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HUMAN BEINGS UNDERGROUND

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ABSTRACT

The conditions for people who work in underground facilities has, to a very limited extent, been the subject of serious discussion, problem analysis or research. Knowledge within this subject area is, as a result, very limited (Chapter 2).

A framework of reference which demonstrates the factors which influence human beings' reactions to spending periods of time underground and how these factors interact needs to be developed (Chapter 3).

A more extensive expansion of underground space where human beings will spend periods of time ought not to be explored before more is known about the effects that can occur and the causes of these effects. If after thorough consideration it is decided to site an activity underground, the underground space must be dimensioned and designed in such a way that disadvantages, for example lack of windows and reduced accessibility can be compensated for to the greatest extent possible (Chapter 4).

Continued R and D work on these problems must be carried out (Chapter 5).

Les conditions de travail des personnels employés aux installations de sous-sol ont, dans des limites très étroites, été l'objet de discussions sérieuses, d'une analyse des problèmes ou de recherches. Les connaissances en ce domaine sont, par conséquent, très limitées (Chapitre 2).

Un cadre de référence indiquant les facteurs influençant les réactions de l'être humain lors de séjours souterrains et l'interaction de ces facteurs, doit être réalisé (Chapitre 3).

Une expansion plus importante des espaces souterrains dans lesquels séjourneront des êtres humains ne doit pas être entreprise avant que ne soient mieux connues les conséquences éventuelles ainsi que les causes les ayant provoqué. Si, après maintes considérations, il était décidé de mettre en place une activité souterraine, les dimensions et la forme de l'espace souterrain devraient être conçues pour que les désavantages occasionnés, tels que l'absence de fenêtres ou l'accessibilité réduite soient, dans toute la mesure du possible, compensées (Chapitre 4).

Les études de FOU sur ces problèmes doivent être effectuées (Chapitre 5).

KEYWORDS

Underground environment, human reactions, underground work, physiological reactions, psychological reactions, planning, research.

1

INTRODUCTION

Background

Use of underground space can be expected to increase as urbanization continues and planners and decision makers become more aware of the resource that underground construction represents.

Use of underground space for a whole series of purposes is clearly advantageous both from the technical and economic point of view. Unfortunately, underground space is not as clearly advantageous as an environment for human beings.

Conditions for those working in underground facilities have only to a very limited extent been the subject of serious discussion, problem analysis or research.

In addition to there not existing a total picture of the environmental problems underground, extremely little is known about how the characteristics of underground space affect the individual, both physiologically and psychologically. Assessment of the social effects of spending periods of time underground is also almost entirely undocumented.

Aim

This paper deals with the reactions of human beings to spending periods of time underground and aims at

- indicating the extent of current knowledge on the reactions of human beings to spending periods of time underground
- presenting a framework of reference for analysis of the interaction between individuals and elements in the surroundings
- presenting important environmental aspects to be taken into consideration in the planning of underground space
- indicating the areas requiring further research within the field in question

Scope

The paper only deals with the use of "pure" underground space. Thus, the construction of underground space and its related special working environment problems are not dealt with.

2 CURRENT KNOWLEDGE ON REACTIONS OF HUMAN BEINGS TO SPENDING PERIODS OF TIME UNDERGROUND

With regard to the large number of underground premises which have been constructed, there has been surprisingly few attempts to determine what this implies physiologically and psychologically for people that work or spend periods of time underground.

The few studies that have been carried out have, in the first instance, dealt with how lack of windows influences attitudes, health and work performance.

Studies of how human beings' reactions to spending periods of time underground are influenced by type of occupation, possibility of contact with other people, etc. remain to be carried out.

Physiological Aspects of the Underground Environment

Examination of workers in underground facilities has demonstrated an increase in the frequency of headaches, tiredness, sore eyes, nervousness, and insomnia.

It has been assumed that the above problems that have come to the fore derive from inadequacies in, for example, staff welfare and the relationship between superiors and those working under them at the place of work or inadequacies in ventilation, lighting, etc. (Forssman et al 1961, Hollister 1968, Philbert and Perrin 1977).

Simple medical examinations have not shown any differences between those who work above and below the surface.

