Economic Aspects of Safety in the Greek Construction Industry

VOLUME 1

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ABSTRACT

The thesis addresses the economic impacts of construction safety in Greece. The research involved the development of a methodology for determining the overall costs of safety, namely the sum of *the costs of accidents and the costs of safety management failures (with or without accident) including image cost.*

Hitherto, very little work has been published on the cost of accidents in practical case studies. Moreover, to the author's belief, no research has been published that seeks to determine in real cases the costs of prevention.

The methodology developed is new, transparent, and capable of being replicated and adapted to other employment sectors and to other countries. The methodology was applied to three construction projects in Greece to test the safety costing methodology and to offer some preliminary evidence on the business case for safety. The survey work took place between 1999 and 2001 and involved 27 months of costing work on site. The study focuses on the overall costs of safety that apply to the main (principal) contractor.

The methodology is supported by 120 discrete cost categories, and systematic criteria for determining which costs are included (counted) in the overall cost of safety. A quality system (in compliance with ISO9000 series) was developed to support the work and ensure accuracy of data gathering.

The results of the study offer some support for the business case for safety. Though they offer good support for the economics of safety as they demonstrate need for cost effectiveness. Subject to important caveats, those projects that appeared to manage safety more cost-effectively achieved the lowest overall safety cost.

Nevertheless, results are significantly lower than of other published works for two main reasons; first costs due to damages with no potential to injury were not included and second only costs to main contractor were considered. Study's results are discussed and compared with other publish works.

KEY WORDS

CONSTRUCTION SAFETY, SAFETY COSTS, COSTS OF ACCIDENTS, PREVENTION COSTS, COSTS OF MANAGEMENT FAILURES.

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All three site coordinators, Mr A. Gogos, Mr N. Konstantinidis and Mr A. Spyridonis did their best to gather reliable and valuable data on site. Without their contributions the survey part in the thesis would have been almost impossible to complete successfully. Ms N. Seremeta was the research assistant for the site survey work. She played a critical role in the Thessaloniki (K1-K4) and Ptolemais (PPC) studies.

My staff in MANAGEMENT FORCE supported my work and took over my duties successfully during my frequent absences when visiting Aston University.

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Abbreviations

AC	Accident Cost
ACT	Accident Consequence Analysis
CAR	Cost Analysis Report
CBA	Cost Benefit Analysis
CDM	Construction and Design Management Regulations
CEA	Cost Effectiveness Analysis
EC	European Community
EU	European Union
ESYE	Greek Statistical Department
FIB	Factory Inspectorate Body
GB	Great Britain
GDP	Gross Domestic Product
HO	Head Office
HSC	Health and Safety Commissioning (UK)
HSE	Health and Safety Executive (UK)
IKA	Greek National Security System
ILO	International Labour Office
ISO	International Standardisation Organisation
LCC	Life Cycle Cost
MFwnAC	Management Failure with-no-Accident Cost (wasted costs)
NSC	National Safety Council (USA)
OSH	Occupational Safety and Health
OSHA	Occupational Safety and Health Association (USA)
PC	Prevention Cost
PD	Presidential Decree
PPC	Power Plant Company
PPE	Personal Protective Equipment
QALY	Quality-Adjusted Life Years
SACA	Systematic Accident Cost Analysis
SATE	Greek Association of Construction Companies
SC	Safety Cost
SPI	Safety Performance Indicator
SWLI	Safe Working Load Indicator
UK	United Kingdom
USA	United States of America
VAT	Value Added Tax

Chapter One

INTRODUCTION

1.1 Opening remarks

This thesis describe an evaluation of the costs of preventing accidents and ill health and the costs of health and safety failures in the construction industry in Greece.

There are essentially three reasons for the achievement of high standard of health and safety management. First, there are ethical reasons: it is not satisfactorily for employers to place their work people, and people affected by their work, at risk. Secondly, in most countries there are statutory legal duties to promote and secure safe working conditions. Thirdly, it is argued that preventing accidents and ill health at work is cost-beneficial (see e.g. HSE, 1993; Panopoulos, 1993; Booth, 1996; European Conference on the Costs and Benefits of Occupational Safety and Health, 1997; C. Reis at al, 1999; Geistfeld, 2001). That is to say, any money spent on preventing accidents is justified on economic grounds. So far, the economic case has been justified exclusively on the basis that accidents and ill-health cost individuals, employers, insurance companies, and society at large very substantial sums of money (see e.g. HSE, 1994; Everett et al, 1996, EU OSHA ,2001; Ngai et al, 1999; NSC, 2000; HSE, 2002).

While some research (ibid) has been carried out to determine the costs of accidents and ill health to employers, the insurance companies and to society, the present author believes that there has been very little work on a systematic approach to the costs of prevention. But unless employers know what the prevention costs are then it is impossible to judge whether expenditure on prevention is justified in economic terms.

The work described in this thesis was carried out in the construction industry in Greece for the following reasons:

- the present author is a construction safety expert working in Greece with about 20 years experience in construction;

- he has good contacts with many construction companies, working with them as a consultant health and safety manager;
- the construction industry in Greece, and indeed the construction industry worldwide, is one of the most dangerous industries. In simple terms, it is desirable to do a study of this type where there are sufficient numbers of accidents for a worthwhile comparison to be made between accident costs and prevention costs;
- because the construction industry is notably dangerous, it would be particularly valuable for evidence to be made available to demonstrate to construction companies the economic case for health and safety improvements.

1.2 Research Objectives

The objectives of the work are as follows:

- to develop an accident and ill-health costing methodology applicable to the construction industry in Greece, but also of wider applicability to other industries and to other countries;
- to develop a prevention costing methodology, also applicable specifically to the Greek construction industry, but again of more general relevance;
- to carry out experimental studies on a range of Greek construction sites to validate the costing methodologies;
- to obtain data on the costs of accidents, in their broadest sense, and the costs of prevention leading to an understanding of the relationship between prevention costs and accident costs;
- to provide evidence of the economic case for accident and ill-health prevention generally.

The scope of the practical work of this thesis is limited to large 'principal' contractors as proving an economic case for safety is more relevant to them compared with small businesses. But the study was carried out to identify the key parameters of general relevance. The study examined how easily and accurately the cost of prevention and management failures to companies, individuals insurance company and the society at large can be calculated or at least estimated.

1.3 Methodological challenges

As has already been stated, some work has been carried out to determine the costs of accidents and ill health to Employers, Insurance companies and Society at large. Following Heinrich's landmark studies (Heinrich, 1959) there have been many similar studies carried out in a number of countries (see e.g. HSE, 1993; HSE, 1994; Dorman, 2000; Greek Centre for OSH, 2002; HSE, 2003), or compare accident statistics and reporting systems in Europe (e.g. EFILWC, 1988; HSE, 1991a). Those studies make a general assumption that improving workplace conditions would lead to a cut in the cost of safety for the Employer. Depending on the definitions and classifications of the cost of accidents various studies give different figures, which in some cases vary dramatically. For instance case 1 of HSE (1993) gives for the first aid injury accident an average cost of □12.00 and a non-HSE study referred to in the HSE leaflet "reduce risks-cut costs" (HSE, 2002), gives an average of □50.0 (fixed prices 2002, at a □/£ rate at 0.69).

Also, an area of concern is how businesses ascribe costs and how costs are captured and dealt by the accountants. Though, the information as well as the allocation of the costs would not need to be accurate down to the last decimal point (Rikhardsoon, 2003). For Rikhardsson (2003) 'a "ball park" figure could be as just useful for raising management attention'.

The thesis is about providing data and not exploring the accounting system and how businesses ascribe costs in full details. Though, accounting issues have been considered (see chapter 4 – subsection 4)

These studies reveal that there are significant methodological challenges in determining the costs of accidents. Moreover, as many occupational diseases have long latent periods it is very difficult to determine the long-term costs of ill health (occupational diseases).

While it is axiomatic in many quarters, e.g. HSE (1990), EU OSHA (1997), HSE (1999), C. Protopapas (1998), that safety is cost-beneficial for the Employers, it is remarkable that very little studies have sought to prove this point (see e.g. Johanson Johren, 1993; Riel et al, 1996; European Conference on the Costs and Benefits of Occupational Safety and Health, 1997; Reis C et al, 1999). To prove the economic case we need a costing model. Surprisingly, most of the studies assume that safety pays and call Employers, to invest in accident prevention. For this reason it is worth repeating here that the aim of this work is to develop a comprehensive, handy and versatile methodology and validate it through a survey work with actual figures rather than asserting that 'safety pays' in any case. It does pay if offending the OSH law may result in a fine of □1,000,000. It does not pay if causing a fatal accident does not lead to prosecution or other serious consequences.

Measuring the costs of accidents is time-consuming, and there is scope for considerable debate regarding what costs should be included in the analysis. Moreover, and this is crucial, some accident costs are borne by the employer, and some by insurance companies, by the individuals and by society at large. The latter costs would include the costs of medical treatment. In each country, the costs of accidents born by society will vary depending upon the social security systems in force.

Estimating the costs of prevention presents further challenges (Miller et al, 1995; Larson et al, 1996; Panopoulos, 2000; LaBelle, 2000). While these issues are covered in detail within the body of the thesis, suffice to say now that it is particularly difficult to distinguish between the costs of production/operation and the costs of safety. For example, what proportion of the costs of a scaffold should be a production /operation cost, and what proportion a safety cost? Next, it is possible that an employer will spend more on safety than it is necessary, or may waste money on unnecessary safety measures. An additional point is that the costs of safety may also include management system failures that have not, or will not, lead to accidents.

A substantial part of this thesis is concerned with developing a coherent methodology for determining the costs of accidents (and ill-health) and the cost of management system failures which have not, or will not, lead to accidents and for calculating the costs of prevention. The crucial requirement is that all costing decisions must be transparent and consistent.

In addition to the methodology, the author developed a quality management system to ensure, as far as practicable, the systematic and auditable collection of data.

1.4 Experimental Work

The experimental work was carried out over the period 1999 to 2001 in three construction projects, refurbishment of cooling towers (PPC), office building (ECO) and major road construction (K1-K4).

For the experimental work relevant quality management procedures defined the criteria for selecting the participating companies and projects as well as the key company personnel role job descriptions (see appendix 1). In addition cost reporting and cost analysis pro-formas were developed (see appendix 1). The key role was the site coordinator who identified all incidents and prevention actions and reported to the researcher. The contractors also nominated a research assistant at head office to monitor and support the site work.

The first attempt at a pilot study was carried out on a project to improve shore protection in Thessaloniki (Salonika). This project was aborted because the site management infrastructure of the company THEMELIODOMI SA was insufficiently robust to report accident incidents and prevention costs, despite the company's top management being heavily committed to the programme. It should be born in mind that the present author depended greatly on trained and competent staff completing the relevant pro-formas prepared for the research. This study was abandoned because very little data was produced from the site people. This work emphasised that reliable data could only be obtained where the construction company infrastructure was sufficiently robust to ensure accurate data collection.

The completed pilot study was carried out on a project involving the refurbishment of cooling towers at a power station in northern Greece. This study obtained useful results but some changes were made to the methodology during the pilot study. The main contractor was the Joint Venture THEMELIODOMI SA - TECHNIKI ENOSIS SA.

The first main study was carried out in an office-building contract in a refinery process plant in Thessaloniki. Again the main contractor is THEMELIODOMI SA. This study worked according to schedule and the methodology and gave significant and valuable data.

The other main study involved the construction of a section of a bypass around Thessaloniki. This went very well for the very simple reason that it was the only project with a full time site safety officer plus a safety coordinator. The quality of data and assurance was better than in the earlier cases. The work was carried out by a joint venture partnership involving four companies: J/V PANTECHNIKI SA, ALTE SA, ELTER SA and GETEM SA.

1.5 Structure of the Thesis

The present chapter provides an outline statement of the problem, a brief description of the work carried out, and a route map through the thesis.

Chapter Two

This chapter describes published work in the field relating to the research objectives. It should be emphasised at the outset that the literature directly relating to the costs of accidents and ill health that work is sparse, and the research literature on the costs of prevention almost is negligible.

The literature review also embraces some basic discussion on issues such as cost benefit analysis, cost effectiveness analysis and management and safety accounting.

Chapter Three

Chapter Three provides an outline of the nature and economics of the construction industry in Greece. A detail description of the safety and health issue in the construction industry in Greece as well as an overview of safety and health statistics in the worldwide construction industry is presented.

It also includes an account of the health and safety issue in Greece. The Greek safety statutory provisions are discussed here.

Chapter Four

This chapter describes in detail the development of the methodology for the work including the costing methodology; both as first developed for the pilot study, and as subsequently amended *during* the pilot study. The chapter describes the selection criteria for the construction companies, the research team and their role, the criteria for the selection of the projects as well as procedures and pro-formas for reporting incident and analysing costs.

Chapters Five to Seven

These chapters describe in detail the application of the methodology to three construction sites (pilot study, and the two main studies). They provide a summary of every individual Cost Analysis Report.

Each chapter describes the findings of the survey work and reproduce them in a graphical format. It also discusses safety audit findings and offers Safety Performance Indicator (SPI) scores to determine site safety standards generally.

Chapter Five also includes a brief description of the initial costing study that was abandoned when it became clear that inadequate data was being collected by personnel on site. Chapters six and seven embrace the two main costing studies.

Chapter Eight

This chapter provides a detailed analysis of the costing results both of the pilot study and the two main studies. All the experimental data was consolidated within one database that gives results automatically provided that row data such as unit cost rates and assumptions have been entered. The Excel® database allows various assumptions to be tested to see how they effect the final outcomes.

This chapter also presents a discussion of results including a comparison with other published work. It also examines scenarios where results/figures from other works are used for recalculating costs for the three projects.

Chapter Nine

The final chapter provides detailed conclusions to work, both specific in relation to the construction industry in Greece and also conclusions of more general applicability. The thesis concludes with recommendations for further work.

Chapter Two

RESEARCH ORIENTATION

2.1 Opening remarks

This chapter outlines the evolution of OSH management from a reactive to a proactive approach and the principles of contemporary approaches to prevention. It is also concerned with the factors that motivate employers to allocate sufficient resources to prevention. The chapter then goes on to discuss in greater detail the 'business case' for OSH management, and the techniques available to evaluate in practice appropriate OSH management activity. The chapter concludes with a detailed discussion of research evidence from previous studies of accident costing.

2.2 Evolution of Contemporary OSH Management

The historical approach to OSH management was reactive: organisations only took action after accidents had happened, and the preventive effort was directed exclusively to the prevention of a repetition of the accident that had taken place. This approach was characterised by a tendency to blame the injured person, and to adopt preventive measures that would in time be seen as over zealous. In contrast, the contemporary approach involves the prediction of possible accident scenarios (risk assessment) and devising appropriate controls within a framework of management systems and procedures that have the full hearted consent of both employers and work people, see, for example, European Foundation for the Improvement of Living and Working Conditions (1981), HSE (1993), Booth & Lee (1995), Panopoulos (1996). At the legislative level, the European Framework Directive 89/391 EC (as amended with 91/383 EC) introduced the risk management/assessment approach. PD 17/96 implemented above-mentioned directives provisions into the Greek Statutory system

The European Directive for mobile or temporary worksites (construction sites) 92/57 EC as implemented in the Greek legislative system also adopts a risk assessment approach

(PD 305/96). Underlying the contemporary approach is a belief within organisations that "good safety is good business", see, for example, HSE (1999), Wright et al (2002).

In an HSE study in 1998, 28 companies participated. Virtually all the firms participating in the study have good and some super-high standards of health and safety performance. When asked what motivated them to this, the answers given broke down as shown in table 2.1 (some firms gave more than one answers).

Table 2.1 Reasons for adopting high OSH standards (HSE (1998a)).

Initiative	Answers
Legal compliance	5
Moral/ethical/cultural	11
Loss control/business risk reduction	12
Reputation	8
Quality management aims	9
Customer pressure	3

2.3 The Business Case

As was outlined in the previous chapter, the business case for safety is founded on three, interrelated, issues. First, good employers recognise that it is ethically wrong to expose their personnel (and others) to unacceptable risks (see e.g., Booth 1996, Geistfeld 2001). Secondly, good employers wish in general to comply with their legal duties (see e.g., HSE, 1999). Thirdly, and of greatest importance in the context of the present study, employers believe that expenditure on safety is cost beneficial (see e.g., European Foundation for the Improvement of Living and Working Conditions 1997). As has been stated in Chapter One, the belief that safety is cost beneficial is almost exclusively founded on evidence of the costs of accidents. There is no secure evidence at company level that demonstrates, taking into account prevention costs, that safety is in fact cost beneficial. In Great Britain, the HSE is required to carry out cost benefit analyses (CBAs) to demonstrate the economic case for new regulations, Booth (1983), Booth (1990), HSE (1998). This is also the case in other countries, e.g., the USA, (Geistfeld, 2001). These analyses have tended to be superficial. For example, the GB Construction (Head

Protection) Regulations 1989 were supported by a CBA that simply compared the cost of the additional hard hats required with cash values associated with the predicted reductions of fatal and non fatal head injuries (including assumptions about wearing rates).

It should be understood that the business case for safety is likely to vary dramatically in different countries, depending upon the social insurance benefit system, and the rigour of legal enforcement (HSE, 2002; Geistfeld, 2001). For example in the United States of America the business case is very strong: almost all the costs of accidents, and other harms are borne by employers within a highly litigious society. In Great Britain, the business case is less strong, but is founded on reasonably strict legal sanctions, coupled with a risk averse society. In contrast, until very recently, the business case for safety in Greece was almost nonexistent: though there was an extensive framework of law, the law implementation and enforcement were negligible (Panopoulos, 1993; Greek Centre for OSH, 2000; Messaris, 2003). Moreover, companies with a poor safety record suffered little economically (Greek Institution for Health and Safety at Work, 1999). As it will be explained in Chapter Three, the situation has changed dramatically in the last three years: the Factory Inspectorate are now enforcing the law zealously (www.osh.gr), and perhaps the image of poorly performing companies may damage commercial prospects. (While the research described in this thesis was carried out over the period 1999 to 2001, the relevance of the findings is predicated on a continuation of the recent changes in enforcement policy).

2.4 CBA & CEA and Sensitivity Analysis

This section describes with appropriate references the basis of CBA and cost effectiveness analysis (CEA) together with relevant aspects of management accounting, and economics for management.

In the late 1960s there was considerable development of methods for applying social cost-benefit analysis to investment in developing countries. In the 1970s, these methods began to be applied. Since then they have been applied widely in developed and developing countries (Layard, R. and Glaister, S., 1994).

Cost-benefit analysis is regarded between engineers and safety professionals as a formal analysis method, which, in principle at least, is the most (or perhaps the only) rational basis for making risk tolerability/acceptability judgements. It provides a framework for identifying and quantifying (in common monetary terms) all the desirable and undesirable consequences of a given activity (Booth 1992).

A popular method for deciding upon the economic justification of a project is to compute the cost-benefit ratio (or benefit-cost ratio). This ratio may be expressed as: (Economic decision analysis)

CB = (benefits to the public)/(cost to the government), where the benefits and the costs are present or equivalent annual amounts computed using the cost of money. Benefits are defined to mean all the advantages, less any disadvantages, to the users (Snell, 1997). Similarly, costs are defined to mean all costs, less any savings, that will be incurred by the sponsor.

The cost-benefit ratio is based on quantifying all advantages, disadvantages and costs in monetary terms. Despite that in safety, moral and ethical factors are involved, CBA has been extensively used for justification of safety decisions, as described above.

The CBA is based on an accurate accounting of the benefits and costs. First, the traditional definition of the benefit-cost ratio requires that the net benefits to the user be placed in the numerator and the net costs to the sponsor be placed in the denominator.

To find the net benefits it is necessary to identify those consequences, which are favourable and unfavourable to the user. These unfavourable benefits are usually referred to as disbenefits. When deducted from the positive effects to be realised by the user, the resulting figure represents the net "good" to be engendered by the project.

To determine the net cost to the sponsor, it is necessary to identify and classify the outlays required and the revenues to be realised. These revenues or savings usually represent income generated from the sale of products or services that are developed from the project. These costs include both disbursements and receipts related to the project's initial investment and to its annual operation.

The cost-benefit decision rule gives safety interests, expressed in monetary terms, the same weight as economic interests. Geistfeld argues that this approach apparently violates the safety principle. Moreover, a cost-benefit decision rule that gives equal weight to economic and safety interests often inequitably favours potential injurers at the expense of the potential victims, an inequity that can be identified and quantified with cost-benefit methodology. Geistfeld proposes that the inequity can be mitigated if the cost-benefit decision rule is modified to give the safety interests of potential victims greater weight than the economic interests of potential injurers, the type of weighting sanctioned by the safety principle. This regulatory approach satisfies the methodological requirements of CBA and appears to be a defensible way to implement the safety principle. (In the UK, the principle of 'reasonable practicability' seeks to capture the same idea.)

How economics comes to feature centrally in a discussion of safety (and other risks, e.g., physical risks)? For Lee et al (1983) it is essential to appreciate that improved levels of safety can normally be achieved only at cost of a curtailment in some of the other desirable ways in which a society might make use of its scarce resources. Crudely put, the more a society spends on safety, the less will be available for, say education, housing and the arts. Given that - other things being equal - most people prefer lower rather than higher levels of exposure to the risk of death or injury, it follows that the individual or social choice of an optimal level of safety in any particular context has a significant economic dimension in that and it is a decision concerning the appropriate trade off, or balance, between competing uses of scarce resources.

Despite above arguments, the volume of research on 'Quality-Adjusted Life Years' (QALY) has increased, in favour of an economic approach of safety rather than a "moral base one". QALY measures an individual's 'health'. The community's 'health' is measured as the sum of QALYs. Maximising health is argued to be a natural objective to want to pursue, given a desire to see resources deployed efficiently. "we are concerned with economic with economic efficiency rather than notions on equity or social justice" (Drummond, 1989). Williams (1985) concludes "procedures should be ranked so that activities that generate more gains to health for every £ of resources take priority over those that generate less; thus the general standard of health in the community would be correspondingly higher".

Although CBA is a tool for guiding decisions, it is seldom the only guide to a particular decision. Most decisions are made on several criteria (Snell, 1997). Examples of other criteria, which are often used alongside CBA, are:

- Regional policy;
- Social policy;
- Environmental criteria;
- Self -interest;
- Habit; and
- Risk aversion.

In principle, many criteria that do not immediately seem to be of a financial or economic nature can nevertheless be brought into a CBA by special valuation methods. The fact that it is possible does not necessarily make desirable; it may be better to apply such criteria explicitly alongside the CBA rather than to apply them within it, because such separate treatment is more transparent and open to discussion (Snell, 1997).

Investing on safety, regardless how profitable it can be in comparison with other areas of investment, it is not a straightforward process. Which risks should be primarily mitigated? What does it cost? What would be the benefit (expected cut in accident costs)? Having deciding the risks to invest in, then the effectiveness of the investment should be considered. Cost-effectiveness analysis had its origin in the economic evaluation of complex defence and space systems. Its predecessor, cost-benefit analysis, had its origin in the civilian sector of the economy (economic decision analysis). Much of the philosophy and methodology of the cost-effectiveness approach was derived from benefit-cost analysis and as result there are many similarities in the techniques.

Basically, cost-effectiveness analysis seeks to maximise the extent of achievement of a given beneficial goal within a predetermined budget or, equivalently, to minimise the expenditure required to achieve a pre-specified goal (Fabrycky et al 1998). In particular and in marked contrast with cost-benefit analysis, no attempt is made to place a monetary value upon the beneficial goal.

The effectiveness analysis is appropriate if (a) a decision maker's overall safety budget was predetermined and (b) the sole effect of the various projects under consideration was to improve levels of safety. What cost-effectiveness will not do is to give any indication of the appropriate size of the safety budget; nor will it resolve the problem of project selection whenever different project provide more than one kind of beneficial effect with the mix of benefits differing between projects (Jones-Lee, 1989).

Experienced decision makers rarely confine their interests to a single result of an analysis. Typically, they are concerned with the full range of possible outcomes that would result from the variances in estimates that might occur. Thus a comprehensive economic analysis must investigate how sensitive the study's final results are to changes in the estimates used.

Cost Effectiveness Analysis is critical to allow Management to implement effectively a cost leadership strategy in order to ensure survival in the competition and optimisation of profits (Bartol et al, 1998). Though cost leadership strategy is used mainly by retail industry basic elements may apply to the construction industry as well.

Along with a CEA a Life Cycle Cost (LCC) is also examined for complete project evaluation, examining the cost in the project lifetime.

2.5 Research on accident costing

Since Heinrich's seminal work in accident costing (Heinrich, 1950), a number of other studies in this area have been performed. Research includes both the cost of accidents, generally, or in a specific work sectors. It should be noted that much of the research described in this section was published during, or after, the developmental and experimental work described in this thesis.

Some large companies in developed countries have devised their own accident costing methodologies or operate their own safety programs, based on an economic approach, but there has been little published work relating to construction, and virtually none in any sector in Greece unless a series of articles published in engineering journal by the Author (Panopoulos, 2000; Panopoulos and Booth, 2003). The aim of most of these initiatives was to demonstrate the high costs of accidents, and did not of course address the question whether prevention cost more than the costs of failures to cure.

Nevertheless, the tendency in safety over the last ten years has been increasingly to justify on financial grounds, any "safety decision". This is typified by the UK principle of reducing risks 'so far as is reasonably practicable'.

Most of the studies distinguish between direct and indirect costs in some way although the cost classification criteria often differ and the actual relations between direct and indirect costs cannot be directly compared between studies, see, e.g., HSE (1993), Larson & Betts (1996), Monery (1998), and LaBelle (2000).

These studies reveal that there are significant costs that are not insured. Monery (ibid), for example, states that the ratio of insured and non-insured costs due to work-related ill health in a bank clearing department constitute 1:33, i.e., for every dollar covered by insurance, $33 are not. The work conducted by the GB Health and Safety Executive

(HSE, 1993) founded that this ratio ranges from 1:8 (a transport company case) to 1:36 (a creamery) and depended on factors such as the accident type, industry and company size. The HSE analysis, based as it was on insurance *premiums* is can only provide a crude estimate of this ratio (Booth, 1993). Riel & Imbeau (1998) take this type of cost analysis a step further by proposing a method on Activity Based Costing for the allocation of the Health and Safety insurance costs based on the amount of occupational costs created by each accident (Rikhardsson, 2003). As insurance premiums usually increase in proportion to the number of accidents and the number of claims made then injury costs are used as the driver for the insurance costs. These drivers are then used to allocate the changes in insurance costs, the departments where the accidents occurred. Riel & Imbeau use this method to estimate and justify investment in industrial ergonomics and injury prevention (Riel & Imbeau, 1996).

In 2001 G. Panopoulos presented a paper in the International System Safety Conference, Huntsvile, Alabama, USA where it discussed who accidents investigation and risk assessment are the two sides of the same coin and thus developing detailed risk assessment database we can predict the potential cost of a project for specific safety performance level.

As a matter of thumb, all these studies make specific categorization of the costs to e.g. economic and non-economic (see e.g. Dorman, 2000a), insured and non-insured (see e.g. HSE (1993)), direct and indirect (see e.g. LaBelle, 2000), variable, fixed and disturbance costs (see e.g. Rikhardsoon, 2003). Categorization in one study does not necessary be in any consistence with categorization in other studies and therefore comparing studies it is not a straightforward process. Dorman (2000a) created his one categorization in order to include (cover) the most possible studies and make plausible comments and lead to substantial results.

Many studies performed today give guidance for medium and small companies on what would cost an accident as an average (HSE, 2002).

HSE's (1993) important work on accident costing gives for five different sectors, construction, a creamery (food industry), transportation, oil & gas, and a hospital, an accident triangle, the costs of accidents and the insured: un-insured cost ratios. The study develops a methodology on accident costing. The methodology is based on classification of direct/indirect and insured/un-insured cost of accidents.

HSE (2002) published a guide for calculating cost of accidents. The guide includes three methods. The HSE method gives (a rough estimation) that on average, the cost of un-insured losses is ten times the cost of insurance *premiums* paid for the same period.

Norwich Union Risk Services estimate un-insured losses from accidents in smaller firms adds up to \$315 per employee per year (HSE, 2002).

Finally a non-HSE study (included in their guide) works out the average cost of different types (classified by severity) of accidents. The formula below gives the total annual cost:

> Total un-insured cost = £2097 (average un-insured cost per accident, causing absence from work) * number of accidents) + £33 (average un-insured cost per accident causing only first aid) * number of accidents + £141 (average un-insured cost per accident causing damage to plant, equipment etc. but no one injured) * number of accidents.

Similarly, other studies have been developed for evaluating occupational costs. The Aarchus School of Business and Pricewaterhouse Coopers Denmark (Rikhardsson, 2003) carried out a project during 2001 for measuring the economic effects of health and safety. This Systematic Accident Cost Analysis (SACA) project was focused on developing and testing a method for evaluating occupational costs for companies for use by occupational health and safety professionals. The method was tested in nine Danish companies, within three different industry sectors and the cost of 27 selected occupational accidents in these companies were calculated. One of the main conclusions was that two-thirds of the costs of occupational accidents are visible in the Danish corporate accounting systems reviewed while one-third is hidden from management.

The primary aims of the SACA projects were to (Rikhardsson et at, 2002, also visit www.asb.dk/saca/saca.pdf):

- Develop an accident cost analysis methodology that had a simple methodological basis that could be applied in practice by managers within a short period of time.
- Test this method in a number of companies and calculate the costs of selected occupational accidents in these companies.

To achieve these aims the SACA project rests on two fundamental methodological choices. One is the selection of the qualitative case study method as basis for the overall research (see e.g. Yin, 1989) and the second is the selection of activity mapping as the methodological basis for the evaluation of occupational accident costs, see, e.g., Salafatinos (1995). Sectors selected include construction, cleaning services and furniture manufacturer. Sizes included small, medium and large organisations.

Another method in documenting the consequences of occupational accidents is the Accident Consequences Tree (ACT). The method was developed by Aaltonen et al (1996) and it was originally published in 1996 in a series of articles as well as in a doctoral thesis. This work documents the consequences of accidents for society, the company, and the injured person and then it values these in financial terms. The study in which the method was developed was carried out in 1986-1989 in the Scandinavian furniture companies and included 214 occupational accidents. The ACT method uses predefined forms, on which relevant persons or teams of researchers can document the consequences of occupational accidents. For example the costs of emergency response, hospital costs, cost of revalidation and medical costs are captured on the level of society; lost work time, material damages and service costs are captured at the company level. The total costs at the company level were approximately €440 per accident analyzed. However there was a large difference in the actual costs based on the length of absence and the type of accidents. Accidents causing less than one-day's absence from work incurred an average cost of €42 while accidents with absences of more than a month cost companies approximately €2,000 on the average.

The main innovation of the ACT method is the approach used to evaluate the costs of accidents. This approach is based on documenting what consequences (activities) actually occurred in connection with the accident both within the company but also the society and the injured person. There is not an a priori definition of accident costs. Hidden and visible costs etc. and the cost evaluation are solely based on the resources used in consequences of the accident. The method itself is evidently a research method and its practical applicability might be questioned based on the methodological problems reported (Aaltonen, 1996a). The Authors recognize this, and suggest that a computer programme might be helpful to guide managers and others through the steps involved.

The framework for such a computer programme is described in another article (Aaltonen 1996b). It might be argued though that the use of specific software to calculate the costs of an occupational accident defies the purpose of such a method, meaning that managers should be able to understand and apply an analysis method without having to buy specific software (Rikhardsson, 2003).

Bearing though in mind that the SACA project discussed earlier proved that very few companies use the accounting information system for registration and calculation of accident costs. But the technological possibility of integrating accident cost registration and calculation in accounting information systems is present in most companies, which have modern accounting information systems such as SAP R/3, Oracle etc.

Similarly, there many other studies attempting to develop a methodology, or at least to provide a formula, for the rough estimation of the cost of accidents, see, e.g., Dorman (2000).

In recent years (over the last decade) there has been an upsurge of interest in the economic cost of poor working conditions overall (at company level, or at society level). Also, over a similar period, there has been an increasing interest, and research work, in evaluating where OSH is cost beneficial and developing methodologies to work out the costs of safety.

As stated above, in many countries, prospective OSH legislation must be justified on the basis of a cost-benefit analysis (Geistfeld, 2001). This was introduced in GB in 1983, Booth (1983). HSE carries out explicit valuations in support of policy proposals that require duty holders to make major investments in safety measures, or when introducing new regulations (HSE 2001a).

In 1997 the European Agency for Health and Safety at Work requested by member states to answer a questionnaire on economic aspects of OSH (European Agency for OSH, 1997). The aim of this questionnaire was to give an overview of the current situation in the member states on:

- Costs and benefits of interventions by national administrations and the existence of instruments for the estimation of cost and benefits;
- Estimating of the impact of OSH-information about the application of economic incentives.

The Agency denotes that the above aspect is one of particular interest since in many European countries there is a (renewed) interest in economic factors in occupational health and safety.

The European Agency for OSH is developing a cost methodology on safety (prevention and accidents) based on the answers provided by the above-mentioned questionnaire as well as other input requested by the member states. The methodology will be computer-aided. When this thesis was drafted, the European Agency work had not been completed and therefore cannot be commented upon here.

A model in assessing the cost and benefits of improving the working environment is the 'Balloon' model developed by Johanson & Johren (1993). The idea of this model is to demonstrate the costs and benefits of an investment in a certain figure, where one part of the figure represents the cost side of the investment and other part represents the benefit side of the case.

The methodology, with a practical example, is presented by a publication drawn up by the Department of Occupational Safely and Health of the Finish Ministry of Society Affairs and Health with ILO safe work programme (visit www.ilo./public/anglish/ protection/safe work/econo/barefoot.pdf).

In the international conference on "Implementation of safety and Health on Construction Sites", held in Rotterdam, in 1999, Reis et al (1999) presented research conducted in two Portuguese construction sites. The research aimed at evaluating where prevention is beneficial. The research was based on implementing a safety programme. They calculated all prevention costs (details are not given). As there were no accidents recorded at all, the researchers assumed that the safety programme prevented the expected average accidents and thus calculated the cost of accidents that would on average have occurred if the safety programme had not been implemented. The figures for the average expected accidents were provided from the MAPFRE Portugal, the insurance company that sponsored the safety programme (Reis & Soeiro, 1997). The research showed that the average ratio between the costs of prevention and costs of accidents is 1:4.9 (4.5 in one project and 5.3 in the other) i.e. that 1□ spent on prevention 4.9□ spent on accidents was saved. The research concentrates only on insured costs based on the fact that an insurance company sponsored the programme. Thus, the accident-costing database used gives the insured cost of accidents and not the entirely cost to the contractor or the project (insured and uninsured). It does also not include any image cost. Nevertheless this is one of the most practicable and comprehensive research works performed in the field of economics of construction safety.

G. Panopoulos (2001) strengths the beliefs that the overall safety cost is of greater importance than the cost of accidents itself with the moral issue (see e.g. Geistfeld, 2001) to be of high respect and "untouchable".

Despite the tremendous work done in accident costing up to early 1990's the key question had not been answered clearly and satisfactorily. Is OSH a cost beneficial activity for companies (European Conference on the costs and benefits of Occupational Safety and Health, Hague (1997)).

Though, organizations and experts are still mainly concentrate on the costs of accidents rather than the justification of the improvement based on economic grounds. Geistfeld's argument that the "principle of safety matters more than money" (Geistfeld, 2001) gives another dimension on the economics of safety. In the same direction Dorman (2000) underlines that "in any assessment of the overall burden of occupational injury and disease the main emphasis must be on the human cost – the pain and suffering, loss of function, diminished quality of life and premature death".

Geistfeld (ibid) argues that, despite any apparent inconsistency between a CBA based law and a safety law emphasizing safety over cost considerations, the two regulatory approaches can be reconciled. Geistfeld contents that modified CBA (1) satisfies the requirements of modern welfare economics, (2) can accommodate a wide range of normative economics, and (3) closely conform to important tort practices, suggesting that it implements a version of the safety principle closely corresponding to the version adopted by the tort system. He, finally, concludes that the value of modified CBA is illustrated by the structure it gives to the precautionary principle, a vague regulatory approach based on the safety principle that has become increasingly important and controversial in international law.

Panopoulos (1993) found that in the construction industry, employees believe that the main protective equipment/measure required is "to be careful". In the same study cost seems not to be encountered by the companies at that time either because they do not know what is the cost of accidents or because they simply believe it is negligible in total. The most comprehensive study is that conducted by the Greek Center for Occupational Safety and Health in 2002. The study concentrated on the costs of accidents and particularly on the covered costs by the national security system. According to the study the average cost per accident was 2,900□ for 1997 and 3,000□ for 1998 (including compensations, premature retirement, medical and hospital treatment and general expenses). For construction, the study gives statistical data for accidents and compares those with the accidents in total in construction in Europe. The study is a statistical review rather than a cost study.

At national level, statistical data from the National Statistical Department also do not provide any cost figures (ESYE, 1999). Similarly, the National Security System annual statistical report does not provide any cost information (IKA, 1999).

2.6 Review

Most of the work performed has focused on the cost of accidents. Only in the last decade has there been an upsurge interest in the overall economic aspects of safety. Though, so far very little work has been performed on the cost of safety and the question where prevention is beneficial still waits an answer.

The study that follows was designed to make a significant contribution to an understanding of the costs of accidents and the costs of prevention, ultimately leading to data that can support, or otherwise, the contention that 'safety pays'.

The present work:

- needs no cost classification other than the accounting system of the company uses.
- Needs no extra software to operate
- Can be easily incorporated and facilitated by any existing company information/accounting system
- Can provide real time information
- Can work out any scenarios and be (in future) connected directly with risk assessment data base/software system to run scenarios and assist decision makers
- Answers/covers the safety principle by deciding the soft price units of image

Chapter Three

THE GREEK CONSTRUCTION INDUSTRY

3.1 General

The construction industry in Greece, as elsewhere in the world, is a cyclic economic sector. In Greece there has been an upward trend since the early 1990s and it will continue to expand until the Olympic Games in 2004 and for a period beyond (Greek Ministry of Finance, quarterly report 2003, Kouvaras, 2002).

In these years, the economy of Greece generally has expanded (Greek Ministry of Finance, quarterly report 2003). Greece entered the European economic and monetary union, and embarked on the privatisation policies of many western economies. Greek companies turned into multinational enterprises and mergers took place. In construction particularly, the scene is dramatically different than that of 15 years ago. Nevertheless inherent weaknesses of the industry are still not addressed satisfactorily, as the sector fears a downward trend. As construction is a cyclic economy this makes employer stakeholders reluctant to invest (KATHIMERINI, 23/9/2003).

"Construction is a high-risk industry", according to HSE (2003a). Also statistics reveal that construction scores the highest injury rate in several countries (see e.g. HSE 1999a, IKA 1999). The construction industry in Greece, as in many other countries, accounts for more accidents (injury rate) than any other economic sector. Also statistics reveal that construction has a bad record regarding fatal accidents (see e.g. IKA, 1999; NSC, 2000; EUROSTAT, 2003). Despite efforts and campaigns taken nationally, or more recently by the European Union, construction remains a very high-risk industry (see e.g. Greek Centre for OSH, 2002; European Agency for the OSH, 2000; NSC, 2000; HSE, 2001).

The Greek construction sector statistics reveal (Greek Centre for OSH, 2002) that it:

- represents 11.5% of the gross domestic product (GDP) - an estimate for 2004;

- employs 6.5% of the national workforce, though this figure may be an underestimate;
- accounts for a 16.5% of all recorded accidents (all accidents resulting in injury must be reported to the labour Inspectorate (PD 17/96 and PD 305/96), and
- a startling 57% of all fatal accidents in all industries.

For the year 2004 the expected turnover in construction will be □24.9 billion (11.5% of GDP), compared with an □19.7 billion average for the years 1999-2002. The largest 40 constructions companies accounted for 17% of the total turnover in 2002 (Greek Ministry of Finance, 2003; SATE, 2003), with over 16,000 companies being registered in the National Registry for Public Works.

3.2 Occupational Safety & Health (OSH) in Greece

This section describes the occupational safety and health (OSH) environment in Greece, the legal and administrative background, the organisational arrangements at company level, educational and training arrangements, and accident data.

Greece joined the European Union in 1981. Most of the European directives for OSH have been incorporated into the national legal system. Basic organisational provisions at company and national level had been made with Law 1568/85. Despite those early provisions, enforcement has not been shown before the Olympic projects started.

Following the European Directive 89/391 and 91/383 for safety at workplaces, the parliament passed the bill with two Presidential Decrees (PD); the PD 17/96 (Government Gazette, 1996) and PD 16/96 (Government Gazette, 1996). PD 17/96 provides that all employers employing one or more persons should provide safety practitioner services. Employers with more than 50 employees should also provide a physician. Consultancy companies (PD 95/99) could provide the services of safety practitioner and physician, the so-called External Services for Prevention and Protection (ESPP).

Until 1999, the Factory Inspectorate belonged to the local administrative authorities (Prefecture). From September 1999 (PD 136/99), the Ministry of Labour established an administrative secretariat and the Factory Inspectors Body (FIB). From 140 factor inspectors in 1999, the FIB now has just over 400 factor inspectors. FIB inspections are more frequent than before, resulting often in penalties and prohibition notices.

Despite the Law 1568/85 requiring provision for safety practitioner at workplaces, only in 2001 did the FIB impose controls and urge employers to employ/appoint these services. The qualifications for such services range depend on the category of risk to which the company/activity belongs. However no formal training qualification is needed to perform/provide safety services. "A graduate should be considered properly qualified to perform the duties of a safety practitioner" is the Ministry of Labour concept[1] (PD 294, Government Gazette, 1988).

