surface, which is to be lit and the area calculated, giving the light power per unit of area. Where multiple lamps are used to illuminate the same area, net contribution is obtained. Again, the tabulated light levels (in lux or foot-candles) can be presented as contour lines of constant lighting value, overlaid on the project plan drawing. Hand calculations might only be required at a few points, but computer calculations allow a better estimate of the uniformity and lighting level.

3.2 Illuminance Measurement

This process measures the incident light (in lux) received by a surface. Most countries specify their lighting standard in lux, so this method is most widely used in mine surveys. Three differenttechniques can be used in mine illumination surveys:

- Direct planar measurement.
- Separate measurements for direct and diffused light. Maximum reading method

3.3 Principles of Illuminance Measurement

In mine lighting, illuminance measurements are typically taken for the following purposes:

- To determine the incident luminous energy (lux) on a surface.
- To determine the light output characteristics of a luminaire.
- To determine if illuminance levels are sufficient to qualify the illumination system for DGMS approval.

The illuminance measurement in opencast mines primarily focuses on the following factors:

- **Horizontal Illuminance:** The measure of brightness from a light source, usually measured in foot-candles or lumens, which is taken through a light meter's sensor at a horizontal position on a horizontal surface.

- **Vertical Illuminance:** The measure of brightness from a light source, usually measured in foot-candles or lumens, which is taken through a light meter's sensor at a vertical position on a vertical surface.
- **Uniformity Ratio:** It describes the uniformity of light levels across an area. This may be expressed as a ratio of average to minimum or it may be expressed as a ratio of maximumto minimum level of illumination for a given area.

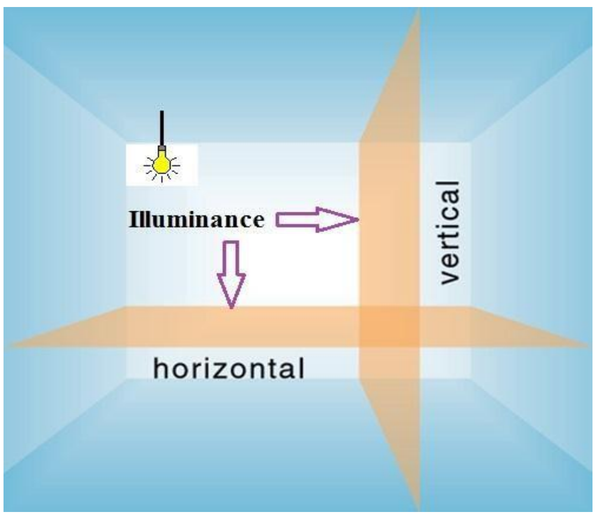

Fig.1 Measurement of Horizontal and Vertical Illuminance

3.4 Design of Lighting System For Opencast Mines

Haul roads, Dumping Yards, moving faces of ore &overburden (OB), within the pit are one of the critical areas in surface mines where lighting installations are not permanent due to regular advancement of the working face. Due to this reason, it is very difficult to maintain the lighting standards, as specified by various regulatory bodies. Lighting in mines presents special problems because of the dark surroundings and low surface reflectance. Hence, scientific design of artificial lighting is very important to achieve the minimum required lighting standards. The parameters to be considered for designing suitable lighting system for opencast mines are as follows:

- Mounting Height
- Spacing
- Overhang

3.5 Design Methodology

The flow chart (Fig. 2) depicts the design methodology for the present research investigation.