English, Australian and German studies have not produced any indications that work carried out under windowless conditions causes illness. In cases where the surroundings have been satisfactory from a hygienic point of view, performance does not seem to have been affected. (Hollister 1968.)

A number of Soviet studies, for example Kokorev 1972, indicate higher absence due to illness, greater tiredness and lower resistance to illness in factories without windows. Artificial lighting, primarily the lack of ultra violet radiation, has been seen as the main cause of these negative health effects. The interpretation of the results of the study are, however, doubtful and the studies have been criticized outside Eastern Europe.

To sum up, it ought to be stated that the physiological effects of periods of time spent underground have not been fully investigated. Even if no obvious negative effects are demonstrated, the possibility of such effects arising must not be disregarded.

Psychological Aspects of the Underground Environment

Lack of windows seem to be the most important aspect as regards human beings' experience of the underground environment. How human beings experience windowless space has also been the subject

of the majority of studies.

The reasons why facilities are located underground or without windows vary considerably.

In town centres, the demand for maximum use of land has resulted in the construction of windowless premises. For some manufacturing and research activities it has been essential to be able to control noise, lighting, temperature and air quality. In facilities such as museums, theatres and schools the aim can be to eliminate sources of distraction. The activities which are carried on in these types of facility vary within wide limits, and not unexpectedly attitudes to windowlessness vary according to the type of activity that is studied (Hollister 1968, Collins 1975). There have been no studies with the aim of determining how reactions to windowlessness are influenced by such factors as period of stay and type of work although it is quite clear that this influence exists.

Studies of human beings in different types of windowless premises clearly show that greatest dissatisfaction occurs in small premises where there is little activity and little chance of contact with other people. Examples of this include small rooms in nursing wards where individuals are bed bound and have little to do. Routine work in offices and industry where employees have limited freedom of movement and where the work is carried on in a small area also belongs to this category (Collins 1975, Wilson 1972, Philbert and Perrin 1977).

Department stores and underground railway stations on the other hand are characterized by large areas with great activity and change involving a large number of people. In dynamic environments of this type windowlessness and the lack of daylight do not seem to have given rise to any tangible demonstration of dissatisfaction.

The conclusion come to on the basis of studies already carried out is that the following factors comprise the most important conditions for the demonstration of dissatisfaction with periods of time spent in an underground environment.

- o boring, monotonous work
- o limited freedom of movement
- o limited social contacts
- o small areas

These factors constitute a static and limited environment which creates a certain amount of stress which seems to be intensified by the lack of windows.

In addition it would seem that varying and stimulating working conditions can, to a certain extent, counterbalance the different inadequacies in the physical environment.

The decision to site a certain activity underground must obviously be preceded by very thorough studies of the conditions for those who are to work there and a more extensive expansion of underground space in which human beings are to spend time must not be implemented before more is known about the effects that can occur and the causes of these effects.

3 GENERAL REFERENCE OUTLINES FOR ANALYSIS OF THE SUBSURFACE ENVIRONMENT

The general reference outlines shown in Fig. 1 illustrate in a simplified way the interplay between the individual and the functional, social and physical environment factors in his/her surroundings. Important characteristic conditions for time spent underground can be obtained from each main group of environmental factors.

The physical and social factors given are aspects which are probably essential for human beings' physiological and psychological reactions to spending periods of time underground.

The reference outlines can be used as a basis for

- o an analysis of the influence of the subsurface environment on the individual
- o an evaluation by the individual concerned of the subsurface environment itself
- o a discussion on the insufficiency of knowledge available and on the need for research

Fig. 1. General reference outlines for evaluation by the individual of time spent in subsurface installations.

4

PLANNING OF UNDERGROUND SPACE - ENVIRONMENTAL ASPECTS

According to Swedish laws on the protection of the working environment, industrial safety officers, industrial safety committees or organizations which represent employees shall participate in the design of the working environment. It is against the background of the special problems of the working environment that are associated with the siting of working premises underground that the participation of these bodies is of particular importance in subsurface planning.

