LECTURE –2

THE CONTENTS OF THIS LECTURE ARE AS FOLLOWS:

1.0 INTRODUCTION TO GLARE

In fact any mining task can be performed quickly, safely, and accurately, if the working field is clearly visible and the miner has the skills and desire to do the job.

Visual performance = Task Visibility + Human Factor

Task visibility depends on four measured variables. These are:

- The size and detail to be seen
- The time available for seeing the task
- The luminance and colour contrasts between the task and its background.
- The average luminance to which the eye adapts when viewing the task.

In any underground mine the first two parameters are not in our control, whereas the last two parameters can be altered wisely by having a good understanding of glare and its effect on task visibility. Glare reduces the task contrast and causes the eye to adapt to a higher luminance level than necessary. Other factors like emotional state, fatigue, motivation, job training, health should be considered in the human factor of the visual performance. Safety and production are adversely affected by irritation and fatigue, caused by glare.

2.0 TYPES OF GLARE

The human eye is sensitive to a particular range of luminance, which is determined by the average adaptive luminance in the visual field. This range at the lower end is determined by the threshold of vision, the point at which an object can just barely be seen. By increasing the luminance level the clarity improves but beyond a certain luminance level, even though we go on increasing the luminance, there won't be any further improvement in the clarity with which we see the object. This we call the upper range of the luminance. The effects on this unwanted light on visual performance is classified into two types,

i. Discomfort Glare, which increases eye fatigue, causes distraction, and generally plays havoc with the human factor.
ii. Disability Glare, which reduces the task visibility

2.1 Discomfort Glare

At higher luminance levels, task visibility is not affected but the human factor will be influenced because of the discomfort experienced due to the sudden increase in light. This discomfort ranges from a slight wincing (slight involuntary shrinking movement of the eye out of pain or distress) reaction to acute pain when exposed to very bright lighting. Discomfort glare increases with the luminance of the glare source, increases with the number of glare sources in the field of view, decreases as the angle of the source from the observer's line of sight increases, and is reduced if glare source is seen in bright surroundings.

Discomfort glare is further divided into two types – saturation glare and contrast glare.

2.1.1 Saturation glare

Saturation glare refers to a situation where the visual field's brightness is beyond the limit of the eye's adaptation ability thus causing irritation. As we know that underground mines are completely dark, this type of glare is completely ruled out in the underground mines.

2.1.2 Contrast glare

Contrast glare, which is most common in the underground mines, occurs when the luminances of the objects we intend to see are within the eye's adaptation limit, but the light source in the visual field has a luminance higher than the eye's adaptation state.

2.2 Disability Glare

The task visibility is directly affected by the disability glare, which ultimately results in the visual performance getting affected. It increases with the age of the eye and decreases as the angle from the glare source to the line of sight increases. It depends mainly on the illuminance from the glare source falling on the eye, and decreases with the distance from the glare source.

Disability glare is sub-divided into two parts, i.e. veiling brightness and successive glare.

2.2.1 Veiling brightness

Veiling brightness is resulted from the scattering of light from the glare source, which results in a loss of contrast perception. Thus in order to obtain the normal level of visibility when veiling brightness is present, the task contrast should be increased and if the veiling brightness is removed then the task returns to full visibility.

2.2.2 Successive glare

Successive glare or transient adaption is resulted by the neural response in retina, which causes a shift in the eye's adaptation state or luminous sensitivity range. Increasing the task luminance can minimize successive glare. Since the eye takes some time to adjust and readapt to the normal conditions, it is characterized by a continuous loss of seeing efficiency even after the glare source is removed.

3.0 GLARE REDUCTION

When any light is misdirected and that usually shines directly on the eye instead of on the object we wish to see, it can be considered as glare. Glare can be reduced to acceptable levels by using several techniques, which keep this unwanted light out of the eye.

1) Use a large number of small sources rather than a small number of high-luminance sources.
2) Mount luminaries out of the field of view of the common work place.
3) Screening, shielding the sources from direct view or coveringwith diffusing platesor filters or cross polarizers greatly reduces glare.
4) Since glare is also due to sudden changes in illuminance, more uniform lighting can reduce it.
5) Educate workers not to shine cap lamps into other workers' eyes when travelling in cages or passing instructions.

6) Use proper or correct lighting and avoid specular materials such as metallic paint on mechanics or wall rock and choose a flat paint when possible.
7) Keep the surrounding and surrounding luminances high. Only 1/30th of the task luminance is necessary for accomplishing the task.

