Economic Overview of Construction Safety

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1. INTRODUCTION

This study addresses the economic analysis of construction safety programs and the impact of the partial or total lack of accident prevention. The data was obtained from several sources, including insurance companies, official statistics, construction companies, hospitals, professional associations and publications. The evaluation of the costs of accidents in construction was made on the basis of real events and simulations of other types of accidents. The costs of prevention were obtained from several of the participants in this study, especially construction companies.

The ultimate object of the study was to obtain an economic comparison of accidents and their prevention that would motivate the implementation of safety programs. Accident costs were defined according to the traditional classification of direct or indirect costs. Costs associated with the implementation of safety programs and their consequent attempts to eliminate all accidents were quantified for purposes of comparison and with a view to performing the respective cost-benefit analysis. These costs were subdivided as design, construction and supervision costs. Whilst prevention costs were fixed and constant, accident costs were calculated according to the frequency index and the estimated value for these types of accidents.

The analysis of these values demonstrated that as insurance costs are not affected by the ratio of occurrence, these present a lower risk than any other type of accident. The results indicate that there is a clear economic advantage to the implementation of safety programs in construction.

2. THE CONSTRUCTION SAFETY PROGRAM AT THE DESIGN STAGE

The cost of a Construction Safety Program (CSP) at the project level was quantified by the AFA, Adão da Fonseca project department, using that for the Ermesinde railway line as an example. Two persons are usually involved in the CSP: 1 engineer who is responsible for developing the program and who does 90% of the work and 1 designer who is responsible for the remaining 10%.

As regards the cost of developing this CSP, the engineer was paid USD 2800 and the designer USD 333 due to the complexity of this task that involved dealing with several specific cases. An average of USD 222 was spent on stationary, copies and revisions. The honoraria are determined by the type of

project, the amount of work involved, its nature, the deadlines and the expected number of workers involved in the construction work.

3. THE ENGIL, S.A. PREVENTION, HYGIENE AND SAFETY AT WORK POLICY

3.1 Introduction

The policy of safety at work has become an increasingly important concern to the company given that in Europe, 15% of all labor accidents and 30% of all fatal accidents in industry occur in the building trade. According to the latest available data, the costs of accidents in construction represent approximately 3% of the volume of trade in this sector.

A major factor of consideration is the peculiarity of the building industry in that construction sites, by nature, are usually portable, that is, each construction project has its own yard and as such production varies from site to site. This situation aggravates the risk as the type of prevention and action implemented in one yard may not apply to another, even though one project may be similar to another.

In ENGIL's experience, and this is supported by the statistics, implementing a proper safety program contributes to a clear decrease in the frequency and seriousness of accidents, increases workers' motivation, reduces the number of potential accidents and is a most effective way of detecting the most qualified workers.

3.2 The Structure of the Company

In 1997, ENGIL's constant concern with improving the safety and health conditions at its construction yards, the increasingly widespread geographic dispersion of its activities and its decentralization of decision-making and responsibilities led the Company to reformulate its corporate structure and to replace the central safety executive body with several executive and consultative bodies.

3.2.1 Safety Committees

The following safety committees are responsible for defining the Company's accident prevention, hygiene and safety policy:

- Central Safety Committee (CSC)
- Regional Safety Committees (RSC)
- Site Safety Committees (SSC)

The Central Safety Committee reports directly to the Board of Directors and acts as its consultative and informative body. Its most important remit is as follows:

a) To contribute to defining the objects of the Company's Accident Prevention, Hygiene, Health and Safety at Work policy;
b) To set the guidelines that will enable the policy to attain the objects set by the Board of Directors;
c) To coordinate and integrate the activities of the several RSCs and to promote the standardization of the Company's current procedures and criteria.