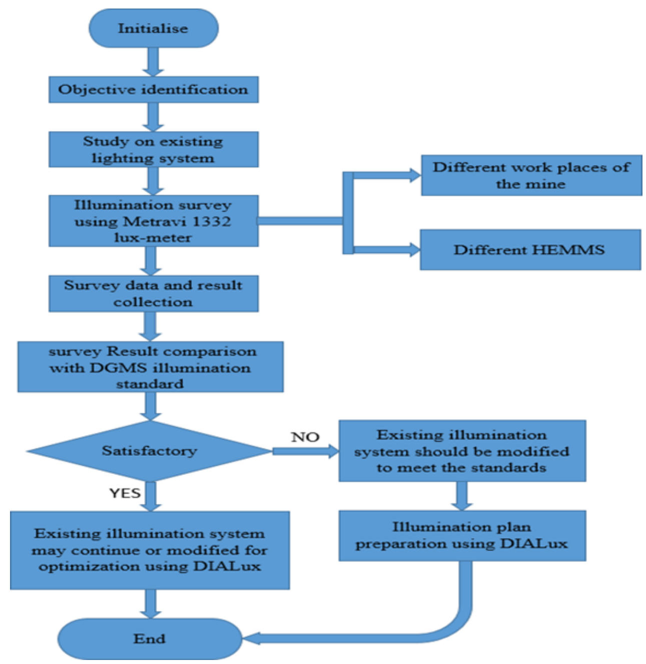

Fig. 2 Flow chart for Illumination Design Methodology for the Project

4. Result and Discussion

4.1 Introduction

The illumination survey was performed in a mechanized opencast manganese mine project (Reliance Sasan coal Mine, Madhya Pradesh) during March 2021. The mine is located Sasan village, Singrauli district, Madhya Pradesh has deposit generally at coordinate 23°57′56″N 82°37′30″E. The maximum thickness of the ore body is 30.2m in the central part and the average thickness is 8.5m. The mine has a total in-situ reserve of 750 million tonnes from which total recoverable is 4.98 million tonnes. The method of extraction was by drilling and blasting in combination with tipping trucks and shovel dumper. The method of overburden removal was by conventional shovel and dumper combination. Ore was transported into stock yard as well as to nearby BDC section. Haul roads were generally maintained keeping the width 10m.

4.2 Results of illumination survey

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The illumination survey readings in various workplaces and HEMMs of the mine are represented inTables 1.

Table 1: Service Road Illumination Survey Data of open cast Mines

Pole No.	Spacing(m)	Road width (m)	Pole height (m)	No. of lamps	Lamp wattage (W)	Illuminance (lux)				Remarks
						L1	L2	L3	L4	
Mine office to the intersection point										
1	-	10	11	1	400	19.4	10.3	3.4	1.6	
2	41	11	11	1	400	18.2	14.3	2.8	1.9	
3	39	9	11	1	400	16.4	12.8	3.9	1.2	
4	38.8	12	11	1	400	17.3	12.8	2.9	0.9	
5	39	10	11	1	400	14.8	11.2	4.9	1.8	
6	43	10	11	1	400	0.5	0.3	0.1	0	**Defectiv**
7	47	10	11	1	400	20	9	3.8	1.4	
8	47.5	11	11	1	400*2	26	16.8	9.2	3.2	
9	35	9	11	1	400	21	11.8	6.4	2.1	
10	37	9.8	11	1	400	19.3	13	6.4	2.5	
11	45	11	11	1	400	18.5	11.2	5.2	1.5	

4.3 Summary of Survey Results and Discussions

The survey results that were recorded during the illumination survey are presented in the Table4.2.

Table 2 Summary of Survey Results

Location	**Minimum Horizontal Illuminance Standards (DGMS) in Lux**	**Measured Horizontal Illuminance (Average) in Lux**	**Remarks**
	0.5-3.0	8.5	Satisfactory
Haul Road 1	0.5-3.0	2.5	Satisfactory
Haul Road 2	0.5-3.0	1.96	Satisfactory
Dumping Road	0.5-3.0	4.96	Satisfactory
Dump Yard	3(Dump Edge)	0.6	Not Satisfactory