There no specific provisions for safety training and therefore no accreditation for whatever safety training is provided in Greece, except the Ministry of Labour accredited training for employers of small companies employing up to 20 personnel and belonging to the low risk category (PD 294/88, PD 15/99). Employers may take a 12-hour training to undertake the role of the safety practitioner in their companies. It is indicative, as far as formal training and accreditation is concerned, that MANAGEMENT FORCE (the present author is the Managing Director of this company) has for the last five years provided safety training only under the umbrella of the UK Institution of Occupational Safety and Health (IOSH) and the UK National Examination Board of Occupational Safety and Health (NEBOSH), in order to ensure a proper accreditation for trainees.

The time allocation to OSH either by internal or external services varies, depending on the risk category (PD 294/88). For high-risk activities (category A) the minimum requirements is 3.5 hours per employee per year, and for low risk activities (category C)

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1 In the higher education system (Technical Universities, Universities and Technological Institutions with five, four and three year duration respectively) there no are safety studies at all. For instance in the National Technical University of Athens, the Civil Engineering Unit, safety consists of a part from the subject "Project Management" which is a one semester subject.

the minimum requirements is 0.4 hours per employee per year. For medium risk (category B) the minimum requirements is 2.5 hours per employee per year. Construction, heavy industries, and chemicals are listed in the high-risk category. The service sector is included in the low risk category.

It is indicative that the Official Journal of the Association of the Ready Concrete Producers, published in the issue November 2002 an article with the title "New Safety Requirements for the Companies", referring to those requirements initially established with Law 1568 of 1985 and becoming of general application with the PD 17 of 1996!

The statistics published by the Institution of Social Security (IKA, 1999), under the Ministry of Labour administration, show a remarkable reduction in accidents though an upward trend in fatal accidents. With a 25-year record at 188 fatal accidents in 2002, a decline achieved in 2002 at 153 fatal accidents (Palmos, 2003). But the Institution's accident compensation payments show also an upward trend. The Institution estimated the costs for compensation from workplace accidents as □55.8millions for 1998 against □54.7millions the previous year (Greek Centre for OSH, 2002).

At EU level, the Greek accident statistics are very encouraging with for instance the over three-days absence from work index (per 100 thousand employees) shows a reduction by 27% over the years 1994 -1999 (Eurostat, 2003).

3.3 Construction Safety in Greece

This section reviews the arrangements for managing OSH in construction over the time period of the research. The list below is based very largely on the author's personal experience.

The list below is illustrating the safety issue in the Greek construction sector (see e.g. ETTAA (2000), Greek Centre for OSH (2002)). Indicatively (but not representatively), the following question has been asked to one of my colleagues, by one of the subcontractors in the construction of a major Olympic Project in Athens. *"A safety practitioner, what is that? Where can a get one?"*

1 Few construction companies had developed a documented OSH Management System. OSH Management Systems were in place in only a few big infrastructure projects. Most companies have not yet appointed a safety practitioner within their organization. This was a legal requirement from 1985 for companies employing more than 150 persons and for all companies since 1996 (L 1568/85, PD 17/96).

2 There is no published guidance in Greek on OSH standards relating to construction.

3 At site level, most construction companies and their subcontractors have not appointed a safety practitioner. At most sites the accident logbook, the safety practitioner logbook and the project safety logbook are not in place. Only a very few projects operating under a Project Management scheme have implemented an OSH management system. These are very few (e.g. Athens Airport, natural gas projects, Athens Metro, Athens Music Hall, and the motorway from Patras to Thessaloniki).

4 All contracts stipulate that "the Contactor is solely responsible for the health and safety on site and all expenses for prevention are covered by Contractor's offer" (PD 609/85, MD no 889/2003). Only MD no 889/2003 provides specifications on safety requirements according to PD 305/96 and PD 17/96, for first time ever in public works.

5 For public projects the lowest bid invariably succeeds. Competition is very fierce. Public offers to tender stipulate a 'budget' price. In some cases contractors have been prepared to carry out the work for as little as 17% of the budget price, but more typical is the range 40 to 60% (Soldatos, 2002).

6 Supervising Engineers do not stop the work, or impose sanctions, even when the site standards are very weak.

7 There were no prosecutions of, or prohibition notices imposed upon, construction companies during the research period, but as stated above, following the dramatic increase in the size of the Factory Inspectorate, legal sanctions are now commonplace.

8 There are no OSH training requirements.

9 There are no compulsory qualifications for scaffolders, or for any other trades, except welders and electricians. Moreover there are no obligatory qualifications for technicians. In general, the educational standards of construction workers are low, and many immigrant construction workers barely speak any Greek (or English). (In recent years about 650,000 immigrants from Asia and former Warsaw Pact countries have started working in construction, few with prior experience of the industry. Perhaps 65% of the workers building the Olympic village in 2001-2002 were immigrants.

10 Qualified operators are insufficient to operate the substantial amount of site plant and equipment according to the association of site equipment operators.

11 Only major infrastructure and other big construction projects were insured. Normally projects running under the Project Management scheme were covered by an insurance policy. Most projects, for instance all building projects in the private/individual construction sector, were not insured.

12 Insurance companies carried out no audits.

13 The Institution of Social Security carried out no audits.

14 Most contractors act as subcontractors and they employ normally 1-5 persons. A large number of self-employed people work in the construction sector. This number ranges widely due to the very high mobility in the sector.

15 Companies were not keeping records of accidents or money spent for safety.

16 Also safety organizations (enforcing authorities) except IKA (Institution of Social Security) are not in a position to present any statistical data for accidents and costs, simply because they do not keep such records.

17 Accidents are reported to various organisations. Recording and analysing methods vary. Sector accidents statistics are not available. There is no provision for reporting or recording incidents. Accidents to the general public associated with construction site activities would never be encountered in the sector statistics. For instance vehicular accidents resulting from unguarded /unprotected construction works on roads would be recorded by police simply as traffic accidents.

18 Construction sector provides host for 23.3% of migrants (MRB 2003). The safety standards in their origin countries are as average lower than in Greece. Also their willingness and capability to understand and implement applicable safety standards is not a straightforward task.

For issue 18 above I believe that to overcome a negative influence to the safety performance of the current economical refuges in Greece and specially in the construction sector, a national strategic programme is required, not simply actions only on site level (Protopapas, J., 2002). MANAGEMENT FORCE, as other few organizations have understood the problem and developed training packages in various languages. MANAGEMENT FORCE has developed the basic training and regulation package in six languages (including Romanian, Albanian, Russian, Arabic, English, French). Ministry of Culture developed a safety guide in four languages (Greek, Albanian, Polish and Romanian). This guide was disseminated to all workers in the Olympic projects of the jurisdiction of the ministry (Ministry of Culture, 2002). The guide was based on a MANAGEMENT FORCE standard site safety notes guide (not published; part of the Health and Safety Plan developed by the company for the clients' construction projects). Bearing in mind that personal factors consist of one of the three human errors parameters, the other two being the organisation; and the job (HSE, 1991), this issue is critical.

In summary, construction OSH management and statutory enforcement were weak or non-existent during the research period. It must be stressed however that the situation has changed radically in the last year. These changes have a very significant impact on the economic case for effective OSH management. The Greek Factory Inspectorate now employs about 400 inspectors. (As will be discussed later, the construction projects used in the costing survey work *did* possess reasonably effective OSH management systems; accurate costing studies are only practicable on well-managed sites with effective safety management systems and competent accounting practices.)

Chapter Four

DEVELOPMENT OF THE METHODOLOGY

4.1 Opening remarks

This chapter describes the development of, and the rationale for, all the necessary elements of the methodology for obtaining and analysing the costs of failure and the costs of prevention in construction projects.

The following issues are covered:

- The theoretical background supporting the practical development of the costing methodology.
- Delineating the boundaries of the research. This involves deciding whose costs are going to be considered in the study. In principle at least, it would be possible to determine the costs to employees, the costs to employers, and the costs to society at large.
- The practical development of an accident and prevention costing model capable of being used on-site, involving in particular a cost equation that seeks to demonstrate transparently the factors that are included in the cost analysis. These include the:
  - costs of accidents, e.g. compensation, replacement of injured staff, idle time, additional overtime, investigation costs; and also including (more speculatively) the prospective costs associated with loss of corporate image;
  - costs associated with management failures even though no accident in fact resulted, e.g. fines for failure to comply with statutory requirements, provision of inadequate precautions;
  - costs of prevention, e.g. the wages of site safety personnel, the direct costs of edge protection on scaffolds, and personal protective equipment.
- The preparation of an Excel® spreadsheet to be used both to carry out numerical calculations, to analyse the results on the basis of different assumptions (for example choosing the image cost multiple associated with particular accidents), and to facilitate graphical presentation of data.

- The preparation of a quality management system to ensure accurate data collection on-site.
- The preparation of a simple construction safety audit question set to evaluate as objectively as possible site safety standards.
- The criteria for selecting construction companies and construction sites for the practical field data collection.

4.2 Boundaries of the Study

The costs of accidents or other harm and the costs of prevention are borne, in principle at least, and to varying degrees, by employees, by subcontractors, by main contractors, by clients, by the public (as individuals), by insurance companies, by regulatory agencies and by the state generally.

The decisions were based on an analysis performed at the early stages of this work. A summary of the results of the analysis is presented in subsection 4.4.2 below. The full study report is presented in appendix 2. The aim of this analysis was (a) to identify all costing parameters to all above entities and (b) identify the feasibility of obtaining reliable data for all those parameters. On completion of this analysis the decision was made fairly rapidly that the study should concentrate exclusively on the costs to main contractors. There were two simple reasons for this decision: first, a demonstrated business case was primarily relevant to main contractors, secondly, the feasibility of data collection for the other groups identified would be impracticable, and in any event would lead to a study of almost unlimited scope and duration.

4.3 Theoretical Background

The 'standard' mathematical model for OSH Cost Benefit Analysis (CBA) is (Boyle, 2003):

$$\text{Safety Cost (SC)} = \text{Prevention Cost (PC)} + \text{Accident Cost (AC)} \quad (1)$$

Equation (1) is illustrated in figure 4.1.

Aston University

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Figure 4.1 The standard mathematical model for OSH CBA (source: Boyle, 2003)

4.3.1 Enhanced mathematical Model

In my study I consider an additional cost category to include costs incurred due to poor working conditions without an accident having occurred. These are costs relating to e.g. fines and penalties, litigation, loss of corporate image, and inappropriate prevention expenditure. I have introduced the term *"management failure–with–no-accident cost"* (MfwnAC) to capture all these costs. Of these costs constituting the MfwnAC only the costs of image loss has been identified as important, and only by a few studies, and there has been no practical research to establish the appropriate values of loss of image costs, see e.g. (Dorman, 2000a).

Taking into consideration MfwnAC equation (1) will be:

Safety Cost (SC) = Prevention Cost (PC) + Accident Cost (AC) + Management Failure-with-no-Accident Cost (MfwnAC) (2)

or SC = PC + AC + MFwnAC

Equation (2) is illustrated in figure 4.2.

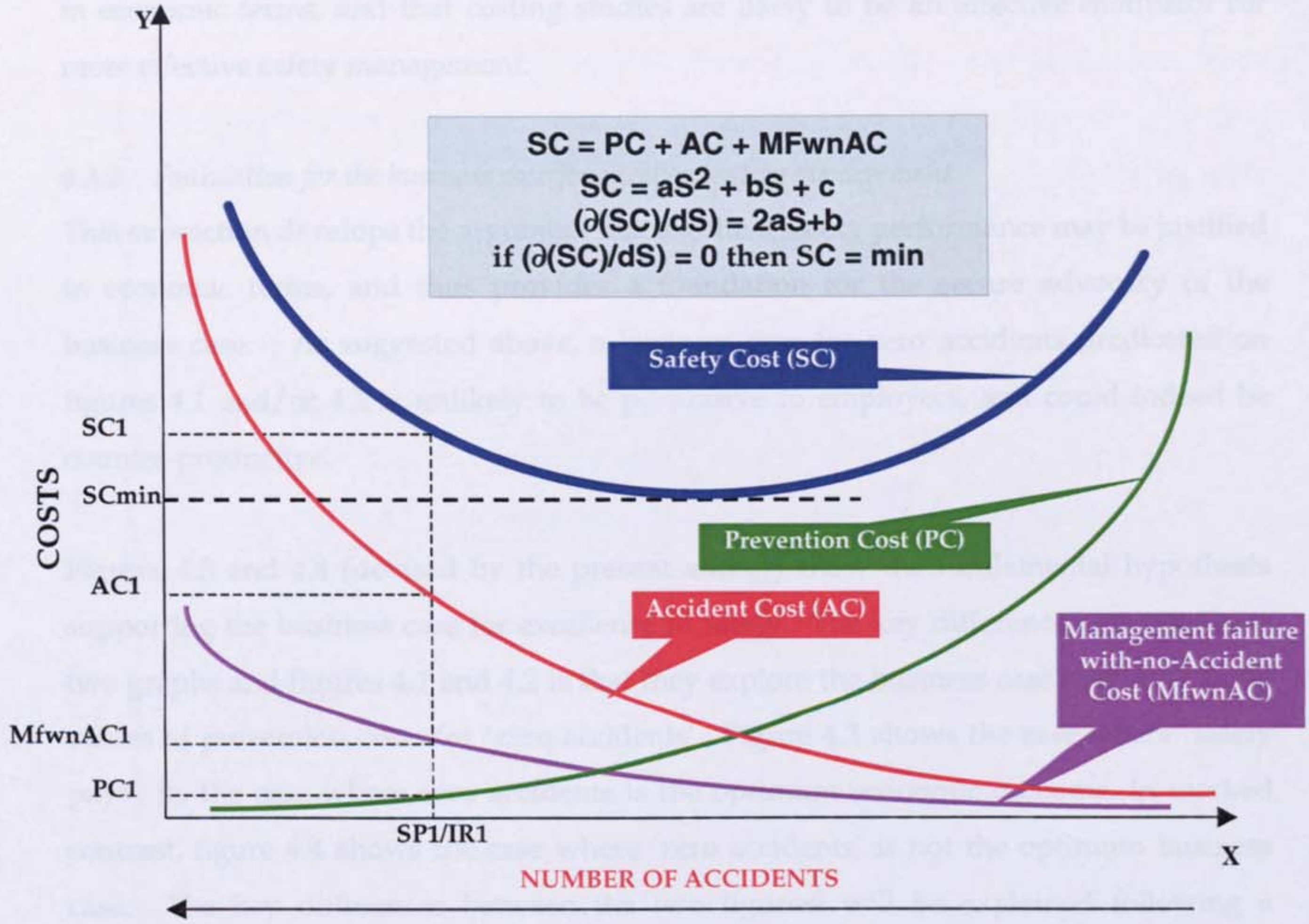

Figure 4.2 The enhanced standard mathematical model for OSH CBA with the inclusion of Management failure-with-no-accident cost (MfwnAC)

I will return to equation (2) in subsection 4.4, where the cost modelling is discussed, to define the key terms (parameters) and identify the component parts of these parameters, but first it is necessary to consider the implications of figures 4.1 and 4.2 in the context of the business case for safety.

The problem with figure 4.2 (and also, of course, figure 4.1) is that they suggest that the aspiration for continual improvement leading to a state of zero accidents is only achievable at infinite cost. Thus these graphs are unhelpful in the promotion of zero accidents as a plausible corporate goal. The next subsection presents and discusses the hypothesis, via graphical representations, that prevention efforts leading to zero accidents can, in some circumstances, represent the best business case. This is the foundation for arguing that continual improvements in safety standards may be justified in economic terms, and that costing studies are likely to be an effective motivator for more effective safety management.

4.3.2 Foundation for the business case for excellent safety management

This subsection develops the argument that excellent safety performance may be justified in economic terms, and thus provides a foundation for the secure advocacy of the business case. As suggested above, a business case for zero accidents predicated on figures 4.1 and/or 4.2 is unlikely to be persuasive to employers, and could indeed be counter-productive.

Figures 4.3 and 4.4 (devised by the present author) show the fundamental hypothesis supporting the business case for excellence in safety. The key difference between these two graphs and figures 4.1 and 4.2 is that they explore the business case assuming finite values of prevention costs for 'zero accidents'. Figure 4.3 shows the case where 'safety pays', ie, the case where zero accidents is the optimum economic outcome. In marked contrast, figure 4.4 shows the case where 'zero accidents' is not the optimum business case. The key differences between the two figures[2] will be explained following a description of the graphs themselves.

The horizontal axis, on both graphs, is the number of accidents. The vertical axes give the total Safety Cost (SC) which is the addition of Prevention Costs (PC), Accident Costs (AC) and Management failures with no Accident Costs (MfwnAC).

In both figures, the line denoted 'Average accident cost in industry' (AC) increases non-linearly. The reason is that, according to 'Heinrich's Triangle', the greater the number of accidents, the greater the likelihood that some very serious (and costly) accidents will occur. The curve 'Average management failure with-no-accident ...' shows that as accidents increase, so will MfwnAC (as suggested in figure 4.2). Excluded in the present

[2] Note that the curves on the two graphs are representative only, as a result of difficulties with curve plotting in 'PowerPoint®.

case are the costs of inefficient safety management, as only the optimum prevention case is considered[3]. This curve 'Optimum prevention cost' represents the appropriate prevention cost associated with the number of accidents[4]. This curve is also non-linear because preventing the 'residual' risks could be disproportionately expensive, as was shown in figures 4.1 and 4.2. Finally, the 'Optimum safety cost' presents the addition of the costs of the other three curves.

For the zero accidents scenario the AC is of course zero. As only the optimum prevention cost is considered, the MfwnAC is also zero, as stated above, and the SC equals the optimum prevention cost for zero accidents (Panopoulos and Booth, 2003). Here the *'100% of optimum PC for zero accidents'* is equal to the *'100% of optimum SC for zero accidents'* point in both graphs.

The key questions now are, with the number of accidents increasing:

- Does the PC decrease *slower* than the AC and the MfwnAC increase? Or
- Does the PC decrease *faster* than the AC and the MfwnAC increase?

In figure 4.3, the crucial point is that the 'best' case is represented by 'zero' accidents because of the relative movement of the contributing costs - the 'Optimum SC' is at its lowest value at 'zero' accidents.

In contrast to figure 4.3, figure 4.4 represents the case where the prevention cost declines faster than the management failure cost increases for up to a certain number of accidents and then for higher number of accidents (statistically the more severe are then expected) the management failure cost gains ground over the prevention cost. Here the optimum business case is one where having a certain number of accidents is the 'best' result. Therefore, safety, or more strictly absolute safety, does not pay. But a break-even point

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[3] In practice, it makes little difference to the overall argument if the costs of inefficient safety management are included in this curve.

[4] Note that this curve is correctly described, as 'optimum' because it is assumed that all the monies spent on safety was justified and cost-effective.

is reached where a large number of (often expensive) accidents can be seen to be more expensive than 'zero accidents'. Moreover, the break-even point may never be reached.

Zero accidents is likely to be the optimum business case (figure 4.3) if:

- there is a likelihood that there will be a high proportion of serious accidents, e.g. falls from heights;
- the prevention cost falls gradually as safety standards deteriorate.

In contrast, the case for 'allowing' some accidents to happen is likely to be the optimum business case (figure 4.4) if:

- there is a likelihood that there will be a high proportion of minor injury accidents, e.g., falls on the level;
- the prevention costs fall dramatically as safety standards deteriorate.

In the construction industry, it may be argued that figure 4.3 best represents reality. First, the industry is associated with potentially large numbers of serious accidents. Secondly, site *compliance* with good safety standards is the crucial issue. If the appropriate safety facilities are already provided e.g. edge protection and PPE, the prevention cost has been largely spent. What matters is whether the edge protection is kept in place, and that the PPE is worn. This case is predicated on a positive safety culture where compliance is the norm, and the cost-effective use of resources.

The fundamental hypothesis that 'zero accidents' is the optimum business case is a plausible argument that can be adopted in discussion with employers. This is in contrast with the 'standard' CBA representation which offers a less than ideal conclusion. The assumption that figure 4.3 is a plausible scenario sustains the argument that measuring the costs of accidents and the costs of prevention is a worthwhile activity that can be used to motivate, and promote best practice. If figure 4.4, or more sharply figures 4.1/4.2, represented reality better than figure 4.3, then the danger would exist that the findings of accident and accident prevention costing research might de-motivate employers. Here, the findings would quite possibly be that accidents are cheaper than prevention. It should be stressed of course that 'zero' accidents as the optimum outcome is dependent on the numerical values assigned to the various categories of cost (which may vary significantly from country to country) and this is the issue to which I will now turn.

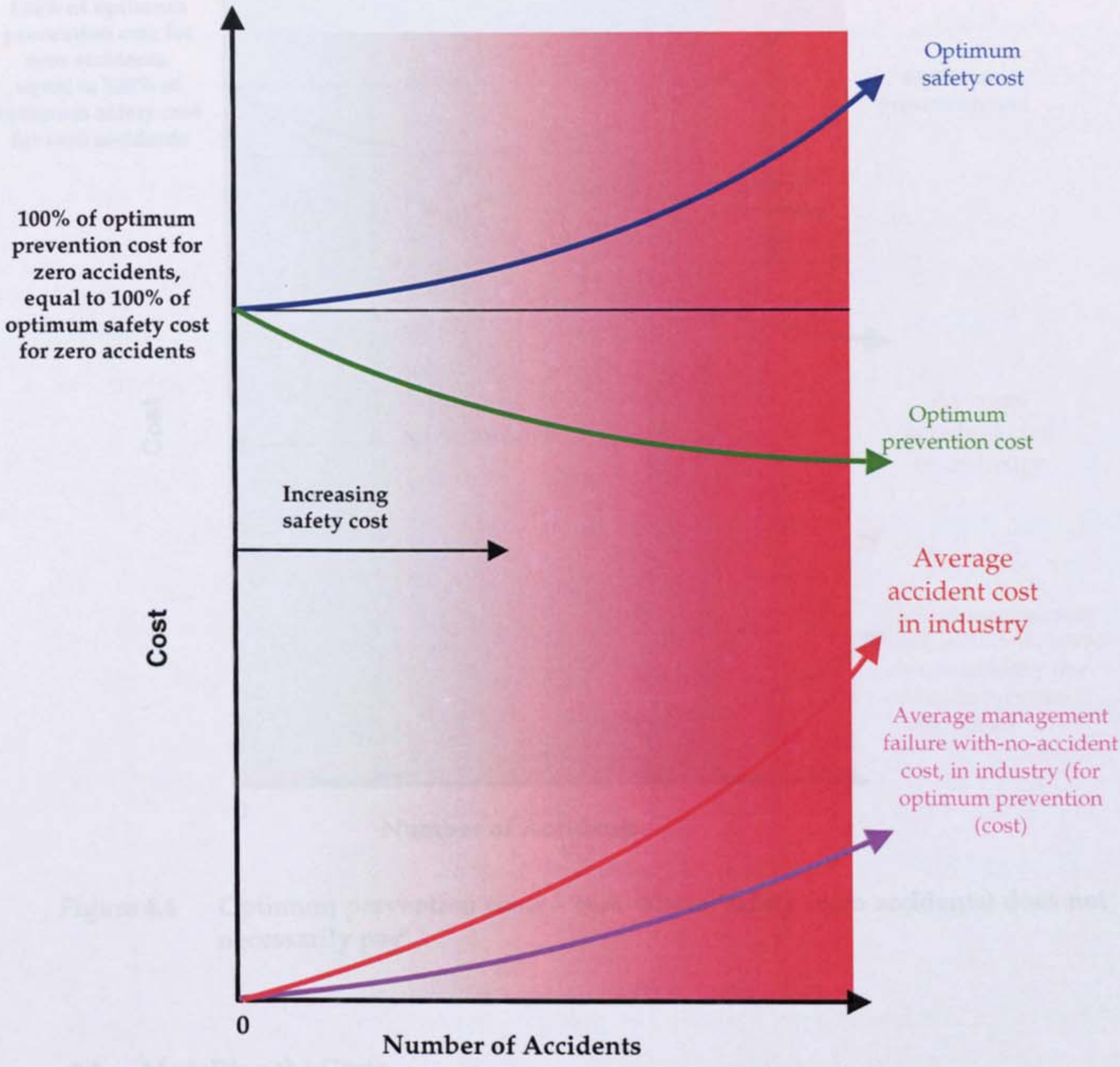

Figure 4.3 Optimum prevention costs – case where 'safety (zero accidents) pays'

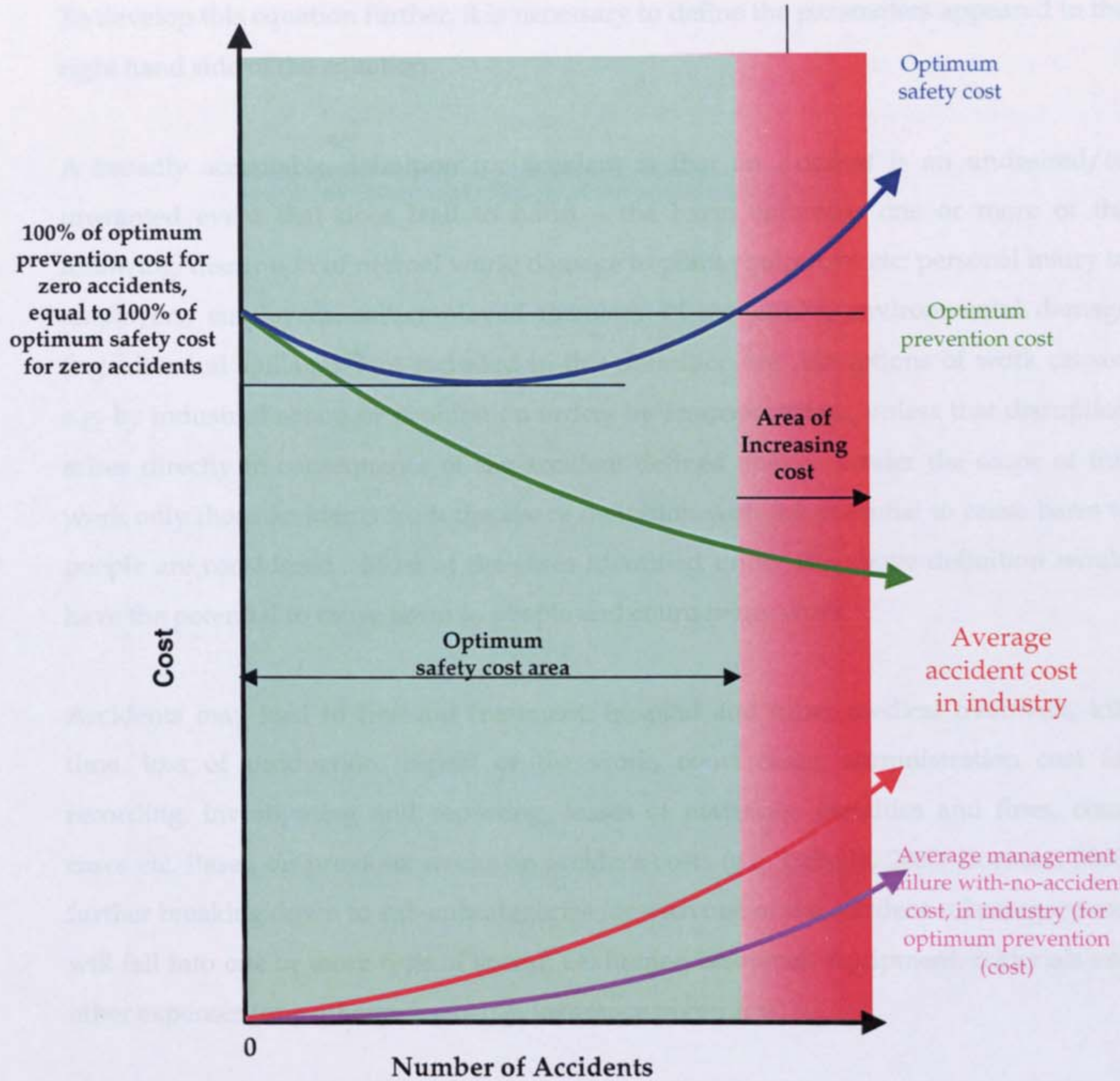

Figure 4.4 **Optimum prevention costs – case where 'safety (zero accidents) does not necessarily pay'**

4.4 Modelling the Costs

4.4.1 Definitions

The enhanced cost modelling as discussed in subsection 4.3.1 is given by the equation (2):

SC = PC + AC + MfwnAC (2)

To develop this equation further, it is necessary to define the parameters appeared in the right hand side of the equation.

A broadly acceptable definition for accident is that an *Accident* is an undesired/or unwanted event that does lead to harm - the harm embraces one or more of the following: disruption of normal work; damage to plant equipment etc; personal injury to employers, employees, self-employed members of the public; environmental damage (e.g. chemical spillage). Not included in this definition are disruptions of work caused e.g. by industrial action or prohibition orders by an inspectorate, unless that disruption arises directly in consequence of the accident defined above. Under the scope of this work only those accidents from the above definition with the potential to cause harm to people are considered. Most of the cases identified under the above definition would have the potential to cause harm to people and count in my work.

Accidents may lead to first aid treatment, hospital and other medical treatment, idle time, loss of production, repeat of the work, court cases, administration cost for recording, investigating and reporting, losses of materials, penalties and fines, court cases etc. Based on previous works on accident costs (e.g. LaBelle, 2000; Dorman, 2000) further breaking down to sub-subcategories for each one of the accident subcategory cost will fall into one or more type of spend: i.e. human resources, equipment, materials and other expenses (one-off expenses - e.g. insurance premiums).

This study treats image cost separately. Therefore image cost is a fifth category of spends.

Thus all costs (tangible and intangible) due to an accident fall into one of the above five types (i.e. human resources, equipment, materials other expenses (one-off expenses), and image). For instance, a pause in work after an accident costs for the non-working time of the people (e.g. hourly rate times the non-worked hours) and the equipment (e.g. hourly rate times the non-worked hours). Thus, the accident cost is given by equation (3), below.

$$AC = \text{IDLE TIME COST} + \text{ADMINISTRATION COST} + \ldots + \text{COURT COST} \Leftrightarrow$$

$$AC = (\text{HUMAN} + \text{MATERIALS} + \text{EQUIPMENT} + \text{EXPENSES} + \text{IMAGE})_{\text{IDLE TIME COST}} + (\text{HUMAN} + \text{MATERIALS} + \text{EQUIPMENT} + \text{EXPENSES} + \text{IMAGE})_{\text{ADMINISTRATION COST}} + \ldots + (\text{HUMAN} + \text{MATERIALS} + \text{EQUIPMENT} + \text{EXPENSES} + \text{IMAGE})_{\text{COURT COST}} \Leftrightarrow$$

$$AC = ((\text{hourly rate} * \text{hours})_{\text{HUMAN}} + (\text{pieces} * \text{number of pieces})_{\text{MATERIALS}} + (\text{hourly rate} * \text{hours})_{\text{EQUIPMENT}} + \text{EXPENSES} + \text{IMAGE})_{\text{IDLE TIME COST}} + (\text{hourly rate} * \text{hours})_{\text{HUMAN}} + (\text{pieces} * \text{number of pieces})_{\text{MATERIALS}} + (\text{hourly rate} * \text{hours})_{\text{EQUIPMENT}} + \text{EXPENSES} + \text{IMAGE})_{\text{ADMINISTRATION COST}} + ((\text{hourly rate} * \text{hours})_{\text{HUMAN}} + (\text{pieces} * \text{number of pieces})_{\text{MATERIALS}} + (\text{hourly rate} * \text{hours})_{\text{EQUIPMENT}} + \text{EXPENSES} + \text{IMAGE})_{\text{COURT COST}} \Leftrightarrow$$

$$AC = \Box_{\text{HUMAN}} + \Box_{\text{MATERIALS}} + \Box_{\text{EQUIPMENT}} + \Box_{\text{OTHER EXPENSES}} + \Box_{\text{IMAGE}} \Leftrightarrow$$

$$AC = \sum \Box_{\text{ACi}} \qquad (3),$$

where $i = \text{HUMAN, MATERIALS, EQUIPMENT, EXPENSES, IMAGE}$

Following same analysis for the prevention cost and management failure with-no-accident cost equation (1) is equivalent to equation (3) below.

$$SC = \sum \Box_{\text{ACi}} + \sum \Box_{\text{PCi}} + \sum \Box_{\text{MFwnACi}} \Leftrightarrow$$

$$SC = \sum\sum \Box_{ji} \qquad (4)$$

where $i = \text{HUMAN, MATERIALS, EQUIPMENT, EXPENSES, IMAGE}$

$j = \text{AC, PC, MFwnAC}$

Prevention includes all those hardware and software in systems and procedures that are necessary for the prevention of accidents. Prevention cost does not include any spending on software or hardware which is needed for operational reasons, even a safety benefit might accrue, see section 4.2.2 below.

Under the scope of this work, failures also include inefficiencies in safety management. Under this perspective management failures include both non-compliances and inefficiencies in prevention and resources allocation as discussed earlier in this chapter. Any cost born due to management failure as defined above and not resulting in an accident is considered as management failure-with-no accident cost.

As has just been discussed in detail, the key principle of the work is that the total costs to be determined are the numerical addition of costs associated with accidents, costs associated with management failures not resulting in an accident, and prevention costs. While this is straightforward, there are considerable challenges in determining the sub-categorization of each of these costs, their calculation or how otherwise the cost data is obtained, and the determination of plausible indirect costs such as loss of corporate image. Moreover, the estimation of the costs of prevention is bedeviled by an uncertainty between what constitutes an 'operational' cost - a cost of an activity to get the work done, and a prevention cost - a cost exclusively for safety which does not contribute to 'production'.

The key costs are:

> *Accident cost (AC)* means any cost including damage costs due to an incident resulting in injuries or with the potential to cause injuries. Thus accident costs under the scope of this work are limited to those with the potential to harm people.
>
> *Management failure with-no-accident cost (MfwnAC)* means any wasted expenditure, which makes no real contribution to prevention and/or costs due to failing to meet applicable safety standards, though no accident has occurred and irrespective of the potential for an accident.
>
> *Prevention Cost (PC)* means any expenditure made in an effective and timely way to prevent accidents occurring.

The study used *standard expressions* in order to classify in terms of monetary quantification, each one of the contributing parameters of the cost of safety. The standard expressions and their interpretation are given below. These standard expressions have been used in the analysis performed for defining the scope of the thesis as discussed in the subsection 4.2 of this Chapter (see also appendix 2).

Cost is known means that there are invoices or other documents (pay roll book) that proves what is the cost exactly, without any further calculations. By adding up all invoices and documents, the total cost can be found.

Cost is calculated means that calculations are required to work out the exact cost to be allocated. For instance PPE bought in another project and used, then they were brought in a the project under survey. What is the cost to allocate on these PPE, calculations are needed.

Cost is estimated means that due to various uncertainties, cost can only be estimated based on previous experience. Production loss for instance in construction (due to e.g. a fatal accident) can only be estimated as production in most cases is not fixed per day/group.

Cost is quantified means that the cost is non-economical and has to be expressed into monetary terms in order to be included in the calculations. In that case assumptions are required. For instance, value of life is a cost that has to be quantified. Quantification is based on previous works. Should no works exist hereto, then the cost is assumed, see next definition.

Cost is assumed means that there are no previous work to help quantification and therefore a non-economic cost must be assumed based on the best judgement could be made. Therefore, cost is assumed to be an amount that is believed to be realistic. For instance the costs of pain and suffering. (The present study was only concerned with the costs to the main contractor as discussed above, and the analysis (appendix 2) showed that no costs of this type were incurred. Therefore there was no need to provide speculative figures, as is the case of the image costs).

4.4.2 Costs Quantification

Tables 4.1 to 4.8 show what accidents may result in, in terms of quantifying cost parameters. The tables are an extract from the analysis performed to define the boundaries of this work (appendix 2). For the expected occurrences, the author indicates the difficulty in getting a reliable figure in monetary terms. Difficulty is expressed by using the classification provided in subsection 4.4.1 above.

The analysis was based on (a) the type of the safety parameter and the quantifiable phase of it and (b) on the existing accounting management system of the companies in Greece.

Table 4.1 Costs of Workforce Injuries (AC (A))

REF	DESCRIPTION OF COST	How obtained
A.01	Stoppage or slow down the normal activity(ies) at the scene of an accident to see the problem, see what is needed for the injured person, until other department is taking over the situation, transfer the person and personnel return to their jobs	calculated
A.02	Lower production the next days by personnel that witnessed a severe accident mainly for psychological reasons	estimated
A.03	Stoppage of activity(ies) if the injured person is a key person for the job (e.g., tower crane operator, welder etc)	known
A.04	Treatment of the injured person until transportation to the hospital if needed or home and transportation to	estimated
A.05	Visiting the injured person to the hospital, speaking to his/her family etc	assumed
A.06	Rescue operations	calculated.
A.07	Accident formalities to the authorities	calculated
A.08	Company investigates the accident	calculated.
A.09	Reporting to an insurance company	calculated
A.10	Wages compensation to the injured person(s) for days not at work	known
A.14	Injured person remains partially disabled. He/she is able to fill only a few positions	estimated
A.15	Legal costs	known
A.16	Compensation of wages, opportunity costs, moral compensation, disability compensation, extra costs to the family etc, to the injured person for lost income, potential lost income, moral restoration and family inconvenience	assumed

REF	DESCRIPTION OF COST	How obtained
A.17	Enforcing Authorities impose on the Company an administration fine.	known
A.18	Company is found guilty according to the criminal law. Sentence might be a fine and/or imprisonment	known
A.19	Company's profile, image and reputation	assumed
A.20	Local authorities may take a austere position and policy regarding the company that would have a negative influence overall on the company during construction	assumed
A.21	Supervising Engineer and Owner may take an austere position and policy regarding the company and this would reflect in the contract administration.	assumed

Table 4.2 Costs of Injuries to the Public (AC (B))

REF	DESCRIPTION OF COST	How obtained
B.01	Stoppage or slow down the normal activity (ies) in the scenic area of an accident to see the problem, see what is needed for the injured person(s), until other department is taking over the situation, transfer the person (s) and personnel return to their jobs	calculated
B.02	Lower production by personnel that witnessed a severe accident, mainly for psychological reasons	estimated
B.03	Treatment of the injured person until transportation to the hospital if needed or home and transportation to	estimated
B.04	Visiting the injured person to the hospital, speaking to his/her family etc	assumed
B.05	Accident formalities to the authorities	calculated
B.06	Company investigates the accident	calculated
B.07	Reporting to the Insurance	calculated
B.13	Legal costs (If case goes to court)	calculated
B.14	Compensation of wages, opportunity costs, moral compensation, disability compensation, extra costs to the family etc, to the injured person for lost income, potential lost income, moral restoration and family inconvenience	known
B.15	Enforcing Authorities impose to the Company an administration fine	known
B.16	Company is found guilty according to the criminal law. Sentence might be a fine or/and imprisoning	known
B.17	Company's profile, image and reputation	assumed
B.18	Hardening of local authorities position and policy against the company with consequences to their requirements or easements required by the company during construction	estimated
B.19	Hardening of Supervisor, Employer position and policy against the company in respect to managing contractor and the contract	assumed

Table 4.3 Costs of Damage or Loss of Project Materials (AC(C))

REF	DESCRIPTION OF COST	How obtained
C.01	Damaged or lost materials have to be replaced	calculated
C.02	Damaged or lost materials might be replaced first priority if project in danger to be delayed	assumed
C.03	Damaged or lost materials have to be replaced but project will be delayed	quantified
C.04	Damaged materials are repaired/rectified/modified to avoid delays	calculated
C.05	If damaged or lost materials will not be made available on time delaying the project, this may influence contractors cash flow	assumed
C.06	If damaged or lost materials will not be made available on time delaying the project, this may influence other projects this contractor is constructing	assumed
C.07	If damaged or lost materials will not be made available on time delaying the project, this may urge contractor not to bid for another contract	assumed

Table 4.4 Costs of Damage or Loss of Project Equipment (AC (D))

REF	DESCRIPTION OF COST	How obtained
D.01	Any damage to equipment generates idle time	calculated
D.02	Damage to main equipment may require temporary replacement by hiring to avoid delays or excess idle time	calculated
D.03	Damage to main equipment may lead to delays. Then cases C.03, C.05, C06 and C.07 are applicable	See cases C.03, C.05, C06 and C.07
D.04	Severe damage to equipment may lead to buy new equipment (e.g. a generator when damaged by fire) or reconstructed (e.g. a scaffold when collapsed)	estimated
D.05	No well-serviced mechanical equipment may produce exhausts beyond upper level	calculated
D.06	Enforcing Authorities may impose penalties and stoppage of operation if identify site equipment that are not supplied with a licence or a valid licence or are operated by unqualified personnel	estimated

Table 4.5 Costs of Damage or Loss to the Overall Project (AC (E))

REF	DESCRIPTION OF COST	How obtained
E.01	A distinguished part of the project is damaged and it can be easily remade	estimated
E.02	A damage that influences other activities has to be rectified	estimated
E.03	A damage leads to delays and penalties are imposed	calculated
E.04	A damage leads to delays and then consequences of cases C.03, C.05, C06 and C.07 are applicable	costs as per cases C.03, C.05, C06 and C.07 shall be considered

Table 4.6 Costs of Damage or Loss to 'Third Party' Property (AC (F))

REF	DESCRIPTION OF COST	How obtained
F.01	Third party damages are compensated completely by the private Insurance. No trials.	assumed
F.02	Individuals for compensation further to the insurance covers take civil action.	estimated
F.03	Damages not covered by Insurance scheme. In most cases there is a limit that insurance companies do not pay for e.g. up to 100.000 Greek Drachmas	assumed

Table 4.7 Costs of Damage or Loss to Public Utilities, Public Buildings etc (AC (G))

REF	DESCRIPTION OF COST	How obtained
G.01	Third party damages are compensated completely by the private Insurance. No trails	assumed
G.02	Civil action is taken by Public Utilities Organisations for compensation further to the insurance covers	assumed
G.03	Damages not covered by Insurance scheme. In most cases there is a limit that insurance companies do not pay for e.g. up to 100.000 Greek Drachmas	estimated
G.04	Criminal prosecution may be ordered in cases of extreme damages with severe consequences to the general public and the society in general	assumed

Table 4.8 Costs of Damage to the Environment (AC (H))

REF	DESCRIPTION OF COST	How obtained
H.02	Enforcing Authorities impose only rectification measures.	estimated
H.03	Enforcing Authorities impose fines and prosecutions further to rectification measures.	assumed

Similarly to the Tables 4.1 to 4.8 above the Table 4.9 below shows what management failures with-no-accidents may result in, in terms of quantifiable cost parameters. The table is again an extract from the same analysis performed to define the boundaries of this work. Difficulty in getting an accurate figure in monetary terms is indicated.