The Regional Safety Committees report to the CSC. These bodies are responsible for encouraging and supervising the application, at a regional level, of the Company's Hygiene, Health and Safety at Work policies and the CSC's directives. Their most important remit is as follows:

a) To make a monthly examination of the incidence of accidents in their region;
b) To support and encourage the Accident Prevention and Work Safety activities of the executive bodies;
c) To propose and investigate all accidents and incidents that, due to their nature or consequences, may bring to light markedly abnormal situations;
d) To keep the CSC informed of their activities through the Minutes of their monthly meetings and other informative documents.

The Site Safety Committees report to the RSC responsible for the area in which their site is located and are responsible for acting on and implementing the Company's safety policy and directives on their respective sites. SSCs, consisting of a minimum of 3 members, are created on all sites where so required by the number of workers (Article 57, CCTJ – Collective Bargaining Agreement). Their duties are as follows:

a) Make regular inspections of all and installations and materials of interest to Hygiene and Safety at Work;
b) Ensure compliance with all legislation, collective bargaining agreement clauses, internal regulations and instructions on Hygiene and Safety;
c) Request and examine suggestions from workers on matters of hygiene and safety and present them at Committee meetings;
d) In the case of workers who are hired for the first time or who have been transferred from another site, provide training, instructions or advice in matters of hygiene and safety at work, as required, and encourage their use of the safety equipment that is made available to them.

3.2.2 Prevention and Safety Offices

The Prevention and Safety Offices, just like the RSCs, are created according to sectors. Given that these are executive bodies, there are currently only two such sectors: Head Office (HAPSO) and Northern Branch (NPSO), The HAPSO is responsible for implementing the Company Hygiene, Health and Safety policy everywhere that ENGIL is active (including inter-regional areas) except for those under the direction of the Northern Branch (NPSO) whose volume and diversity of work justify the creation of an independent sector.
Prevention and Safety Offices, as corporate executive bodies, are attached to the Construction Work Support Departments. They are composed of civil engineers and project and site prevention and safety specialists whose principle remit is as follows:

- Develop and implement the Site Safety and Health Program
- Inspect and audit site safety
- Prepare monthly accident incidence reports (accident frequency index)
- Submit annual activity reports
- Issue technical opinions on projects
- Offer training and information to every employee at all levels
- Publish Safety information and technical instructions
- Create check-lists for assessing risks
- Investigate new materials, equipment and technology of value to Prevention and Safety at Work in the building trade.
- Attend meeting of in-house Safety Committees (CSC, RSC)
- Contact and work with external entities and experts in this sector
- Encourage contacts and the exchange of information with schools, universities and other bodies
- Create a Safety document database
- Develop a Prevention and Safety Quality Management System with a view to standardizing procedures
- Keep projects and sites informed of all that is of great value regarding the application of better safety conditions for workers.

4. COST OF DEVELOPING THE CONSTRUCTION SAFETY PROGRAM

Two ENGIL projects were studied: I – Tapada do Outeiro, a USD 15.9 million power station built over two years and II – Edificio das Antas, a USD 2.2 million housing complex built over ten months. In the case of the Tapada do Outeiro, the cost of the wages paid to the safety team consisting of a safety expert, a foreman (who dedicated 10% of his time to safety) and two unskilled workers, for an average of 160 hours/normal months + 40 hours/month overtime, represented a total of 200 man hours/month on safety, and two carpenters whose cost is entered here in terms of the overtime they worked.

In the case of the Edificio das Antas, although the safety expert was only employed as a member of the team until February 1998 as his services were dispensed with once the project entered the finishings stage, the remainder of the team was as above and the cost of their wages were those of an average of 160 hours/normal months + 40 hours/month overtime, a total of 200 man hours/month on safety, and "half" a carpenter whose cost is entered here in terms of the overtime he worked.

The above labor costs include wages, holiday pay, one month's bonus pay, social security payments, taxes, individual work accident insurance, absences, etc., in other words, all applicable staff charges required under law.