4.0 MINE LIGHTING AND ITS EFFECTS ON ACCIDENTS, PRODUCTION AND HEALTH

We have certain evidences that show the impact that lighting has on the workers productivity, safety and morale. Though the general level of lighting in a mine does not approach the standards, taking mine economics into account, a strong need to improve lighting over that supplied by vehicle headlights or the common cap lamp is felt.

The importance of visibility and its relation to accident rates has already been proved (Roberts, 1954) and is shown in Fig. 1.

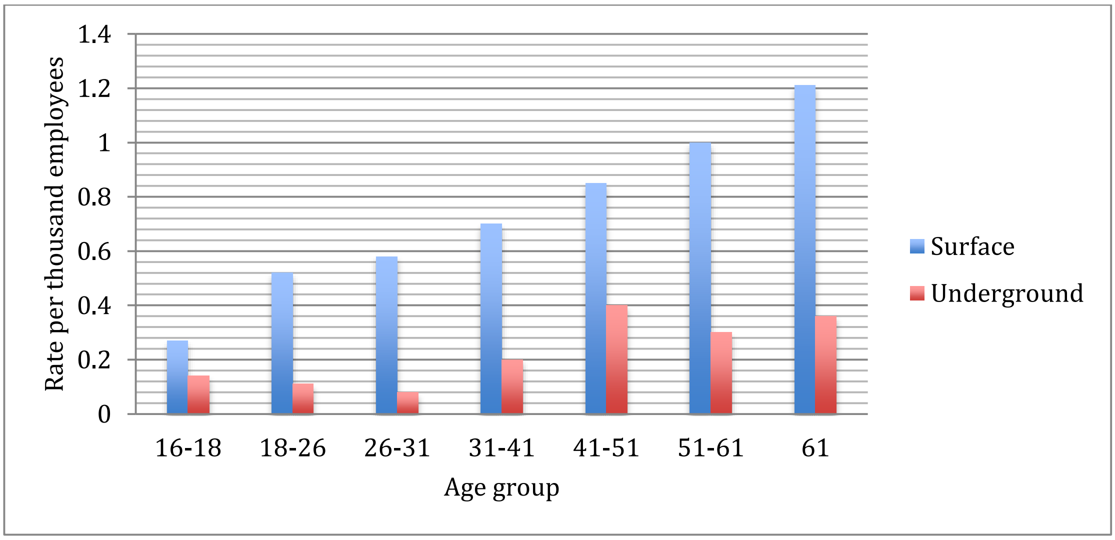

Fig. 1 Fatality rates in various age groups in British coal mines

Here a comparison is made of the fatality rates in the various age groups employed. Fatalities are considerably high in older underground workers as visual performance deteriorates with the advancing age and this can be countered by improving the lighting environment. The need for better underground lighting is inferred as it may help an old worker recover from a dangerous position in time, to avoid an accident, if he has more time to react.

Production losses, lowering of work quantity, increase in error frequency and accident rates are a result of visual stress.

4.1 Lighting and Accidents in Mines

Lighting intensity related to accidents is gaining more attention across the globe. A research on mine lighting was carried out in a Hungarian mine, where one part of the mine was lighted with artificial lights and the other part illuminated only with cap lamps. The accident rate has decreased by 60% in the part that was lit by artificial lights. A correlation was established between the illumination level and the number of accidents which is given in Table 1 (Trotter, 1982).

Table 1 Impact of illumination on number of accidents

Illumination (Lux)	Number of Accidents (%)
20	100
200	68
250	58

35% of all minor accidents in Indian underground coal mines are attributed to the poor lighting condition (Mishra and Dixit, 1978). In another mine study in a large West Virginia coal mine in the United States, six production sections were in operation through out the 24-month period during which the test was carried out. Not a single major accident was reported during this time period in the only section in which mine lighting system was installed (Trotter, 1982).

In another study conducted by the General Electric, it was showed that an accident reduction of 32% occurred when the illuminance level was raised from 50 Lux to 200 Lux (Grandjean, 1969).

Low light condition can cause visual fatigue, irritation and reddening of the eye lids, double vision, headache, decrease in the powers of accommodation and convergence, and a decrease in contrast sensitivity and speed of perception (Jensen, 1977). The effects of light intensity on performance and fatigue is shown in Fig. 2 (Schaffer, 1961).