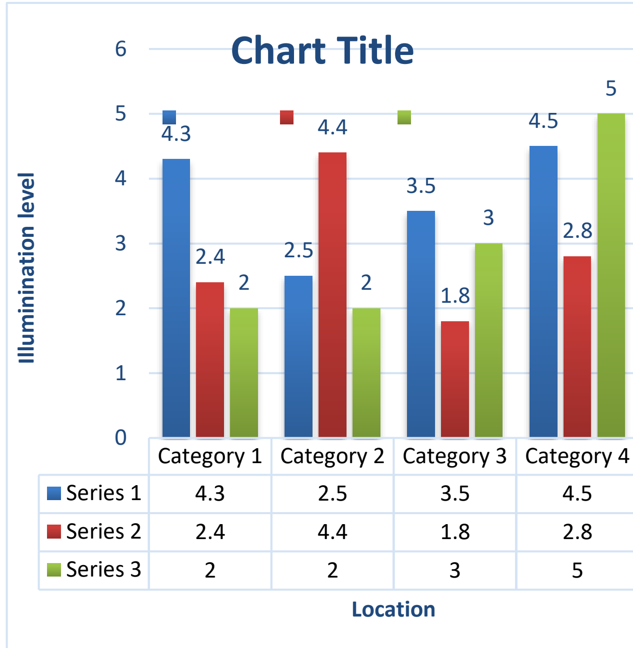

Fig.3 Summery of survey of light illumination

To design an appropriate luminaire for the road lighting, prime concern is visibility problems because the surrounding area are dark. The lumen output of the lamp ought tobe enough, so the road surface has the desired brightness for visibility and even brightness. In general, high pressure sodium discharge lamps are most liked for the road lighting designbecause they have higher lumen outputs and efficiency compared to other lighting sources. HPSV lamps emit radiation with wavelengths that are less visible to insects and therefore insects are not remarkably attracted to them. Measurement of road illuminance was conducted by creating a virtual grid between two consecutive poles. The horizontal illuminance at each of the points was measured. The road was segregated into four sections along the width as L1, L2, L3, and L4 which represented points at distances of 2.5m, 5m, 7.5m, and 10m, respectively. The illuminance measurement obtained during the survey for service road, haul road1, haul road2 anddumping road satisfied the minimum DGMS lux levels but uniformity of lighting was absent which is a focus point for good road lighting as per the international standard. For the dump yardlux levels were checked at the edge of the yard. As, dump edges need to be seen clearly by the dumper operator hence it is essential to provide adequate illumination to avoid slide/fall accidents. There was no fixed lighting for the dump yard, so the illuminance was inadequate.

5. Conclusion and Recommendation

5.1 Conclusions

The illumination survey was carried out at Sasan coal Mine, the data collected were analyzed and the following conclusions were drawn:

- For service road the average lux levels found was 8.5 lux, which fulfills the standards set by DGMS i.e. (0.5 to 3.0) lux.
- The haul roads did not have any lighting poles installed. The average lux levels found were 2.5 and 1.96 which falls in the range of DGMS standard.
- The dumping road had an average lux value of 4.96 which was satisfactory but was illuminated by mobile lighting towers due to which there was no uniformity in light distribution.
- The edges of the dumping yard were not properly illuminated. The lux value found was 0.6 which was not satisfactory as per the recommended DGMS standards (3 lux). Design of proper layout has been done which fulfills the DGMS norms.
- The cabin lighting of all HEMMs were fulfilling the DGMS standards (30 lux) except the Atlas Copco CM470 drilling machine, in which the lux level found was 16.6. A 75 -100 W Incandescent lamp or 18-22 W CFL lamp can be installed to provide proper illumination.

5.2 Recommendations

The following recommendations can be considered to improve the visual level in the workplaces:

- Installation of 250-Watt lamps for the roadways so that the number of poles can be reduced resulting less cost for pole installation and more free areas for movement of vehicles.
- Truck mounted illumination system can be used instead of fixed lighting system at the places which are vulnerable to damage caused by blasting.
- The cabin lighting of HEMMs can be improved by installing A 75 -100 W Incandescent lamp or 18-22 W CFL lamp.
- High mast lighting tower must be installed in the dump yard to meet the standards at the edges of the dump yard.

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