Table 4.9 Costs of Management Failures - no accidents

REF	DESCRIPTION OF COST	How obtained
A.01	A factory Inspectorate visits results in a fine	quantified
A.02	A factory Inspectorate visit results in a stoppage of construction activities until Contractor remedies the findings	estimated
A.03	Works not to commence until Contractor submits an OSH Safety Plan to authorities	calculated
A.04	Subject to contractual provisions a penalty is imposed for no compliance with contractual safety requirements	quantified
A.05	Works are hold until Contractor complies with contractual, safety requirements	quantified

Finally, similarly to Tables 4.1-4.9 above, the Table 4.10 below shows gives relative information and classification for prevention costs.

Prevention costs are either calculated or known. The table is again an extract from the same analysis performed to define the boundaries of this work. Difficulty in getting an accurate figure in monetary terms is indicated.

Table 4.10 Prevention Costs

REF	DESCRIPTION OF COST	How obtained
C01	Train their personnel and/or subcontractors personnel.	calculated
C.02	Develop safety management systems	calculated
C.03	Maintain safety management systems	calculated
C.04	Buy PPE	calculated
C.05	Buy new equipment, materials etc	estimated
C.06	Funding big safety events such as conferences and exhibitions	known

4.4.3 Costs Breakdown

Table 4.11 shows the break down of the safety costs into the three main categories (level 2) and then into the sub-categories (level 3) and the sub-subcategories/unit cost (level 4).

Table 4.11 Breakdown Structure of the Safety Costs (part of)

Level 1	Level 2	Level 3	Level 4
Safety cost			
	prevention		
		Safety management system	
			General manager
			Safety practitioner
			Etc
		PPE	
			Helmet
			Safety boots
			Etc
		Etc	
	accident		
		Idle time	
			Labour
			Foreman
			Etc
		compensation	
			3-day cover labour
			Over 3-day cover labour
			Etc
		Etc	
	Management failure with-no-accident		
		Idleness	
			JCB
			Pilling system
			Etc
		Penalties & fines	
			Penalty
			Fine
		Etc	
	Image		
		Accidents	
			TYPE A casual accidents, return up to next day
			TYPE B casual accidents resulting between one day up to three days absence
			Etc
		Etc	

Table 4.12-4.14 shows the full breakdown, including all unit rate costs applied to each one of the surveyed projects. The breakdown is consistent with equation (3) of the subsection 4.3.2. The table 4.12-4.14 was used for the development of the spreadsheet. The table 4.12-4.14 also presents costings considerations, though these are discussed in more details later in this Chapter (subsection 4.4.4.).

Table 4.12 Safety Cost Breakdown - Prevention Cost

PREVENTION COST		
CODE	**CATEGORY**	**COSTINGS CONSIDERATION**
PC-SMS	SMS DOCUMENTATION	The e.g. HSP has been developed at the beginning of the project. It is also reviewed during the execution of the work. Besides the work of e.g. the safety coordinator may require input form the site engineers, designers and others. Upon completion for the implementation needs participation of the hierarchy and feedback from construction people. Also typing work, printing, mailing, etc costs are to be considered, control time allocation, registering, approve and paying invoices/paying wages and insurance.
PC-STF	STAFFING	Interview, employment procedures/contract, wages, car use, car fuel and maintenance, travelling, accommodation, average absence from work, firing cost, office space, office operational costs, PC, printers, camera, automation consumables, proper time allocation for safety if not full time job, control time allocation, registering, approve and paying invoices/paying wages and insurance.
PC-MTN	MEETINGS	Hourly rate for the participants in the meeting, meeting room space and operational cost, hound outs, keep minutes of meeting, follow up, call next meeting, idle time if delayed, control time allocation, registering, approve and paying invoices/paying wages and insurance.
PC-SAS	SAFETY STUDIES	Tender, receive offers/proposals, evaluate proposals, approve order, order, time allocation for company people and costs based on PC-STF above for supervision and implementation, improvements and modifications, reproduce printed materials, register communication and studies (document control), control time allocation, registering, approve and paying invoices/paying wages and insurance.
PC-TRN	TRAINING	Internal research identifying training needs, market research/tender, receive offers/proposals, evaluate proposals, approve order, order, training materials, training room space and operation, travelling cost, time allocation based on above PC-STF subcategory, trainers wages, register the training, control time allocation, registering, approve and paying invoices/paying wages and insurance.
PC-PPE	PPE	Internal research identifying PPE needs, market research/tender, receive offers/proposals, evaluate proposals, approve order, order, store, transfer, register, maintain, replace, time allocation for a specific project (against life time of the specific PPE), control time allocation, registering, approve and paying invoices/paying wages and insurance.
PC-EXT	EXTERNAL SERVICES	Tender, receive offers/proposals, evaluate proposals, approve order, order, time allocation for supervision based on PC-STF subcategory,

PREVENTION COST		
CODE	CATEGORY	COSTINGS CONSIDERATION
		control time allocation, registering, approve and paying invoices/paying wages and insurance.
PC-EQP	SAFETY EQUIPMENT	Internal research identifying safety equipment needs, market research/tender, receive offers/proposals, evaluate proposals, approve order, order, store, transfer, register, operate, maintain, replace, time allocation for a specific project (against life time of the specific safety equipment), control time allocation, registering, approve and paying invoices/paying wages and insurance.
PC-FRS	FIRE SAFETY	Internal research identifying safety equipment needs, market research/tender, receive offers/proposals, evaluate proposals, approve order, order, store, transfer, register, operate, maintain, replace, time allocation for a specific project (against life time of the specific safety equipment), control time allocation, registering, approve and paying invoices/paying wages and insurance.
PC-MDS	MEDICAL SURVEILLANCE	Physician wages, personnel time allocation, internal procedures, practise space, operational costs, equipment and consumables, external clinical examinations, control time allocation, registering, approve and paying invoices/paying wages and insurance.
PC-AGM	AGENTS MONITORING	Internal research (preliminary risk assessment) identifying agents monitoring needs, market research/tender, receive offers/proposals, evaluate proposals, approve order, order, for equipment, maintenance, calibration, consumables, store, transfer, register, operate, maintain, replace, time allocation for a specific project (against life time of the specific agents monitoring equipment), control time allocation, registering, approve and paying invoices/paying wages and insurance.
PC-OTH	OTHER Any other minor or occasional subcategory	Similar as above

Table 4.13 Safety Cost Breakdown – Accident Cost

B. ACCIDENTS COST		
CODE	CATEGORY	COSTINGS CONSIDERATION
AC-IDL	IDLENESS	Cost of personnel being kept idle calculated according to the PC-STF considerations. Allocate exact time of idleness. Also costs of equipment being kept idle including operator, hiring cost, penalties, risk equipment to leave the project, costs for market research/tender, receive offers/proposals, evaluate proposals, approve order, order, register invoices, approve and paying invoices, opportunity costs for equipment and personnel.
AC-FTR	FIR. AID TREATMENT	Time allocated for injured to provide them with first aid treatment, including transfer to first aid station, first aider time if not calculated under staffing or external services, first aid materials costs calculated as per PC-EQP subcategory above.

B. ACCIDENTS COST		
CODE	CATEGORY	COSTINGS CONSIDERATION
		Be careful-no idle time is considered here, no compensations
AC-ADM	ADMINISTRATION	Time allocation of staffing and external services for any incident occurring for making arrangements for remedies, keeping production running, replacements, investigating, dealing with authorities, reporting, telephones, faxes, insurance inquiries/investigations.
AC-HTR	HOSP. TREATMENT	Same as AC-FTR and on top any hospital expenses, insurance cover/premiums.
AC-PRD	PRODUCTION LOSS	Cost of work to redo, cost for removing false works, opportunity costs, reduce production, image
AC-CMP	COMPENSATIONS	Compensate according to the contract/national insurance scheme. Increased: Interview, employment procedures/contract, wages, car use, car fuel and maintenance, travelling, accommodation, average absence from work, firing cost, office space, office operational costs, PC, printers, camera, automation consumables, control time allocation, registering, approve and paying compensations, insurance premiums, image.
AC-RCT	RECRUITMENT	Interview, employment procedures/contract, wages, car use, car fuel and maintenance, travelling, accommodation, firing cost, office space, office operational costs, PC, printers, camera, automation consumables, control time allocation, registering, approve and paying invoices/paying wages and insurance, reduce production, addition al training, control time allocation, registering, approve and paying invoices/paying wages and insurance.
AC-CRT	COURT CASE	Lawyers, court expenses, travelling, time allocation and cost calculation according to PC-STF subcategory, image/publicity, invoicing, register invoices and expenses, approve invoices, pay invoices and expenses.
AC-DMG	DAMAGES & LOSSES	Repairs, market research/tender, receive offers/proposals, evaluate proposals, approve order, order, store, replace, investigations and supervision time allocation, control time allocation, registering, approve and paying invoices/paying wages and insurance, insurance cover/premiums, insurance investigation and procedures.
AC-PNL	PENALTIES & FINES	Fines penalties, image, appeal
AC-OTH	OTHER Any other minor or occasional subcategory	

Table 4.14 Safety Cost Breakdown – Management Failure With-no-Accident Cost

C. MANAGEMENT FAILURE WITH-NO-ACCIIDENT COST		
CODE	CATEGORY	COSTINGS CONSIDERATION
FC-PNL	PENALTIES & FINES	As AC-PNL above
FC-CRT	COURT CASE	As AC-CRT above
FC-IDL	IDLENESS	As AC-IDL above
FC-INT	INTERVENTION	As per incurring case(s)
FC-OTH	OTHER Any other minor or occasional subcategory	

4.4.4 Discussion of uncertainties

This sub-section sets out the criteria that determine which of the overall project costs are to be included as "prevention/safety costs". While the allocation of the costs in most cases is clear-cut, there are nonetheless a significant number of situations where it was not straightforward to decide in which category it falls.

There two main categories of uncertainty: (a) when a spend is a safety cost or an operational cost and (b) when a safety cost is to be included, on the grounds of practicality, in the calculations.

Category (a) includes all those cases that subject to the circumstances they might be considered as prevention cost or as purely an operational cost. For instance is a scaffold safety equipment and included in the prevention cost or it is set up for purely operational reasons to let the job be done faster and less costly? Though if the latter is the case, toe-board and handrails are not part of the operational features of scaffold (not needed for the work to be done) and if installed it is for purely safety purposes and therefore should be included as a prevention cost.

Category (b) includes all those cases where it may be impracticable to include a spend in the prevention/safety count. For instance all tower cranes come with a Safe Working

Load Indicator (SWLI), which is a safety device. The crane could operate and do the job without the SWLI. But to count this cost as prevention cost we need to know what proportion of the hire cost of the tower crane is for the SWLI, which is impracticable. Though considering that the SWLI goes out then we would know (invoiced) what is the replacement cost; still we do not know the lifetime of it to calculate the proportionate cost for the specific project.

Besides the main two categories there are also other cases of uncertainty like image cost and overhead costs where a decision must be taken on what is to count and at what value. It is generally accepted that accidents and poor safety performance may impair the image of an organisation with respect to its employees, to involved /associated organisations and to others and the general public, for example, where the shares are trading in the stock market. Recently in Greece (April 2003) shares of Corinth Pipes SA stopped trading when an accident occurred resulting in six deaths, two serious casualties and another six casualties. In the UK shares of Jarvis plc plummeted following two train de-railments, which were associated with poor track maintenance for which Jarvis were probably responsible.

For all activities there is an overhead cost like product surveys, transportation, storage, accounting. For instance before a helmet (like any other PPE) is issued to an employee standards have been drawn up, surveys of availability and costs are made, an order placed, invoice issued, helmet stored and transported to the site, invoiced paid and filed, and finally the helmet given out is registered to an employee.

For all those cases of uncertainty identified during the course of work a detailed discussion follows, supporting the methodology of the work. Discussion of each individual case concludes/answers 'what', 'when' and 'how' it counts, making, if necessary, assumptions. Assumptions concern what (and when) is counted (included/not included in the cost of safety) and how it counts (how much).

Table 4.15 'Criteria for inclusion or non-inclusion of costs (safety and operational costs)' below presents a summary of all cases, assumptions and conclusions. The Table includes of course not just the cases where there was uncertainty about whether costs should be included, but also, for completeness, all cases where there was no uncertainty. The Table is founded on the researcher's experience, on the characteristics of the Greek construction industry, the Greek economy and society.

The main effort made, when coming across a case of uncertainty, was (a) to be realistic, (b) to ensure transparency of the work and (c) to ensure that the survey would be completed on time.

All assumptions are presented in a manner that enables anyone who intents to use this work as a basis for future research, to alter them. Of course all the assumptions set out in Table 4.16 are free-standing, and have no 'hidden' impact on other costing decisions. These assumptions (for example, the estimated life time of hard hat) affect the precise costs allocated to a specific area, but do not affect the overall methodology

Figures 4.5 to 4.7 present in a flow chart format the criteria for including costs based on a method statement, costs following an accident, and costs associated with performance measurement.

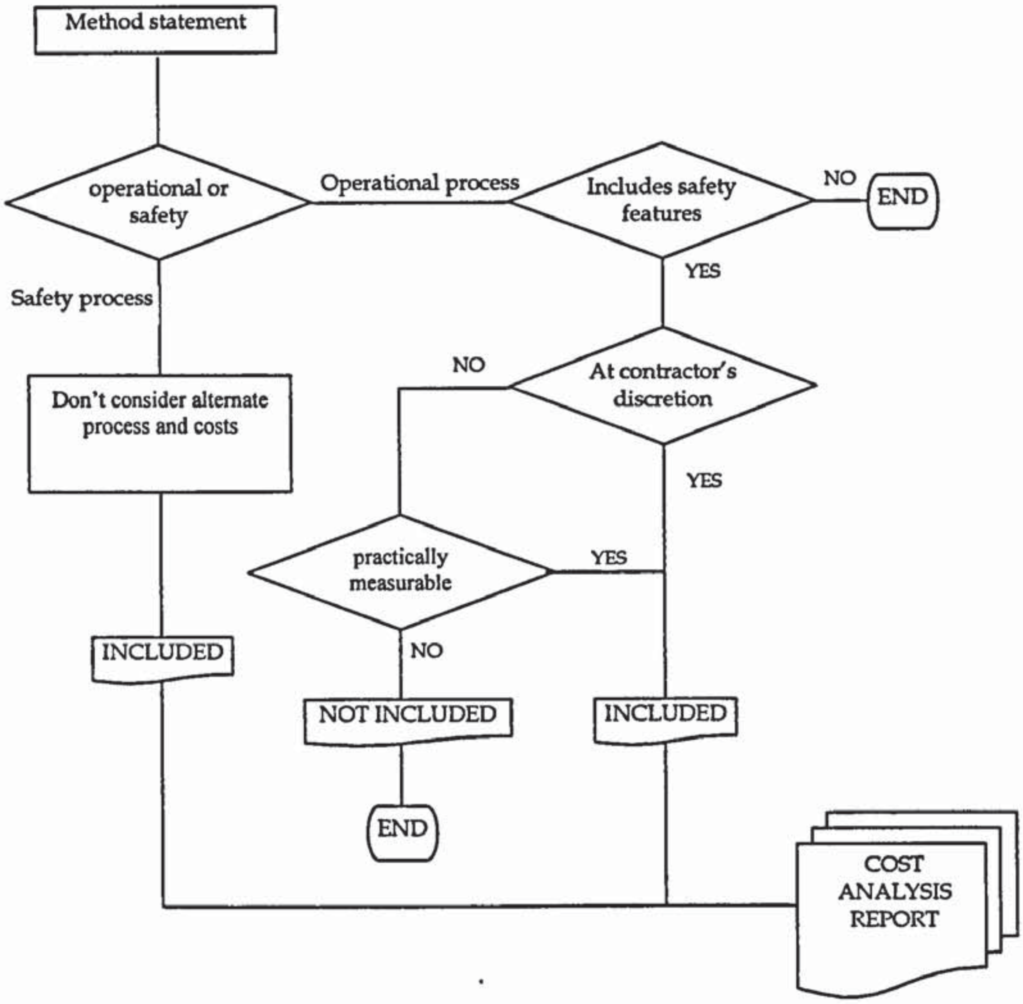

Figure 4.5 Costing Algorithm - Criteria for including costs based on a method statement

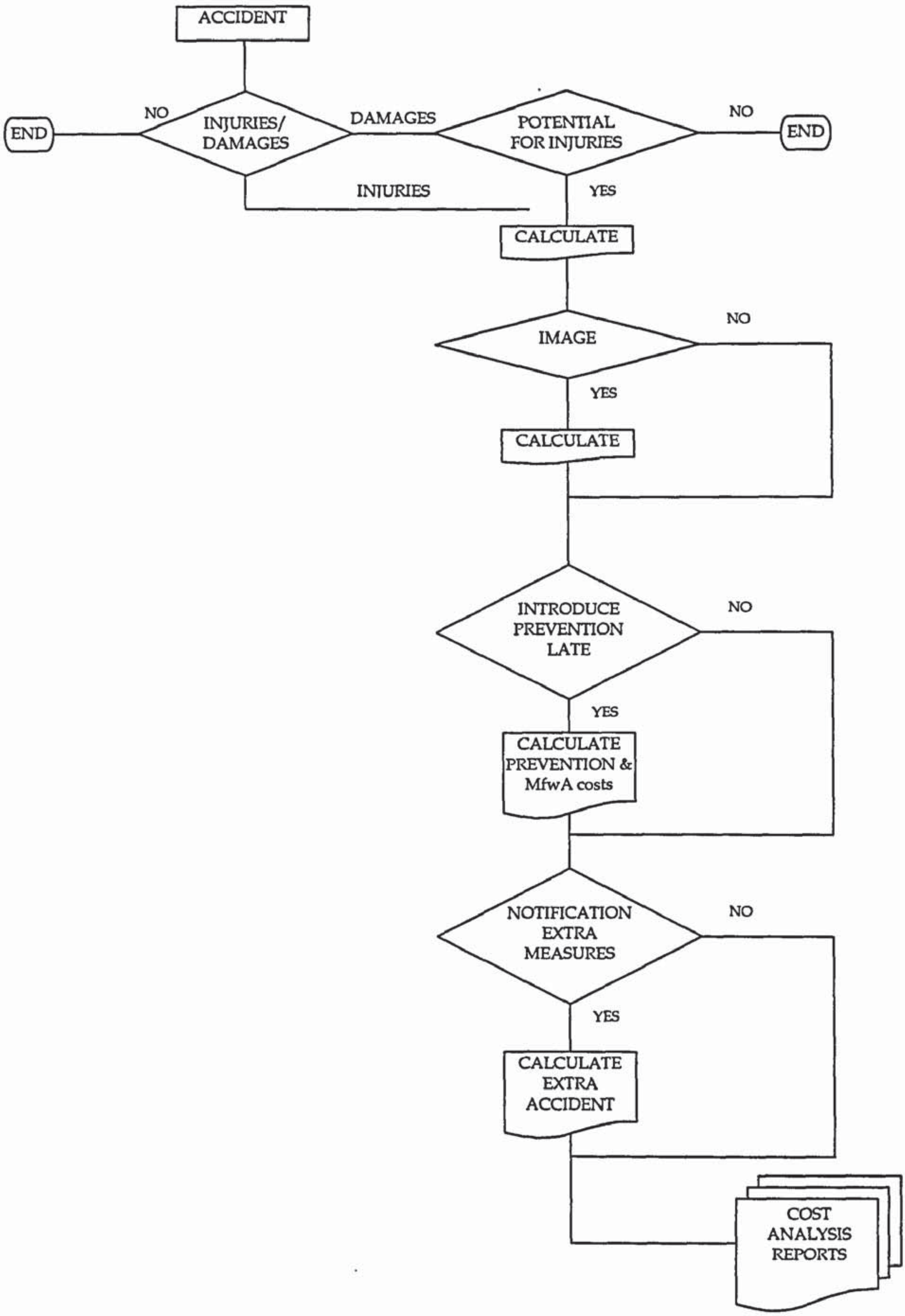

Figure 4.6 Costing Algorithm – Criteria for including costs based on an accident

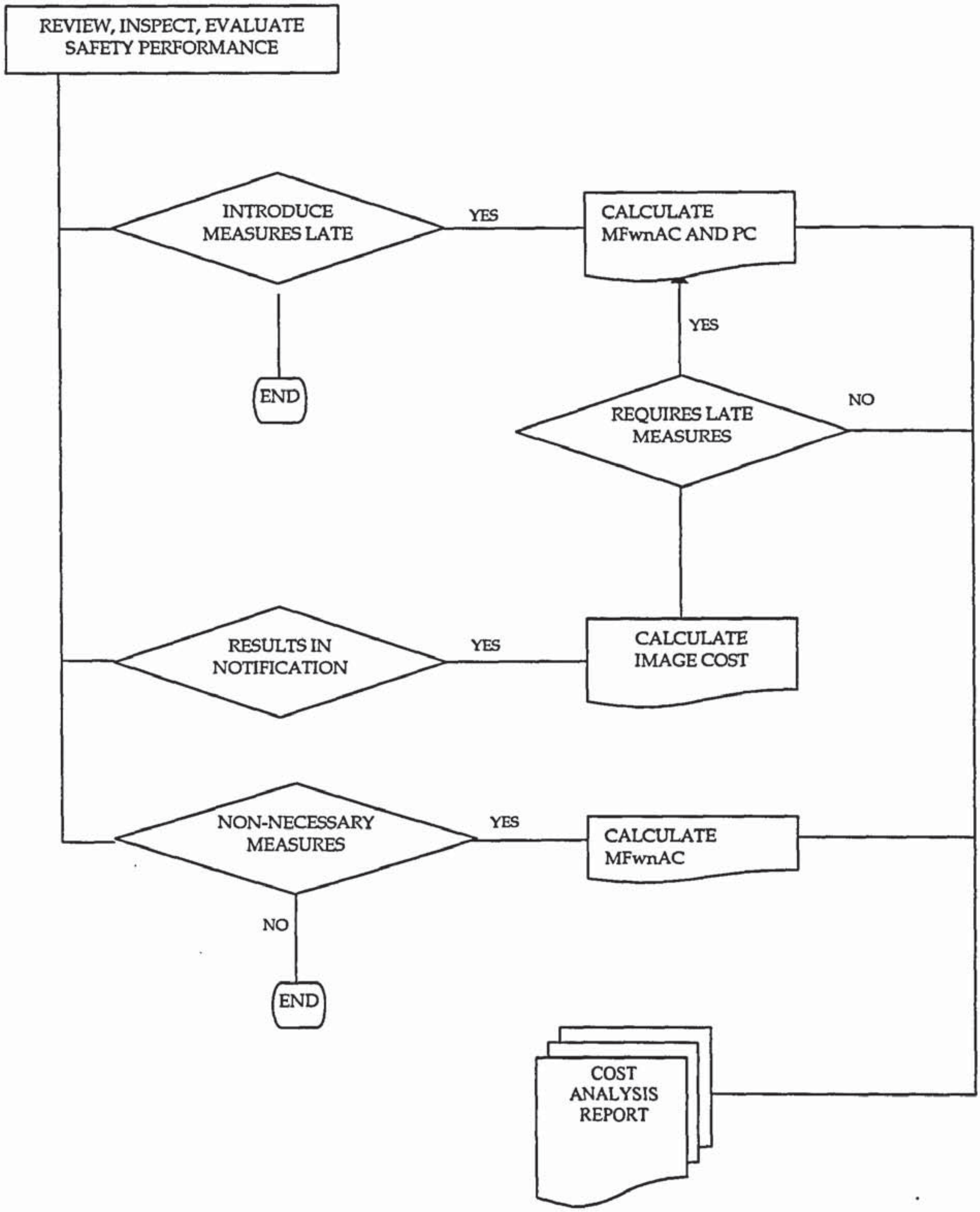

Figure 4.7 Costing Algorithm - Criteria for including costs based on measuring safety performance

Table 4.15 Criteria for inclusion or non-inclusion of costs (safety and operational costs)

NO	ISSUE	EXAMPLES	CRITERIA	SAFETY COST		OPERATIONAL COST
				incl.	Not incl.	
01	PPE used for protection; if not used work could be done	Helmet Safety shoes/boots Eye protection Safety harness Ear protection Respiratory protection Gloves Clothing and other body protection	Discretion Discretion Discretion Discretion Discretion Discretion Discretion Discretion	□ □ □ □ □ □ □ □		
02	PPE used for operational purposes; if not used work could not be done this way e.g. work without fresh air supply apparatus in a low O2 (lower than 16%) confined space	Clothing Safety harness Respiratory protection Clothing and other body protection				□ □ □ □
03	Scaffold used only as an operational structure (access and working platform); toe board and barriers are not included. Support is included.	Scaffold for brick laying Facading Painting Cleaning Repair works on outside surface				□ □ □ □ □ □
04	Scaffold used for safety despite the standard operational procedures.	Corner columns Long (over 0,40meters) outside columns Beams Edge protection - fall protection	Discretion Discretion Discretion	□ □ □		
05	Scaffold safety features (toe board, hand/middle rails, additional plank)	All scaffolds	Discretion	□		
06	Hire/use site equipment and trucks (excluding pure safety features e.g. reverse alarm, platform cover, horn and the alike)	Loader Excavator Driller Grader Asphalt layer Breaker Bulldozer Compact cylinder Truck Dumper				□ □ □ □ □ □ □ □ □ □
07	Site Equipment and trucks safety features	Reverse alarm Horn Alarms Platform cover Cabin air-condition	Practicality		□ □ □ □ □	
08	Hire/use lifting appliances and gear (excluding pure safety features SEE NO 07), used based on an operational decision e.g. for getting the job done faster, no other access technique/method.	Tower crane Mobile crane Hoist Elevator Working platform	Discretion			□ □ □ □ □

NO	ISSUE	EXAMPLES	CRITERIA	SAFETY COST		OPERA-TIONAL COST
				incl.	Not incl.	
09	Hire/use, setting up lifting appliances and gear based on a safety driven decision.	Avoid manual handling regardless progress of work Ensure fast transfer of casualties in case of an accident al lowest levels Ease access and egress in a confined space Avoid walkways though traffic Work on heights regardless standard operational methods	Discretion Discretion Discretion Discretion Discretion	☐ ☐ ☐ ☐ ☐		
10	Lifting appliances and gear safety features as applicable	Access ladder Safe working load indicator Mobile communication Cabin air-condition Reverse alarm Moving signal Boom stop Earthing	Practicality Practicality Discretion Practicality Practicality Practicality Practicality Discretion	☐ ☐	☐ ☐ ☐ ☐ ☐ ☐	
11	Licensee for driving and operation	Site equipment Truck Vehicle Cranes Machines				☐ ☐ ☐ ☐ ☐
12	Annual (or as applicable) third party inspection and certification	Tower crane Mobile crane Elevator Working platform	Discretion Discretion Discretion Discretion	☐ ☐ ☐ ☐		
13	Scheduled maintenance of any operational considered equipment, including checks of safety features	All of the kind	Practicality		☐	☐
14	Setting up, operate, scheduled maintenance and repair of any safety considered equipment.	All of the kind	Discretion	☐		
15	Repair of operational equipment safety features	All	Discretion	☐		
16	Only accidents resulting in injuries or with potential to result in injuries are encountered.	Injuries Damages=	Practicality	☐ ☐		
17	Only proportional value of the equipment in conjunction with (a) equipment lifetime and remaining duration of the project will be considered.	PPE Safety equipment Equipment safety features	CAP	☐ ☐ ☐		
18	Accountings. Prices are not fixed, subject to a low 4,2% overall inflation in Greece between start and finish the survey.	Pilot study 2000 Main study 2001				

NO	ISSUE	EXAMPLES	CRITERIA	SAFETY COST		OPERA-TIONAL COST
				incl.	Not incl.	
19	Image cost will be encountered subject to circumstances.	Accidents Notifications Compliance failure				
20	Overhead cost	Prevention cost Accident cost Management failure with no accident cost		□* □* □*		
21	Others costs	Sanitary facilities in the main site office facilities Sanitary facilities separately in the works sites Security services – safety proportion		 □ □	□**	

* These come out as a percentage on the initially calculated cost
** Covered by the overhead cost

Table 4.16 (below) summarises assumptions made on costing. For assumptions a detail discussion had been held, taking into consideration (a) my experience, (b) accounting issues, (c) particular characteristics of the Greek construction industry, economy, and societal perception and understanding of the key element of each of the cases under discussion and it was based on the analysis discussed and presented earlier in this subsection and (d) previous works, especially for accident costing. As mentioned in subsection 2.5, various studies make different categorisation of the accident and ill-health costs.

This present work aims at identifying and calculating the private cost (see Dorman (2000a)) to the main contractor (employer) and includes economic costs to the extent that are measurable (see figures 4.5 to 4.7), including as appropriate direct and indirect costs, (see e.g. LaBelle, 2000; and HSE, 1993), insured and non-insured costs (see e.g. HSE, 1993), financial and opportunity costs (see e.g. HSE, 1993 and Dorman, 2000a) and non-economic costs (see e.g. Dorman, 2000a) to the extent that it could be quantified.

As in most studies, it was not possible to do this study without making a large number of assumptions. Calculating opportunity costs and non-economic costs is a difficult enterprise and usually depends on a willingness to make questionable assumptions, but economically speaking, there is no alternative (see e.g. Dorman, 2000a).

For example, for the purpose of conducting CBAs, HSE (HSE, 2001a) currently takes as a benchmark that the value for preventing a fatality (VPF) is about £1,000,000 (2001 figure). Though this in not the value that society, or the courts, might put on the life of a real person or the compensation appropriate to its loss. The figure derives from the value used by the department of Transport.

All assumptions made in this work are presented and explained clearly throughout the text in order to ensure transparency and allow changes and adaptation.

Accident costing (and safety costing in general) in construction industry is rather important for effective budgeting and bidding purposes (Rikhardsson, 2003). Accounting issues have been considered and tackled accordingly, through this work. The Greek General Accounting System is base for costings (PD 1123/80) as it has been explained by reputable and well recognised authors, see e.g. Alifantis (2001); Alifantis is also a collaborator of Arthur Andersen LLP, an international accountancy company.

Also my experience from my company (where, inevitably, I am involved with these issues, for over four years now) and especially from 27 months of the survey dealing with the Joint ventures (two projects) and company (one project) accountants helped me to define how to allocate into the system the various costs.

Table 4.16 Summary of Assumptions

REF NO.	ISSUE	ASSUMPTION
1	ACCIDENT ONLY TO PEOPLE OR ALL ACCIDENTS	An accident or near miss would be encountered by this study only if man or third party is actually or potentially involved.
2	EQUIPMENT: AN OPERTIONAL OR SAFETY COST	An equipment is a safety cost if chosen for protection only and the work could be carried out without it and it is an operational cost if chosen for operational purposes, regardless whether it may also provide some safety protection to people.
3	SAFETY FEATURES AND SAFETY COST OF OPERATIONAL EQUIPMENT	The cost of the said features may come under the cost of prevention or cost of management failure without accident. Said features, if missing, may also cause accidents and give accident cost. The said features will be eventually

REF NO.	ISSUE	ASSUMPTION
.		tackled during a safety audit and will count in the safety performance level. It might be taken as a compromise to omit costs of the said features, but it seems pretty logic based on the analysis above. Nevertheless it must be pointed out that counting this cost to the cost of safety would produce more accurate data and it is recommended to be so in a work adequately financed. Thus the cost of the (a) safety and (b) safety/operational features do not count to the prevention cost but they do count to the management failure without accident cost when reported.
3.1	EQUIPMENT: SETTING UP, RUNNING AND MAINTAINING	A scheduled project considers demands and capacity and set up site rules. Then any jeopardise might be in vain and accidents remain. No safety cost is considered for operating and maintaining the equipment properly.
4	COST OF THE SAFETY MANAGEMENT TEAM (SMT)	All safety personnel wages and operational cost (traveling for safety, phoning for safety etc) should be considered as prevention cost. If proved that safety personnel are not delivering the required service (no matter why) then this is a cost of management failure with no accident. If proved that some of the safety personnel services are not really required or it is wasted (e.g. training immigrants in a non-understandable languages/way) then this is a cost of management failure with no accident.
5	MISSED PREVENTION OR INADEQUATE PREVENTION AND ACCIDENTS	If an accident occurs then any cost born by the accident (either involves safety measures to be taken or not during rectification) it is considered as accident cost. Any cost paid for prevention that proved inadequately is partly prevention cost and partly management failure without accident cost. Any prevention to be taken as a decision after the accident then it is again partly prevention cost and partly management failure without accident cost. Exceptionally, it might be only prevention cost depending on timing matching. When after an accident Factor Inspectorate imposes exaggerated preventive measures, then the cost of these measures is preventive cost to that extent that it is justified by the risk assessment and the excess is accident cost.
6	SECURITY AND SAFETY	A percentage of discrete security costs are also preventive costs. For site campus and non-linear sites, a 25% of the security cost is allocated to prevention cost. For patrolling a linear site security, a 75% of the security cost is allocated to prevention cost.
7	MANAGEMENT & ADMINISTRATION - OVERHEAD COST	The management and administration cost of a project should also be counted. For the thesis a 10% on top of the prevention cost and the management failure with no accident cost represent the management and administration cost for the prevention management failure activities, respectively.
8	COST CALCULATION	Costs have been calculated in Euros; Greece has jointed the European Monetary System. Costs referring to this study are all based on pricing in Greece.

REF NO.	ISSUE	ASSUMPTION
		For calculating the costs the following assumptions were made. Value Added Tax (at a rate of 18% in Greece) is not included as it is refunded, based on the fact that all companies participating in the survey make profit the last three years (according to annual economic reports of all six companies which participated in the study). Though I must admit that in the two out of the three cases it was a join venture and not a single company. It is noted that for joint ventures in Greece it is not obligatory to issue an annual economic report and are not taxed; the companies venturing are taxed. The study works out the cost to the contractor before tax. This cost can be reduced by 37,5% (tax rate for Companies which are Societe Anonyme, as all six companies are) income tax, based on the fact that all companies participating in the survey make profits the last three years. For car costs, site equipment costs and the alike, the cost is based on the average market price. It includes vehicle/equipment cost, driver/operator wages (including insurance). In most of the cases the site equipment and trucks are hired. A remarkable percentage of the cases concern a self employed - contractor with a truck, or a loader, or an excavator, or a crane etc. It does not based on the contract provisions, as many agreements are verbal and come under specific arrangements. Also pricing costs for employees is based on the average market pricing. Most engineers do not belong to a company; they are freelancers. Subcontractors employ most labour-force. Opportunity costs have not considered at all.
9	SANITARY AND CATERING FACILITIES	When these facilities are installed within the main site office complex, then their cost is covered by the management and administration cost. If these facilities are distinctively allocated on the works site then rent/set up and running cost will be counted as prevention cost.
10	EQUIPMENT LIFE TIME AND REMAINING VALUE	A purchase for say of safety signs might be done at any time during the construction phase. If the lifetime of the signs excess remaining construction period then these signs have a remaining value (to be used in another project) and thus their cost should be proportionally allocated to this specific project. If lifetime is given by the manufacturer for the said (construction site) conditions, then this is to be considered. Otherwise the expected lifetime is known by experience. For instance, for road signs, the expected life time is 18 months, as within this period of time they have to be relocated many times, some would be damaged during transportation and setting up, some will be stolen. For consistency, standardization and transparency it is given below for some equipment the expected (and used in this study) lifetime. Road signs: 18 months Helmets: 4 months Safety boots: 6 months

REF NO.	ISSUE	ASSUMPTION
		General purpose gloves: 1month Metal Scaffold elements: 60 months Wooden staff tailored cut: project use only Wooden staff - industrial production/cut: 18 months
10.1	EQUIPMENT LIFE TIME AND REMAINING VALUE AND STUDY PERIOD	Always consider the remaining time for the survey and count the proportional cost for this period. Exception for (a) the imminent costs of an accident and (b) particular management failure without accident cases.
11	IMAGE	For image cost see subsection 4.4.4.1
12	FIXED PRICES	I did not in fact work on fixed prices for the simple reason that all costs are related to the budget of the individual project. All comparisons are based on percentages. Moreover between March 2000 and December 2001 that pilot study and main study started and completed the cumulative inflation in Greece is 4,2% (1,7% in 2000 and 2,5% in 2001). Though I must admit that changes in wages between these years and also between these years and 2003 are ranging between 15% for labor and 30% for engineers.
13	ACCOUNTING	For costing the Greek General Costing System has been observed. This work aims at (a) providing a methodology for costing and (b) raising management attention of the business side. Therefore in cases of law or diminishing costs, where costing information or calculations for accurate costing were complicated and time consuming assumptions were made such as e.g. for traveling costs, safety equipment etc. all those assumptions are clearly discussed/presented in the relevant cost Analysis Reports.

4.4.4.1 IMAGE COST

Companies spend money to sustain their image (reputation). Following an accident a company may feel obliged to spend money to restore their image. This is the basis of including an image cost in the present study. Dorman (2000a) and HSE (1998) both draw attention to the loss of corporate image that a company might suffer as a result of a serious accident or poor working conditions. Also, companies would lose image as a result of a much-publicised prosecution resulting from either of the above.

In this study 'image' embraces the perception of others on how good a company is. A good corporate image may lead people and organizations involved in a project to become more willing to support the contractor. Low image may lead them to be inflexible and strict. Moreover, as discussed in chapter 2, a loss of image could lead to a reduction in shareholder value.

For the purposes of this survey a preliminary image rating has been developed. This will help anyone using this study to make their own amendments, for example according to the standards applying to their country. In the UK, HM Treasury has published all those technical conventions required for a CBA to be completed and used generally by Government (HM Treasury, 1997). Though similar work does not exist in Greece, the image cost in this study gives an indicative value expressed in money that a contractor would be willing to pay to reverse the situation and restore the company's image to the status before the incident(s).

The image rating in the first instance was based on the prospective negative influence on the following people and organizations, arising from accidents and management failures with-no-accidents:

- Supervising Engineer
- Factory Inspectors
- Subcontractors
- Suppliers
- Designers
- Employees
- Freelancers
- Authorities
- Others and the general public

It should be noted that while the study involves the (estimated) costs of loss of image, the costs involved in seeking to improve image are not included.

Table 4.17 gives the assumed image cost ratings. The ratings are based on the experience of the author of the local (Greek) construction market, and represent a starting point for refining image cost values. The important point is that image costs should be included even though at this stage the figures are to some extent speculative. The 'calibration' of image costs will be identified as an area for further work, see sub-section 9.7).

Table 4.17 Image Cost Rating

INCIDENT	IMAGE COST
1. ACCIDENTS TO PEOPLE	
TYPE A casual accidents, return up to next day	0.0
TYPE B casual accidents resulting between one day up to three days absence	200.0
Sequence of accidents type A, rate over HSE study (i.e. 1.3accident/year/employee)	200.0
Sequence of accidents type B, rate over HSE study (i.e. 1.3accident/year/employee)	800.0
Accident with over three days absence from work, no disabilities, temporary or permanently	1,000.0
Temporary disabilities	3,000.0
Permanent disabilities	9,000.0
Fatal	27,000.0
2. DAMAGES	
Negligible damages up to 200Euros	0.0
Minor damages (200 to 1,000Euros)	300.0
Low damages (1,000 to 10,000Euros)	900.0
Moderate damages (10,000 to 100,000Euros)	2,700.0
Big damages (100,000 to 500,000Euros)	8,100.0
Catastrophic damages-over 500,000Euros and redo the project or a part of	24,300.0
3. COMPLIANCE	
Failing to comply/no consequences, verbal notification	0.0
Failing to comply/minor consequences, written notification	300.0
Failing to comply/moderate consequences, penalty	1,500.0
Failing to comply/high consequences, stop the work	4,500.0
Failing to comply/severe consequences, prosecution	13,500.0

4.5 Spreadsheet Development

All three completed projects worked under their own unit rates for safety costs sub-subcategories. Therefore different calculation had to be made. Additionally any comparisons, alterations or corrections in units, unit rates etc could occur. Therefore to ensure fast calculation, easy comparisons between the three projects as well as to provide a workable programme that it could work out any similar exercise, an 'excel' spreadsheet was developed. This is shown in Table 4.18. In the actual spreadsheets, each individual cost report was entered in a separate column between 'Unit Rate', column (C) and 'Total Units', column (E).

The first column is the cost category, subcategory (under category heading) and the sub-subcategory (under subcategory heading), the second column is the unit (metric or other), the third column is the rate per unit, the subsequent n-number of columns are the units per case (data form the Cost Analysis Report), the column (E) gives the total units for each cost sub-subcategory and the (G) column gives the total cost of the sub-subcategory. The spreadsheet calculates also the total cost of each subcategory and the overall safety cost and gives costs in percentages of the category/subcategory they belong. It also gives the percentage of the cost categories to the overall safety cost and the project value.