As regards the safety equipment, the cost of both collective and individual protective equipment was calculated. Other costs were those of the civil liability insurance coverage for each site.

The Edificio das Antas project has not yet been completed and as such this study only refers to the period from its beginning in August 1997 to June 1998. Thus, as the value of the civil liability insurance coverage will devalue as the work continues, this was calculated as the total value of the insurance x total value of the project / total cost of the work.

5. FIXED STRUCTURAL COSTS

In addition to the above costs, there also are the structural charges, i.e., those related to labor, training, administrative overheads and fixed assets. The labor charges are those incurred by two engineers, one secretary and a safety expert, for an average of USD 60,000 for 1997. Travel charges are included in this item and represent an average of USD 556 per employee. Thus, these three employees (the engineers and the safety expert) spend an average of USD 16,700 over 11 months.

As regards training in the field of safety, an average of USD 2778 is spent annually which, added to the cost of travelling to the training costs (USD 2778), represents a sum total of USD 5556. Fixed assets (office equipment, tables, chairs, computers, etc.) totaled USD 299730 in 1997. Depreciation of these assets is calculated over 4 years, a value of USD 7440 per annum. Lastly, the administrative overheads (stationary, diskettes, printer ink, postage, etc.) are approximately USD 450/month, i.e., USD 5340 per annum.

We also quantified the cost of the safety and health program at the level of each construction site, although this proved somewhat difficult. The administrative costs (all the support to the project), those of the engineers, designers and safety experts involved in developing the Site Safety and Health Program, expenditure in stationary, copies, revisions, etc. and estimated salaries are entered as structural costs. An average of fifteen (15) days is necessary for developing a Site Safety and Health Program.

Site Safety Meetings are held twice a month for both projects. These meetings at the Tapada do Outeiro site cost USD 260 per meeting for a total of approximately USD 12,440 and, at the Edificio das Antas site, USD 200 per meeting for a total of USD 4,000.

Normally, a site is only inspected every 3 weeks and only by one person. Only in exceptional cases do these inspections occur more frequently and their cost is included under structural costs.

Five days were spent in studying the Tapada do Outeiro project and two days were spent on the Edificio das Antas project.

Activity	Cost	Cost of Prevention	Percentage
Labor	747 118	19 746	2.64%
Equipment	258 367	392	0.15%
Material	1 037 914	5 420	0.52%
Sub-contracts	812 703	400	0.05%
Other	12 903	8 000	62.00%
Total	**2 869 005**	**33 958**	**1.18%**

Table I – Tapada do Outeiro: Safety Implementation Costs
(in thousands of PTE)

Activity	Cost	Cost of Prevention	Percentage
Labor	165 755	3 615	2.18%
Equipment	47 782	965	2.02%
Material	164 248	1 125	0.68%
Sub-contracts	14 875	0	0.00%

Other	5 142	766	14.90%
Total	**397 802**	**6 471**	**1.63%**

Table II – Edificio das Antas: Safety Implementation Costs
(in thousands of PTE)

6. COMPARISON OF COSTS

Collecting information regarding the economic aspect of construction accidents proved difficult due to the sensitive nature of this information and to the legal implications of its publication. The solution we therefore adopted was to make an exhaustive list of all the types of costs that could be related to the different types of construction accidents. Naturally, our primary source was MAPFRE Portugal, the insurance company that sponsored the initial research.

There were no accidents on either of the two projects we studied. In order to evaluate the benefits of safety plans, we used the accident rates for Portugal during 1996 and simulated accidents for both projects taking into account the size of the project, the number of workers involved, the region and the type of injuries suffered. The injuries were chosen from the list of most frequent types of accidents: death, head injury, eye injury, chest injury, severe hand injury, arm injury, leg injury, foot injury and slight hand injury. Nine cases were selected for each project and the respective economic analysis was performed.