Already at the overall planning stage, investigations ought to be carried out as to whether an underground siting is suitable from the environmental point of view. Against the background of that already known about human beings' reaction to spending periods of time underground, as described in Chapter 2, we would recommend that an underground site should only come into question for activities which do not require permanent working or spending of time underground. In overall planning proposals justification for and the consequences of the underground siting of a particular activity ought therefore to be clearly presented. A decision on the underground siting of a certain activity must be preceded by thorough studies of the conditions for those who will spend time in the facility. This is particularly the case for personnel intensive activities such as shops, hairdressers, smaller workshops, etc. If, after careful assessment, it is considered possible to place an activity underground which involves people working there, the underground space must be designed and dimensioned to compensate - as far as possible - for such disadvantages as lack of windows and reduced accessibility.

Planning criteria as regards the design of underground premises from the environmental point of view ought to be developed and systematized through research development and norm giving work. A preliminary attempt to formulate such criteria is made below. These criteria could be a starting-point for a discussion of environmental aspects on the planning of underground space.

- o Underground areas ought to be spacious and easily surveyed in order to prevent the creation of a feeling of being shut in (in extreme cases, claustrophobia) and to facilitate social contacts at work
- o It shall not be necessary for an individual to work alone or work without visual contact with his colleagues since solitary work in combination with lack of windows can be assumed to be an extreme psychological ordeal. "Windows" can, for example, be installed in dividing walls between different underground areas
- o A varied design of rooms ought to be aimed at, using as an aid well-thought out colour schemes and the artistic design of floors, walls, ceilings as well as fittings and fixtures
- o Special attention must be paid to lighting since artificial lighting alone could be experienced as tiring. Underground premises ought therefore, if possible, offer contact with daylight through the construction of skylights, see Fig. 2

- o In cases where high noise levels are produced it may be necessary to line the rock cavity with sound proofing material or locate the sources of noise to a part of the premises where such activities are isolated by sound-proofed walls
- o Possibility of placing eating, resting and relaxing functions in such a way that open air contact is achieved, at least during certain times of the day ought to be studied as a matter of course at the planning stage (see Fig. 3)
- o Horizontal and ramp connections with the surface implies better access to underground premises than vertical connections, see Fig. 4. Ability to evacuate premises is facilitated considerably at the same time as the "psychological distance" to the surface is reduced. The design of entrances and connecting walkways is also of importance from the psychological point of view
- o The technical systems ought to be equipped with safety systems which come into operation if normal service, for example, fresh air systems or lighting cease to function. An example of measures designed to raise safety levels is to equip underground premises with double evacuation routes in order to prevent staff from being trapped in the case of fire or other unforeseen events
- o The advantages obtained from underground siting in terms of "thermal comfort" ought to be taken into consideration. Heat loss and gain is reduced which is why an even and pleasant climate can be achieved. At the same time, however, attempts ought to be made to reduce the problems of humidity and cold which can arise

Fig. 2. Some contact with daylight can be achieved through the use of skylights in underground premises.

Fig. 3. An example of surface siting of rest areas

Fig. 4. Horizontal connection with the surface ought to be given priority.

5 A SUGGESTION CONCERNING THE FORMULATION OF RESEARCH REQUIREMENTS

We suggest that future research work within this range of problems be divided into the following three phases:

- PHASE 1 Plotting of the extent of subsurface work and environmental problems.
- PHASE 2 The effects of the subsurface environment on human beings from the physiological, psychological and social angles.
- PHASE 3 Formulation of planning recommendations and the development of technical solutions.

5.1 Phase 1

The aim of plotting of this type would be to provide a review of the different types of subsurface installation and work. This must cover not only actual work places, but also places that people occasionally visit and spend time in below ground level. A general review of this type could provide the basis for choice of installations and subsurface work for closer study.

5.2 Phase 2

The occurrence of stress symptoms and psychosomatic problems in various types of subsurface work could be investigated, comparisons being made with similar working situations above ground level. The example, absenteeism due to sickness and staff turnover for various trades and professions underground could be used as a gauge of the mental stress involved in the work.

5.3 Phase 3

The third phase would cover the formulation of recommendations for the planning and building of subsurface installations from the environmental standpoint. These recommendations could, for example, include:

- the suitability of various activities for subsurface location
- regulation concerning working hours in different types of activity
- the accessibility of subsurface premises in relation to the surface of the earth
- special demands concerning architectural and aesthetic design

This phase would also involve the development of layout principles and technical solutions for subsurface premises based on the planning recommendations suggested.

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