Having decided/calculated the unit rates all it is needed it is to identify the units spent/occurred per sub-subcategory. The spreadsheet calculates automatically the cost per sub-subcategory, subcategory, and category and per case/incident. To free the method from local monetary units the spreadsheet calculates also all costs in percentages of the project value. The spreadsheet can calculate in any currency required. This is easily obtainable by giving exchange rates in the background worksheet, described next.

In the software format Table 4.18 is ready-to-use supported by a background worksheet (not shown here, but included in each costing study, Chapters Five to Seven), which provides the actual rates per unit (hourly rate, price per item etc).

In practice the spreadsheet supports up to 250 cases/incidents (six columns reserved for costs, units, rates and calculations) on a single working sheet. Thus excel limits initially the cases/incidents to 250. To overcome this limitation either more sheets on the same workbook should be used (e.g. one for each cost category; prevention, management failure with-no-accident, accidents and image) or a database programme should be developed. The database programme should have exactly the same structure and philosophy as the excel one.

Table 4.18 Costing Spreadsheet

	COSTS (list all subcategories and sub-subcategories of the cost units)	UNIT	UNIT RATE	INDIVIDUAL COST REPORTS				TOTAL UNITS	TOTAL COST	PERCENTAGE OF THE SAFETY COST	PERCENTAGE OF THE PROJECT VALUE
CODE	(A)	(B)	(C)	(D1)	...	(Dn-1)	(Dn)	(E)	(F) = (C)*(E)	(G) = (Fx)/(Fy)	(H) = (Fx)/(b)
				CAR1	...	CARn-1	CARn				
	BUDGET								(Fb)		
	PREVENTION								(Fp)= (Cp)*(Ep)	(Gp)=(Fp)/(Fs)	(Hp)=(Fp)/(Fb)
	MFWNA								(Fmf)= (Cmf)* (Emf)	(Gmf)=(Fmf)/(Fs)	(Hmf)=(Fmf)/Fb)
	ACCIDENT								(Fa)= (Ca)*(Ea)	(Ga)=(Fa)/(Fs)	(Ha)=(Fa)/(Fb)
	IMAGE								(Fi)= (Ci)*(Ei)	(Gi)=(Fi)/(Fs)	(Hi)=(Fi)/(Fb)
	TOTAL SAFETY COST								(Fs) = (Fp)+ (Fmf)+(Fa) +(Fi)	100%	(Hs)=(Fs)/Fb)
	PREVENTION COST								(Fp)= □(Fpi)		
PC-SMS	SMS ETC DOCUMENTS								(Fp1)= □(Fp1,j)	(Gp1)=(Fp1)/(Fp)	
	director (Project Manager)	hour							(Fp1,1)		
	manager (Site Manager)	hour							(Fp1,2)		
	engineer (Project Engineer)	hour							(Fp1,3)		
	safety officer	hour							(Fp1,4)		
	safety practitioner	hour							(Fp1,5)		
	safety coordinator (engineer)	hour							(Fp1,6)		
	printable documents	set							(Fp1,7)		
PC-STF	STAFFING (SAFETY ORGANISATION)								(Fp2)= □(Fp2,j)	(Gp2)=(Fp2)/(Fp)	
	safety practitioner (engineer)	hour							(Fp2,1)		
	safety coordinator (engineer)	hour							(Fp2,2)		
	safety officer (manager)	hour							(Fp2,3)		
	engineer	hour							(Fp2,4)		
	labour	hour							(Fp2,5)		
	physician	hour							(Fp2,6)		
	Nurse	hour							(Fp2,7)		
	first aider (foreman)	hour							(Fp2,8)		
	fire team (foreman)	hour							(Fp2,9)		
	cleaning services								(Fp2,10)		
PC-MTN	MEETINGS								(Fp3)= □(Fp3,j)	(Gp3)=(Fp3)/(Fp)	
	director (Project Manager)	hour							(Fp3,1)		
	manager (Site Manager)	hour							(Fp3,2)		
	engineer (Project Engineer)	hour							(Fp3,3)		
	safety practitioner (engineer)	hour							(Fp3,4)		
	safety coordinator	hour							(Fp3,5)		

Ep=□ (Dp1 + Dp2 + ... + Dpn-1 +Dpn)
Emf=□ (Dmf1 + Dmf2 + ... + Dmfn-1 +Dmfn)
Ea=□ (Da1 + Da2 + ... + Dan-1 +Dan)

	COSTS (list all subcategories and sub-subcategories of the cost units)	UNIT	UNIT RATE	INDIVIDUAL COST REPORTS				TOTAL UNITS	TOTAL COST	PERCENTAGE OF THE SAFETY COST	PERCENTAGE OF THE PROJECT VALUE
CODE	(A)	(B)	(C)	(D1)	...	(Dn-1)	(Dn)	(E)	(F) = (C)*(E)	(G) = (Fx)/(Fy)	(H) = (Fx)/(b)
				CAR1	...	CARn-1	CARn				
	(engineer)										
	safety officer (manager)	hour							(Fp3,6)		
	physician	hour							(Fp3,7)		
	Nurse	hour							(Fp3,8)		
	first aider (foreman)	hour							(Fp3,9)		
	fire team (foreman)	hour							(Fp3,10)		
	secretary	hour							(Fp3,11)		
	technician (welder, pipe fitter, etc)	hour							(Fp3,12)		
	operator	hour							(Fp3,13)		
	foreman	hour							(Fp3,14)		
	labour	hour							(Fp3,15)		
	security services	hour							(Fp3,16)		
	materials	set							(Fp3,17)		
PC-STD	SAFETY STUDIES								(Fp4)= □(Fp4,j)	(Gp4)=(Fp4)/(Fp)	
	director (Project Manager)	hour							(Fp4,1)		
	manager (Site Manager)	hour							(Fp4,2)		
	engineer (Project Engineer)	hour							(Fp4,3)		
	safety coordinator (engineer)								(Fp4,4)		
	secretary	hour							(Fp4,5)		
	consumables (paper-cartridges etc)	set							(Fp4,6)		
PC-TRN	TRAINING								(Fp5)= □(Fp5,j)	(Gp5)=(Fp5)/(Fp)	
	director (Project Manager)	hour							(Fp5,1)		
	manager (Site Manager)	hour							(Fp5,2)		
	engineer (Project Engineer)	hour							(Fp5,3)		
	safety practitioner (engineer)	hour							(Fp5,4)		
	safety coordinator (engineer)	hour							(Fp5,5)		
	safety officer (manager)	hour							(Fp5,6)		
	physician	hour							(Fp5,7)		
	Nurse	hour							(Fp5,8)		
	first aider (foreman)	hour							(Fp5,9)		
	fire team (foreman)	hour							(Fp5,10)		
	secretary	hour							(Fp5,11)		
	technician (welder, pipe fitter, etc)	hour							(Fp5,12)		
	operator	hour							(Fp5,13)		
	foreman	hour							(Fp5,14)		
	labour	hour							(Fp5,15)		
	security services	hour							(Fp5,16)		
	materials	set							(Fp5,17)		

	COSTS (list all subcategories and sub-subcategories of the cost units)	UNIT	UNIT RATE	INDIVIDUAL COST REPORTS				TOTAL UNITS	TOTAL COST	PERCENTAGE OF THE SAFETY COST	PERCENTAGE OF THE PROJECT VALUE
CODE	(A)	(B)	(C)	(D1)	...	(Dn-1)	(Dn)	(E)	(F) = (C)*(E)	(G) = (Fx)/(Fy)	(H) = (Fx)/(b)
				CAR1	...	CARn-1	CARn				
PC-PPE	PPE								(Fp6)= □(Fp6,j)	(Gp6)=(Fp6)/(Fp)	
	helmet	pcs							(Fp6,1)		
	safety shoes	pcs							(Fp6,2)		
	gloves - impact - all purposes	pcs							(Fp6,3)		
	gloves - welder	pcs							(Fp6,4)		
	eye protection - welder	pcs							(Fp6,5)		
	eye protection - grinding	pcs							(Fp6,6)		
	ear protection - one use	pcs							(Fp6,7)		
	ear protection - muffs	pcs							(Fp6,8)		
	masks - one use (box of 50)	pcs							(Fp6,9)		
	reflective vest	pcs							(Fp6,10)		
	respiratory mask - with air feeder	pcs							(Fp6,11)		
	face shields	pcs							(Fp6,12)		
	isotherm underwear	pcs							(Fp6,13)		
	climbing helmet	pcs							(Fp6,14)		
	Knees protection	pair							(Fp6,15)		
	Wellington boots	pair							(Fp6,16)		
	waterproof trousers	pcs							(Fp6,17)		
PC-EXT	EXTERNAL SERVICES								(Fp7)= □(Fp7,j)	(Gp7)=(Fp7)/(Fp)	
	safety	month							(Fp7,1)		
	physician	month							(Fp7,2)		
	Nurse	month							(Fp7,3)		
	security	month							(Fp7,4)		
	studies	pcs/av							(Fp7,5)		
	safety lump sum	pcs/av							(Fp7,6)		
PC-EQP	SAFETY EQUIPMENT & SIGNS								(Fp8)= □(Fp8,j)	(Gp8)=(Fp8)/(Fp)	
	Metal scaffold safety features per meter	metre							(Fp8,1)		
	Metal scaffold per meter								(Fp8,2)		
	wooden scaffold safety features per meter	metre							(Fp8,3)		
	wooden scaffold per meter	metre							(Fp8,4)		
	wooden ladders 4m high	pcs							(Fp8,5)		
	metal ladders average	pcs							(Fp8,6)		
	safety signs 450/600/650	pcs							(Fp8,7)		
	horizontal signing	case/av							(Fp8,8)		
	mobile traffic lights	pair							(Fp8,9)		
	operate mobile traffic lights	hour							(Fp8,10)		
	reflective net	metre							(Fp8,11)		

CODE	COSTS (list all subcategories and sub-subcategories of the cost units)	UNIT	UNIT RATE	INDIVIDUAL COST REPORTS				TOTAL UNITS	TOTAL COST	PERCENTAGE OF THE SAFETY COST	PERCENTAGE OF THE PROJECT VALUE
CODE	(A)	(B)	(C)	(D1)	...	(Dn-1)	(Dn)	(E)	(F) = (C)*(E)	(G) = (Fx)/(Fy)	(H) = (Fx)/(b)
				CAR1	...	CARn-1	CARn				
	flashing lights	pcs							(Fp8,12)		
	cat eyes	pcs							(Fp8,13)		
	install cat eyes	pcs							(Fp8,14)		
	foreman	hour							(Fp8,15)		
	technician (welder, pipe fitter, etc)	hour							(Fp8,16)		
	engineer	hour							(Fp8,17)		
	labour	hour							(Fp8,18)		
	fencing metal supports	pcs							(Fp8,19)		
	materials and labour for setting up road barriers	metre							(Fp8,20)		
	wood/metal barricading materials scaffold type, incl. Labour for one off	metre							(Fp8,21)		
	road barrier	pcs							(Fp8,22)		
	road barrier labour	metre							(Fp8,23)		
	traffic cones 0.75m	pcs							(Fp8,24)		
	metal fence	metre							(Fp8,25)		
	metal fence put up labour	metre							(Fp8,26)		
	road sings base labour and putting up	pcs							(Fp8,27)		
	road sings base material	pcs							(Fp8,28)		
	Put up reflective net labour cost, inch materials	metre							(Fp8, 29)		
	Equipment certification	item							(Fp8, 30)		
	Special road signs	case							(Fp8, 31)		
	safety ropes	metre							(Fp8,32)		
	welder canopy								(Fp8,33)		
	pick-up car with driver	hour							(Fp8,34)		
	printable documents	set							(Fp8,35)		
PC-EMR	EMERGENCY								(Fp9)= ∑(Fp9,j)	(Gp9)=(Fp9)/(Fp)	
	Engineer	hour							(Fp9,1)		
	foreman	hour							(Fp9,2)		
	labour	hour							(Fp9,3)		
	JCB with operator	hour							(Fp9,4)		
	truck up to 9 cubic meters with driver	hour							(Fp9,5)		
	pick up with driver	hour							(Fp9,6)		
PC-FRS	FIRE SAFETY								(Fp10)= ∑(Fp10,j)	(Gp10)=(Fp10)/(Fp)	
	fire extinguishers	pcs							(Fp10,1)		
	fire extinguishers charge								(Fp10,2)		
PC-MDS	MEDICAL SURVEILLANCE								(Fp11)= ∑(Fp11,j)	(Gp11)=(Fp11)/(Fp)	
	medical surveillance	person							(Fp11,1)		

	COSTS (list all subcategories and sub-subcategories of the cost units)	UNIT	UNIT RATE	INDIVIDUAL COST REPORTS				TOTAL UNITS	TOTAL COST	PERCENTAGE OF THE SAFETY COST	PERCENTAGE OF THE PROJECT VALUE
CODE	(A)	(B)	(C)	(D1)	...	(Dn-1)	(Dn)	(E)	(F) = (C)*(E)	(G) = (Fx)/(Fy)	(H) = (Fx)/(b)
				CAR1	...	CARn-1	CARn				
PC-AGM	AGENTS MONITORING								(Fp12)= □(Fp12,j)	(Gp12)=(Fp12)/(Fp)	
	agents monitoring	agent							(Fp12,1)		
PC-OTH	OTHER								(Fp13)= □(Fp13,j)	(Gp13)=(Fp13)/(Fp)	
	MFWNAC								(Fmf)= □(Fmfi)		
MF-PNL	PENALTIES AND FINES								(Fmf1)= □(Fmf1,j)	(Gmf1)= (Fmf1)/(Fmf)	
	penalties	case							(Fmf1,1)		
	fines	case							(Fmf1,2)		
MF-CRT	COURT CASE								(Fmf1)= □(Fmf2,j)	(Gmf2)= (Fmf2)/(Fmf)	
	court expenses	case							(Fmf2,1)		
MF-IDL	IDLENESS								(Fmf3)= □(Fmf3,j)	(Gmf3)= (Fmf3)/(Fmf)	
	labour	hour							(Fmf3,1)		
	foreman	hour							(Fmf3,2)		
	engineer	hour							(Fmf3,3)		
	technician	hour							(Fmf3,4)		
	operator	hour							(Fmf3,5)		
	crane 3T with operator	hour							(Fmf3,6)		
	crane 10T with operator	hour							(Fmf3,7)		
	crane 40T with operator	hour							(Fmf3,8)		
	platform truck with driver	hour							(Fmf3,9)		
	heavy equipment with operator	hour							(Fmf3,10)		
	JCB with operator	hour							(Fmf3,11)		
	truck up to 9 cubic Meters with driver	hour							(Fmf3,12)		
	truck over 9 cubic Meters with driver	hour							(Fmf3,13)		
	pilling system with operator	hour							(Fmf3,14)		
	bobcat - type, with driver/operator	hour							(Fmf3,15)		
	water blasting system with operator	hour							(Fmf3,16)		
	pick-up car with driver	hour							(Fmf3,17)		
MF-FML	FALSE MATERIALS EQUIPMENT & LABOR								(Fmf4)= □(Fmf4,j)	(Gmf4)= (Fmf4)/(Fmf)	
	non CE helmet	pcs							(Fmf4,1)		
	non CE safety belts	pcs							(Fmf4,2)		
	false printable materials set	set							(Fmf4,3)		
	false fencing set	set							(Fmf4,4)		

	COSTS (list all subcategories and sub-subcategories of the cost units)	UNIT	UNIT RATE	INDIVIDUAL COST REPORTS				TOTAL UNITS	TOTAL COST	PERCENTAGE OF THE SAFETY COST	PERCENTAGE OF THE PROJECT VALUE
CODE	(A)	(B)	(C)	(D1)	...	(Dn-1)	(Dn)	(E)	(F) = (C)*(E)	(G) = (Fx)/(Fy)	(H) = (Fx)/(b)
				CAR1	...	CARn-1	CARn				
	false spot lighting	set							(Fmf4,5)		
	false barricade	set							(Fmf4,6)		
FM-INT	INTERVENTION								(Fmf5)= □(Fmf5,j)	(Gmf5)= (Fmf5)/(Fmf)	
	intervention	case							(Fmf5,1)		
MF-OTH	OTHER								(Fmf6)= □(Fmf6,j)	(Gmf6)= (Fmf6)/(Fmf)	
									(Fmf6,1)		
	ACCIDENT COST								(Fa)=□(Fai)		
AC-IDL	IDLENESS								(Fp1)= □(Fa1,j)	(Ga1)=(Fa1)/(Fa)	
	engineer	hour							(Fa1,1)		
	foreman	hour							(Fa1,2)		
	labour	hour							(Fa1,3)		
	technician	hour							(Fa1,4)		
	operator	hour							(Fa1,5)		
	crane 3T with operator	hour							(Fa1,6)		
	crane 10T with operator	hour							(Fa1,7)		
	crane 40T with operator	hour							(Fa1,8)		
	platform truck with driver	hour							(Fa1,9)		
	heavy equipment with operator	hour							(Fa1,10)		
	JCB with operator	hour							(Fa1,11)		
	truck up to 9 cubic Meters with driver	hour							(Fa1,12)		
	truck over 9 cubic Meters with driver	hour							(Fa1,13)		
	pilling system with operator	hour							(Fa1,14)		
	bobcat - type, with driver/operator	hour							(Fa1,15)		
	water blasting system with operator	hour							(Fa1,16)		
	pick-up car with driver	hour							(Fa1,17)		
	guinite mixer	hour							(Fa1,18)		
AC-FTR	FIRST AID TREATMENT								(Fa2)= □(Fa2,j)	(Ga2)=(Fa2)/(Fa)	
	material	case							(Fa2,1)		
	labour	hour							(Fa2,2)		
AC-ADM	ADMINISTRATION								(Fa3)= □(Fa3,j)	(Ga3)=(Fa3)/(Fa)	
	administration	case/av							(Fa3,1)		
AC-HTR	HOSPITAL TREATMENT								(Fa4)= □(Fa4,j)	(Ga4)=(Fa4)/(Fa)	

	COSTS (list all subcategories and sub-subcategories of the cost units)	UNIT	UNIT RATE	INDIVIDUAL COST REPORTS				TOTAL UNITS	TOTAL COST	PERCENTAGE OF THE SAFETY COST	PERCENTAGE OF THE PROJECT VALUE
CODE	(A)	(B)	(C)	(D1)	...	(Dn-1)	(Dn)	(E)	(F) = (C)*(E)	(G) = (Fx)/(Fy)	(H) = (Fx)/(b)
				CAR1	...	CARn-1	CARn				
	hospital treatment	hour							(Fa4,1)		
	labour	hour							(Fa4,2)		
	transportation	hour							(Fa4,3)		
AC-PRD	PRODUCTION LOSS								(Fa5)= □(Fa5,j)	(Ga5)=(Fa5)/(Fa)	
	engineer	hour							(Fa5,1)		
	foreman	hour							(Fa5,2)		
	labour	hour							(Fa5,3)		
	crane 3T with operator	hour							(Fa5,4)		
	crane 10T with operator	hour							(Fa5,5)		
	crane 40T with operator	hour							(Fa5,6)		
	platform truck with driver	hour							(Fa5,7)		
	heavy equipment with operator	hour							(Fa5,8)		
	JCB with operator	hour							(Fa5,9)		
	truck up to 9 cubic Meters with driver	hour							(Fa5,10)		
	truck over 9 cubic Meters with driver	hour							(Fa5,11)		
	pilling system with operator	hour							(Fa5,12)		
	bobcat - type, with driver/operator	hour							(Fa5,13)		
	water blasting system with operator	hour							(Fa5,14)		
	pick-up car with driver	hour							(Fa5,15)		
	materials	case/av							(Fa5,16)		
	guinite mixer with operator and assistant	hour							(Fa5,17)		
AC-CMP	COMPENSATION								(Fa6)= □(Fa6,j)	(Ga6)=(Fa6)/(Fa)	
	compensating insurance 3 days cover, labour	hour							(Fa6,1)		
	compensating insurance balance cover, labour	hour							(Fa6,2)		
	compensating insurance balance cover, technician	hour							(Fa6,3)		
	compensating insurance balance cover, technician	hour							(Fa6,4)		
	compensating insurance balance cover, operator	hour							(Fa6,5)		
	compensating insurance balance cover, operator	hour							(Fa6,6)		
AC-RCT	RECRUITMENT								(Fa7)= □(Fa7,j)	(Ga7)=(Fa7)/(Fa)	
	recruitment labour	hour							(Fa7,1)		
	overtime labour	hour							(Fa7,2)		
	recruitment technician	hour							(Fa7,3)		

	COSTS (list all subcategories and sub-subcategories of the cost units)	UNIT	UNIT RATE	INDIVIDUAL COST REPORTS				TOTAL UNITS	TOTAL COST	PERCENTAGE OF THE SAFETY COST	PERCENTAGE OF THE PROJECT VALUE
CODE	(A)	(B)	(C)	(D1)	...	(Dn-1)	(Dn)	(E)	(F) = (C)*(E)	(G) = (Fx)/(Fy)	(H) = (Fx)/(b)
				CAR1	...	CARn-1	CARn				
	overtime technician	hour							(Fa7,4)		
AC-CRT	COURT CASE								(Fa8)= □(Fa8,j)	(Ga8)=(Fa8)/(Fa)	
	court expenses	case							(Fa8,1)		
AC-DMG	DAMAGES & LOSSES								(Fa9)= □(Fa9,j)	(Ga9)=(Fa9)/(Fa)	
	damages	case							(Fa9,1)		
	losses								(Fa9,2)		
AC-PNL	PENALTIES AND FINES								(Fa10)= □(Fa10,j)	(Ga10)=(Fa10)/(Fa)	
	penalties	case							(Fa10,1)		
	fines	case							(Fa10,2)		
	IMAGE COST								(Fi)=□(Fii)		
IM-INJ	INJURY								(Fi1)= □(Fi1,j)	(Gi1)=(Fi1)/(Fi)	
	TYPE A casual accidents, return up to next day	case							(Fi1,1)		
	TYPE B casual accidents resulting between one day up to three days absence	case							(Fi1,2)		
	sequence of accidents type A, rate over HSE study (i.e. 1.3accident/year/employee)	case							(Fi1,3)		
	sequence of accidents type B, rate over HSE study (i.e. 1.3accident/year/employee)	case							(Fi1,4)		
	accident with over three days absence from work, no disabilities, temporary or permanently	case							(Fi1,5)		
	temporary disabilities	case							(Fi1,6)		
	permanent disabilities	case							(Fi1,7)		
	fatal	case							(Fi1,8)		
AC-DMG	DAMAGES								(Fi2)= □(Fi2,j)	(Gi2)=(Fi2)/(Fi)	
	negligible damages up to 400Euros	case							(Fi2,1)		
	minor damages (400 to 1000Euros)	case							(Fi2,2)		
	low damages (1000 to 10000Euros)	case							(Fi2,3)		
	moderate damages (10000 to 100000Euros)	case							(Fi2,4)		
	big damages (100000 to 500000Euros)	case							(Fi2,5)		
	catastrophic damages-over 500000Euros and redo the	case							(Fi2,6)		

	COSTS (list all subcategories and sub-subcategories of the cost units)	UNIT	UNIT RATE	INDIVIDUAL COST REPORTS				TOTAL UNITS	TOTAL COST	PERCENTAGE OF THE SAFETY COST	PERCENTAGE OF THE PROJECT VALUE
CODE	(A)	(B)	(C)	(D1)	...	(Dn-1)	(Dn)	(E)	(F) = (C)*(E)	(G) = (Fx)/(Fy)	(H) = (Fx)/(b)
				CAR1	...	CARn-1	CARn				
	project or a part of										
IM-FLR	FAILURE TO COMPLY								(Fi3)= □(Fi3,j)	(Gi3)=(Fi3)/(Fi)	
	failing to comply/no consequences, verbal notification	case							(Fi3,1)		
	failing to comply/minor consequences, written notification	case							(Fi3,2)		
	failing to comply/moderate consequences, penalty	case							(Fi3,3)		
	failing to comply/high consequences, stop the work	case							(Fi3,4)		
	failing to comply/severe consequences, prosecution	case							(Fi3,5)		

4.6 Quality Management Systems and Site Data Collection

For the whole work a quality system complying with ISO 9001 was established to ensure the quality of the work. Quality procedures had been set up regarding numbering of documents, registering documents and doing the survey work. For defining and explaining the management and the disciplines within it for the thesis I drew up the quality procedure number PhD-PR-MN-01 for "The Thesis Management System". I revised it twice and final the revision is placed in Appendix 1.

A quality procedure was drawn up for "Surveying Safety Cost Parameters on Site". This explains who is involved to this work, what type of information is needed and what forms are used. This quality procedure has been numbered PhD-PR-QL-03 and it has been revised three times until final revision 3 which is placed in Appendix 1.

Also a quality procedure for the "Participation of Construction Companies in the Research" was drawn to specify the role, responsibilities and benefits for the construction companies (and Joint Ventures) to participate in the survey work. The procedure defines the key persons for the survey work and gives the job description for them. This quality procedure has been numbered PhD-PR-MN-02 and it has been revised three times until final revision 3 which is placed in Appendix 1.

Questions such as where the data shall be collected from; what are the data flow process and how data generation and flow shall be secured for the whole period up to the end of the field survey; the duration of the survey; what are the training needs for any involved entity or person, had to be discussed and answered satisfactorily. This step shall be definitely planned and designed carefully to ensure that all contributing parameters are monitored successfully and accurate data is regularly flowing from the sites to the researcher.

4.7 Audit Question Set

There was a significant possibility for cases such as:

(a) low safety performance (little safety prevention cost) but no accidents (low cost accidents); and
(b) high spend in prevention but also a high accident cost.

Either of the two would mislead employers and make them believe that this was not their case. Also the information for my work would lack correlation between costs and performance, as incidents may not necessarily occur during the survey period and incidents not all reported (as expected). To avoid my work sailing between the scila and haribdhys, I employed safety auditing and introduced the Safety Audit Indicator (SPI) to provide a semi-quantitative indication for the safety performance.

A very simple site audit was prepared to make a basic assessment of safety standards on the sites where the costing analysis was carried out. This is shown in Table 4.13. The method "+2/-2" (Panopoulos, 1996) was selected as being the one widely used in Greece and also now adopted for auditing of the Olympic projects. Panopoulos (ibid) presents a review of proprietary audit systems, including the International Safety Rating System (ISRS).

For the audit, five key areas were selected, safety organization; equipment certification; safety equipment and facilities; inspections and maintenance; and employees' compliance with regulations. Selection was based on my personal experience as an auditor (what areas to be inspected in those projects) as well as on the W.S. Atkins 'Bespoke' audit method, and the ISRS audit method, Distribution Safety Managers' Group (1993).

For each key area, five fields were audited, 25 in total. The values then of the SPI can range from '-50' to '+50'.

Table 4.19 Site Audit Question Set

No	Question
1	Competent Safety practitioner
2	HSP
3	Safety responsibilities allocated
4	Safety meetings
5	Safety training on site
6	Certified lifting appliances
7	All equipment CE marked
8	All vessels certified
9	All operators licensed
10	All site equipment licensed
11	Approved type scaffold
12	All PPE CE marked
13	Approved type ladders
14	Proper signage
15	Site arrangements for hygiene, fencing, entrance control, sanitary, first aids, fire safety, emergencies
16	Equipment maintenance
17	Lifting appliances inspections
18	Trench inspections
19	Scaffold inspections
20	Electrical inspections
21	Wear helmet and safety shoes
22	Wear other appropriate PPE as required
23	Use only approved type equipment
24	Use/operate only if authorised
25	All access and egress are safe

4.8 Selection of Construction Companies and Sites

The two main selection criteria for the construction companies to participate are (a) for Management to demonstrate their willingness to participate and (b) Companies to have in place or under development an ISO9000 quality assurance system. The site organisation and the company management should support the survey work. A third criteria concerns project budget and duration. The budget should be over □1.0million and duration of at least six months.

Additionally, the project should not have constraints such as being behind schedule or in short of resources (e.g. equipment, personnel). In many cases, projects are dramatically delayed or suspended because the design has not been finalised, permissions have not obtained, land acquisition has not completed etc.

Selection of the companies and the projects have been guided by the two relevant quality procedures for "Surveying Safety Cost Parameters on Site" (PhD-PR-QL-03) and for the "Participation of Construction Companies in the Research" (PhD-PR-MN-02) as described earlier in section 4.6 of this Sector.

I selected a representative sample of eight companies from the list of the largest 100 construction companies in Greece (based on the 1998 fiscal year economic results) and sent letters to their managing directors. The selection was based on the criteria of company size. I chose three from the top 20 another three between 21 and 50 and another two from 51 to 100.

Familiar with local ethics, culture and attitudes, I decided to speak with the companies whom I knew best. I spoke to the companies personally, to explain what the survey was about and the benefits for the company of participation. With the exception of ELLINIKI TECHNODOMIKI SA I spoke to the top management or owners of the companies personally. In ELLINIKI TECHNODOMIKI SA I spoke with the Quality Manager.

Five companies expressed warm interest; ELLINIKI TECHNODOMIKI SA, THEMELIODOMI SA, N. KAMATAKIS SA, ELTER SA and ATERMON SA (listed by magnitude from the biggest to smaller). Finally, only two participated: THEMELIODOMI SA with two projects, one in Joint Venture with TECNHIKI ENOSIS

SA and ELTER SA with a project in Joint Venture with PANTECHNIKI SA, ALTE SA and GETEM SA. In all cases an agreement was signed to ensure that project would be carried out properly and satisfactorily to the end.

Chapter Five

PILOT STUDY - PPC COOLING TOWER REPAIRS

5.1 Introduction

As was described in the final section of Chapter Four, arrangements were made with THEMELIODOMI SA, a construction company based in Thessaloniki, for the survey programme. THEMELIODOMI SA's top management had demonstrated a clear willingness to contribute to both the pilot study and the main study. The only matter to consider was to select an appropriate pilot project. The PPC Cooling Tower Repair project was chosen only after an abortive study of shore protection work. This shore protection research will be briefly described here, as important lessons were learnt which were carried forward into the subsequent studies.

5.2 Shore Protection Project

The discussion about the pilot project started with THEMELIODOMI SA in early June 1999. The project 'pilling along Kalochori shore and waterproofing of the Kalochori area' was chosen. The Thessaloniki Prefecture was the client. The pilot survey work started in early September 1999. The project was in progress when it was selected. The works were repetitive all along the shore. At that time it was very likely, subject to financing, that the client would award the Contractor an extension, i.e., more length of shore to be protected. THEMELIODOMI SA expected to participate in the main study with this project if an extension of works would be awarded to the Company.

The first indication on how badly the pilot study was going came just a few weeks after we started. Hence, on my second visit paid in early November I decided to abort the study, because the site organization was not able to generate any data at all. What happened was typical of Greek construction projects as described in Chapter Three.

With the wisdom of hindsight, the main disadvantages of this project proved to be:

- The Prefecture of Thessaloniki (as most, if not all, Prefectures in Greece as well as any other similar administrative authority in Greece, e.g. Municipalities) was understaffed, with major difficulties in supervising and monitoring construction projects.
- The Contractor's site leadership had been allocated to a foreman, normally on site, with the nominated site manager not present on a daily basis.
- No safety responsibilities had been allocated.
- Financing of the project was not guaranteed by the Prefecture of Thessaloniki, at the beginning of the project and during the course of the work, so at various stages the work came to a halt
- Personnel in the project would not support generating a reliable and considerable flow of data, despite induction training and THEMELIODOMI SA top management instructions.
- No safety logbook was maintained on site.

The main conclusion was that a reliable flow of data could be generated only if it was generated pro-actively by senior site staff. What I had to look for in the next pilot selection was commitment to the survey of site personnel.

5.3 Summary of the PPC Cooling Tower Project

THEMELIODOMI SA established after the failure of the shore protection work a Safety Management Function reporting directly to the Projects Manager. Ms Natali Seremeta took the position. But of great importance, Natali agreed to be nominated as Research Assistant for the survey work. Her role proved crucial.

THEMELIODOMI SA in joint venture with TECHNIKI ENOSIS SA had been awarded the contract for the "reinforcement and renovation of the cooling towers 1-4" of a Public Power Company (PPC) plant in Ptolemais, close to Kozani, some three hours drive from Thessaloniki and six hours drive from Athens.

The scope of the work included:

- cleaning the cooling towers by removing any loose materials and worn out concrete and revealing of the steel bars;
- treatment of the steel bars for cleaning (water/sandblasting) and insulation;
- spraying guinite (a kind of liquid concrete);
- fitting concrete rings at the top of the towers.

The first meeting for the Project was carried out in mid November 1999 in Thessaloniki with THEMELIODOMI SA top management (including the Projects Director Mr. Xatzitheodosiou) and Ms Seremeta. This meeting was followed by instructions to site personnel emphasising the importance of supporting the survey and co-operating with Ms Seremeta and myself, and led to extended induction training for senior site personnel, including the site safety practitioner. The site organisation was very strong, guaranteeing a good flow of reliable data. Nevertheless again we had problems with data flow, especially concerning minor occurrences, as it will be illustrated and explained below.

The main topics of the training included:

- what the survey is for;
- Benefits from the survey;
- Requirements for data and data quality;
- Techniques to help getting the information.

The survey lasted to the end of the project in October 2000. Seven visits (11 days) were paid by Ms Seremeta, four visits (six days) by me and one visit (two days) by my Aston supervisor, together with Ms Seremeta and me.

The pilot study worked very well, in general, and validated the core design elements of the methodology, quality systems and pro-formas.

The methodology was improved by developing the safety audit tool and performance indicator described in the previous chapter. For during the course of the pilot study, we identified that the survey might provide misleading results: it is a matter of chance for accidents to occur, and the absence of preventive measures does not necessarily lead to accidents taking place. Similarly accidents with very high costs could occur despite preventive efforts. To have at least a simple approach/indicator I decided to introduce the '+2/-2' safety auditing and performance methodology. This would provide a safety performance level indicator and could explain partly any no prevention - no accident cases and the opposite.

Being a small site with a strong engineering team, skilled workpeople, and close supervision by the client, PPC, facilitated the work. Despite these advantages, as summarised in Table 5.1 (in contrast with shore protection case), the pilot study resulted in only ten Cost Reports and thirteen Cost Analysis Reports. The table Table 5.1 below summarises the disadvantages of Kalochori shore protection and the advantages of the PPC project.

Table 5.1 Shore Protection and PPC Cooling Tower Project Comparisons

	Shore Protection (Aborted Study)	Cooling Tower Project Pilot Study
1	The Owner of the Project is the Prefecture of Thessaloniki. Prefecture of Thessaloniki (as most if not all) is understaffed with major difficulties in supervising and monitoring construction projects.	The Owner of the Project is PPC, with a very good reputation in safety and strong supervision. The project was supervised on a daily basis by two dedicated supervisors.
2	The site leader was a foreman, whilst the nominated site manager was not present on a daily basis.	The site organisation was very strong, consisting of the Site Manager, a 20-year experience engineer, the deputy Site Manager a 7-year experienced engineer and the general foreman a 30-year experienced person.
3	No safety responsibilities had been allocated and no safety personnel had been nominated.	The responsibilities of the safety practitioner had been allocated to the deputy Site Manager.
4	The scope of work extended during the project and it was expected to be extended further (more length of protected shore). The project life in uncertainty.	The scope of work was clearly defined in the contractual documents.
5	Financing of the project not guaranteed by the Prefecture of Thessaloniki, at the beginning of the project.	No financing problems at all.
6	No guaranteed progress. Periods of idleness.	An agreed time schedule was a binding document.
7	Safety culture and experience of personnel in the project would not assist them to generate a reliable and considerable flow of data.	The safety culture of the environment, a PPC plant, as well as that of the site key personnel was relatively (to the Greek standards) satisfactory.
8	No safety logbook was maintained on site.	A safety log book, a safety Practitioner recommendations book and accidents book were maintained on site.
9	—	Additionally, PPC would require that a Health and Safety Plan would be developed for the project.

The project key personnel and the survey personnel are shown on the Table 5.2 below.

Table 5.2 PPC Site and Survey Personnel

Name	Company	Position in the Company	Position in the Project	Survey personnel
N. Xatzitheodosiou	THEMELIODOMI SA	Projects Director	Project manager	THEMELIODOMI Project manager
N. Seremeta	THEMELIODOMI SA	H&S Officer	Safety Manager	Site coordinator
S. Papadopoulos	TECHNIKI ENOSIS SA	Civil Engineer/ Construction team	Site Manager	
A. Gogos	THEMELIODOMI SA	Electrical Engineer/ Construction team	Site Engineer & Safety Practitioner	Site coordinator assistant & Research Assistant
T. Gotzios	THEMELIODOMI SA	Foreman/ Construction team	Foreman	
G. Panopoulos	MANAGEMENT FORCE	Managing Director	Researcher	Researcher

5.4 Survey Results[5]

As referred in the subsection 5.3, the survey resulted in ten Cost Reports and thirteen Cost Analysis Reports. All Cost Reports resulted in an equivalent number of Cost Analysis Reports. Additional three Cost Analysis Reports resulted from my intervention. Some data was missed that cannot be estimated either in terms of the number of Cost Reports or their value.

For gathering the data the Cost Report was used, whilst for cost analysis the Cost Analysis Report was used. Each Cost Analysis Report is discussed briefly below.

5.4.1 COST ANALYSIS REPORT AHS-A-001/15.02.2000

It concerns an ACCIDENT where a welder irritated his eyes insisting to work without eye protection. The event occurred though the welder had been provided with appropriate eye protection. The event would have been avoided if the welder had been trained appropriately and/or the Contractor had imposed a strong supervision. The

[5] Figures may vary slightly from spreadsheet as they have been calculated manually before data entry into the spreadsheet, round up and adjustments (e.g. special signs mean value).

welder claimed that he believed eye protection was not necessary and irritation caused shortly after he started the work but he did not stop before the end of the day.

The contractor hired a replacement welder for the weekend to get the job finished by Monday morning to avoid delaying associated activities. The injured person took 10 (working) days off. The event resulted in a total 2,951.20 Euros loss plus an image cost at 1,000.00 Euros. (The basis for the calculation of image costs is given in Chapter Four, section 4.4).

5.4.2 COST ANALYSIS REPORT AHS-A-002/20.02.2000

It concerns PREVENTION COST and MANAGEMENT FAILURE WITH NO ACCIDENT spent for Personal Protective Equipment (PPE). The PPE was only used within the lifetime of the project, thus its full cost is allocated to this project. Some PPE was non-CE marked and discarded. Discarded PPE was in small quantities, about the 5% of the overall cost. Also same part of the CAR included safety signs with cost allocation respectively to the remaining duration of the project. The Prevention cost was 1,462.60 Euros, and the Management Failure with-no-Accident Cost was 45.00 Euros.

5.4.3 COST ANALYSIS REPORT AHS-A-003/10.07.2000

It concerns PREVENTION COST and MANAGEMENT FAILURE WITH NO ACCIDENT spent for Personal Protective Equipment (PPE). It also includes climbing safety equipment such as climbing helmets, knee protection etc, considered not necessary for operational reasons but for the safety of personnel, though ropes count as operational equipment, as the work could not be done without them.

A considerable amount of PPE, especially harnesses for those working in the elevating working platforms were non-CE marked and discarded. Removed PPE costs were about 70% of the prevention cost. Also same CAR included safety fire extinguishers with cost allocation to the remaining duration of the project. The Prevention cost was 1,327.9 Euros, and the Management Failure with-no-Accident Cost is 1,080.00 Euros.

5.4.4 COST ANALYSIS REPORT AHS-□-004/10.07.2000

It concerns an ACCIDENT, which occurred when a crane had finished work and was manoeuvring when an outrigger slipped out. The operator had forgotten to secure the outrigger before leaving. The outrigger hit a parked car, the car overturned and hit the electrical cable and damaged it resulting in a power cut. No one was hurt. This activity was not insured, as the mobile crane insurance did not cover damage within a construction site; only for traveling on public roads. The event resulted in an accident cost of 4,069.20 Euros and an image cost set at 900.00 Euros.

5.4.5 COST ANALYSIS REPORT AHS-A-005/10.07.2000

It concerns an ACCIDENT where a gunite mixer/pressure operator injured his eye, working without eye protection. Goggles were available. He was given five days off. The accident happened 15 minutes before the end of the shift. During his absence, he was replaced by a person not experienced in gunite operations. A reduction in 50% of normal production has been estimated according to the site survey report. The event resulted in an accident cost of 1,670.20 Euros, and an image cost of 1,000.00 Euros.

5.4.6 COST ANALYSIS REPORT AHS-A-006/15.07.2000

This is a MANAGEMENT FAILURE WITH NO ACCIDENT. MULCHEN, J/V's Subcontractor, used two elevating working platforms for the works. To ensure safety MULCHEN upon J/V instructions used an extra safety rope for each platform. That system operated from the beginning of the works to the day of the intervention, 15/7/2001. For this extra rope MULCHEN used an extra man. During my inspection I analysed the system proving that the extra rope was of no use at all. The safety system for the elevating platform had been designed by the platform provider and certified by third party inspection. The system was enough in case of emergency. The extra rope in fact would not be part of the system at all in an emergency. It would stay idle. The Management Failure with-no-Accident cost was 12,478.00 Euros. Also there was a saving due to my expert intervention of 21,837.00 Euros. The working platforms would be used for another 3.5 months.

5.4.7 COST ANALYSIS REPORT AHS-A-007/31.10.2000

This is a PREVENTION cost. A site Engineer had been nominated Safety Practitioner for the Project. This had been a parallel work to his main work as site engineer. He had been also nominated assistant site manager according to the contract requirements. The assumed time allocation as safety practitioner was a hour/day (his estimation). Thus the overall time he spent for safety was 410 hours. Additional time consumption for specific purposes is not included. The prevention cost was 4,797.00 Euros.

