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Study on workers' evacuation in an industrial company

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ABSTRACT

The purpose of this study was to evaluate the influence of a training period on the worker's behaviour, and consequently on their evacuation time, in case of emergency.

Three fire drills were undertaken, being the first one preceded by a warning signal.

The following variables were considered:

- Initial time, i.e. time taken by the first worker to reach the respective section meeting point.
- Final time, i.e. time taken by the last worker to reach the respective meeting point.
- Average age of the workers in each section.
- Number of workers in each section.
- Average distance of each section relatively to the corresponding meeting point.

The plant's fire risk was evaluated by the Gretener method and evacuation times were compared with calculated values through theoretical expressions.

A factorial method of data analysis, named Principal Component Analysis, was considered.

In spite of data scarceness, it could be observed in the last fire drill a better attitude towards fire risk and an increased awareness of safety issues.

The workers' age as well the number of workers seems to have no influence in the evacuation time.

1. Introduction

Along the years, human behaviour has been recognised as a factor related to life losses in fires.

Fires have frequently dramatic consequences due to non-use of egress means, caused by heat and smoke, or simply by their obstruction (Miguel, 2007).

A study about human behaviour in fires in UK (Ramachandran, 1990) concluded that response either to fire alarms or to sound messages was frequently inadequate.

In case of hotels (Groner, 2000), when an alarm is set by dawn, only a reduced number of occupants dress themselves and leave their rooms. These occupants use often lifts, which is an incorrect procedure.

People in general do not like to be interrupted and want to avoid anxiety feelings related to fire eruption.

The better is risk perception, when an alarm signal is detected, the more adequate the human reaction will be.

Many fire safety researchers define human behaviour as nature episodes, where occupants take a variety of sequenced actions in which each episode has a considerable number of observable actions (Ozel, 2001).

The sequence of decision procedures is important in fire emergency but action plans relative to execution of each individual episode are also of utmost importance.

Fire drills are undertaken in different workplaces, such as factories and administrative buildings, and they aim at familiarizing the respective occupants with the existing evacuation means (Cote et al., 1997).

They provide to the management important data concerning occupants' response and installed fire protection systems.

A good planning and execution of a fire drill is an important tool for the creation of a better and safer work environment.

The main objective of this study was to evaluate the influence of a training period on the workers' behaviour in an industrial company and, consequently, on their evacuation time in case of emergency.

2. Development of the study

The following variables were considered taking in account its direct influence on the evacuation time:

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- Initial time, i.e., time taken by the first worker to reach the respective section meeting point (It).
- Final time, i.e., time taken by the last worker to reach the respective meeting point (Ft).
- Average age of the workers in each section (Ag).
- Number of workers in each section (Nu).
- Average distance of each section relatively to the corresponding meeting point (Dist).

Three fire drills were then undertaken, having the first one been preceded by a previous alarm.

The plant's fire risk was previously evaluated by the Gretener method (Silva, 2000), considering the potential hazards and the existing protection measures.

For a better understanding, the Gretener method is based on the evaluation of the effective fire risk for a defined building. The following factors are considered:

– Hazards inherent to the building.
– Hazards inherent to the content.
– Normal protection measures.
– Special protection measures.
– Constructive measures.
– Activation danger.

The effective fire risk is subsequently compared to the permissible one, whose value is defined for each case and building type.

The quotient between the permissible and the effective fire risk represents the safety factor (γ), which must be greater than or equal to 1.

In the present study, the following values were obtained:

– Ground floor: $\gamma = 6.35$.
– First floor (plant): $\gamma = 1.03$.
– First floor (administrative department): $\gamma = 3.26$.

Table 1
Excerpt of obtained data in the undertaken fire drills.

	Variables					
	It1	Ft1	...	Ag	Nu	Dist
Individuals						
ArP	20	37	...	34	29	60
M78	30	49	...	34	47	70
...	...	...	...	...	...	...
CP	28	42	...	32	236	20
PT	15	19	...	37	65	30

Table 2
Variables' codification.

Variables	Codification
Evacuation time of the 1st worker of the section in the 1st fire drill (s)	It1
Evacuation time of the last worker of the section in the 1st fire drill (s)	Ft1
Evacuation time of the 1st worker of the section in the 2nd fire drill (s)	It2
Evacuation time of the last worker of the section in the 2nd fire drill (s)	Ft2
Evacuation time of the 1st worker of the section in the 3rd fire drill (s)	It3
Evacuation time of the last worker of the section in the 3rd fire drill (s)	Ft3
Average age of the workers in each section (years)	Ag
Number of workers in each section	Nu
Average distance of each section relatively to the corresponding meeting point (m)	Dist

Table 3
Individuals' codification.

Sections	Codification
Fur warehouse	ArP
Assembly 7 + 8	M78
Cutting	Cort
Sewing-Índia	CI
Solas	Sola
Modelation (production)	Mop
Finished product	ArPA
Assembly 1 + 2	M12
Finishing 1	Ac1
Finishing 2	Ac2
Finishing 3	Ac3
Finishing 4	Ac4
Materials' warehouse	ArM
Assembly 3 + 4	M34
Assembly 5 + 6	M56
Sewing	C
Sewing pairs	CP
Insoles–Heel	PT

The fire safety conditions are, therefore, acceptable, according the Gretener method.

For the fire simulation a smoke production device was used.

Once the objective was to evaluate the workers' behaviour, no further advice was given.

The training period, provided to the workers, consisted in:

- Recognising the different alarms in the plant and its meaning.
- Definition of egress means for each section.
- Elucidating expected and desirable behaviour, namely not running, switching off the existing machinery and, when reaching the meeting point, proceeding to workers' account in each section.

In the end of each fire drill a meeting with foremen was done, aiming at correcting unsafe behaviour.

3. Data treatment

3.1. Statistical approach

The available information was subjected to an univariate and multivariate treatment.

The Principal Component Analysis (PCA), which is a factorial method of data analysis in multivariate statistics, was then selected.

PCA is an essentially descriptive technique adapted to the treatment of data included in multidimensional frameworks (Benzécri, 1980).

PCA's objective is the description of the relational structures subjacent to starting data. It allows the visualization, through bidimensional charts (factorial plans), not only of the relations' system inside of each variable sets (matrix columns) or individuals (matrix rows), but also of the relations' systems between variables and individuals (Góis, 1993).

3.2. Initial description

Our matrix of initial data contains quantitative variables, whose codifications can be observed in Table 1. Data obtained in the three fire drills, individualize by sections (matrix individuals) the different evacuation times.

Variables' and individuals' codifications are described in Tables 2 and 3.