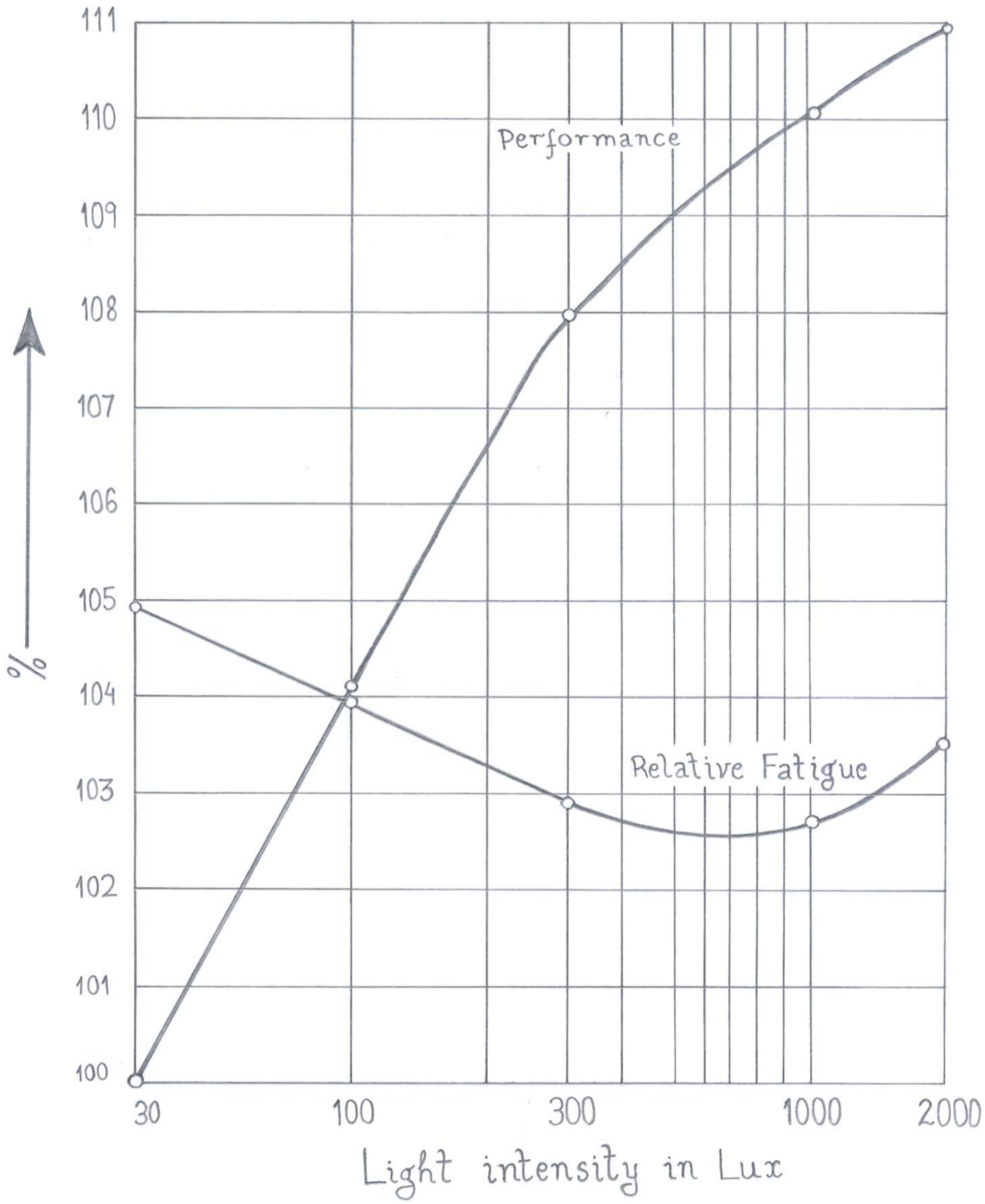

Fig. 2 Effects of light intensity on performance and fatigue (after Schaffer, 1961)

4.2 Lighting and Fatal Accidents in Mines

The factors that contribute to the accidents and injuries can be grouped into three categories (Trotter, 1982):

a) Host: Those aspects of the worker that may influence his involvement in an accident or resulting in an injury. This includes inadequate training, unsafe attitude, fatigue, boredom, frustration, worry, intoxication, violating mine rules etc.

b) Agent: The object that may cause the injury or accident to occur.

c) Environment: The circumstances that surround the occurrence of accident or injury. Several factors like noise, temperature, illumination, humidity, dust, air velocity etc. are taken into consideration.