5.4.8 COST ANALYSIS REPORT AHS-A-008/31.10.2000

This is a PREVENTION cost. The THEMELIODOMI SA Head Office Safety Officer conducted some safety inspections throughout the project. Some of them were combined with the ones performed for the survey programme. Thus we consider only the independent ones, three in total.

A total of three days spent is estimated including travelling to and from Thessaloniki (500 Km in total). For the HO site visits, the Safety Practitioner had to make himself available three hours per visit, on average. Thus in total nine man-hours safety Practitioner was counted. Prevention cost is 496.5 Euros. (Travel expenses have not been included.)

5.4.9 COST ANALYSIS REPORT AHS-A-009/31.10.2000

This is PREVENTION cost. The Head Office Safety Officer prepared a Health and Safety Plan. The time spent was 40 hours. Also it required a spend of 1hour of project manager and 8 hours of site safety practitioner. The prevention cost was 794.20Euros.

5.4.10 COST ANALYSIS REPORT AHS-A-010/31.10.2000

This is a PREVENTION cost. Safety meetings took place during the HO safety Officer's site visits. HO Safety Officer meetings time and Safety Practitioner meetings time have been counted in CAR AHS-A008. Total involvement for the Project Manager was three hours and the same for the Site Manager. All costs were allocated to this project. The Prevention cost was 114.90 Euros.

5.4.11 COST ANALYSIS REPORT AHS-A-011/31.10.2000

This is a PREVENTION cost. All four elevating platforms were inspected and certified by a third party body (TUV HELLAS Ltd). Though certification lasted for 12 months and the certification effective day was 5/2/2001 the certification cost was allocated entirely to the project. Disassembling and assembling elsewhere would require re-inspection and the issue of a new certificate. The prevention cost was 1,800.00 Euros.

5.4.12 COST ANALYSIS REPORT AHS-A-012/31.10.2000

This is PREVENTION cost. For the works in tower no 3 a scaffold was erected in a parabolic shape. The scaffold was necessary for the job, extended water-blasting works and thus the scaffold itself was not considered as safety cost, though the safety features such as the handrail and the middle rail were considered as prevention costs. The materials cost was allocated according to the scaffold's presence on site, namely six months, compared with the estimated lifetime of the materials of three years. The labour cost for erecting and dismantling the safety components of the scaffold were allocated as prevention cost safety according to the Spreadsheet formula. (It was not of course necessary to know the total cost of the scaffold). The prevention cost was 2,712.50 Euros.

5.4.13 COST ANALYSIS REPORT AHS-A-013/31.10.2000

This is a PREVENTION cost. J/V has appointed MANAGEMENT FORCE a safety consultancy contract for mainly contractual safety matters. That was a lump sum contract for the whole project period of a value of 1,680.00 Euros.

5.5 Safety Audits

As discussed in Chapter Four and earlier in this chapter during my first visit on site the following question had to be answered. Could accidents happen despite safety expenditure, or could accidents 'not happen' even with no prevention spend?

I needed a means to secure the survey from misleading results and conclusions. The most appropriate method was to conduct safety audit. I am experienced with safety audit method "+2/-2" which I developed and used from 1996. The "+2/-2" method would provide a rather qualitative approach, but this I judged as sufficient.

The Safety Performance Indicator (SPI) was then introduced giving an indicator of the safety performance. No weighting factors were used to avoid complexity that the Greek construction industry cannot support (refer for Greek Industry weaknesses in safety to Chapter 3).

I conducted two safety audits and the SPI was measured at 9 and 17 respectively, see Table 5.3. The SPIs were good for Greek sites, from my experience. The project required work in heights; around 100 meters (highest cooling tower is 106 meters and works had to performed on the top ring in all four of them); J/V's strong safety philosophy and PPC strong supervision as well as contractual provisions were the main reasons. The workforce in electromechanical projects is more safety-aware than the workforces in the building industry or in the building of roads. My Internal Supervisor, Prof R.T. Booth with substantial experience of the refurbishment of blast furnaces and related plant, considered that the site safety standards were on a par with his experience in Great Britain. His views were of course based on only two days on site.

Table 5.3 Safety Performance Audit findings

No	Question	AHS-Aud-1	AHS-Aud-2
1	Competent Safety practitioner	0	0
2	HSP	-1	-1
3	Safety responsibilities allocated	-1	-1
4	Safety meetings	0	0
5	Safety training on site	-1	-1
6	Certified lifting appliances	2	2
7	All equipment CE marked	2	2
8	All vessels certified	2	2
9	All operators licensed	2	2
10	All site equipment licensed	2	2
11	Approved type scaffold	2	2
12	All PPE CE marked	-2	2
13	Approved type ladders	2	2
14	Proper signage	-1	0
15	Site organisation for hygiene, fencing, entrance control, sanitary, first aids, fire safety, emergencies	-2	-1

No	Question	AHS-Aud-1	AHS-Aud-2
16	Equipment maintenance	1	1
17	Lifting appliances inspections	2	2
18	Trench inspections	0	0
19	Scaffold inspections	0	0
20	Electrical inspections	0	0
21	Wear helmet and safety shoes	-2	-1
22	Wear other appropriate PPE as required	-2	-1
23	Use only approved type equipment	1	1
24	Use/operate only if authorised	2	2
25	All access and egress are safe	1	1
	Total	**09**	**17**

5.6 Cost Analysis

Table 5.4, below, summarises the safety cost per category and subcategory. The full Cost Analysis Report Presentation Table in Appendix 5 gives an analytical overview of all costs incurred in the Pilot per unit cost and per Cost Analysis Report.

Table 5.4 also gives the percentage in each category against the total safety cost and the project budget. It also gives the percentage of each subcategory against the total of the category it belongs to. Figure 5.1 gives an overview of the safety cost distribution in percentages of the project budget and the overall safety cost.

Table 5.4 PPC case - Safety Cost summary

PILOT STUDY COST SHEET	(PPC)		
COSTS CATEGORY/SUBCATEGORY	COST □	CATEGORY %	BUDGET %
BUDGET	**2,330,565.00**		
PREVENTION	15,186.70	37.61	0.65
MFWNA	13,603.40	33.69	0.58
ACCIDENT	8,691.00	21.52	0.37
IMAGE	2,900,00	7.18	0.12
TOTAL SAFETY COST	40,381.00.10	100.00	**1.73**
PREVENTION COST		**SUBCATEG. %**	**SAFETY COST %**
SMS DOCUMENTATION	794.20	5.41	1.99
STAFFING (SAFETY ORGANISATION)	4,797.00	32.69	12.03
MEETINGS	612.30	4.17	1.54
SAFETY STUDIES	0.00	0.00	0.00
TRAINING	0.00	0.00	0.00
PPE	2,164.70	14.26	4.14

EXTERNAL SERVICES	1,680.00	11.45	4.21
SAFETY EQUIPMENT & SIGNS	5,110.00	34.82	12.82
EMERGENCY	0.00	0.00	0.00
FIRE SAFETY	28.50	0.19	0.07
MEDICAL SURVEILLANCE	0.00	0.00	0.00
AGENTS MONITORING	0.00	0.00	0.00
OTHER	0.00	0.00	0.00
MFWNAC			
PENALTIES AND FINES	0.00	0.00	0.00
COURT CASE	0.00	0.00	0.00
IDLENESS	0.00	0.00	0.00
FALSE MATERIALS EQUIPMENT & LABOUR	1,125.00	8.27	2.82
INTERVENTION	12,478.40	91.73	31.30
OTHER	0.00	0.00	0.00
ACCIDENT COST			
IDLENESS	937.50	10.79	2.35
FIRST AID TREATMENT	0.00	0.00	0.00
ADMINISTRATION	116.00	1.33	0.29
HOSPITAL TREATMENT	77.20	0.89	0.19
PRODUCTION LOSS	1,109.80	12.77	2.78
COMPENSATION	2,672.40	30.75	6.70
RECRUITMENT	764.00	8.79	1.92
COURT CASE	0.00	0.00	0.00
DAMAGES & LOSSES	3,014.00	34.68	7.56
PENALTIES AND FINES	0.00	0.00	0.00
IMAGE COST			
INJURY	2,000.00	68.97	5.02
DAMAGES	900.00	31.03	2.26
FAILURE TO COMPLY	0.00	0.00	0.00

The overall cost of safety is spread into 18 subcategories with the top-five, intervention, safety equipment, staffing, damages and injuries accounting for the 69,52% of it and half of them (nine out of 18) for the 86.78%. Cumulative percentages and safety cost distribution by magnitude are shown in Figure 5.2.

The project was very 'unlucky' with intervention costs accounting for 30.90% of the overall safety cost. Intervention costs are twice as accident costs and almost as high as the prevention cost. Contractor's inappropriate high safety concerns lead to the intervention cost.

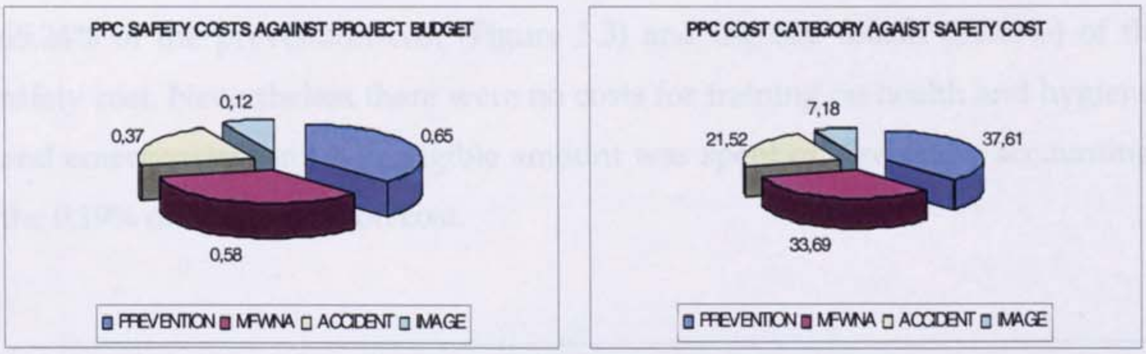

Figure 5.1. PPC safety cost distribution in percentages

The image cost though it is not very much as a percentage of the project budget, counting only for the 0.12%, costs as much as the PPE, safety meetings and the SMS documentation together and it is as much as about the one fifth (19%) of the whole prevention cost. Figure 5.2 gives an overview of the costs by magnitude and cumulative percentages of the cost of safety subcategories.

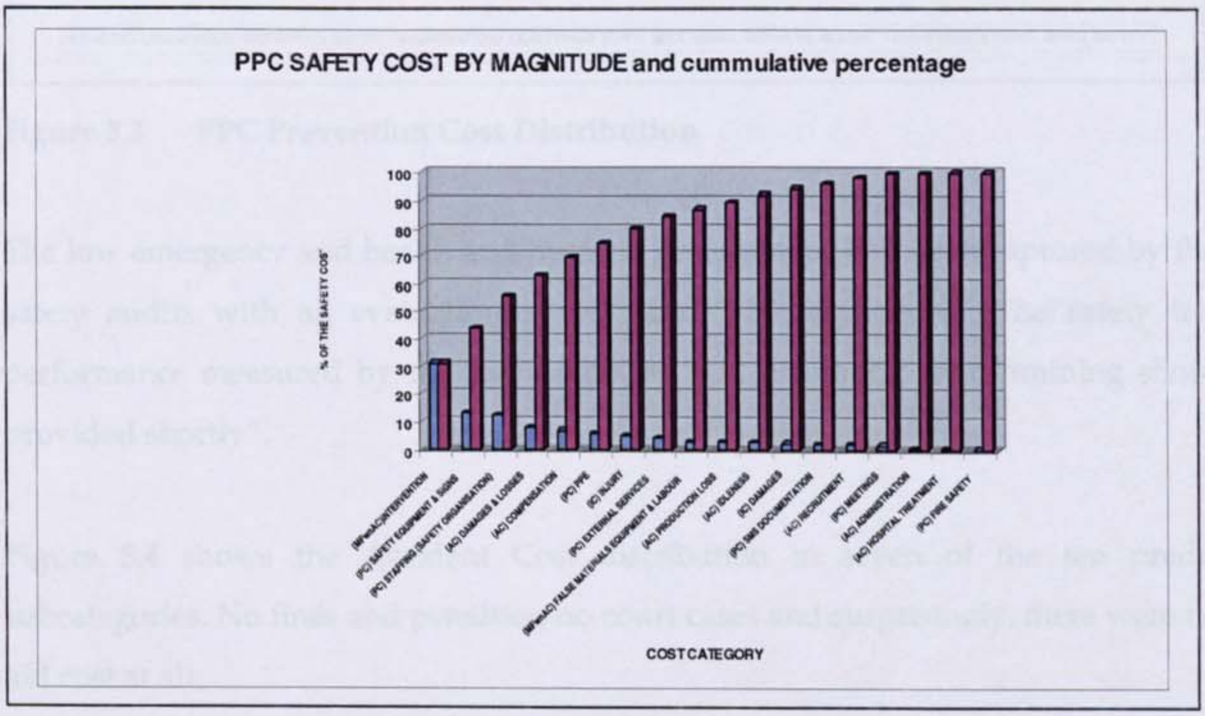

Figure 5.2 Safety cost distribution by magnitude and cumulatively

The prevention cost is not satisfactorily distributed amongst all predefined prevention cost subcategories with money allocated only to seven out the 12 predefined subcategories. Staffing and safety equipment dominate this category, accounting for 65.24% of the prevention cost (Figure 5.3) and the one fourth (24.53%) of the overall safety cost. Nevertheless there were no costs for training on health and hygiene matters, and emergencies, and a negligible amount was spent on fire safety accounting only for the 0.19% of the prevention cost.

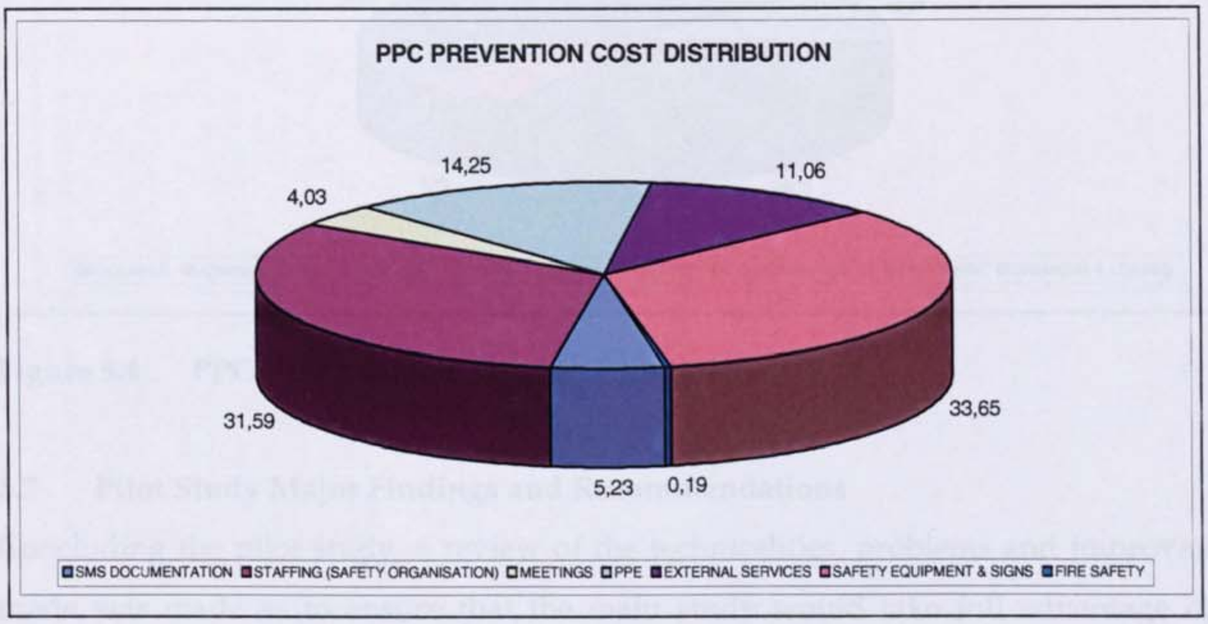

Figure 5.3 PPC Prevention Cost Distribution

The low emergency and health and hygiene performance had been captured by the two safety audits with an evaluation at "-2" and "-1" respectively. The safety training performance measured by the two audits at "–1" indicating that "training should be provided shortly".

Figure 5.4 shows the Accident Cost distribution in seven of the ten predefined subcategories. No fines and penalties, no court cases and surprisingly, there were no first aid cost at all.

The image cost has been calculated at €2,900.00 counting for the 7.18% of the safety cost and 0.12% of the project budget. The image cost imposed by the two over 3-days absence cases and the crane incident with low (between €1,000.00 and €10,000.00) damages. Neither accident in fact leads to a prosecution.

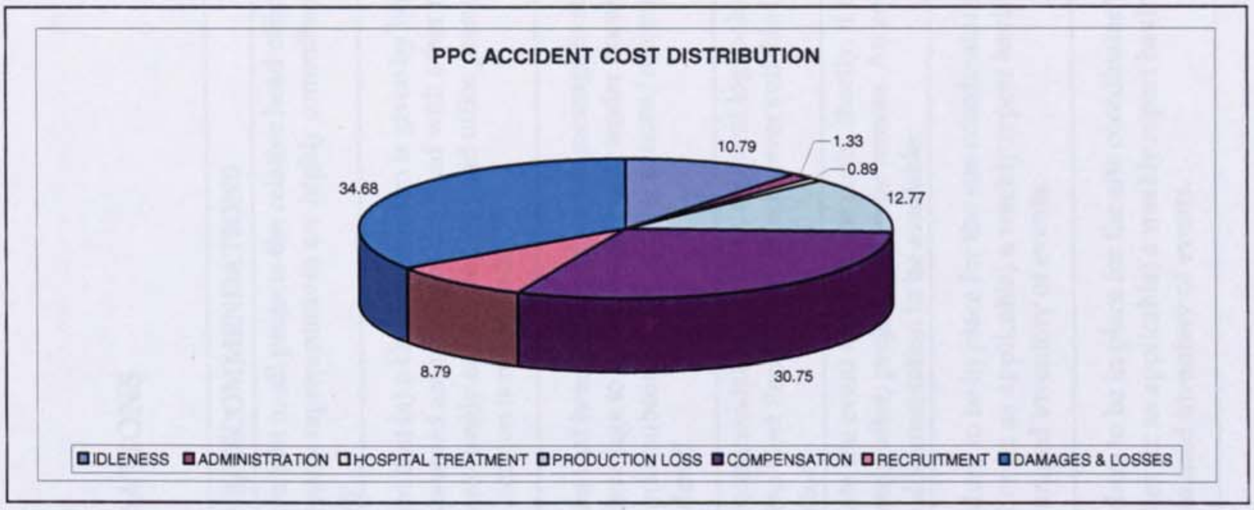

Figure 5.4 PPC-case Accident Cost distribution

5.7 Pilot Study Major Findings and Recommendations

Concluding the pilot study, a review of the technicalities, problems and improvements made was made as to ensure that the main study would take full advantage of this experience. The Table 5.5 below summarises the critical findings and recommendations of the pilot study.

Table 5.5 PPC PILOT STUDY SUMMARY OF ISSUES AND RECOMMENDATIONS

ISSUE	COMMENTS	ACTIONS/RECOMMENDATIONS
HEAD OFFICE PEOPLE COMMITMENT	VERY HIGH	Make sure that in all projects the relative head office personnel and company representatives are highly committed to the survey and safety
SITE OFFICE PEOPLE COMMITMENT	MODERATE AND LOWER	Make sure that (a) a clear instruction is given by head office, (b) people involved are not up to the head with other responsibilities, (c) they are closely moderated by head office personnel, (d) projects location is not remote.
SUBCONTRACTORS COMMITMENT	VERY HIGH	Make sure that head office passes the message to subcontractors; if at tender stage to be included in the tender documents. Subject to the works subcontracted, similar actions/recommendations to be considered.
DATA COLLECTION GENERAL	VARIES FROM 100% ON MAJOR EVENTS TO VERY LOW ON MINOR ONES	Apart recommendations bellow, an event logbook to be utilised instead the Cost Report or both whatever suitable for the site coordinator.
DATA COLLECTION FOR MAJOR EVENTS	100%	Investigate the event and analyse costs, shortly, if not immediately after; projects not to be remote. An access to all relevant documentation to be available.
DATA COLLECTION FOR MODERATE EVENTS	REASONABLY SATISFACTORY	A procedure to be in place for the site coordinator to send to the Researcher (cc as applicable) a weekly report having answered a predetermined inventory of events.
DATA COLLECTION FOR MINOR EVENTS	LOW	A procedure to be in place for the site coordinator to send to the Researcher (cc as applicable) a weekly report having answered a predetermined inventory of events.

ISSUE	COMMENTS	ACTIONS/RECOMMENDATIONS
QUALITY OF DATA	REASONABLY SATISFACTORY	Investigate the event and analyse costs, shortly, if not immediately after; projects not to be remote. An access to all relevant documentation to be available.
COSTS SHALL BE CALCULATED ON THE NET WAGES INCLUDING TAXATION AND INSURANSE, THUS TOTAL COST TO THE COMPANY AND NO PROFIT SHALL BE CONSIDERED	Various countries (even amongst those of the EU member states) follow different accounting and taxation systems. More over the Greek taxation system is under review.	Costs shall be calculated on the basis of pay roll
SENSITIVITY ANALYSIS	Most data lost concerns events with minor cost comparatively to the costs of the events identified, though amount of data missed is not identifiable but could be extrapolated either by the level of safety measured by auditing the project or relevant studies	A procedure to be in place for the site coordinator to send to the Researcher a weekly report having answered a predetermined inventory of events.
LEVEL OF SAFETY - SAFETY AUDITS	SAFETY AUDITS HELP. As a matter of pure chance a site performing a poor safety level might have no major accidents. Simultaneously it is impossible to report all minor events.	Safety audits should monitor safety level, thus potential accident costs.

Chapter Six

MAIN STUDY 1 - ECO REFINERY

6.1 Introduction

The ECO-case is the first of the two main study projects. It started in May 2001 and was completed in the following December. The ECO-case costing survey covered all the project duration (as was the case with the pilot study).

The project involves an office-building contract in a refinery process (ECO) plant in Thessaloniki. The principal contractor was THEMELIODOMI SA.

As a building project, it used a low-skilled and inexperienced workforce (MRB 2003) in contrast with to pilot study project, and in comparison with construction workers generally. The project itself was not risky: no significant work at heights, heavy equipment, shafts, atriums and other openings.

6.2 Summary of the ECO project

ECO SA is a subsidiary of HELLENIC PETROLEUM SA. ECO SA, the commercial branch of the HELLENIC PETROLEUM SA, had recently merged with MAMIDAKIS OIL SA, another oil company. Amongst the improvements in the MAMIDAKIS OIL SA premises were to renovate and extend the existing office building, to set up a medium voltage (20KV) transformer and to do landscape work around the office building. It was a civil engineering project with very little electro-mechanical work. As with most civil work and especially building work, so with this project all work was subcontracted.

THEMELIODOMI SA had been awarded the nine-month contract after bidding one million Euros for the work, thus an average 110,000 Euros per month. Technically the project presented no difficulties. Consequently 110,000 Euros works per month could easily be achieved at a low/not fixed production rate. Subcontractors did the work at their own pace, though following generally the overall time schedule. Generally, building subcontractors in small projects do not guarantee a standard daily (or weekly) production. Their personnel vary in persons and numbers from day to day. ECO case was not an exception to this rule and site was finally audited only once.

The project is representative of small size building projects, though this is not a typical Greek building project (e.g., private housing, offices) as it was supervised by a well-experienced company (ASPROFOS SA, an engineering company, with great experience), on behalf of the owner. ECO SA is known for strict and demanding supervision. Though the site was within the oil premises it was physically isolated and fenced properly to avoid any interference. This project presented no risk to the other ECO SA activities on the site.

THEMELIODOMI SA appointed the same head office team, Mr Hatzithodosiou as Project Manager and Mrs Seremeta as Research Assistant. On site, THEMELIODOMI SA appointed Mr Konstantinidis, as site engineer, and research site coordinator. Mr Konstantinidis undertook also the role of the Site Safety Practitioner. As a site engineer he was on site on all working days.

A meeting took place before commencing research work on site with Mrs Seremeta Mr Konstantinidis, the site manager and myself. I explained to them, and particularly to Mr Konstantinidis, that their role was crucial for the research and having in mind the failure with Kalahari I put all my efforts to ensure that the people felt comfortable with their roles. Mr Hatzitheodosiou gave instructions to Mr Konstantinidis himself.

Mr. Konstantinidis, being present at all times on site was able to ensure good data generation and good data flow, though being overloaded (a) he could not always complete weekly reports and (b) might have lost some interested data. But Mr. Konstantinidis implemented a monitoring system by writing up a report straight after an incident had occurred.

THEMELIODOMI SA Head Office is located within half an hour's drive from the site. Mrs Seremata, as safety practitioner for other THEMELIODOMI SA projects in ECO visited the site frequently. In total I visited the site twice, Mrs Seremata visited the site nine times.

In respect now to the eight questions rose after the Kalohari project (initial pilot study) experience the answers are listed in Table 6.1 below.

Table 6.1 Shore Protection and ECO-Case Project Comparisons

	Shore Protection	ECO SA CASE Main study 1
1	The Owner of the Project is the Prefecture of Thessaloniki. Prefecture of Thessaloniki (as most if not all) is understaffed with major difficulties in supervising and monitoring construction projects.	The Owner of the Project is ECO SA, with a very good reputation in safety and strong supervision. The project was supervised in daily basis by two nominated supervisors (with other responsibilities as well).
2	The site leader was a foreman, whilst the nominated site manager was not present in a daily basis.	The site organisation consisting of the site manager and the site engineer. Nevertheless the site was supported by THEMELIODOMI SA organization in ECO SA, a full-staffed site team. A safety practitioner had been appointed.
3	No safety responsibilities had been allocated and no safety personnel had been nominated.	A safety practitioner had been appointed. Safety responsibilities had been allocated to subcontractors and the safety practitioner had provided them with safety training.
4	The scope of work extended during the project and it was expected to be extended further (more length of protected shore). The project life in uncertainty.	The scope of work was clearly defined in the contractual documents.
5	Financing of the project not guaranteed by the Prefecture of Thessaloniki, at the beginning of the project.	No financing problems at all.
6	No guaranteed progress. Periods of idleness.	An agreed time schedule was a binding document, though subcontractors worked at their own pace within time schedule boundaries.
7	Safety culture and experience of personnel in the project would not assist them to generate a reliable and considerable flow of data.	The safety culture of the environment, an ECO SA site, as well as that of the site key personnel was relatively (to the Greek standards) satisfactory. Pure safety culture of building subcontractors.
8	No safety logbook was maintained on site.	A safety log book, a safety Practitioner recommendations book and accidents book were maintained on site.
		Additionally, ECO SA would require that a Health and Safety Plan would be developed for the project.

The answers provided are generally satisfactory. But, we had still to cope with some problems, mainly concerning the behavior of subcontractors'.

The scope of work covered:

- Demolition of non structural elements of the existing building;
- Reinforcement of the existing building;
- Electrical and mechanical works for the existing building and the new building;
- Aluminum works (windows, external doors) for the existing building and the new building;
- Wood work (internal doors) for the existing building and the new building;
- Flooring for the existing building and the new building;
- False ceiling, walls/separations, floors for the existing building and the new building;
- Painting works for the existing building and the new building;
- Finishing works for the existing building and the new building;
- Excavations for the extension building (new building);
- Concrete works for the new building;
- Construction of the substation (transformer) building;
- Installing the transformer;
- Landscape works;
- Commissioning.

The contract was signed in May 2001, construction started in June 2001 and completed in December 2001, according to the approve time schedule.

The project key personnel and the survey personnel are shown in the table below.

Table 6.2 ECO Site and Survey Personnel

Name	Company	Position in the Company	Position in the Project	Survey personnel
N. Xatzitheodosiou	THEMELIODOMI	Construction Director	Project manager	THEMELIODOMI Project manager
N. Seremeta	THEMELIODOMI	H&S Officer	HO Safety Officer	Research assistant
N. Vouli	THEMELIODOMI	Civil Engineer	Site Manager	
Konstantinidis	THEMELIODOMI	Civil Engineer	Site Engineer & Safety Practitioner	Site coordinator
THEMELIODOMI SA ECO TEAM	THEMELIODOMI	Construction team	Engineers and admin	
G. Panopoulos	Management Force	Director	Researcher	Researcher

The Researcher carried out site training on site in April 2001 before the project started. The main topics of the training included:

- What this survey is for;
- Benefits from the survey;
- Requirements for data and quality of data;
- Techniques to help getting the information.

In this training all site key personnel participated. Refresher training was given to the Site Coordinator in June 2001.

6.3 Survey Results[6]

For gathering data a report was generated by the research assistant at her convenience. The Cost Report was not used (as decided when the pilot study was concluded). For cost data collection and analysis the Cost Analysis Report was used. Cost Analysis Reports are annexed to this work (appendix 6). Costs are discussed briefly below.

6.3.1 COST ANALYSIS REPORT EEL-A-001/4-5-2001

It concerns a MANAGEMENT FAILURE WITH NO ACCIDENT: money spent for improper signage. The Safety Practitioner produced paper safety signs printed out from his computer. Signs did not comply in size and colour with standards. This within ECO SA site was taken as management failure with no accident cost, including an image cost. The Supervising Engineer made a specific entry in the Safety Log Book on 15/6/2001. Management Failure with-no-Accident Cost was 222.20□. The Image cost was 300.00 □.

6.3.2 COST ANALYSIS REPORT EEL-A-002/5-5-2001

It concerns a PREVENTION COST for fencing the site. We assumed that both steel bars and plastic warning net would not be used (no remaining value) in another project. The Prevention cost was 104.00 Euros.

[6] Figures may vary slightly from spreadsheet as they have been calculated manually before data entry into the spreadsheet, round up and adjustments (e.g. special signs mean value).

6.3.3 *COST ANALYSIS REPORT EEL-A-003/22.05.2001*

It concerns a PREVENTION COST for preventing welding activities from rain. The Prevention cost was 234.20 Euros.

6.3.4 *COST ANALYSIS REPORT EEL-A-004/22-5-2001*

It concerns a PREVENTION COST for managing traffic at the nearby junction in order to allow long trucks transporting to the site the steel bars to manoeuvre safely. The Prevention cost was 236.80 Euros.

6.3.5 *COST ANALYSIS REPORT EEL-A-005/27-5-2000*

It concerns a PREVENTION COST for protecting cabling by hanging them up around the site instead of leaving them on the ground. The Prevention cost was 16.30 Euros.

6.3.6 *COST ANALYSIS REPORT EEL-A-006/29-5-2001*

This is a MANAGEMENT FAILURE WITH NO ACCIDENT and PREVENTION COST. The steel bar shop is next to the main road. To fence it the contractor set up a plastic net. For this there is a specific entry in the Safety Log Book on 1/6/2001 as a notification by the Supervising Engineer. An image cost is also encountered. Also the contractor put up four proper traffic signs. Traffic signs are considered to be prevention costs. Traffic signs were transferred from another site and are expected to be used in a further site after the steel bar shop closes. Management Failure with-no-Accident Cost was 43.60 Euros. The Prevention cost was 131.60 Euros. The Image cost was 300.00 Euros.

6.3.7 *COST ANALYSIS REPORT EEL-A-007/29-5-2001*

This is a MANAGEMENT FAILURE WITH NO ACCIDENT. For lighting the steel yard a spot was installed. This was annoying the oncoming traffic and did not provide adequate lighting for the shop area. The Management Failure with no Accident cost was 128.60 Euros.

6.3.8 COST ANALYSIS REPORT EEL-A-008/19-6-2001

This is a PREVENTION cost. A first aid station was set up. One could claim that there was a (a) management failure with no accident cost because the first aid station was not set up from the very beginning and thus the cost is covering only the about 7/9 of the project and (b) an image cost (again management failure with no accident cost) because the site did not have a first aid station for about two months. The counter-argument is that the THEMELIODOMI SA site office in ECO SA would have supported any first aid case and also before end of June there was not much activity on site. The Prevention cost was 115.60Euros.

6.3.9 COST ANALYSIS REPORT EEL-A-009/19-6-2001

This is an ACCIDENT. A window was broken. The Workforce stopped working for a quarter of an hour as the site was cleaned up and a contractor provided and replaced the window. Nobody was hurt. An image cost was also encountered. The Accident cost was 133.60 Euros.

6.3.10 COST ANALYSIS REPORT EEL-A-010/18-7-2001

This is ACCIDENT. A water supply pipe (2.5") was damaged. THEMELIODOMI SA rectified the water supply pipe. The Water Company did not interfere nor charge anything to THEMELIODOMI SA. A plumber from the market was hired to fix it. The Piling team idle time was only about 40 minutes despite it taking three hours to rectify the damage. The Accident cost was 256.00 Euros.

6.3.11 COST ANALYSIS REPORT EEL-A-011/19-7-2001

This is PREVENTION cost. For piling works, betonite had been used. To clean up the site from betonite a team was set up. The betonite was disposed as per local authorities instructions. This was picked up from a safety practitioner's entry to the Safety Log Book. The Prevention cost was 66.50 Euros.

6.3.12 COST ANALYSIS REPORT EEL-A-012/2-8-2001

The Safety Practitioner produced paper safety signs printed out from his computer. Signs did not comply in size and with standards. This within ECO SA site was seen as a management failure with no accident cost, including an image cost to others (ECO SA). This was the second time this had happened (see 6.3.1), and no further image cost was included. The Management Failure with-no-Accident Cost was 87.70 Euros.

6.3.13 COST ANALYSIS REPORT EEL-A-013/9-8-2001

This is a PREVENTION cost. THEMELIODOMI SA safety practitioner trained subcontractors' safety personnel and provided them with safety notes including relevant parts of the Health and Safety Plan. An entry has been made to Safety Log Book on 26-6-2001. The training cost was fully allocated to this project as it was held in the early stages of the work. The Prevention cost was 226.10 Euros.

6.3.14 COST ANALYSIS REPORT EEL-A-014/9-8-2001

This is a PREVENTION cost. THEMELIODOMI SA safety practitioner trained the THEMELIODOMI SA personnel in PPE. The PPE safety notes were developed exclusively for this project. Also personnel time was counted. An entry was been made in the Safety Log Book on 26-6-2001. The Training cost was fully allocated to this project as it was held in the early stages of the work. The Prevention cost was 195.00 Euros.

6.3.15 COST ANALYSIS REPORT EEL-A-015/9-8-2001

This is an ACCIDENT cost. In total six accidents with minor injury occurred resulting in first aids on site with return to work immediately afterwards. No image cost was considered. The Accident cost was 110.00 Euros.

6.3.16 COST ANALYSIS REPORT EEL-A-016/9-8-2001

This is a PREVENTION cost. THEMELIODOMI SA safety practitioner trained the THEMELIODOMI SA personnel in first aid, following six first aid accidents in June. An entry was been made to Safety Log Book on 6-7-2001. Training material was produced only for this training. The Training cost was fully allocated to this project as it was held in the early stages of the work. The Prevention cost was 107.50 Euros.

6.3.17 COST ANALYSIS REPORT EEL-A-017/9-8-2001

This is a MANAGEMENT FAILURE WITH NO ACCIDENT COST and a PREVENTION COST. No storage area had been designated on site. Thus all stored materials had to be relocated and the area cleaned up. The Management Failure with no Accident cost was 181.20 Euros. The prevention cost was 62.30 Euros.

6.3.18 COST ANALYSIS REPORT EEL-A-018/9-8-2001

This is a PREVENTION cost. Barricade the openings at the transformer-building terrace barricaded after formwork removal. The safety practitioner had made an entry in the Safety Log Book on 10-7-2001. The barricade consisted of wooden materials and warning tape. The Prevention cost was 132.00 Euros.

6.3.19 COST ANALYSIS REPORT EEL-A-019/12-8-2001

This is a PREVENTION cost. The Safety Practitioner produced paper safety signs printed out from his computer and posted them. The signs were better than before and almost complied with the applicable standards (failing only to be the exact size). The Prevention cost was 180.80 Euros.

6.3.20 COST ANALYSIS REPORT EEL-A-020/23-8-2001

This is a PREVENTION cost. Cleaning the site from debris, chopped parts, paper packs etc. The Prevention cost was 111.70 Euros.

6.3.21 COST ANALYSIS REPORT EEL-A-021/23-8-2001

This is a PREVENTION cost. Site fencing was damaged and thus it had to be improved. The initially installed fencing cannot be assumed a management failure with no accident as the fence was found damaged four months later. This kind of improvement is considered acceptable. So this is prevention cost and fully allocated to this project. The Prevention cost was 42.00 Euros.

6.3.22 COST ANALYSIS REPORT EEL-A-022/28-8-2001

This is an ACCIDENT. In total nine accidents with minor injuries occurred in July 2001 resulting in first aid on site and return to work immediately after. The Accident cost was 100.4 Euros and the Image cost was 200.00 Euros.

6.3.23 COST ANALYSIS REPORT EEL-A-023/23-8-2001

This is a MANAGEMENT FAILURE WITH NO ACCIDENT cost. For barricading openings and edges at the main building terrace after removing form work and before bricklaying work, plastic nets and warning tape (nine metres high) were employed, instead of proper barricading as with the transformer building (see paragraph 6.3.18). This is for signing/warning but not for protection. An Image cost was also encountered as there was a double entry in the Safety Log Book from the Supervising Engineer on the 10th and the 18th of August 2001. Management Failure with no Accident cost was 91.00 Euros, and the Image cost was 300.00 Euros.

6.3.24 COST ANALYSIS REPORT EEL-A-024/23-8-2001

This is a PREVENTION cost. This was for replacing the inadequate barriers referred to in 6.3.23. The Prevention cost was 793.40 Euros.

6.3.25 COST ANALYSIS REPORT EEL-A-025/7-9-2001

This is ACCIDENT. In total six accidents with minor injuries occurred in August 2001 resulting in first aid on site and return to work immediately after. The Accident cost was 62.00 Euros and the Image cost was 200.00 Euros.

6.3.26 COST ANALYSIS REPORT EEL-A-026/17-9-2001

This is a PREVENTION cost. Four new pairs of safety shoes were issued to the THEMELIODOMI SA personnel. Thus personnel were provided with safety shoes for all nine months (safety shoes are supposed to last six months before replacement). The Prevention cost was 105.60 Euros.

6.3.27 COST ANALYSIS REPORT EEL-A-027/7-9-2001

This is a PREVENTION cost. After a safety inspection of scaffolding by the company safety practitioner, additional elements were installed for (a) support and (b) protection from falls. The Scaffold is operational equipment in this project and is used to do the work, though partially it is used to do the work safely. This will be analysed separately at the end of the project. The additional work for support and protection is a safety (prevention) cost. The Prevention cost was 228.80 Euros.

6.3.28 COST ANALYSIS REPORT EEL-A-028/10-10-2001

This is a PREVENTION cost. Barricading was fitted to the external staircase. Proper barricading for protection from falls from heights was also installed along the external staircase. The Prevention cost was 308.00 Euros.

6.3.29 COST ANALYSIS REPORT EEL-A-029/10-10-2001

This is an ACCIDENT cost. In total five accidents with minor injury occurred in September 2001 resulting in first aid on site and return to work immediately after. The Accident cost was 95.40 Euros and the Image was 200.00 Euros.

6.3.30 COST ANALYSIS REPORT EEL-A-030/10-10-2001

This is a MANAGEMENT FAILURE WITH NO ACCIDENT cost. The Safety Practitioner produced paper safety signs printed from his computer. The Signs did not comply in size or colour with standards. This within ECO SA site was considered a management failure with no accident cost. It does not include an image cost as no notification was issued (See EEL-A-001 and specific entry in the Safety Log Book on 15/6/2001). The Management Failure with no Accident cost was 93.50 Euros.

6.3.31 COST ANALYSIS REPORT EEL-A-031/30-10-2001

This is a PREVENTION cost. Replacement safety helmets and gloves for the THEMELIODOMI SA personnel. Thus helmets and gloves were available for the whole project period. Personnel had been provided with gloves and helmets from the available in stock. The Prevention cost was 72.30 Euros.

6.3.32 COST ANALYSIS REPORT EEL-A-032/12-11-2001

This is an ACCIDENT cost. A man was injured in his eye. He was taken to hospital for medical treatment. He left hospital a few hours later. The Accident cost was 687.50 Euros and the Image cost was 200.00 Euros.

6.3.33 COST ANALYSIS REPORT EEL-A-033/22-12-2001

This is a MANAGEMENT FAILURE WITH NO ACCIDENT cost and a PREVENTION cost. The cable duct was barricaded ensuring safe passage and lighting was installed. The work was just for this project. Thus this is prevention for the remaining 15 days and management failure for the previous 255days. The Prevention cost was 7.50 Euros, and the Management Failure with no Accident cost was 112.50 Euros.

6.3.34 COST ANALYSIS REPORT EEL-A-034/22-12-2001

This is an ACCIDENT cost. In total nine accidents with minor injuries occurred in November 2001 resulting in first aid on site and return to work immediately after. (Note that in some months no minor injuries were reported.) The accident cost was 137.60 Euros with an Image cost of 200.00 Euros.

6.3.35 COST ANALYSIS REPORT EEL-A-035/30-12-2001

This is a PREVENTION cost. THEMELIODOMI SA appointed a safety practitioner for this project as per the minimum legal requirements, namely two hours per month. Additional safety activities (e.g., for training, signage have been listed separately). The Prevention cost was 339.30 Euros.