6.1 Tapada do Outeiro

Cost	PTE	USD
Insurance	8 000	44 450
Development of the Company Safety Program	160	890
Development of the Site Safety Program	2 920	16 225
Implementation of the Site Safety Program	25 958	144 210
Structural Costs	3 963	22 020
Accidents	0	0
Total Cost of Prevention	**41 023**	**227 905**

Table III – Tapada do Outeiro: Costs related to Safety

The accident frequency index was used to compare the cost of prevention and the cost of accidents. Whilst prevention costs were fixed and constant, total accident costs (CA) were calculated according to the frequency index (FI) and the estimated value for these types of accidents by means of the following formula:

$$CA = \frac{\text{Nº of total accidents} \times \text{Nº of workers employed} \times \text{Cost of the Accidents} \times \text{Duration of the Work in Months}}{\text{Total number of workers} \times 12 \text{ months}}$$

Cost	PTE	USD
Death	382	2 125
Head injury	20 655	114 750
Eye injury	19 820	110 110
Arm injury	16 858	93 655
Severe hand injury	37 375	207 640
Chest injury	32 431	180 170
Leg injury	22 529	125 160
Slight hand injury	24 209	134 495
Foot injury	35 299	196 105
Insurance Premium	8 000	44 450
Total Costs	**185 127**	**1 028 040**

Table IV – Tapada do Outeiro: Estimated Accident Costs without Safety Program

6.2 Edificio das Antas

Cost	PTE	USD
Insurance	766	4 255
Development of the Company Safety Program	300	1 670
Development of the Site Safety Program	1 271	7 060
Implementation of the Site Safety Program	5 705	31 690
Structural Costs	346	1 925
Accidents	0	0
Total Cost of Prevention	**8 388**	**46 600**

Table V – Edificio das Antas: Costs related to Safety

Cost	PTE	USD
Death	80	445
Head injury	4 303	23 905
Eye injury	4 129	22 940
Arm injury	3 512	19 510
Severe hand injury	7 787	43 260
Chest injury	67 565	37 535
Leg injury	4 693	26 070
Slight hand injury	5 043	28 020
Foot injury	7 354	40 855
Insurance Premium	766	4 255
Total Costs	**44 423**	**246 795**

Table VI – Edificio das Antas: Estimated Accident Costs without Safety Program

7. CONCLUSIONS

The analysis of the estimated cost of accidents as compared to the cost of preventing these shows that there are clear economic benefits to implementing prevention and safety programs and that construction companies should have an effective Construction Safety Policy. The relation between the cost of prevention and the cost of accidents that could be expected to occur in the absence of a Site Prevention and Safety Program was of 22% for the Tapada do Outeiro project and 19% for the Edificio das Antas project. (Table VII)

Project	Estimated Cost of Accidents	Cost of Prevention	Relation between Cost of Accidents and Cost of Prevention
Tapada do Outeiro	PTE 185 127 000 (USD 1 028 485)	PTE 41 023 000 (USD 227 905)	4.5
Edificio das Antas	PTE 44 423 000 (USD 246 795)	PTE 8 388 000 (USD 46 600)	5.3

Table VII – Ratio between Accident Costs and Safety Costs

8. BIBLIOGRAPHY

1. FUNDAÇÃO EUROPEIA PARA AS CONDIÇÕES DE VIDA E DE TRABALHO – Do projecto ao estaleiro: estatisticas dos acidentes de trabalho, Inspecção Geral do Trabalho e Instituto Nacional de Estatistica, Lisbon, Portugal, 1994.
2. HEALTH AND SAFETY – The costs of accidents at work, HSE, Series Booklet, London, UK, 1996.
3. MIGUEL, A., Manual de Higiene e Segurança no Trabalho, Porto Editora, Porto, Portugal, 1995.
4. IDICT, Coordenação da Segurança, Lisbon, Portugal, 1997.
5. REIS, C. and SOEIRO, A., Análise Económica de Segurança na Construção, MAPFRE Portugal, Lisbon, 1997.