The brain cannot interpret the visual signals when the required information is not available due to insufficient lighting. Processing of the image is slow and it takes longer to react to the situation. The slowness in speed of perception has been the cause of many underground accidents over the years. Keeping in mind, the safety considerations, particularly where moving machinery are involved, the illuminance level should be kept high.

4.3 Accident Reporting

According to Trotter, (1982), enough evidence exists to show that lighting often plays a vital role in the underground accidents. Generally the name, location, witness, act being performed, equipment used, and the time of accident etc. are recorded in the accident record report. The method and condition of the lighting at the accident site, specifying the involvement of lighting in the accident, should be mentioned along with recording the actual photometric values for severe accidents. These measurements can be made with the help of suitably calibrated photometers. Additional illumination system can be designed with the help of the valuable information available by the compilation of accident records over a period of time. According to Trotter (1982), after installing additional lighting system, there will be a drop in the accidents as compared to before installation of additional light sources.

4.4 Lighting and Production

Trotter, (1982) has described about the results carried out by various scientists relating light levels to that of production. Some of the important studies as reported by Trotter (1982) are produced below.

Based on several experiments on Lighting vs. Productivity, it has been observed that generally performance increases up to 1000 Lux (Reported by Trotter based on the study of Schaffer, 1961). Increasing the illuminance beyond this value may seem justified in terms of production, but it will have severe consequences as it results in glare. The economic cut-off point depends on the nature of the task. The more difficult the visual task, the greater the need to light it well.

A study was made of the effects of increasing the illumination in an American cotton mill (Grandjean, 1969). After increasing the intensity of light from 170 lux to 340 lux, production rose by 4.6%. As the production cost fell by 25%, it was further decided to increase the illumination to 750 lux. Production again rose by 10.5% measured from the 170 lux base and production costs were lowered by nearly 40%.

In another experiment, the productivity of keypunch operators dropped by 12% when the lighting was reduced from the 1600 lux to 540 lux and increased back to its former value when the lighting was increased back to 1600 lux (Jensen, 1977). A vast number of experiments show that increase in the lighting conditions increases the performance and productivity. As the illuminance level increases, the visual performance of the older workers approaches that of the younger workers as shown in Fig. 3.