6.3.36 COST ANALYSIS REPORT EEL-A-036/30-12-2001

This is a PREVENTION cost. THEMELIODOMI SA HO Safety Officer visited/inspected the site for the purpose of Company Safety Programme four times and spent in total 13 hours, including driving to and from the site. This time is allocated to the project cost as had to do with project safety issues. Her work is counted as prevention cost for the project. The Site practitioner had to allocate an equal time (as minimum to that one encountered to safety Officer). The Prevention cost was 333.80 Euros

6.3.37 COST ANALYSIS REPORT EEL-A-037/30-12-2001

This is a PREVENTION cost. A health and Safety Plan was produced for the project by the HO officer and reviewed by the Safety Practitioner. During construction period the safety practitioner revised that accordingly. The time of the safety practitioner has been recorded by EEL-A-035. Only HO work is accounted for here. The Prevention cost was 382.80 Euros.

6.3.38 COST ANALYSIS REPORT EEL-A-038/22-12-2001

This is a PREVENTION cost. For work on the external face of the building subcontractors erected scaffolds (and charged accordingly the company). Scaffolds erected to (a) do the job, e.g., painting and (b) to do the job safely, e.g., form work of the corner columns and the long outside columns. Also scaffolds were erected inside the building for operational purposes. Only the cost for scaffolds used for working at the outside of the corner columns (form work, insulate outside columns) is considered as prevention cost. The Prevention cost was 756.00 Euros.

6.4 SAFETY AUDITS

As decided in the pilot study, the project had to be audited. As most of the works here were civil work and were subcontracted, they were progressed at the subcontractors pace. Although, the intention was to audit the project twice, I achieved only one audit. (On two other occasions I visited the site when virtually no work was going on.)

The SPI in this project was measured at three (3) corresponding to moderate/moderate likelihood/severity for potential accidents.

Table 6.3 illustrates the safety performance measured at the only audit.

6.5 Cost Analysis

Table 6.4, summarises the safety cost per category and subcategory. The full Cost Analysis Report Presentation Table in Appendix 6 gives an analytical overview of all costs incurred in the ECO project survey.

Table 6.4 gives the percentage in each category against the total safety cost and the project budget. It also gives the percentage of each subcategory against the total of the category it belongs to. Figure 6.1 gives an overview of the safety cost distribution in percentages of the project budget and the overall safety cost.

Table 6.3 ECO-case Safety Audit

No	Question	Rate
1	Competent Safety practitioner	0
2	HSP	1
3	Safety responsibilities allocated	1
4	Safety meetings	0
5	Trained personnel for safety	0
6	Certified lifting appliances	0
7	All equipment CE marked	0
8	All vessels certified	0
9	All operators licensed	-2
10	All site equipment licensed	2
11	Approved type scaffold	0
12	All PPE CE marked	2
13	Approved type ladders	2
14	Proper signage	0
15	Site organisation (hygiene, fencing, entrance control, sanitary, first aids, fire safety)	-2
16	Equipment maintenance	0
17	Lifting appliances inspections	2
18	Trench inspections	0
19	Scaffold inspections	0
20	Electrical inspections	0
21	Wear helmet and safety shoes	-2
22	Wear other appropriate PPE as required	-1
23	Use only approved type equipment	0
24	Use/operate only if authorised	-1
25	All access and egress are safe	1

	Total	3

Prevention cost exceeded the overall safety management cost (including occurrences with accidents and with-no-accidents and the image cost). If image cost (which is the most 'soft' cost in my methodology) is not considered then the prevention cost would be almost as much as double the cost of management failures.

Table 6.4 ECO - case Safety Cost summary

ECO CASE COST SHEET	(ECO)		
COSTS CATEGORY	COST €	SC %	BUDGET %
BUDGET	110,0513.6		
PREVENTION	5,288.00	54.36	0.48
MFWNA	959.60	9.86	0.09
ACCIDENT	1,580.80	16.25	0.14
IMAGE	1,900.00	19.53	0.17
TOTAL SAFETY COST	9,728.4	100.00	0.88
PREVENTION COST		CATEG. %	SAFETY COST %
SMS DOCUMENTATION	3,82.80	7.24	3.94
STAFFING (SAFETY ORGANISATION)	439.90	8.32	4.52
MEETINGS	485.60	9.18	4.99
SAFETY STUDIES	0.00	0.00	0.00
TRAINING	528.00	9.99	5.43
PPE	177.80	3.36	1.83
EXTERNAL SERVICES	0.00	0.00	0.00
SAFETY EQUIPMENT & SIGNS	2,917.80	55.18	29.99
EMERGENCY	0.00	0.00	0.00
FIRE SAFETY	0.00	0.00	0.00
MEDICAL SURVEILLANCE	0.00	0.00	0.00
AGENTS MONITORING	0.00	0.00	0.00
OTHER	356.10	6.73	3.66
MFWNAC			
PENALTIES AND FINES	0.00	0.00	0.00
COURT CASE	0.00	0.00	0.00
IDLENESS	297.60	31.02	3.06
FALSE MATERIALS EQUIPMENT & LABOUR	480.80	50.10	4.94
INTERVENTION	0.00	0.00	0.00
OTHER	181.20	18.88	1.86
ACCIDENT COST			
IDLENESS	209.70	13.26	2.16

HOSPITAL TREATMENT	136.40	8.63	1.40
PRODUCTION LOSS	48.10	3.04	0.49
COMPENSATION	533.00	33.72	5.48
RECRUITMENT	0.00	0.00	0.00
COURT CASE	0.00	0.00	0.00
DAMAGES & LOSSES	132.00	8.35	1.36
PENALTIES AND FINES	0.00	0.00	0.00
IMAGE COST			
INJURY	1,000.00	52.63	10.28
DAMAGES	0.00	0.00	0.00
FAILURE TO COMPLY	900.00	47.37	9.25

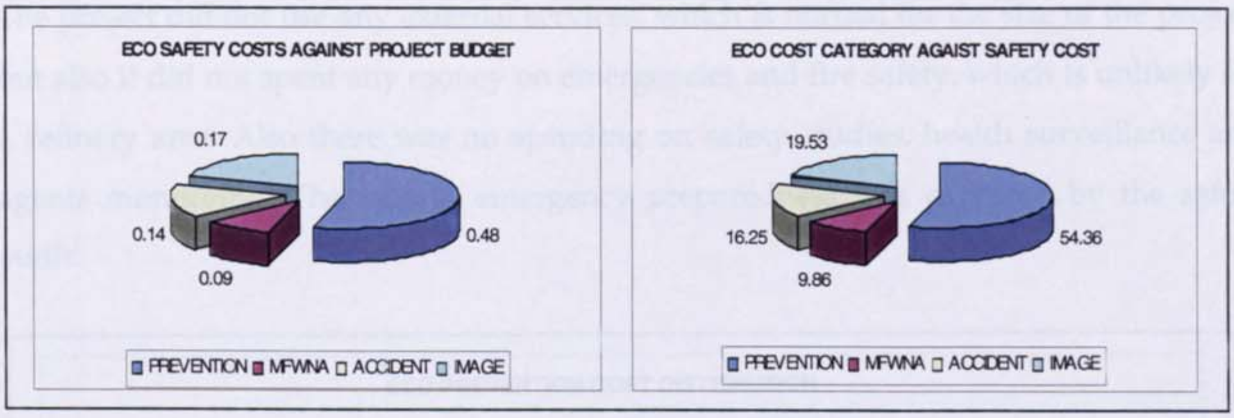

Figure 6.1 ECO Safety Cost Distribution in percentages

The overall cost of safety is spread into 19 subcategories with the top-three, image cost for injury and image cost for damages and losses accounting for 49.52% of it and the half of them (nine out of 19) for 80.06%. Cumulative percentages and safety cost distribution by magnitude are shown in Figure 6.2.

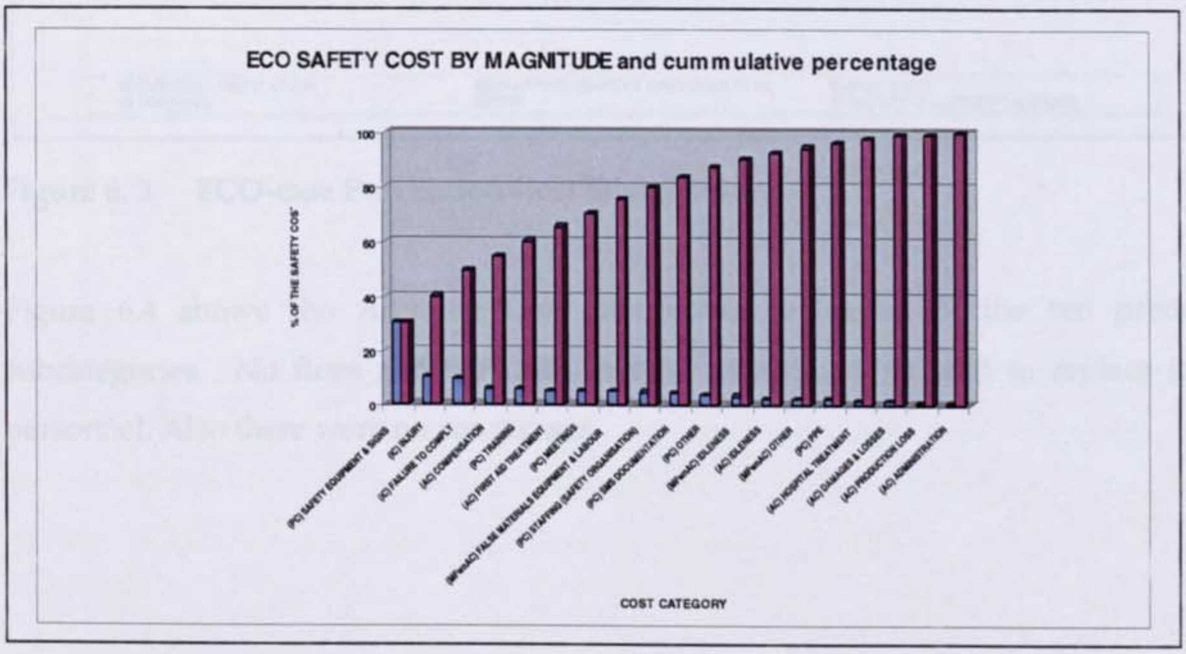

Figure 6.2 ECO –case Safety cost distribution by magnitude and cumulatively

The prevention cost is not satisfactorily distributed amongst all predefined prevention cost subcategories with money allocated only to six subcategories out the 12 predefined. Though with safety equipment accounting just over 55% the other six subcategories (including the non classified 'other') shares reasonably the remaining 45% (Figure 6. 3).

The project did not use any external services, which is normal for the size of the project, but also it did not spent any money on emergencies and fire safety, which is unlikely for a refinery area. Also there was no spending on safety studies, health surveillance and agents monitoring. The lack in emergency preparedness was captured by the safety audit.

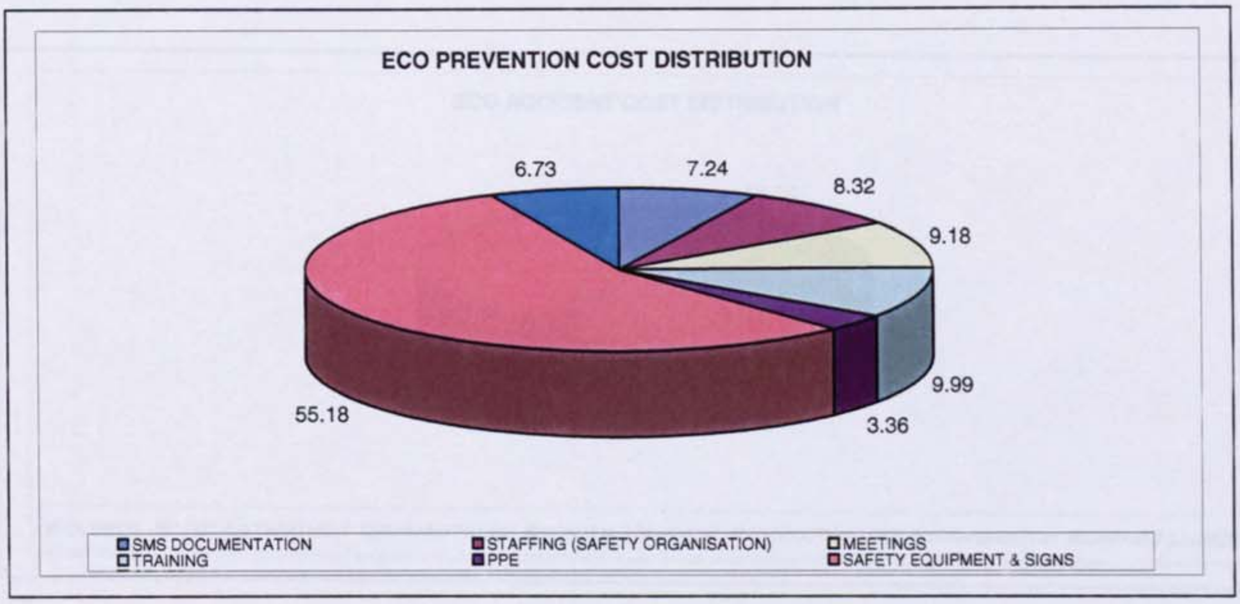

Figure 6. 3 ECO-case Prevention Cost Distribution

Figure 6.4 shows the Accident Cost distribution in seven of the ten predefined subcategories. No fines and penalties and no recruitment of staff to replace injured personnel. Also there were no court cases.

The 34 accidents resulting in first aid only cost 853.30 Euros, accounting for the 0.05% of the project value, the 5.18% of the safety cost and the 31.88% of the accident cost. As a matter of rough comparison with other studies, the HSE study (1993) study would give 714.00 Euros and the HSC proposed method HSE (2002) would give 1,700.00 Euros (see Chapter 8).

First aid treatment and compensation were about equal and represented together two thirds of the overall accident cost.

Despite a series of accidents the idleness cost is very low, representing one of the building industry characteristics; the work goes at the pace of subcontractors at projects of this scale.

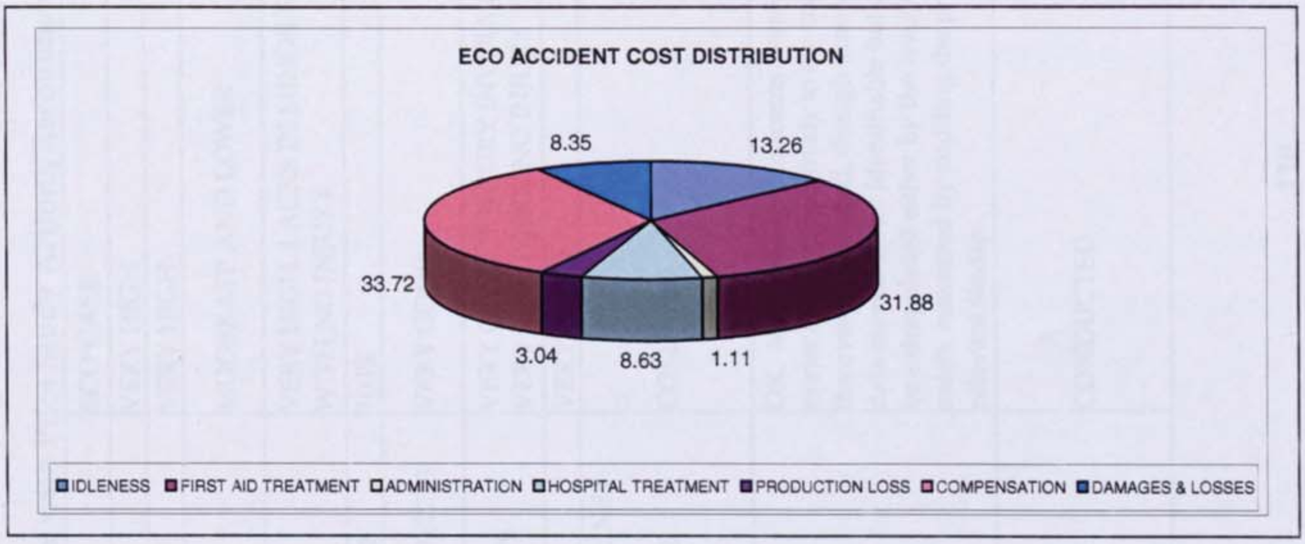

Figure 6.4 ECO-case Accident Cost distribution

The image cost has been calculated at €1,900.0 counting for 19.53% of the safety cost and 0.17% of the project value. The image cost imposed by three cases of failure to comply, one over 3-days absence case, and a series of minor accidents exceeded by 1.3 times the HSE rate i.e., 1.3 accidents/year/employee (see Chapter 4).

Table 6.5 ECO - case Compliance with Pilot Study Actions/Recommendations

PILOT STUDY ISSUE	ECO CASE	COMMENTS
HEAD OFFICE PEOPLE COMMITMENT	VERY HIGH	
SITE OFFICE PEOPLE COMMITMENT	VERY HIGH	
SUBCONTRACTORS COMMITMENT	MODERATE AND LOWER	Especially building subcontractors are reluctant to support any initiatives in any area.
DATA COLLECTION GENERAL	VERY HIGH. LACKS IN MINOR EVENTS WITH NO INJURY	A logbook had been used
DATA COLLECTION FOR MAJOR EVENTS	100%	
DATA COLLECTION FOR MODERATE EVENTS	VERY GOOD	Site person overloaded with site responsibilities. A daily report did not work.
DATA COLLECTION FOR MINOR EVENTS	VERY GOOD IF INJURY INVOLVE VERY LOW WHEN NO INJURY	Site person overloaded with site responsibilities. A daily report did not work.
QUALITY OF DATA	VERY GOOD	Good analysis by the site person
COSTS SHALL BE CALCULATED ON THE NET WAGES INCLUDING TAXATION AND INSURANSE, THUS TOTAL COST TO THE COMPANY AND NO PROFIT SHALL BE CONSIDERED	COMPLIED	Costs shall be calculated on the basis of wages
SENSITIVITY ANALYSIS	OK. Most data lost concerns events with minor cost comparatively to the costs of the events identified, though amount of data missed is not identifiable but could be extrapolated either by the level of safety measured by auditing the project or relevant studies	Site person overloaded with site responsibilities. A daily report did not work.
LEVEL OF SAFETY - SAFETY AUDITS	CONDUCTED	Only one safety audit conducted, due to irregularity in work progress, subject to the building subcontractors programme.

Chapter Seven

MAIN STUDY 2 - K1-K4 BYPASS

7.1 Introduction

The K1-K4 case was a far bigger project than the other two cases. The Thessaloniki bypass road project from junction K1 to junction K4 was a 36-month project and the budget was 105.6 million Euros.

EGNATIA ODOS SA was the client for the project. EGNATIA ODOS SA established for the construction and operation of EGNATIA ODOS a highway of approximately 680 kilometres from the Ionian Sea (west Greece) to the Greek-Turkey boarder. EGNATIA ODOS includes a new bypass (an old one already exists) of Thessaloniki (running outside the old one). EGNATIA ODOS SA awarded the section from Junction K1 to Junction K4 (both junctions included) to joint venture C.I.SARANTOPOULOS SA - ALTE SA - ELTER SA - GETEM SA, see further details below.

Seeking companies and projects to participate in the survey work, back in 1998 and 1999, I had contacted ELTER SA and ALTE SA. This time the joint venture went out to tender for external health and safety services. We (MANAGEMENT FORCE) bid successfully for the tender and it was also agreed with the joint venture would participate in the survey on the costs of safety.

The K1-K4-case was running in parallel to the ECO-case. There was very little to communicate between the two projects as both went very well. The K1-K4-case also reconfirmed the methodology. No problems with carrying out the work occurred apart from shortcomings in minor incidents reporting.

This project enriches the survey by a case where a proper safety team was in place and above all the project management was very committed to safety as declared from the beginning of our cooperation, as well as demonstrated later during the course of the work.

7.2 Summary of the K1-K4 Bypass Project

The project had been awarded to the joint venture C.I.SARANTOPOULOS SA - ALTE SA - ELTER SA - GETEM SA, now (since early 2002) PANTECHNIKI SA- ALTE SA - ELTER SA - GETEM SA, when PANTECHNIKI SA merged with C.I.SARANTOPOULOS SA.

My company appointed a full time site safety officer, Alekos Spyridonis. He was given also the role of the safety practitioner. The joint venture had already appointed the safety coordinator during the construction phase of the work, according to Greek Law, equivalent to the UK CDM regulations). Alekos was then appointed research site coordinator. I believed that there was no need for a research assistant in this case, as I had to visit, by contract, the site every month and Alekos would be full time on safety issues.

We started the survey in May 2001, and it was completed by the end of December. To work out the figures I took the approved payment certificates from May 1, 2001 to December 31, 2001 instead of a linear proportion of the budget in respect to the time of the survey (i.e., eight months survey out of 36 months overall project duration). The works had commenced in February 2001 and were expected to finish by January 2004

The project included the construction of a new road of 20 kilometres and the associated civil and electrical-mechanical works (including four junctions (overpasses). Mostly, subcontractors carried out the concrete works. For earth works the joint venture used their own capacity and resources as well as subcontractors. For asphalt laying the works were fully subcontracted. The construction was carried out at several locations at a distance from each other. Where subcontractors were given the work, the ability of reporting minor incidents including those resulting in first aid only was limited.

The concrete works subcontractors have more or less the same attitude as the building industry subcontractors, as described in section 6.2. I gave a short description of their attitude and problems of work pace. Building a road might be occasionally worse than that as the control over subcontractors is even less due to distance from the head office.

The project budget and duration is representative of big infrastructure projects, similar to the ones under construction in Greece for Highway Patras to Thessaloniki, ATTIKI ODOS (Athens bypass), IONIAN ODOS (along the Greece west Coast), and the EGNATIA ODOS connection roads.

EGNATIA ODOS SA, the owner, implemented an extensive health and safety management system for the project. The owner requires a similar system for all projects awarded.

Prior to commencing the survey work on site, a meeting took place with Mr. Georgiou, Alekos, Mr. N. Poulios, the safety coordinator, and myself to explain what the work requires and what instructions should be given to the engineers and subcontractors.

In respect now to the eight questions raised after the Kalochori project (initial pilot study) experience the answers are listed in the table below. The answers provided are satisfactory. Though, we had still to deal with some problems, mainly concerning subcontractors' response in reporting minor incidents, as was mentioned above.

The scope of the work covered:

- Access to site;
- Demolish any structures impeding access;
- Earth works;
- Concrete works for underground structures (e.g., sewage system, drainage system);
- Concrete bridges;
- Asphalt paving;
- Electrical-mechanical works for lighting;

- Road (crash) barriers;
- Road signing;
- Finishing works

Table 7.1 Shore Protection and K1-K4 Project Comparisons

	Initial pilot study	K1-K4 CASE; Main study 2
1	The Owner of the Project is the Prefecture of Thessaloniki. Prefecture of Thessaloniki (as most if not all similar authorities) is understaffed with major difficulties in supervising and monitoring construction projects.	The Owner of the Project is EGNATIA ODOS SA, with a very good reputation in safety and strong supervision. EGNATIA ODOS SA has been supported by Brown& Root UK (project manager) and awarded three contracts for Construction Managers (CM) who are acting as supervising engineers. The central sector CM is responsible for the K1-K4 project. CM has a full time function for OSH. Also EGNATIA ODOS SA has established an OSH department.
2	The site leader was a foreman, whilst the nominated site manager was not present on a daily basis.	The site organisation is very well structured including, site manager, quality engineer, traffic arrangements function, site safety officer, site engineers, foremen with clear disciplines.
3	No safety responsibilities had been allocated and no safety personnel had been nominated.	A full time site safety officer had been appointed. Additionally a safety coordinator has been nominated (not full time). Safety responsibilities had been allocated to subcontractors and the site safety officer had provided them with safety training.
4	The scope of work extended during the project and it was expected to be extended further (more length of protected shore). The project life in uncertainty.	The scope of work was clearly defined in the contractual documents.
5	Financing of the project not guaranteed by the Prefecture of Thessaloniki, at the beginning of the project.	No financing problems at all.
6	No guaranteed progress. Periods of idleness.	An agreed time schedule was a binding document, though subcontractors in mode of occasional violation of the time schedule of no overall impact.
7	Safety culture and experience of personnel in the project would not assist them to generate a reliable and considerable flow of data.	The safety culture of the joint venture project team very good (the project manager and the safety coordinator had experienced a fatal accident n previous projects). Though poor safety culture of concrete works subcontractors.
8	No safety logbook was maintained on site.	All statutory requirements for safety books satisfied.
		Additionally, EGNATIA ODOS SA would require that a Health and Safety Management System including the Health and Safety Plan would be developed for the project.

The works also included the re-pavement of five kilometres of finished part of the road, previously done by another contractor but rejected for quality reasons.

The project key personnel and the survey personnel are shown on the table 7.2 below.

Table 7.2 K1-K4 Site Personnel

Name	Company	Position in the Company	Position in the Project	Survey personnel
C. Georgiou	J/V	N/a	Project manager	J/V Project Manager
A. Spiridonis	J/V (Management Force)		Site Safety Officer	Research assistant & Site coordinator
G. Panopoulos	Management Force	Director	Researcher	Researcher

Training was provided on site by the Researcher in May 2001. The main topics were the same as described in the two earlier case studies. In this training all site key personnel participated. Refresher training was given to the Site Coordinator in June 2001.

7.3 Survey Results[7]

For gathering data a report was generated by the research assistant at his convenience. Mr Spiridonis also kept a separate logbook for incidents, training, meetings and other prevention costs. The Cost Report was not used (as decided when the pilot study was concluded).

For cost data collection and analysis the Cost Analysis Report was used. Cost Analysis Reports are in Appendix 7. Each Cost Analysis Report is described briefly below.

7.3.1 COST ANALYSIS REPORT TRR-A-001/25-5-2001

It concerns a PREVENTION COST spent for signage. This cost is relevant to the lifetime of the signs and includes labor for putting up. The prevention cost was 622.50 Euros.

7.3.2 COST ANALYSIS REPORT TRR-A-002/4-6-2001

It concerns an ACCIDENT COST. Reinforcement collapsed as a worker removed the supports. No one was hurt. The reinforcement was replaced. An image cost was also encountered. The Accident cost was 295.80 Euros, and the Image cost was 300.00 Euros.

[7] Figures may vary slightly from spreadsheet as they have been calculated manually before data entry into the spreadsheet, round up and adjustments (e.g. special signs mean value).

7.3.3 COST ANALYSIS REPORT TRR-A-003/4-6-2001

It concerns a PREVENTION COST for buying goggles for welding activities.

The Prevention cost was 29.40 Euros.

7.3.4 COST ANALYSIS REPORT TRR-A-004/4-6-2001

It concerns a PREVENTION COST for buying four wooden ladders. Cost was fully allocated to the surveyed period. The Prevention cost was 131.50 Euros.

7.3.5 COST ANALYSIS REPORT TRR-A-005/4-6-2000

It concerns a PREVENTION COST for buying and putting up reflecting net and traffic cones. The costs are allocated fully to the surveyed period. The Prevention cost was 730.30 Euros.

7.3.6 COST ANALYSIS REPORT TRR-A-006/4-6-2001

This is a PREVENTION COST. A meeting took place on the 23/5/2001 for drafting the safety policy in the project. The Prevention cost was 90.40 Euros.

7.3.7 COST ANALYSIS REPORT TRR-A-007/4-6-2001

This is a PREVENTION COST. The Project required special signs (besides standard ones) for diverting traffic, warning drivers etc. This is a cost for special signs allocated to the surveyed period according to the lifetime of the signs and includes erection costs. The Prevention cost was 64.50 Euros.

7.3.8 COST ANALYSIS REPORT TRR-A-008/4-6-2001

This is PREVENTION cost, involving the purchase of general-purpose gloves. The Prevention cost was 52.80 Euros.

7.3.9 COST ANALYSIS REPORT TRR-A-009/20-6-2001

This is an ACCIDENT COST. A site person descending a staircase slipped on spilt lubricants and fell off to the base of the staircase. Only first aid needed but with the person next day back to work in muscular pain for 10 working days, a loss of production averaged at 50% was estimated. No image cost was encountered. The Accident cost was 628.70 Euros.

7.3.10 COST ANALYSIS REPORT TRR-A-010/20-6-2001

This is a PREVENTION COST for buying road barriers. The cost has been allocated according to the barriers' lifetime and survey duration. It concerns only the purchase cost; other CARs covered installation. The Prevention cost was 265.60 Euros.

7.3.11 COST ANALYSIS REPORT TRR-A-011/20-6-2001

This is a PREVENTION COST for buying and putting up road signs and special signs. The cost has been allocated according to the barriers' lifetime and survey duration. The Prevention cost was 687.90 Euros.

7.3.12 COST ANALYSIS REPORT TRR-A-012/30-6-2001

This concerns a PREVENTION COST for buying and putting up reflecting net and traffic cones. The costs were fully allocated to the survey period. The Prevention cost was 4,095.00 Euros.

7.3.13 COST ANALYSIS REPORT TRR-A-013/30-6-2001

This is an ACCIDENT COST. A rear bar fell off and hurt a worker's hand. First aid only was needed, though the injured person was taken to hospital. He returned to work on the next day. No image cost was encountered. The Prevention cost was 146.20 Euros.

7.3.14 COST ANALYSIS REPORT TRR-A-014/12-7-2001

This is a PREVENTION COST. J/V bought high quality helmets (15.0 Euros each), in order to ensure satisfaction and better compliance. The site safety officer confirmed better compliance. Full costs were allocated to the survey period. The Prevention cost was 875.00 Euros.

7.3.15 COST ANALYSIS REPORT TRR-A-015/12-7-2001

This is a PREVENTION COST for safety boots. Full costs were allocated to the survey period. The Prevention cost was 150.00 Euros.

7.3.16 COST ANALYSIS REPORT TRR-A-016/31-7-2001

This is a PREVENTION COST for safety PPE (gloves, welders' gloves and high visibility vests). Full costs were allocated to the survey period. The Prevention cost was 205.10 Euros.

7.3.17 COST ANALYSIS REPORT TRR-A-017/31-7-2001

This is a PREVENTION COST for buying 200 pairs of safety shoes. Full costs were allocated to the survey period. The Prevention cost was 2,500.00 Euros.

7.3.18 COST ANALYSIS REPORT TRR-A-018/31-7-2001

It concerns PREVENTION COST for buying and putting up reflecting net. Full costs were allocated to the survey period. The Prevention cost was 1,920.00 Euros.

7.3.19 COST ANALYSIS REPORT TRR-A-019/31-7-2001

It concerns a PREVENTION COST spent for road signs and safety signs. This cost was relevant to the lifetime of the signs and the remaining period of the survey and included labour time for installing them. The prevention cost was 652.50 Euros.

7.3.20 COST ANALYSIS REPORT TRR-A-020/31-7-2001

This is an ACCIDENT COST. An employee riding a motorbike fell off. Only first aid treatment was necessary, though in hospital which he left on the same day. No image cost was encountered. The Accident cost was 278.40 Euros.

7.3.21 COST ANALYSIS REPORT TRR-A-021/23-8-2001

This is a PREVENTION COST for safety training of the site management team. The Cost was fully allocated to this project, as refresher training would be required in six months time. The Prevention cost was 429.10 Euros.

7.3.22 COST ANALYSIS REPORT TRR-A-022/30-8-2001

It concerns a PREVENTION COST spent for road signs, safety signs, flashing lights and zebra crossings. This cost is relevant to the lifetime of the signs and the remaining period of the survey and includes labour for installation. The prevention cost was 4,660.90 Euros.

7.3.23 COST ANALYSIS REPORT TRR-A-023/20-9-2001

This is an ACCIDENT COST. The assistant surveyor was trying to remove/cut grass in order to install a surveying point (topographical point) and he wounded his foot. No image cost was encountered. The Accident cost was 264.60 Euros.

7.3.24 COST ANALYSIS REPORT TRR-A-024/30-9-2001

This is an ACCIDENT COST. A worker fell off a low level platform resulting in an injury to his left leg. The Accident happened at 11:00 am. The injured person was transferred to the hospital. He came back to work in three days. An Image cost was encountered. The Accident cost was 627.40 Euros and the Image cost was 200.00 Euros.

7.3.25 COST ANALYSIS REPORT TRR-A-025/30-9-2001

This concerns a PREVENTION COST spent for road barriers installation and Horizontal signage. This cost was relevant to the lifetime of the signs and the remaining period of the survey and included labour for installation. The prevention cost was 1,379.00 Euros.

7.3.26 COST ANALYSIS REPORT TRR-A-026/30-9-2001

This concerns a PREVENTION COST spent for road signs, and zebra crossings. This cost was relevant to the lifetime of the signs and the remaining period of the survey and included labor for installation. The prevention cost was 1,207.50 Euros.

7.3.27 COST ANALYSIS REPORT TRR-A-027/30-9-2001

This is an ACCIDENT COST. A worker irrelevant to the operation of the piling equipment attempted to be involved and two finger ends were amputated. The Factory Inspectorate investigated the event. No court case so far (revised 13/6/2003). The

Accident occurred at 11:00. He was absent from work for 33 days. An Image cost was encountered. The Accident cost was 4,022.40 Euros, and the Image cost was 1,000.00 Euros.

7.3.28 COST ANALYSIS REPORT TRR-A-028/30-09-2001

It concerns a PREVENTION COST spent for road signs. This cost is relevant to the lifetime of the signs and the remaining period of the survey and includes labor for installation. The Prevention cost was 45.10 Euros.

7.3.29 COST ANALYSIS REPORT TRR-A-029/10-10-2001

It concerns PREVENTION COST spent for mobile traffic lights including operation cost. The purchase cost is relevant to the lifetime of the traffic lights. The prevention cost was 552.30 Euros.

7.3.30 COST ANALYSIS REPORT TRR-A-030/30-9-2001

This concerns a PREVENTION COST spent for road signs and safety signs. This cost is relevant to the lifetime of the signs and the remaining period of the survey and includes labor for installation. The prevention cost was 513.10 Euros.

7.3.31 COST ANALYSIS REPORT TRR-A-031/30-09-2001

This is a PREVENTION COST relating to Site management safety meetings. All costs were allocated to the remaining survey period, as the topics did not cover issues beyond that period. The Prevention cost was 823.00 Euros.

7.3.32 COST ANALYSIS REPORT TRR-A-032/30-09-2001

This concerns a PREVENTION COST spent for road signs, road special signs, road barriers, cats' eyes, and horizontal signage. This cost was relevant to the lifetime of the signs and the remaining period of the survey and included labour for installation. The Prevention cost was 495.20 Euros.

7.3.33 COST ANALYSIS REPORT TRR-A-033/31-12-2001

This is an ACCIDENT COST. A worker riding a motorbike at 09:00 am hit a car when the driver of the latter decided to turn right without signalling. Only first aid treatment in hospital was necessary and he was back at work on the same day after examinations in hospital. No image cost was encountered. The Accident cost was 267.70 Euros.

7.3.34 COST ANALYSIS REPORT TRR-A-034/31-12-2001

This concerns a PREVENTION COST spent for road signs purchased and installed between 21/11/2001 and 31/12/2001. This "last buy" cost was relevant to the lifetime of the signs and the remaining period of the survey and included labour. The Prevention cost was 362.00 Euros.

7.3.35 COST ANALYSIS REPORT TRR-A-035/31-12-2001

This is a PREVENTION COST for EXTERNAL SERVICES, namely the Safety management services from MANAGEMENT FORCE for eight months. The Prevention cost was 25,825.60 Euros.

7.3.36 COST ANALYSIS REPORT TRR-A-036/31-12-2001

This is a PREVENTION cost. Overall 204 men were trained during the period May-September 2001. Training was provided by the Site Safety Officer (Management Force) as part of his duties. The Prevention cost was 1,576.70 Euros.

7.3.37 COST ANALYSIS REPORT TRR-A-037/31-12-2001

This is a PREVENTION COST for an emergency team-system for adverse weather conditions in December 2001. The Prevention cost was 3,958.90 Euros.

7.3.38 COST ANALYSIS REPORT TRR-A-038/31-12-2001

This is a PREVENTION COST for a security/safety/emergency team for Christmas 2001 (23-31/12/2001). A part of this cost was allocated to the survey as a safety cost. The Prevention cost was 4,534.80 Euros.

7.3.39 COST ANALYSIS REPORT TRR-A-039/31-12-2001

This is a PREVENTION COST. EXTERNAL SERVICES, namely a physician for eight months, visiting the site for six hours a week. The Prevention cost was 5,688.00 Euros.

7.3.40 COST ANALYSIS REPORT TRR-A-040/31-12-2001

This is a PREVENTION COST. A Health and Safety Plan was drafted by the safety coordinator and reviewed and approved by the Project Manager. Time allocation and revision provisions apply, taking into account that the plan would be reviewed twice over the 36 months period at 25% of the initial cost; the cost for the eight months survey period is allocated. The Prevention cost was 355.60 Euros.

7.3.41 COST ANALYSIS REPORT TRR-A-041/31-12-2001

This is a PREVENTION COST. A site engineer had been appointed safety coordinator. For the survey period, his involvement was limited, as a safety manager (external services) had been appointed, and estimated at two hours per week, thus a total of 69 hours. The Prevention cost was 1,124.70 Euros.

7.3.42 COST ANALYSIS REPORT TRR-A-042/31-12-2001

This is a PREVENTION COST. The Safety management system was prepared by external services (Management Force) but printed in the company (on site) and discussed and reviewed by the Project Manager and the Safety Coordinator. It was also disseminated to all engineers as applicable and to subcontractors. The cost for presenting it to all during the site meetings and trainings has already been counted (see R-TRR-021). The Prevention cost was 366.40 Euros.

7.3.43 COST ANALYSIS REPORT TRR-A-043/31-12-2001

A review Cost Analysis Report for prevention cost spent on barricading edge at heights (bridge works) and also putting up wooden ladders, scaffold type to get access to these construction locations. The Prevention cost was 2,020.70 Euros.

7.4 Safety Audits

Three safety audits were conducted during the survey period. The first audit measured the safety performance as it was found when we started the survey (and coincidently when Management Force services arrival on site on May 1, 2001); the second was in September and the third in December 2001. The SPI shows a steady improvement from the warning level '-26' up to '13' with the value in between in the moderate range '1'.

Table 7.3 K1-K4-case Audit

No	Question	Rate Jun 01	Rate Aug 01	Rate Dec 01
1	Competent Safety practitioner	-2	1	2
2	HSP	0	1	1
3	Safety responsibilities allocated	-1	1	1
4	Safety meetings	-1	1	1
5	Trained personnel for safety	-1	0	1
6	Certified lifting appliances	-1	0	1
7	All equipment CE marked	0	0	1
8	All vessels certified	0	0	0
9	All operators licensed	-2	-1	-1
10	All site equipment licensed	0	1	1
11	Approved type scaffold	-2	-2	0
12	All PPE CE marked	-1	2	1
13	Approved type ladders	-2	-2	-1
14	Proper signage	-1	0	1
15	Site organisation (hygiene, fencing, entrance co sanitary, first aids, fire safety)	-1	0	1
16	Equipment maintenance	0	1	1
17	Lifting appliances inspections	-1	-1	-1
18	Trench inspections	-1	0	0
19	Scaffold inspections	-1	0	1
20	Electrical inspections	-1	-1	0
21	Wear helmet and safety shoes	-2	1	-1
22	Wear other appropriate PPE as required	-1	-1	0
23	Use only approved type equipment	-1	1	1
24	Use/operate only if authorised	-1	0	1
25	All access and egress are safe	-2	-1	1
	Total	**-26**	**1**	**13**

The SPI of 13 is considered satisfactory considering the average safety performance in road works (from my experience ranging between –10 to 0).

Table 1 below illustrates the safety performance measured at the three audits. Surprisingly, there are audited areas giving lower performance in the third audit than the second. Such areas are those of great human behavior influence, e.g. wearing helmet (which is a matter of culture and climate in Greece).

It is questionable where a varied allocation of the prevention cost would have given better results. For instance, better training of the workforce or closer supervision on site would ensure a better implementation of the PPE.

There might be other policies such as a yellow-card system or dismissal for non-compliance. These would cost very little but they might prove very effective. Nevertheless Greece is not the country that these systems have been tested before and the risk of touching sensitive chords and affecting labour relations has to be considered.

The relationship between audit scores and safety costs is discussed further in section 7.5.

7.5 Cost Analysis

Table 7.4, summarises the safety cost per category and subcategory. The full Cost Analysis Report Presentation Table in Appendix 7 gives an analytical overview of all costs incurred in the Pilot and in each main study. Table 7.4 gives the percentage in each category against the total safety cost and the project budget. It also gives the percentage of each subcategory against the total of the category it belongs to.

The prevention cost dominates, in any case the safety cost, accounting for the 89.20% of the overall safety cost. The accident cost accounts for the 8.78% of the safety cost and finally the image cost is only 2.02%.

Remarkably there is no management failure with-no-accident cost at all. Though the accident cost is very low; surprisingly only eight incidents were identified and reported.

Table 7.4 K1-K4-Case Safety Cost summary

K1-K4 COST SHEET	(K1-K4)		
COSTS CATEGORY	COST	SAFETY COST %	BUDGET %
BUDGET	22,890,682.3		
PREVENTION	68,707.50	89.53	0.30
MFWNA	0.00	0.00	0.00
ACCIDENT	65,31.70	8.51	0.03
IMAGE	1,500.00	1.95	0.01
TOTAL SAFETY COST	76,739.20	100.00	**0.34**
PREVENTION COST		CATEG. %	SAFETY COST %
SMS DOCUMENTATION	722.20	1.05	0.94
STAFFING	1,127.50	1.64	1.47
MEETINGS	913.20	1.33	1.19
SAFETY STUDIES	0.00	0.00	0.00
TRAINING	2,005.60	2.92	2.61
PPE	3,812.20	5.55	4.97
EXTERNAL SERVICES	31,513.40	45.87	41.07
SAFETY EQUIPMENT & SIGNS	20,379.50	29.66	26.56
EMERGENCY	8,233.90	11.98	10.73
FIRE SAFETY	0.00	0.00	0.00
MEDICAL SURVEILLANCE	0.00	0.00	0.00
AGENTS MONITORING	0.00	0.00	0.00
OTHER	0.00	0.00	0.00
MFWNAC			
PENALTIES AND FINES	0.00	#DIV/0!	0.00
COURT CASE	0.00	#DIV/0!	0.00
IDLENESS	0.00	#DIV/0!	0.00
FALSE MATERIALS EQUIPME LABOUR	0.00	#DIV/0!	0.00
INTERVENTION	0.00	#DIV/0!	0.00
OTHER	0.00	#DIV/0!	0.00
ACCIDENT COST			
IDLENESS	1,016.30	15.56	1.37
FIRST AID TREATMENT	76.00	1.16	0.10
ADMINISTRATION	151.50	2.32	0.20
HOSPITAL TREATMENT	1,092.80	16.73	1.47
PRODUCTION LOSS	848.60	12.99	1.14
COMPENSATION	3,150.90	48.24	4.24
RECRUITMENT	0.00	0.00	0.00
COURT CASE	0.00	0.00	0.00
DAMAGES & LOSSES	195.60	2.99	0.26
PENALTIES AND FINES	0.00	0.00	0.00
IMAGE COST			
INJURY	1,200.00	80.00	1.56
DAMAGES	300.00	20.00	0.39
FAILURE TO COMPLY	0.00	0.00	0.00

Subcontractors are reluctant in reporting incidents if they are minor. From my experience there had been cases that they were negative in reporting incidents to authorities, which have resulted in hospital short treatment - first aid.

The Greek Centre for OSH also acknowledges underreporting in their report 'Risk Assessment based on accidents statistics' (2002).

For the K1-K4 figures (table 7.4 above), the following comments must be considered:

- Prevention costs included part of the operational equipment setup only for safety reasons e.g. scaffolding safety features (fall protection) of the retaining walls and overpasses, a total length of 194 meters of protection.
- Prevention costs did not include any certification cost for lifting gear and appliances.
- Accident costs for minor events with no injury were not included, as they were not reported.
- Accident cost for minor events with only first aid injury not involving transfer to hospital was not included as not reported.

It is interesting to compare the audit scores (section 7.3) with the trends in Accident costs and Prevention costs. Figure 7.1 below shows the assumed linear improvement of the SPI between two consecutive audits, compared with the accident costs (per incident). SPI measured '–23' (first audit), '1' (second audit) and '13' (third audit). Accident costs are shown in bars. Axis Y1 gives SPI and axis Y2 gives the cost of accidents.

Surprisingly, the most severe and costly accidents happened with higher SPI. Nevertheless, a quick look at Table 7.3 above shows that there were relevant cases in '-2' and '-1' rate during the second audit and the third audit. Therefore weak risk control cases were identified during the second and the third audit, which lead to those 'more severe accidents' though less likely when compared with earlier dates of the survey (see first audit). Figure 7.2 presents the cumulative cost of accidents, prevention and safety and the SPI through the study period. The figure shows a stabilization of the overall cost trend with the SPI reaching a good value for Greek normal practice, though there are still areas in '-1' rate.

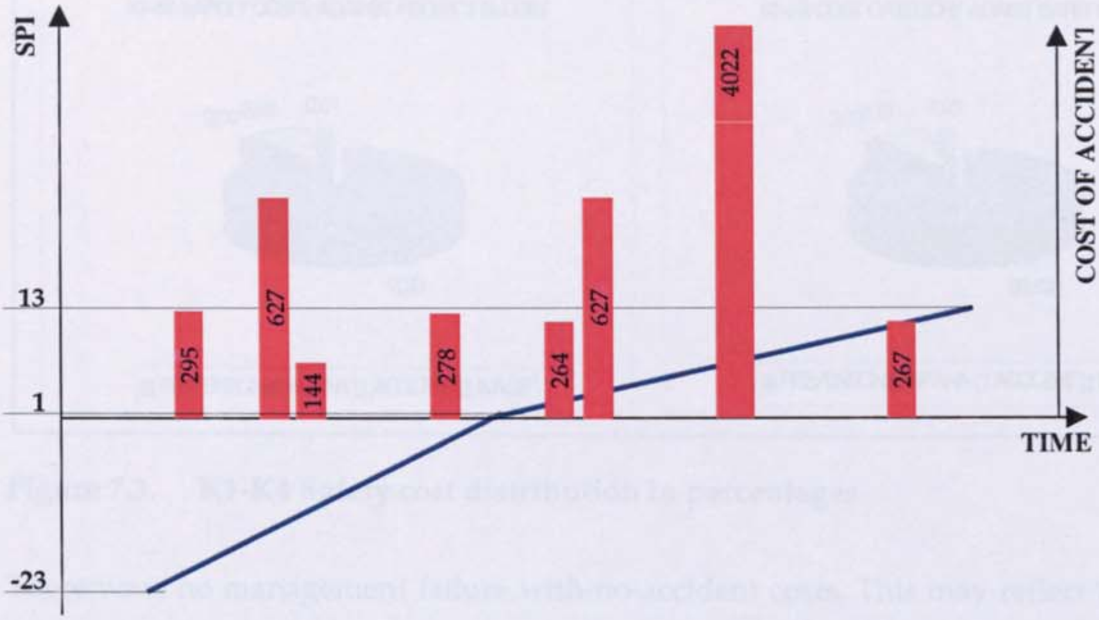

Figure 7.1 Costs of Accidents over time compared with audit SPI scores

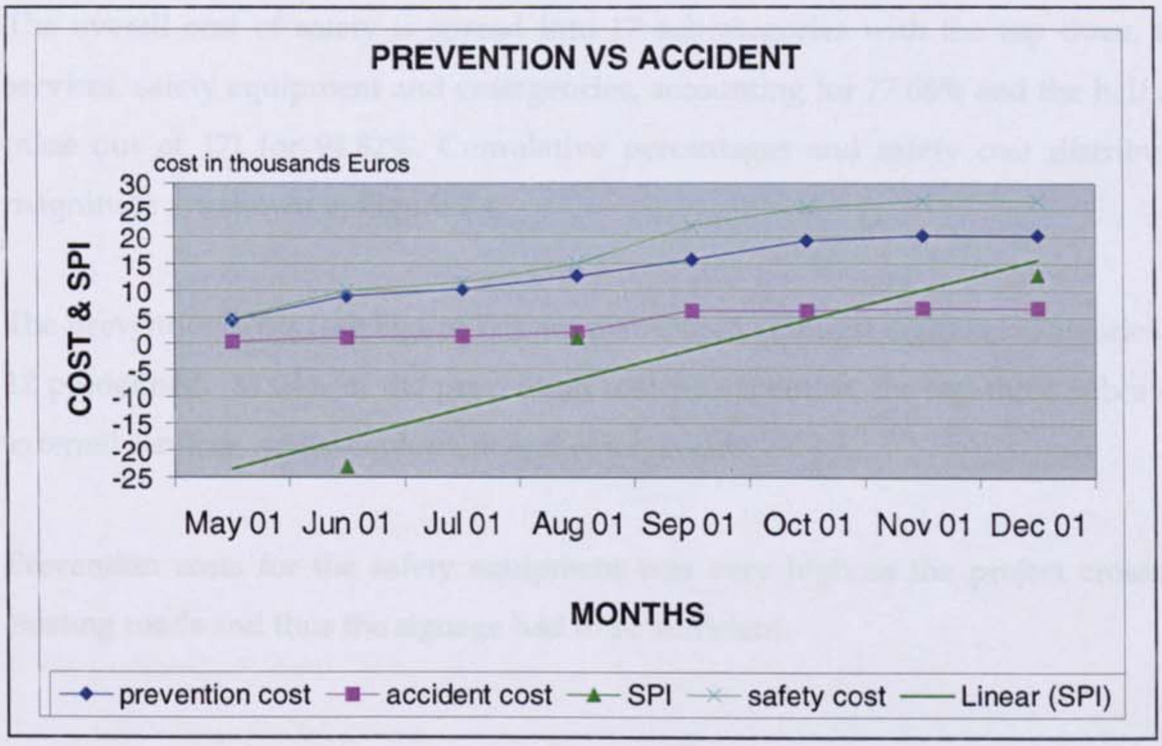

Figure 7.2 Cumulative costs compared with audit SPI scores

Figure 7.3 gives an overview of the safety cost distribution in percentages of the project budget and the overall safety cost.

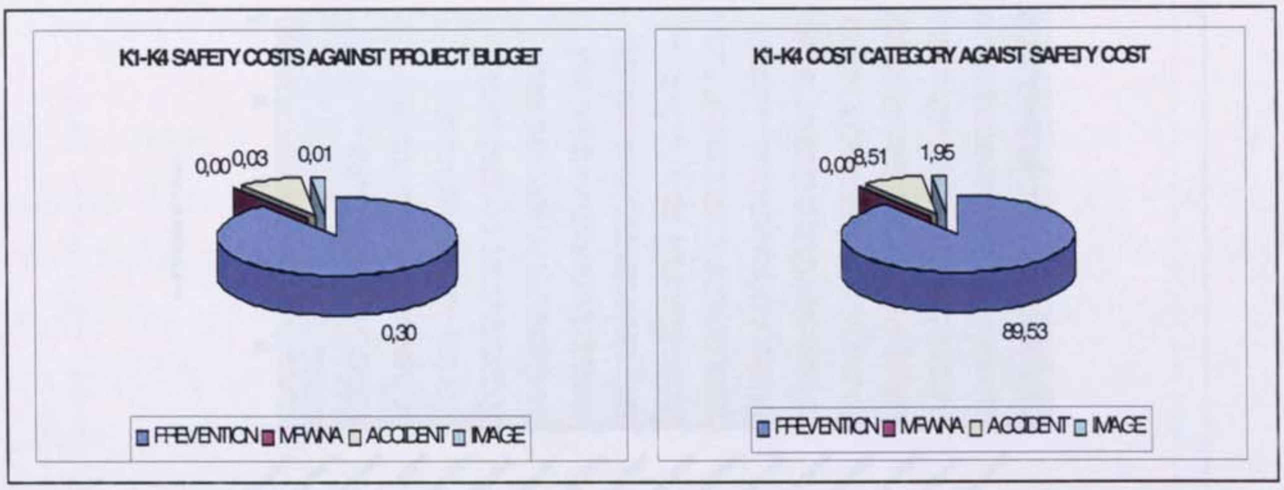

Figure 7.3. K1-K4 Safety cost distribution in percentages

There were no management failure with-no-accident costs. This may reflect the effective management on site, and the close safety supervision provided by Management Force. Prevention dominates the cost of safety and accounted for 89% of it.

The overall cost of safety is spread into 17 subcategories with the top three, external services, safety equipment and emergencies, accounting for 77.66% and the half of them (nine out of 17) for 94.82%. Cumulative percentages and safety cost distribution by magnitude are shown in Figure 7.4.

The prevention costs (see Figure 7.5) are distributed amongst eight subcategories out the 12 predefined. 87.06% of the prevention cost was spent on the top-three subcategories: external services, safety equipment and emergencies.

Prevention costs for the safety equipment was very high as the project crosses other existing roads and thus the signage had to be sufficient.

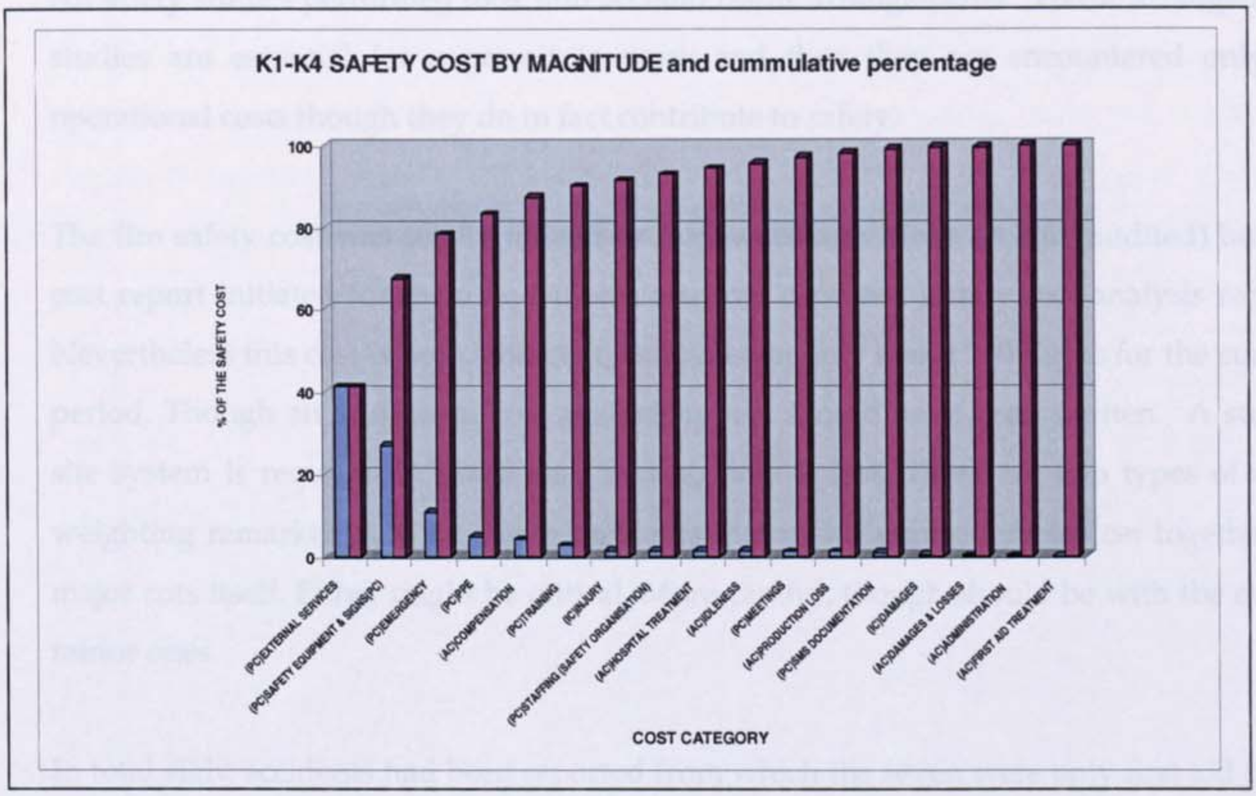

Figure 7.4 Safety cost distribution by magnitude and cumulatively

The emergency procedures set up after a forecast for adverse weather over 2001 Christmas period. This cost is remarkable, accounting for 12.41% of the prevention cost and being in the top-three representing the 11.07% of the total safety cost.

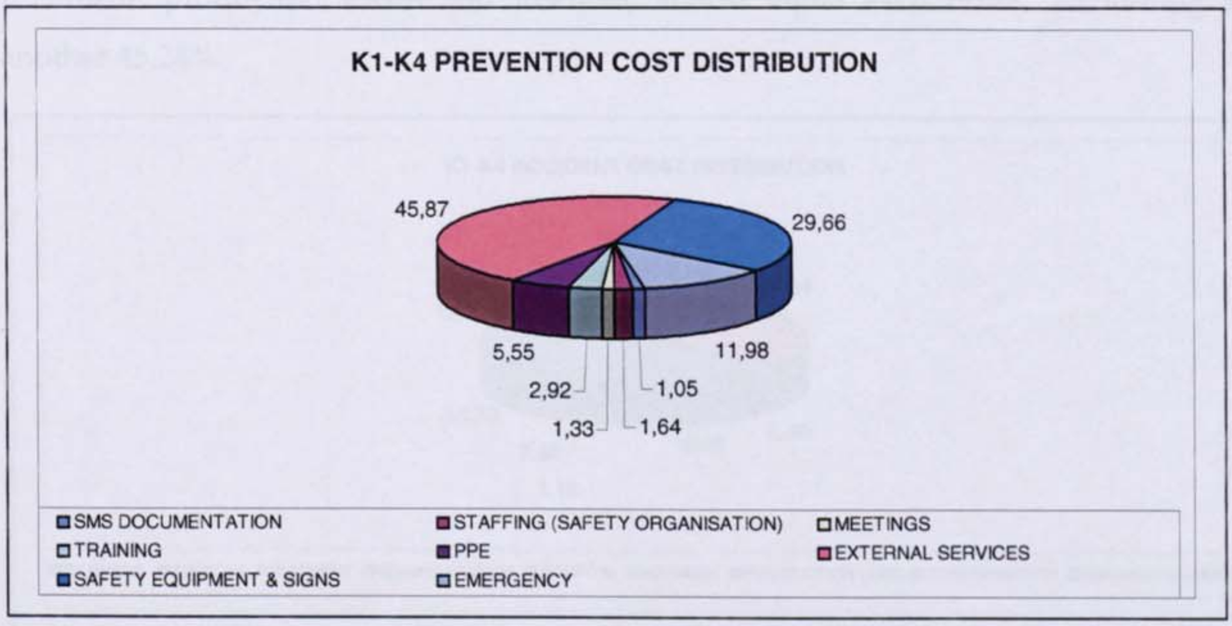

Figure 7.5 K1-K4 Prevention Cost Distribution

All safety studies performed took into account traffic arrangements. Traffic arrangement studies are essential for a permit to work and thus they are encountered only as operational costs though they do in fact contribute to safety.

The fire safety cost was totally missed as they were provisions on site (audited) but no cost report initiated for them and it was also not captured in any cost analysis report. Nevertheless this cost is not significant, estimated at only about 180 Euros for the survey period. Though an additional cost analysis report should have been written. A strong site system is required to make sure that no data is lost. There are two types of data weighting remarkably. A lot minor incidents that make a considerable cost together or major cots itself. Either might be critical. More careful, though should be with the many minor ones.

In total eight accidents had been reported from which the seven were only first aid cases whilst the other one resulted in a partial amputation of the distal of two fingers.

Figure 7.6 shows the Accident Cost distribution in seven of the ten predefined subcategories. The overall cost of accidents was 6,531.70 Euros with compensation accounting for almost the 50% (48.24%) and another three subcategories, hospital treatment, production losses and idleness, almost equal each other, accounting for another 45.28%.

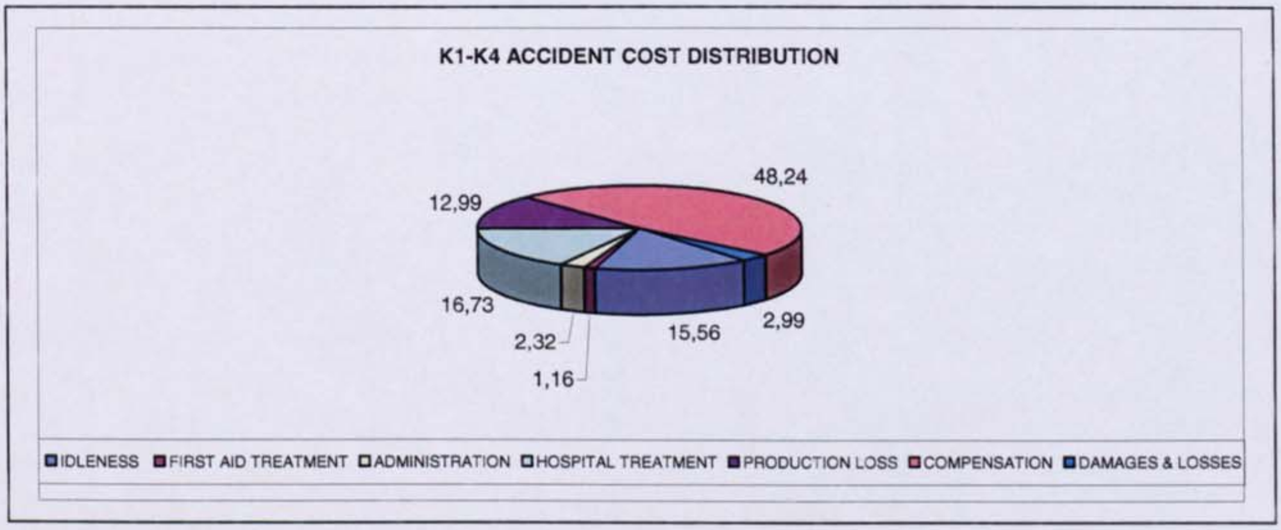

Figure 7.6 K1-K4 Accident Cost Distribution

There were no fines and penalties and no recruitment of staff to replace injured persons. In contrast with the other two cases, the Factory Inspectorate inspected the project during the survey period. They investigated the accident of the piling case, and they inspected the site in June 2001. They were also attended by invitation the presentation of the project Safety Management System, and finally they inspected the site in November and in December, totaling five visits. Nevertheless they did not issue any improvement or prohibition notice, and they did not take any prosecutions.

The image cost has been calculated at □1,500.00 counting for 2.02% of the safety cost and 0.01% of the project budget. The image cost imposed by two injury cases and one for damages.

Table 7.5 K1-K4 Case Compliance with Pilot Study Actions/Recommendations

PILOT STUDY ISSUE	K1-4 CASE	COMMENTS
HEAD OFFICE PEOPLE COMMITMENT	VERY HIGH	Project Management Team
SITE OFFICE PEOPLE COMMITMENT	VERY HIGH	Site management team
SUBCONTRACTORS COMMITMENT	MODERATE AND LOWER	Especially those in concrete works were rather reluctant to support any data generation.
DATA COLLECTION GENERAL	VERY HIGH. LACKS IN MINOR EVENTS WITH NO INJURY	A logbook had been used
DATA COLLECTION FOR MAJOR EVENTS	100%	
DATA COLLECTION FOR MODERATE EVENTS	VERY GOOD	Presumably most incidents if not all reported.
DATA COLLECTION FOR MINOR EVENTS	MODERATE TO LOW IF INJURY RESULTS VERY LOW TO ZERO WHEN NO INJURY	Subcontractors reluctant to report any such data. Also personnel feel no reporting such data even if they have a minor first aid accident themselves.
QUALITY OF DATA	VERY GOOD	Good analysis by the site person
COSTS SHALL BE CALCULATED ON THE NET WAGES INCLUDING TAXATION AND INSURANSE, THUS TOTAL COST TO THE COMPANY AND NO PROFIT SHALL BE CONSIDERED	COMPLIED	Costs shall be calculated on the basis of wages
SENSITIVITY ANALYSIS	OK. Most data lost concerns events with minor cost comparatively to the costs of the events identified, though amount of data missed is not identifiable but could be extrapolated either by the level of safety measured by auditing the project or relevant studies	
LEVEL OF SAFETY - SAFETY AUDITS	OK	Three safety audits conducted.

Chapter Eight

ANALYSIS DISCUSSION

8.1 Introduction

This chapter provides a detailed analysis of the costing results both of the pilot study and the two main studies, comparing findings between the three projects as well as with published work.

All the experimental data was consolidated within one Excel® database that gives results automatically provided that row data such as unit cost rates and assumptions have been entered.

Also hypothetical scenarios are examined based on actual data and reallocation of resources. The Excel® database allows various assumptions to be tested to see how they effect the final outcomes. Safety Performance measured in the three projects (the safety audits) plays an important role in this analysis.

8.2 Basis for Costing

As was stated in Chapter Four, the data for unit costs in this research was held over to this Chapter, to form part of the discussion of the research findings (and it would have been space-consuming to present Table 8.1 (see below) separately for each of my cases. The costing was based on the assumptions made in Chapter Four, and the unit cost rates given below for each individual project. The unit cost rates are substantiated with invoices, payroll lists and payment certificates as applicable, all provided by the Projects' management.

VAT is not included, as it assumed that projects are profitable for the contractors and thus VAT receipts balance the VAT expenditures. No other taxes have been considered to calculate the costings. For the costings only costs applying to the main contractor or reimbursed costs for subcontractors has been considered.

Cost reports generated from site were classified according to a minimum cost of 15□ - those involving a cost of less than 15□ were not included in the study. This is the same criterion as that adopted by HSE (1993). For the rest of the reported incidents, a Cost Report Analysis was drawn. Cost analysis is based on cost units and unit rates. For all three projects I used the rates given by the project management for labour, materials, equipment etc.

As stated above, all costings have been entered into the Excel® database. Therefore any modification, and alteration is easy. Table 8.1 below gives the unit cost rates used.

Table 8.1 Unit Cost Rates

COSTINGS RATE				
COST	UNIT	PPC	EKO	K1-K4
MANPOWER				
director (Project Manager)	hour	22.00	15.60	40.40
manager (Site Manager)	hour	16.30	14.00	22.00
engineer (Project/Site Engineer)	hour	11.70	11.70	11.70
Secretary	hour	9.30	8.50	8.50
safety practitioner (engineer)	hour	11.70	11.70	0.00
safety coordinator (engineer)	hour	0.00	11.70	16.30
safety officer (manager)	hour	16.30	14.00	22.00
Physician	hour	0.00	0.00	0.00
Nurse	hour	0.00	0.00	0.00
first aider (foreman-or engineer))	hour	16.30	11.70	16.30
fire team (foreman)	hour	0.00	0.00	0.00
technician (welder, pipe fitter, etc)	hour	31.80	31.80	16.10
Operator	hour	19.10	17.00	19.10
Foreman	hour	18.70	18.70	25.70
Labour	hour	17.30	14.80	13.80
security services	hour	0.00	0.00	13.80
cleaning services	hour	6.90	8.10	9.90
training materials	package	10.00	10.00	25.00
printable documents	set	25.00	35.00	50.00
EXTERNAL SERVICES				
Safety	month	140.00	0.00	3,228.20
Physician	month	0.00	0.00	711.00
Nurse	month	0.00	0.00	0.00
security	month	0.00	0.00	0.00

COSTINGS RATE				
COST	UNIT	PPC	EKO	K1-K4
Studies	month	0.00	0.00	0.00
safety lump sum	month	0.00	0.00	0.00
PPE				
Helmet	pcs[8]	2.90	2.90	17.50
safety shoes	pair	19.00	17.60	25.00
gloves - impact - all purposes	pair	1.30	1.10	1.10
gloves – welder	pair	4.00	3.70	2.70
eye protection - welder	pcs	3.50	3.50	2.90
eye protection - grinding	pcs	2.20	2.20	
ear protection - one use	pair			
ear protection – muffs	pair			
masks - one use (box of 50)	pcs	5.20	5.20	
reflective vest	pcs		10.20	11.00
respiratory mask - with air feeder	pcs	261.20		
face shields	pcs	3.30		
non CE helmet	pcs	1.80		
isotherm underwear	pcs	10.80		
climbing helmet	pcs	20.50		
knees protection	pair	6.50		
Wellington boots	pair	7.40		
waterproof trousers	pcs	3.50		
non CE safety belts and helmet set	pcs	135.00		
SAFETY EQUIPMENT & SIGNS				
metal scaffold safety features per meter	meter	3.50	4.70	
metal scaffold per meter	sqm/day		0.20	
wooden scaffold safety features per meter	meter			
wooden scaffold per meter	meter			
wooden ladders 4m high	pcs			32.90
metal ladders average	pcs			
safety signs 450/600/650	pcs/av	28.00	30.80	42.60
mobile traffic lights	pair			995.00
operate mobile traffic lights	hour			13.80
flashing lights	pcs			30.20
reflective net	meter		0.70	0.70
cat eyes	pcs			4.70
install cats eyes labour	meter			1.30
road barrier	pcs			61.30
road barrier labour	meter			6.80
traffic cones 0.75m	pcs			4.80

[8] pcs, short for 'pieces', ie, cost for a single item.

COSTINGS RATE				
COST	UNIT	PPC	EKO	K1-K4
fence (metal), 1.8-2.00 high	meter		3.20	
wood/metal barricade materials scaffold type, incl. Labour for one off	meter		11.00	
equipment certification	pcs	450.00		
Labour set up signs (traffic and site signs)	pcs	1.40	1.80	2.70
materials for traffic signs base	pcs	0.30	0.30	0.30
put up reflective net labour cost, incl. materials	meter	0.40	0.60	0.90
welder canopy	sqm		3.50	
horizontal signing	case/av			100.00
special road signs average	pcs/av			130.90
fencing metal supports	pcs			
FIRE SAFETY				
fire extinguishers dry powder 6kg	pcs	19.00		
fire extinguishers charge	pcs			
MEDICAL SURVEILLANCE				
medical surveillance	person			
AGENTS MONITORING				
agents monitoring	agent			
PENALTIES AND FINES				
Penalties	case/av			
Fines	case/av			
COURT CASE				
court expenses	case/av			
EQUIPMENT				
crane 3T with operator	hour	16.50	25.70	22.00
crane 10T with operator	hour	25.70	36.70	33.00
crane 20T with operator	hour	66.00	55.00	44.00
platform truck with driver	hour	22.00	22.00	22.00
heavy equipment with operator	hour	44.00	44.00	44.00
JCB with operator	hour	20.20	25.70	25.70
truck up to 9 cubic metres with driver	hour	16.50	16.50	16.50
truck over 9 cubic metres with driver	hour	22.00	22.00	22.00
pilling system with operator	hour	0.00	76.30	110.10
bobcat - type, with driver/operator	hour	18.30	18.30	18.30
water blasting system with operator	hour	14.70	0.00	0.00
pick-up car with driver	hour	19.30	19.30	19.30
guinite mixer with operator and assistant	hour	64.60		
ADMINISTRATION COST				
administration cost	case			
COMPENSATION				
compensating insurance 3 days cover	hour	17.30	14.80	13.80

COSTINGS RATE				
COST	UNIT	PPC	EKO	K1-K4
compensating insurance balance cover	hour	13.00	11.10	10.40
compensating insurance balance cover, technician	hour	31.80	31.80	16.10
compensating insurance balance cover, technician	hour	22.00	22.00	11.10
compensating insurance balance cover, operator	hour	19.10	17.00	19.10
compensating insurance balance cover, operator	hour	13.80	12.20	13.80
IMAGE COST				
INJURY				
TYPE A casual accidents, return up to next day	case		0.00	
TYPE B casual accidents resulting between one day up to three days absence	Case	200.00	200.00	200.00
sequence of accidents type A, rate over HSE study (i.e. 1.3accident/year/employee)	case	200.00	200.00	200.00
sequence of accidents type B, rate over HSE study (i.e. 1.3accident/year/employee)	case	800.00	800.00	800.00
accident with over three days absence from work, no disabilities, temporary or permanently	case	1,000.00	1,000.00	1,000.00
temporary disabilities	case	3,000.00	3,000.00	3,000.00
permanent disabilities	case	9,000.00	9,000.00	9,000.00
Fatal	case	27,000.00	27,000.00	27,000.00
DAMAGES				
negligible damages up to 200Euros	case	0.00	0.00	0.00
minor damages (200 to 1000Euros)	case	300.00	300.00	300.00
low damages (1,000 to 10,000Euros)	case	900.00	900.00	900.00
moderate damages (10,000 to 100,000Euros)	case	2,700.00	2,700.00	2,700.00
big damages (100,000 to 500,000Euros)	case	8,100.00	8,100.00	8,100.00
catastrophic damages-over 500,000Euros and redo the project or a part of	case	24,300.00	24,300.00	24,300.00
FAILURE TO COMPLY				
failing to comply/no consequences, verbal notification	case	0.00	0.00	0.00
failing to comply/minor consequences, written notification	case	300.00	300.00	300.00
failing to comply/moderate consequences, penalty	case	1,500.00	1,500.00	1,500.00
failing to comply/high consequences, stop the work	case	4,500.00	4,500.00	4,500.00
failing to comply/severe consequences, prosecution	case	13,500.00	13,500.00	13,500.00

If no values appear in the table above, it means that the subject unit cost did not occur. Throughout, the same cost rates apply whether the cost is prevention, management failure with no accident (i.e., 'wasted' costs), or an accident. For example, a safety manager's cost rate is the same whether he is involved in prevention, e.g., safety training, or failures, e.g., accident investigations.

For image cost I accepted the same rates for all projects though it might be argued that the image cost due to an accident in Ptolemais is less than in Thessaloniki. But applying different image cost rates to three projects would overcomplicate this cost assumption that while not arbitrary, is nonetheless open to debate.

8.3 Results Overview

As different unit cost rates apply to each of the project, a re-run of the categories cost was done based on applying the same unit rates for all three cases. The re-run was performed three times, applying the PPC unit rates, the ECO unit rates and the K1-K4 unit rates.

Table 8.2, below, gives an overview of safety costs in all three projects as percentages of the project budget[9] (the value invoiced), by applying (a) individual unit rates and (b) the same unit rates. This exercise showed that despite wide variations in unit rates the final outcomes are not significantly affected, with the exception of applying the K1-K4 unit rates to PPC. In this case the safety costs are lower by 16%. The second highest change is 4.5% and occurs when applying the K1-K4 unit rates to ECO.

Table 8.2 Cross Check and Analysis of Costs of Safety in the three Projects. All figures are percentages of the overall project value

	INDIVIDUAL CASE %			SAME RATES TO K1-K4 %			SAME RATES TO PPC %			SAME RATES TO EKO %		
COST	K1-K4	ECO	PPC	K1-K4	ECO	PPC	K1-K4	ECO	PPC	K1-K4	ECO	PPC
PREVENTION	0.30	0.48	0.65	0.30	0.43	0.45	0.29	0.50	0.65	0.29	0.48	0.64
MFwnAC	0.00	0.09	0,58	0.00	0.09	0,58	0.00	0.09	0,58	0.00	0.09	0.58
ACCIDENT	0.03	0.14	0.37	0.03	0.14	0.30	0,03	0.16	0.37	0,03	0.14	0.37
IMAGE	0.01	0.17	0.12	0.01	0.17	0.12	0,01	0.17	0.12	0,01	0.17	0.12
TOTAL	0.34	0.88	1.73	0.33	0.84	1.46	0.32	0.91	1.73	0.32	0.88	1.71

The K1-K4 project appear to have succeeded with the best unit rates in part because the work was lower risk, and because safety management was most effective. This was despite injury accidents costing more at K1-K4 than in the other studies - see Table 8.3 below.

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[9] HSE (1993) refers to the 'tender' cost. This figure is likely to be close to, but not necessarily the same as, the overall project costs given here.

My data show that the cost of accidents as a percentage of the project value is very low compared with the findings of HSE (1993). In the HSE construction case, the accident costs as a percentage of tender cost to the main contractor, at about 3.12%, were between 18 times (PPC) and 100 times (K1-K4) greater than my findings. The explanation is largely provided by the very high costs of damage only accidents on the HSE study, while I assume an underreporting of damage only accidents (though with a potential to harm people) in my cases. This is based on my long experience in construction sites. I could hardly think of a site that damage only accidents with trivial or little cost were reported, regardless potential for injury. Also Greek Centre for OSH acknowledges underreporting of accidents resulting in minor injuries in its 2002 review. It is reasonably to assume that the non-reporting of minor damage accidents (with potential to personal injury) has a negligible influence on the overall cost findings, bearing in mind the threshold of 15□. Note that HSE counted damage accidents (presumably) that might not involve the potential of personal injury (in contrast to my definition). Speculatively, HSE's business case for safety may depend heavily on accidents without the potential for personal injury. Certainly, my data does not provide compelling evidence to advance the business case founded just on accident costs. Recalling that my study uses the same threshold criterion and includes direct and indirect as the HSE (1993) the two studies are comparable.

My findings generally support the notion that the business case for safety is founded more on the effectiveness of safety programmes, and the cost-effectiveness of safety interventions, than on the accident costs as a percentage of turnover.

8.4 Survey Analyses and Discussion

This subsection analyses data from each project and examines various hypothetical scenarios for improving the cost of safety. It compares the findings of the three project and the findings of the HSE (1993) construction case and HSE (2002) researches.

Table 8.3 provides an easy reference for accident costs in the three projects and other work to support the analysis and discussion in the following subsections. The HSE data has been converted to Euros at a rate of 0.69£/□.

Table 8.3 Average Accident Costs

	STUDY/REFERENCE									
	K1-K4		ECO		PPC		HSE 1993		HSE 2003	
INCIDENT	Nos	AVERAGE COST	Nos	AVERAGE COST	Nos	AVERAGE COST	Nos	AVERAGE COST	Nos	AVERAGE COST
FIRST AID	5	285	35	34	N/A	N/A	56	12	N/A	50
OVER 3-DAYS	2	2407	1	337	3	1425	0	N/A	N/A	3142
DAMAGE ONLY	1	295	2	195	1	4063	3570	107	N/A	212

HSE (1993) data above refers to the construction case. HSE (2002) presents data from an 'all employers' sample. The numbers of accidents is not given. Data from the other studies presented in HSE (1993) are not included above, but suffice to say that the overall average costs of all injury accidents was 112□, with a range from 12.00□ (the construction case above) to 1,056.00□ (oil platform). Incidentally, the HSE (1993) data infers that there were no accidents that led to *both* injury and damage. It is also not wholly clear whether HSE's damage only accidents could potentially have led to injury. In any event, there seem to be a remarkably high number of damage only accidents in the HSE construction case, which contrasts with my data and also to most of the other HSE cases. It is worth emphasising that the HSE studies were much simpler than mine, as no prevention costs were determined, and that a senior HSE inspector was 'on site' throughout.

The overwhelming conclusion that can be drawn from Table 8.3 is the very wide range of average costs both within the present study, and reported in HSE (1993). In some cases, there is a possible explanation: in K1-K4, for example, all first aid injuries were treated in hospital (some distance away) as there was no First Aid provision on site. But of course it is just for this reason that the reporting of 'minor' first aid cases was likely to be low, and that the first aid injury cost reflects the costs of 'serious' first aid cases only.

8.4.1 PILOT STUDY (PPC PROJECT)

The pilot study survey derived, besides costings, four main finding, as discussed earlier in Chapter 5:

- Very high wasted costs (management failure with-no-accident);
- No safety training provided;
- No first aid accidents reported;
- Use and support by the Safety Audit methodology.

The project was unfortunate with wasted costs (i.e., the cost of management failures with no accidents for 'extra' unnecessary safety precautions, up to the time I intervened and stopped the unnecessary costs) accounting for 30.90% of the overall safety cost.

Wasted costs are twice as high as the accident cost and almost as high as the genuine prevention cost. The wasted costs could have been allocated to prevention (used more effectively) leading perhaps to a reduction in accidents and costs.

Figure 8.1 illustrates the results of a hypothetical scenario, according to which, the wasted cost were instead spent on training and safety personnel. Those two categories were any way the most likely to absorb any additional funding based on the findings of FIB inspections for year 2001 and 2002 (FIB 2001, FIB 2002).

Training would eventually have created a more safety aware workforce and more effective supervision. Staffing would impose better controls on a daily basis over the site safety performance. In that scenario wasted costs are eliminated and the □12,478.00 wasted costs allocated hypothetically to safety training by 25% and staffing by 75%.

In this scenario, the two accidents resulting in eye injury would almost certainly have been prevented - eye protection would have been worn (see CAR 01, paragraph 5.4.1 and CAR 05, paragraph 5.4.5).

Thus (a) the accident cost would have been reduced by a total of €4,540.1, (b) the management failure with-no-accident concerning inappropriate PPE (non-CE marked) is assumed prevented, resulting in another cut of €1,125.00 and (c) image cost concerning the two prevented accidents is eliminated resulting in another cut of €2,000.00, resulting to a total cut of €7,665.10 or 19.4% of the safety cost. This cut would reduce the safety cost to 1.38% of the project budget. Even, excluding image cost and inappropriate PPE, the 0.53% of the budget theoretically spent additionally on prevention would have a positive impact on prevention generally with accident costs going down to 0.20% of the project budget.

Nevertheless, intervention could have occurred at the beginning of the project and the safety cost would then have been accounted for 1.18% of the project budget an almost 31% cut. On the other hand, this failure could have been identified at a later stage of the project and the intervention cost would be even higher. In both cases with no additional resources for training and staffing the SPI would be the one measured and the potential for incidents the same.

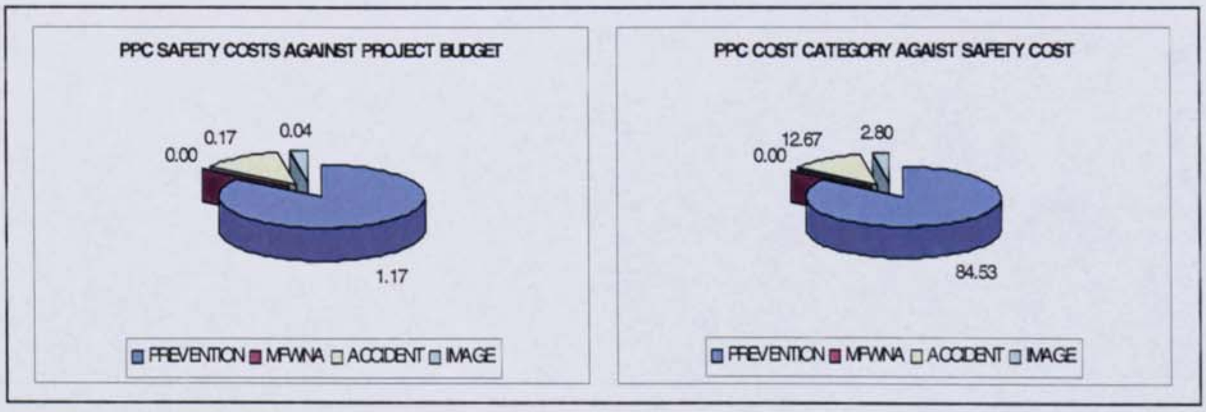

Figure 8.1 PPC case safety cost distribution in percentages for a zero intervention scenario

Management intervention would be required to ensure that a safety cost study had been at first place. In this case if the contractor was satisfied with a safety cost at 1.38% of the project budget, then the 'with intervention case' as described above would apply.