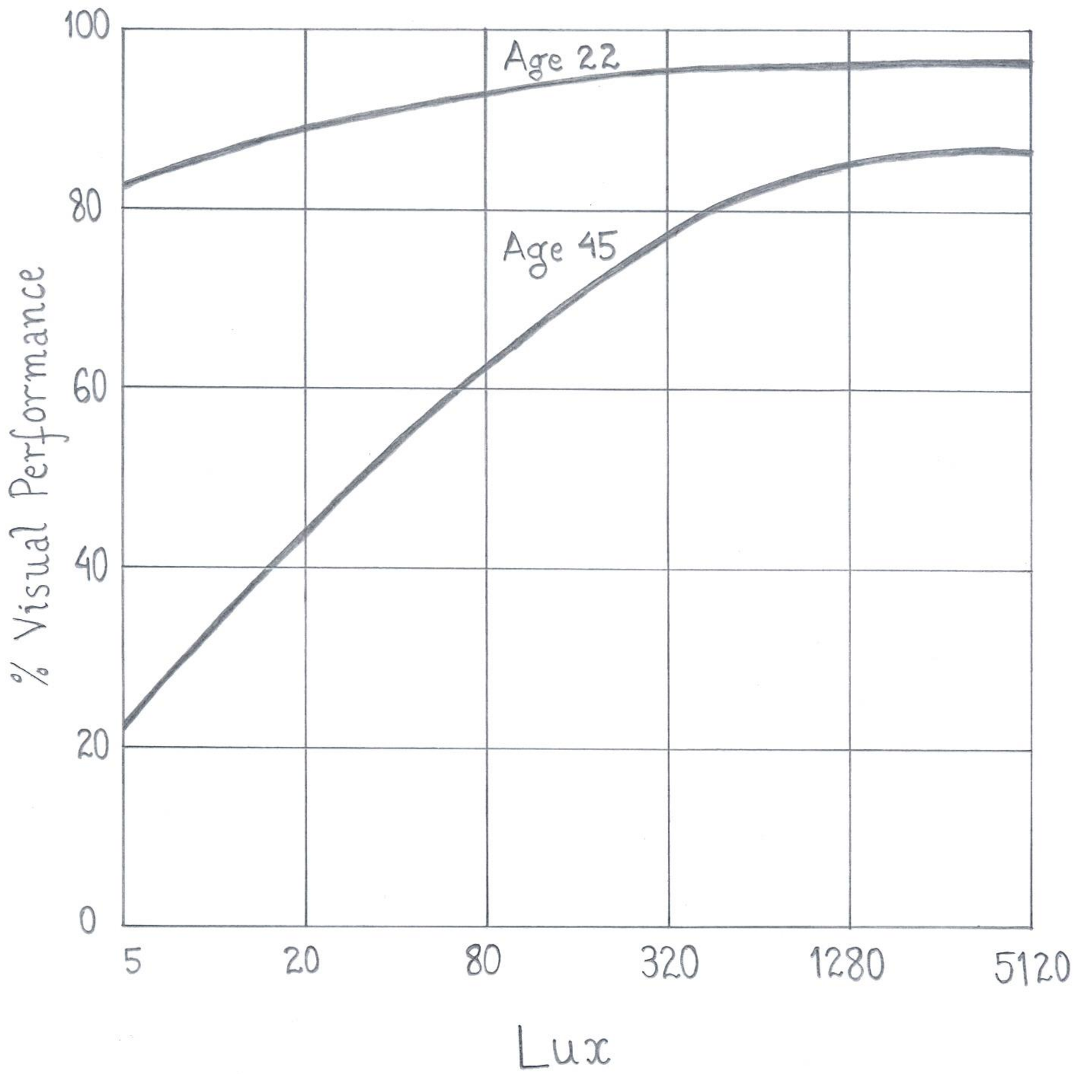

Fig. 3 Comparison of visual performance between two different age groups (after Lyons, 1980)

4.5 Lighting and Health

Coal miners commonly suffer from a disease called nystagmus. Nystagmus produces uncontrollable oscillation of the eyeballs, headache, dizziness and loss of night vision. Working under very low level of light for a long period of time is the main contributing factor to this disease. Since coal is a poor reflector of light, this disease affects many of the coal miners. At one point of time it was estimated that 70% of the underground coal miners suffered from this disorder in Europe and in the UK (Trotter, 1982), many of whom were never able to work underground again. With the introduction of electric cap lamps and improved coal mining methods, nystagmus virtually disappeared.

According to Trotter (1982), visible light of wavelength 380-760 nm produces few hazards if glare is not considered. Surveying of the tunnels is often aided by laser light, but incorrect usage may lead to the damage of the eye. Prolonged exposure can cause eye damage ranging from mild retinal burns to the loss of vision.

However with recent technological advances in new light sources, it is now possible to have lighting levels in the mines that were not achieved previously, hence resulting in increase in safety and efficiency of the work.

4.6 Lighting and Mental Health

The absence of light can cause psychological depression and low morale.

The use of efficient light sources has always been the trend in the mining industry. The spectral energy distributions of these sources are varying more and more from that of the natural light. Mercury vapour lamps produce a bluish white light where as high pressure sodium lamps produce a yellowish light (Trotter, 1982). We usually perceive blue as a cool light and yellow as a warm light. This feeling of cold or warmth could affect a worker’s comfort when combined with the mine’s ambient conditions.

To overcome the increasing cost of electrical energy, there is an increasing tendency in mine to use coloured light. The psychological response of humans to these different colours is different, according to the effect that different colours have on the endocrine system (Trotter, 1982).

According to Trotter (1982), exposure to pure red, raises heartbeat, blood pressure and respiration rate, and produces a sense of excitement. Blue or green lights have a calming or depressing effect. Pink, both reduce excitement and lowers muscle tension, making aggression difficult or impossible.

The use of fluorescent lights that approach the spectral energy distribution of the sun could be one solution to this dilemma, but this involves high capital cost (Trotter, 1982). As an alternative, different types of energy efficient lights in various combinations, such that objects do not appear too blue or green could be used.

Rather than having the worker adapt to very little light, it is very much preferable to have them adapt to the colour of some commonly used light source. (Trotter, 1982).

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