To avoid misunderstandings 'with intervention' it is meant that management intervenes to avoid a €12,478.00 spend on inappropriate prevention and spent this amount on effective prevention. Diagram 8.2 compares costs with intervention and without intervention (the actual situation).

The safety training performance measured by the two audits at "–1" indicating that "training should be provided shortly". Eventually the two accidents resulting in eye injury could have been avoided if people trained in safety and being safety aware would wear the eye protection provided by the contractor. This reasonable hypothesis supports fully the hypothetical scenario presented above.

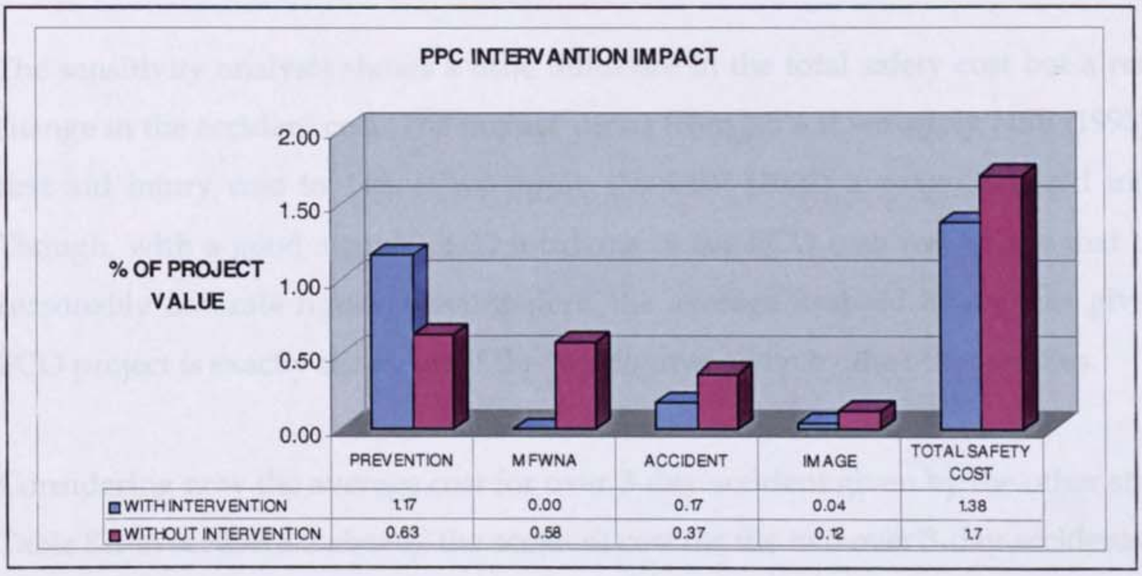

Figure 8.2 PPC – case: Safety costs against project value with and without (actual case) intervention

While no first aid injuries were reported, it is unrealistic to assume that no first aid incidents occurred. Probably minor first-aid incidents occurred in which, from my experience, either the injured person dealt with it personally or they dealt with it locally on site, e.g. the foreman providing 'artificial' first aid treatment like "tobacco stops bleeding" (author was an oral witness). Generally, underreporting of minor incidents (Greek Centre for OSH, 2002)) applies also to this project.

According to the HSE study (1993), with two over 3-day absence injuries we should expect 112 minor injures and 7140 non-injury accidents.

In the similar case of the ECO, main study (see Chapter Six), 34 minor injuries recorded resulting in a total cost of □853.30 and another □800.00 has been assumed as image cost for injuries.

Extrapolating data from the ECO case, for costs, and the HSE study for number of accidents, the expected 112 first aid cases would raise the accident cost by □2,810.00, or 32.3%, the safety cost by 7% and the cost of safety would then account for 1.83% of the project budget from 1.71% now.

The sensitivity analysis shows a little influence in the total safety cost but a remarkable change in the accident cost. The impact varies from 3.5% if we apply HSE (1993) average first aid injury cost to 14% if we apply the HSE (2002) average first aid injury cost. Though, with a good sample of 35 incidents in the ECO case we believe that this is the reasonably accurate figure. Nevertheless, the average first aid injury cost given by the ECO project is exactly the mean of the two figures given by the other studies.

Considering now the average cost for over 3-day accident given by the other studies (see Table 8.2 in section 8.2 above), the accident cost for the two over 3-day accidents could be ranged from as low as 674.00□ applying ECO case data, to 4,814.00□ applying K1-K4 case data and even higher to 6,284.00□ applying the HSC data and respectively the accident cost would be 5,332.00□, 9,472.00□ and 10,942.00□ from the actual 8,690.00□ which give a deviation of -40% to +25%. Respectively the overall safety cost derivation would be approximately -9% to + 6% and the cost of safety would then range between the 1.56% and 1.80% of the project value from 1.71% now.

Though it might not be safe to use the ECO case or the K1-K4 case data as the sample is very small, by applying HSE (2002) we must bear in mind that the unit rates are rather higher, generally, in GB than in Greece. Also it is stresses that the HSC reference gives the un-insured cost whilst my work gives the insured cost covered under an all risk insurance scheme plus the uninsured cost. Thus applying HSC figures, the result might be even higher.

8.4.2 ECO STUDY (ECO REFINERY PROJECT)

The site reported 34 first aid injuries, compared to the five reported by the K1-K4 project and none reported in the PPC project. Partially, this is explained by the fact that the building industry generally leads to more accidents than other construction (from my experience). The SPI captured that with "-2" conformance in wearing helmets and "-1" in wearing other appropriate PPE.

Applying data from Table 8.3 for the cost of accidents the recalculation would give the results presented in the Table 8.4.

Table 8.4 Recalculating the ECO first aid injuries based on other studies data

RESULTS	ECO DATA	Apply K1-K4 DATA	Apply HSE (1993) DATA	Apply HSE (2002) DATA
Average cost of first aid accidents (table 8.3)	34.0	285.0	12.0	50.0
Nos of first aid accidents (table 8.3)	35	5	56	N/A
Cost of first aid accidents	1190.0	9975.0	420.0	1700.0
% of the accident cost	76.3	96.4	53.2	82.8
% of the safety cost	16.3	55.9	8.8	20.6
% variation from the ECO first aid accident cost	+ 738.2	—	- 64.8	+ 47.0
% variation from the ECO accident cost	+ 563.5	—	- 49.6	+ 35.9
% variation from the ECO safety cost	+90.5	—	-64.7	+ 47.1
% accident cost against project value	0.14	0.93	0.07	0.19

Applying K1-K4 first-aid accident average cost will of course dramatically affect the safety cost, with the accident cost increasing from 0.14% to 0.93% of the project value. Same comments given in section 8.4 for the HSE costing methodology also applies here. From an overall view of safety costing, it is arguable where minor incidents could have been prevented and how. A better safety organization support would have avoided most image costs for management failure and management failure with-no-accident (wasted) costs for false materials and labour, accounting for 14% of the safety cost or 1,380.80 Euros. The money could have been used for proper signing. Rough estimation gives an equivalent of 80 proper safety signs. Though in practice these extra signs might contribute little to accident prevention in practice.

The hypothetical scenario considered here is as follows. The cost of safety was recalculated with the following changes:

- Install from the outset 25 proper signs; this would require an equivalent of 460.00 Euros and would save 1,380.80 Euros.
- Install proper barricading of openings from the beginning of the requirement; this would have saved a 600.00 Euro image cost.
- Train the personnel and impose closer safety supervision; the programme would require another two safety training sessions (similar to the one done) and increase safety practitioner time by eight-fold (to twice a week, two hours at a time). The programme would cost 1,949.80Euros. The aim would be to reduce first aid accidents by almost 50%, including avoidance of the one over-three days accident. The cut in costs would then be 1,595.20 Euros.

Table 8.5 gives the safety cost and compares it with the initial (actual case) in parenthesis.

Table 8.5 ECO Safety Actual Costs and Costs of a Hypothetical Scenario with the initial (actual case) in parenthesis.

COSTS CATEGORY	COST	SC %	BUDGET %
PREVENTION	7697.0(5,288.00)	86.96(54.36)	0.70(0.48)
MFWNA	0.0(959.60)	0.00(9.86)	0.00(0.09)
ACCIDENT	1154.1(1,580.80)	13.04(16.25)	0.10(0.14)
IMAGE	0.0(1,900.00)	0.00(19.53)	0.00(0.17)
TOTAL SAFETY COST	8851.1(9,728.40)	100.00	0.80(0.88)

The hypothetical scenario analysis shows that very little could have been done as the improvement of 10% can not be crucial at this level of costs for any contractor to decide in favour of a safety programme.

Though, with the SPI down to 3 (see table 8.6, actual score is de-highlighted), the potential for accidents is quite high and this is what Contractor should consider. A rough hypothetical rerun of the audit with all above actions implemented would give an SPI of 18; see table 8.6 (the hypothetical scenario audit in italics). Thus there is a potential initiative; improve safety, reduce potential costs and pay less. The fundamental hypothesis is here demonstratively confirmed.

Table 8.6 The actual Audit and the Hypothetical Scenario Audit Results

No	Question	Rate	*Rate'*
1	Competent Safety practitioner	0	*-1*
2	HSP	1	*0*
3	Safety responsibilities allocated	1	*1*
4	Safety meetings	0	*0*
5	Trained personnel for safety	0	*1*
6	Certified lifting appliances	0	*0*
7	All equipment CE marked	0	*1*
8	All vessels certified	0	*0*
9	All operators licensed	-2	*1*
10	All site equipment licensed	2	*2*
11	Approved type scaffold	0	*0*
12	All PPE CE marked	2	*2*
13	Approved type ladders	2	*2*
14	Proper signage	0	*2*
15	Site organisation (hygiene, fencing, entrance control, sanitary, first aids, fire safety)	-2	*1*
16	Equipment maintenance	0	*0*
17	Lifting appliances inspections	2	*2*
18	Trench inspections	0	*1*
19	Scaffold inspections	0	*1*
20	Electrical inspections	0	*1*
21	Wear helmet and safety shoes	-2	*0*
22	Wear other appropriate PPE as required	-1	*0*
23	Use only approved type equipment	0	*1*
24	Use/operate only if authorised	-1	*-1*
25	All access and egress are safe	1	*1*
	Total	3	*18*

Automatically certain questions should be answered:

- Would another audit show any improvement?
- Does SPI =3 correspond to the prevention cost spent by the date of the audit?
- Would any prevention cost spent after the audit day be reflected in the SPI?

These questions are all reasonably asked. Though, it must be stressed here that the main and only reason, within the content of this work, for auditing safety performance and establishing the SPI is to give an indication of the potential to have accidents and thus to avoid conclusions like "little prevention and still no accidents". This does not mean that SPI cannot give grounds for further discussion and analysis. On the contrary, it really does. For the purpose of the thesis the SPI is introduced for one reason: to give an indication/'prediction' of the likelihood and severity of accidents and of the accidents cost.

8.4.3 K1-K4 Project

The K1-K4 project also suffers from underreporting of first-aid incidents. It is unlikely that in a project of over 12 locations with 150 personnel in construction, only 5 first aid accidents occurred in 8 months time (for underreporting see e.g. Greek Centre for OSH, 2002).

The HSE study (1993), gives 56 first aid accidents for a period of 18 weeks. Though the two projects are not directly comparable, the HSE study was undertaken in a building of a supermarket building and this is a road building, there are similarities between the two projects.

The HSE study was undertaken between June and November 1991. The construction began in March 1991 and it was completed in April 1992. Therefore we assume that until November 1991, works include, excavations, and earth works generally, foundation, concrete works and electromechanical works at foundation similar to the ones undertaken in K1-K4 project. Later the works in heights and metal structure erection and general building activities would follow. Thus the expected first aid injuries for the K1-k4 taking data from the HSE (1993) study would be around 108 incidents. Similarly if extrapolating data from the ECO case the expected number of first aid injuries would be 420. Applying data from Table 8.3 for 108 first aid accidents the recalculation would give the results presented in the table 8.7.

Table 8.7 K1-K4 Recalculating the first aid injuries based on other studies data

RESULTS	Apply ECO DATA	K1-K4 DATA	Apply HSE (1993) DATA	Apply HSE (2002) DATA
Average cost of first aid accidents (table 8.3)	34.00	285.00	12.00	50.00
Nos of first aid accidents (table 8.3)	35	108	56	N/A
Cost of first aid accidents for K1-K4	8,832.00	35,940.00	6,456.00	10,560.00
% of the accident cost	41.6	85.6	20.0	51.1
% of the safety cost	11.2	34.0	8.4	13.1
% variation from the K1-K4 first aid accident cost for 108 incidents	-88.9	—	-85.8	-82.5
% variation from the K1-K4 overall accident cost for 108 incidents	-25.4	—	-82.0	-70.7
% variation from the K1-K4 safety cost for 108 incidents	-25.4	—	-27.1	-24.0
% accident cost against project value (for 108 incidents)	0.03	0.15	0.03	0.05

Apparently, applying K1-K4 actual average first aid incident cost for 108 incidents, the cost is exaggerated, assuming that 285.00□ per incident is exceptionally high and a matter of chance being in full inconsistence with all other studies. The same comments for costings methodology in HSE and HSC references apply with the one made in subsection 8.3.1.

In the worse (K1-K4 average) of the cases presented in the table 8.7 above, the accident cost is as 'high' as 0.15% of the project value. For the other cases the percentage ranges between 0.03% and 0.05%.

The data for the cost of safety does not really give any opportunity for scenarios as the accident cost and the overall management failure (with or with out accident) is very low. Consequently, for the contractor it might be tempting to assume that reducing the prevention cost, would not lead to an increase in the accident cost.

The SPI answers the question. In the third audit there are four "-1" cases and five "0" cases. In total of 25 audited areas in nine out of them there was a need for an improvement and in four of them this need was very significant. Figure 7.2 above gives the cumulative costs for prevention, accident and the SPI, to give an indication of the trend of these parameters.

Another scenario based on ECO data, considers that the ECO-case, the most efficient one, I believe, in first aid accidents reporting, with SPI=18, audited once, gave 35 first aid accidents. Though the two projects are not similar, still extrapolating data from the ECO project for the K1-K4 one then the accident cost for the K1-K4 case with twelve times more people on site (on average) and a lower SPI (average at "-3"), giving a linear 100% improvement for ECO, would be 41,492.0Euros (4,022.0 for the serious one plus twelve times the 1,580.00□ of ECO case, increased by two 2 (100%)), makes a 0.18% of the project value.

Thus any scenario gives a low accident cost. There are three main reasons for that:

- First the qualitative approach of the safety audit method itself, which gives only a rough indicator for the safety performance, giving "-2" if people do not wear helmets without giving a percentage of non-compliance.
- Secondly the project particularities, e.g. the risk of the road works was not as high as building industry, and the high budget better able to cover safety expenditures. For instance, the K1-K4 project involved twelve times more helmets than in the ECO case but the project value is as much as 20 times higher (for the period covered).
- Thirdly the effectiveness of the site safety management, (not fully captured by the audits as explained above), to tackle high possibility and high severity cases.

Additionally, the project duration was 36 months, and though the survey period of eight months was roughly representative of the project activities, it might not be the project average, or the average of that kind of a project.

Above all it is important to mention that 0.14% of the project value was spent on the external services contributing, presumably to the low accident rate and definitely to no management failure with no accident (wasted costs).

Finally, let us consider, as a hypothetical scenario (scenario 1), investing much more on safety training of the work force, providing another two rounds of training of the workforce. If we presume (very speculatively) that five accidents out of eight reported would have been prevented (see CAR numbers 2, 20, 24, 27, 33), the overall safety cost would be lower by 4%, the accident cost would negligible accounting for just 0.005% of the budget, and the image cost would be eliminated; see Figures 8.3 and 8.4 below.

The expected SPI for scenario 1 is shown on the table 8.8 and is as high as 23 from the highest figure 13 audited. The scenario one gives no "-1" case and only six "0" cases remarkably improved from audit 3 where four areas rated "-1" and five "0". It seems though that the fundamental hypothesis also applies, not as clearly as with the ECO-case, for reasons mentioned before, to this project.

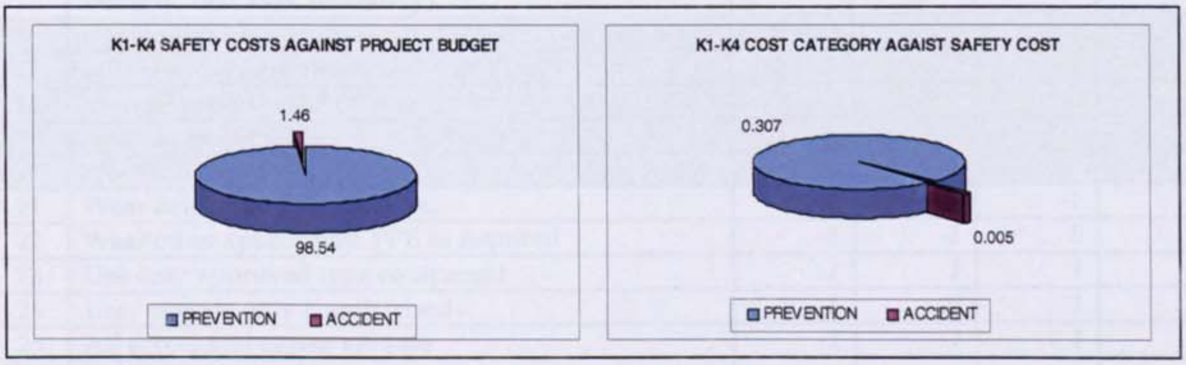

Figure 8.3 K1-K4 – case: Investing on training would eliminate image cost and accident cost would be negligible

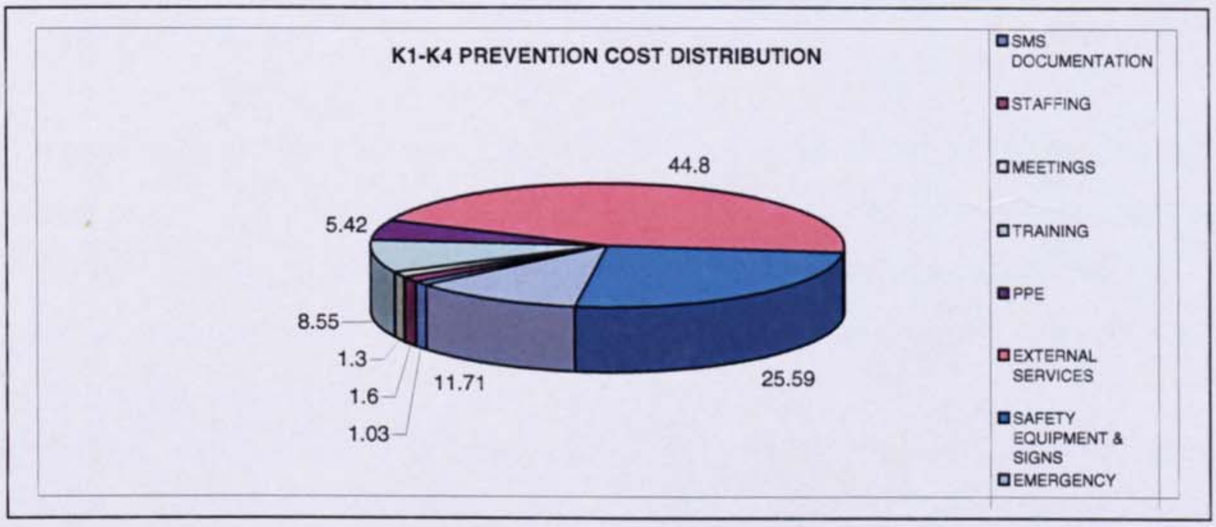

Figure 8.4 K1-K4 – case: The distribution of the prevention cost for scenario 1.

Table 8.8 K1-K4 – case: The scenario 1 hypothetical safety audit.

	Question	*Jun 03*	*Aug 03*	*Dec 03*	**Rate'**
1	Competent Safety practitioner	-2	1	2	**2**
2	HSP	0	1	1	**1**
3	Safety responsibilities allocated	-1	1	1	**2**
4	Safety meetings	-1	1	1	**1**
5	Trained personnel for safety	-1	0	1	**2**
6	Certified lifting appliances	-1	0	1	**1**
7	All equipment CE marked	0	0	1	**1**
8	All vessels certified	0	0	0	**0**
9	All operators licensed	-2	-1	-1	**0**
10	All site equipment licensed	0	1	1	**1**
11	Approved type scaffold	-2	-2	0	**0**
12	All PPE CE marked	-1	2	1	**2**
13	Approved type ladders	-2	-2	-1	**0**
14	Proper signage	-1	0	1	**1**
15	Site organisation (hygiene, fencing, entrance control, sanitary, first aids, fire safety)	-1	0	1	**1**
16	Equipment maintenance	0	1	1	**1**
17	Lifting appliances inspections	-1	-1	-1	**0**
18	Trench inspections	-1	0	0	**1**
19	Scaffold inspections	-1	0	1	**1**
20	Electrical inspections	-1	-1	0	**1**
21	Wear helmet and safety shoes	-2	1	-1	**0**
22	Wear other appropriate PPE as required	-1	-1	0	**1**
23	Use only approved type equipment	-1	1	1	**1**
24	Use/operate only if authorised	-1	0	1	**1**
25	All access and egress are safe	-2	-1	1	**1**
	Total	-26	1	13	**23**

Chapter Nine

Conclusions and Recommendations

9.1 Introduction

This chapter presents the conclusions to the overall research study, and makes recommendations for further work.

The research involved the development of a methodology for determining *the costs of accidents, the costs of safety management failures, and the costs of preventing accidents.* The methodology was applied to three construction projects in Greece. The methodology developed is novel, transparent, capable of being replicated and capable of being adapted to other activities and to other countries.

The methodology utilises the accounting system of a company, and relies on standard 'spreadsheet' (Excel®) software. The methodology can calculate all relevant costs, and if necessary, recalculations may be made to test alternative costing assumptions and 'scenarios'.

The following issues are considered:

- the research rationale;
- the development of the costing methodology;
- the application of the methodology to a pilot study and the two main accident and prevention costing studies. This sub-section covers both the challenges of applying the methodology in practice, and also presents the raw findings of each case;
- a comparative analysis of the three case studies, compared also with published work where relevant;
- a critical review of the methodology, its application, and the findings of costing studies generally;
- recommendations for further work.

9.2 Research Rationale

Most published work in the economics of safety has focused only on the cost of accidents. In the last decade there has been an upsurge of interest in the overall economic aspects of safety. But very little work has been performed on the overall cost of safety (covering both the costs of accidents and costs of prevention) and the question whether prevention costs are cost-beneficial has not been answered. In construction itself there has been very limited work. The HSE study (HSE, 1993) is dominant though some other work has been performed (e.g. Panopoulos, 1993; Reis et al, 1999). In Greece, estimates are made only of the *societal* costs of accidents.

There is a need for a coherent safety costing methodology of general application, not only in construction but other economic sectors as well. First, the method would assist in Cost Benefit Analyses (CBAs) carried out nationally to determine the economic case for new regulations. More importantly, a coherent methodology could be used to demonstrate to employers the 'business case' for investing heavily in accident prevention programmes.

9.3 Development of the Costing Methodology

A detailed description of the development of the costing methodology is given in Chapter Four. A study performed by the author at the very early stage of the work defined the boundaries of the research. While the method has been designed and developed to measure the costs of safety to a main contractor, the method could also be used by sub-contractors, insurance companies and perhaps by national or international agencies. The method determines the actual costs that are expended by a main contractor, and these costs may include those associated with accidents to sub-contractors' staff if the accidents lead to expenditure by the main contractor. Equally, if the main contractor supplies 'free' the safety equipment to subcontractors' personnel, this cost would also count as main contractor's expenditure. The method at present does not take into account any safety expenditure by sub-contractors that would in principle be an addition to the sub-contractors tender price, but this cost source could easily be added to the methodology where it is believed that these costs are significant.

The overall cost of safety in this study comprise the addition of:

- the identified costs of accident (and in some cases ill-health[10]) prevention;
- the costs of management failures with-no-accident (wasted costs);
- the identified direct costs of accidents;
- the 'image' costs associated with management failures and accidents.

The total list of all cost units that comprise the overall safety cost (120 items) is included in Table 8.1 above.

Two factors determine whether a prevention cost is included in the calculations. First, whether the cost is exclusively for safety (included), or whether the cost is primarily an operational cost (not included). For example, a scaffold is usually needed for operational reasons, so this cost is not included, but the scaffold's edge protection is included as a prevention cost. Secondly, whether the prevention cost can reasonably be calculated or estimated. For example, it would not be possible to include the cost of a SWL indicator on a hired crane. In practice most prevention costs (e.g. the costs of safety personnel on site, or the costs of PPE) are not subject to uncertainty and can be calculated easily and accurately, using unit cost rates supplied by the contractor (see Table 8.1).

The cost of management failures with-no-accidents (wasted cost) is an important element of the methodology. These costs include, as examples the cost of PPE that does not conform to CE standards, and the costs of litigation. At a more sophisticated level, some prevention activities may simply be irrelevant to prevention.

The loss of image to a contractor (e.g. adverse publicity following an accident or a prosecution) have significant cost implications, but are difficult to quantify with certainty. In this study an image cost rate has been used that was based on the author's

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10 Note that some prevention costs involved the prevention of occupational ill health. No cases of ill health were reported, and as occupational diseases often are associated with long latent periods, the long-term savings associated with health prevention are not captured in the studies.

expert judgement, but the rate can easily be changed by altering a 'constant' in the costing spreadsheet.

The costs of accidents that led to damage to plant and equipment etc, but did not involve personal injury were only included in the analysis if the accident could have resulted in personal injury. (This definition is different than that used in HSE (1993), which included all damage accidents regardless their potential to result in injury).

9.4 The application of the methodology to a pilot study and the two main studies

The methodology was tested in three construction projects: a pilot study (PPC case) was performed first and then the main study with two projects (K1-K4 and ECO cases).

The practical application of the methodology requires, as a minimum:

- a quality management system, to ensure the generation of reliable data;
- the full support of site management;
- competent safety staff on site to ensure, inter-alias, comprehensive data capture;
- a site Safety Management System, and thorough accounting facilities and record keeping.

In general, these requirements were met to a large extent in all three projects. K1-K4 fulfilled these requirements better than the other two projects.

During the pilot study, the need was identified to relate the costing findings with a site safety audit that gave a 'Safety Performance Level' (SPL). The audit was used to ensure that the methodology would have a safety net to take account of cases such as:

- poor safety performance (low safety prevention cost) but where, by chance a small number of accidents actually occurred;
- a high prevention cost that, again by chance, was combined with a high accident rate.

9.4.1 MAJOR COST FINDINGS

The cost to the main contractor ranged from 0.33% of the value of the project (tender price) in K1-K4 - case to 1.71% (PPC - case) with the intermediate value at 0.88% for the ECO - case.

Table 9.1 gives an overall preview of the cost findings and the subsequent Table 9.2 gives a more detail preview with costs per sub-category cost units in the three projects.

The major findings of the PPC pilot study were:

- the wasted cost (management failure with-no-accident cost) was as high as 31.3% of the overall safety cost;
- there was no safety training, but the workforce was highly experienced;
- one damage-only incident resulting in an accident cost accounting for 45% of the accident costs and about 10% of the safety cost;
- there are no first-aid incidents reported at all;
- the overall safety cost represented 1.73% of the overall project budget, and
- an average Safety Performance Indicator score of +13 (on a scale from -50 to +50).

The major findings of the ECO study were:

- 35 first-aid incidents were reported;
- image costs accounts for the 20% of the cost of safety;
- PPE accounts only for the 3% of the prevention cost;
- the overall safety cost represented 0.88% of the overall project budget, and
- a Safety Performance Indicator score of +3 (only one audit).

The major findings of the K1-K4 study were:

- no management failures with-no-accident costs (wasted costs);
- the prevention cost accounted for 89.6% of the safety cost;
- the overall safety cost was negligible; representing only 0.33% of the project value; and

- an average Safety Performance Indicator score of –4 (but moving from –26 at the start, to a final audit score of +13).

Table 9.1 The raw findings of the three studies – Overall presentation

	PPC – PILOT STUDY			ECO – MAIN 1 STUDY			K1-K4 – MAIN 2 STUDY		
COSTS CATEGORY	IN €	CATEGORY/ SAFETY COST %	CATEGORY/ BUDGET %	IN €	CATEGORY/ SAFETY COST %	CATEGORY/ BUDGET %	IN €	CATEGORY/ SAFETY COST %	CATEGORY/ BUDGET %
BUDGET	2,330,564.9			1,100,513.6			22,890,682.3		
PREVENTION	15,186.7	37.61	0.65	5,288.0	54.36	0.48	68,707.5	89.53	0.30
MFWNA	13,603.4	33.69	0.58	959.6	9.86	0.09	0.0	0.00	0.00
ACCIDENT	8,691.0	21.52	0.37	1,580.8	16.25	0.14	6,531.7	8.51	0.03
IMAGE	2,900.0	7.18	0.12	1,900.0	19.53	0.17	1,500.0	1.95	0.01
TOTAL SAFETY COST	40,381.1	100.00	1.73	9,728.4	100.00	0.88	76,739.2	100.00	0.34

Table 9.2 Detailed review of the costs per subcategory and cost unit in all three projects.

	PPC – PILOT STUDY			ECO – MAIN 1 STUDY			K1-K4 – MAIN 2 STUDY		
COSTS UNITS	IN €	SUB-CATEGORY/ CATEGORY %	SUB-CATEGORY/ SAFETY COST %	IN €	SUB-CATEGORY/ CATEGORY %	SUB-CATEGORY/ SAFETY COST %	IN €	SUB-CATEGORY/ CATEGORY %	SUB-CATEGORY/ SAFETY COST %
PREVENTION COST									
SMS DOCUMENTATION	794.2	5.23	1.97	382.8	7.24	3.94	722.2	1.05	0.94
STAFFING (SAFETY ORGANISATION)	4,797.0	31.59	11.88	439.9	8.32	4.52	1,127.5	1.64	1.47
MEETINGS	612.3	4.03	1.52	485.6	9.18	4.99	913.2	1.33	1.19
SAFETY STUDIES	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00
TRAINING	0.0	0.00	0.00	528.0	9.99	5.43	2,005.6	2.92	2.61

	PPC - PILOT STUDY			ECO - MAIN 1 STUDY			K1-K4 - MAIN 2 STUDY		
COSTS UNITS	IN €	SUB-CATEGORY/ CATEGORY %	SUB-CATEGORY/ SAFETY COST %	IN €	SUB-CATEGORY/ CATEGORY %	SUB-CATEGORY/ SAFETY COST %	IN €	SUB-CATEGORY/ CATEGORY %	SUB-CATEGORY/ SAFETY COST %
PPE	2,164.7	14.25	5.36	177.8	3.36	1.83	3,812.2	5.55	4.97
EXTERNAL SERVICES	1,680.0	11.06	4.16	0.0	0.00	0.00	31,513.4	45.87	41.07
SAFETY EQUIPMENT & SIGNS	5,110.0	33.65	12.65	2,917.8	55.18	29.99	20,379.5	29.66	26.56
EMERGENCY	0.0	0.00	0.00	0.0	0.00	0.00	8,233.9	11.98	10.73
FIRE SAFETY	28.5	0.19	0.07	0.0	0.00	0.00	0.0	0.00	0.00
MEDICAL SURVEILLANCE	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00
AGENTS MONITORING	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00
OTHER	0.0	0.00	0.00	356.1	6.73	3.66	0.0	0.00	0.00
MFWNAC									
PENALTIES AND FINES	0.0	0.00	0.00	0.0	0.00	0.00	0.0	#DIV/0!	0.00
COURT CASE	0.0	0.00	0.00	0.0	0.00	0.00	0.0	#DIV/0!	0.00
IDLENESS	0.0	0.00	0.00	297.6	31.02	3.06	0.0	#DIV/0!	0.00
FALSE MATERIALS EQUIPMENT & LABOUR	1,125.0	8.27	2.79	480.8	50.10	4.94	0.0	#DIV/0!	0.00
INTERVENTION	12,478.4	91.73	30.90	0.0	0.00	0.00	0.0	#DIV/0!	0.00
OTHER	0.0	0.00	0.00	181.2	18.88	1.86	0.0	#DIV/0!	0.00
ACCIDENT COST									
IDLENESS	937.5	10.79	2.32	209.7	13.26	2.16	1,016.3	15.56	1.32
FIRST AID TREATMENT	0.0	0.00	0.00	503.9	31.88	5.18	76.0	1.16	0.10
ADMINISTRATION	116.0	1.33	0.29	17.6	1.11	0.18	151.5	2.32	0.20
HOSPITAL	77.2	0.89	0.19	136.4	8.63	1.40	1,092.8	16.73	1.42

	PPC - PILOT STUDY			ECO - MAIN 1 STUDY			K1-K4 - MAIN 2 STUDY		
COSTS UNITS	IN €	SUB-CATEGORY/ CATEGORY %	SUB-CATEGORY/ SAFETY COST %	IN €	SUB-CATEGORY/ CATEGORY %	SUB-CATEGORY/ SAFETY COST %	IN €	SUB-CATEGORY/ CATEGORY %	SUB-CATEGORY/ SAFETY COST %
TREATMENT									
PRODUCTION LOSS	1,109.8	12.77	2.75	48.1	3.04	0.49	848.6	12.99	1.11
COMPENSATION	2,672.4	30.75	6.62	533.0	33.72	5.48	3,150.9	48.24	4.11
RECRUITMENT	764.0	8.79	1.89	0.0	0.00	0.00	0.0	0.00	0.00
COURT CASE	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00
DAMAGES & LOSSES	3,014.0	34.68	7.46	132.0	8.35	1.36	195.6	2.99	0.25
PENALTIES AND FINES	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00
IMAGE COST									
INJURY	2,000.0	68.97	4.95	1,000.0	52.63	10.28	1,200.0	80.00	1.56
DAMAGES	900.0	31.03	2.23	0.0	0.00	0.00	300.0	20.00	0.39
FAILURE TO COMPLY	0.0	0.00	0.00	900.0	47.37	9.25	0.0	0.00	0.00

9.5 Comparative analysis

The comparative analysis of the three studies demonstrates that the more spent in prevention as a percentage of the safety cost, the lower the safety cost (see Table 9.1 above).

In the K1-K4 case the prevention cost accounts for 89.57% of the overall safety cost and the overall cost of safety is only 0.33% of the project value. In the PPC case the prevention cost accounts only for the 37.61% of the overall safety cost and the overall cost of safety is as high as 1.73% of the project value. In the ECO case the prevention cost accounts for the 54.36% of the overall safety cost and the overall cost of safety is only 0.88% of the project value. Figure 9.1 provides an un-scaled illustration of this tendency. The low costs of safety recorded in the studies are not a reflection of poor safety standards in Greece – the safety standards in *major* construction projects in Greece are comparable with those of the UK, and require compliance with the same EU directives.

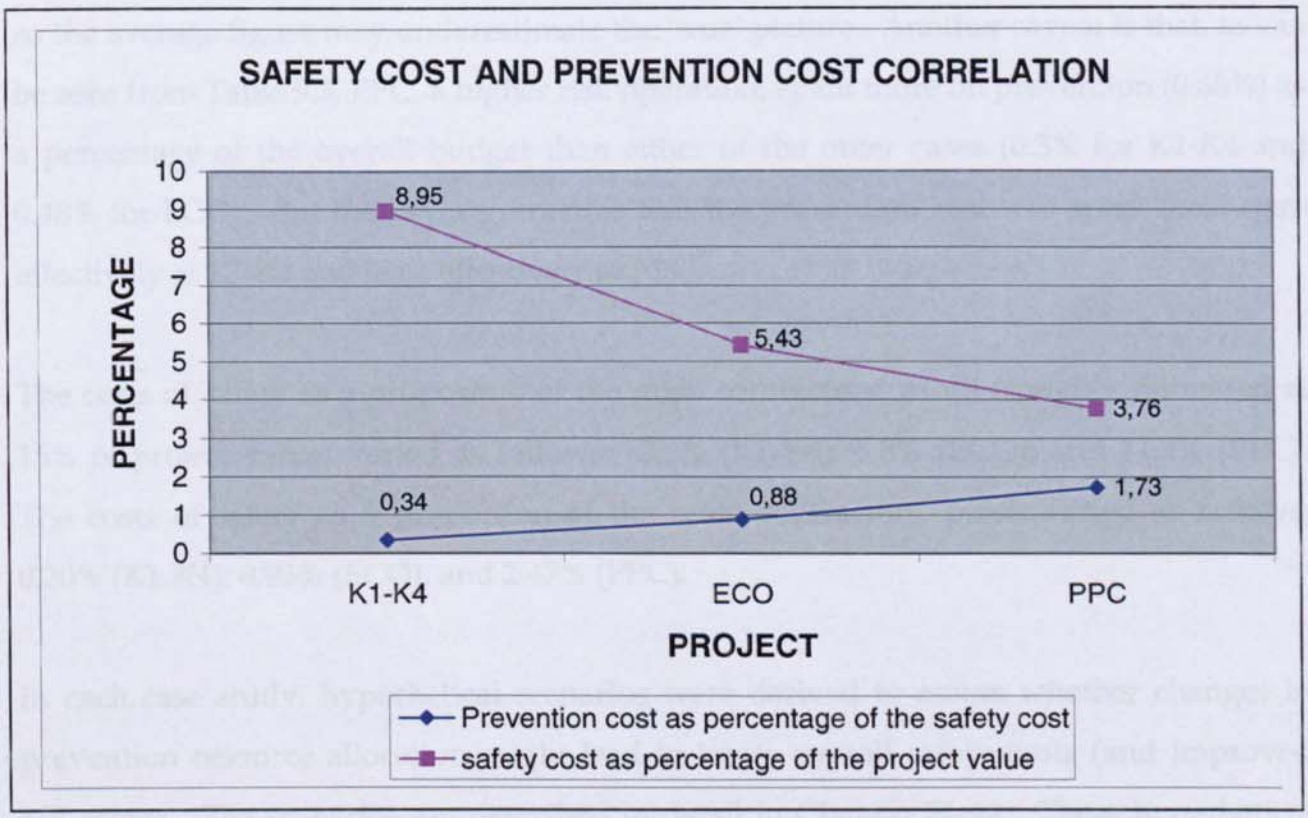

Figure 9.1. The relationship between prevention costs and the overall costs of safety (shown from left to right, K1-K4, ECO and PPC)

In very recent years, regulatory interventions to promote and secure compliance have increased dramatically, and now bear comparison with UK practice. The Greek Factory Inspectorate now employs about 400 inspectors. Moreover the costing studies were only practicable on well-managed sites with reasonably effective OSH (and accounting) systems.

The analysis of the safety cost spend in the three cases showed that effective safety management can optimise safety cost and improve safety performance in parallel. Caution should be exercised in presuming that this finding is necessarily wholly valid within the context of the present study, and it is far from certain that this is a conclusion of universal applicability. It nonetheless provides some tentative support for the argument that 'safety pays'. The key reservation about this finding is that it is not consistent with the findings of the SPI scores. However, the SPI audit was a very crude indicator, and for example, did not distinguish between the risk implications of non-use of PPE. Moreover, the K1-K4 SPI score improved dramatically as the work progressed, so the average figure may underestimate the 'true' picture. Another caveat is that, as can be seen from Table 9.3, PPC, a higher risk operation, spent more on prevention (0.65%) as a percentage of the overall budget than either of the other cases (0.3% for K1-K4 and 0.48% for ECO). But the key argument is that the prevention cost was spent most cost-effectively at KI-K4 and least effectively at PPC.

The costs of safety as a proportion of the main contractors' profit (roughly estimated at 15% of project value) varied as follows: 2.2% (K1-K4); 5.8% (ECO), and 11.5% (PPC). The costs of safety as a proportion of the main contractors' profit varied as follows: 0.20% (K1-K4); 0.93% (ECO), and 2.47% (PPC).

In each case study, hypothetical scenarios were derived to assess whether changes in prevention resource allocation might lead to lower overall safety costs (and improved SPI scores. The scenarios are described in detail in Chapter Eight. These hypothetical scenarios review is presented in Table 9.3 below.

Table 9.3 Hypothetical scenarios impact on actual findings

PARAMETER	K1-K4		ECO		PPC	
	MEASURED %	SCENARIO %	MEASURED %	SCENARIO %	MEASURED %	SCENARIO %
PREVENTION	0,30	0.31	0,48	0.70	0,65	1,17
MFWNA	0,00	0.00	0,09	0.00	0,58	0.00
ACCIDENT	0,03	0.01	0,14	0.10	0,37	0.17
IMAGE	0,01	0.00	0,17	0.00	0,12	0.04
TOTAL SAFETY COST	0,33	0.31	0,88	0.80	1,73	1.7
SAFETY PERFORMANCE INDICATOR	-4	23	3	18	13	25

Table 9.5 below shows what is the average cost of incidents in the three studies and another two studies (HSE 1993 and HSE 2003). It also gives the number of accidents incurred in each study in order to substantiate (or reject) in statistical grounds the average cost figure.

Table 9.4 Average Accident cost, in the three Projects and other two studies (HSE, 1993) construction case and HSE 2003)

	STUDY/REFERENCE									
	K1-K4		ECO		PPC		HSE 1993		HSE 2003	
INCIDENT	Nos	AVERAGE COST	Nos	AVERAGE COST	Nos	AVERAGE COST	Nos	AVERAGE COST	Nos	AVERAGE COST
FIRST AID	5	285	35	34	N/A	N/A	56	12	N/A	50
OVER 3-DAYS	2	2407	1	337	3	1425	0	N/A	N/A	3142
DAMAGE ONLY	1	295	2	195	1	4063	3570	107	N/A	212

Reviewing the findings of the three projects and other similar work (where it is possible: this is the only study that has looked at prevention costs[11], wasted costs and image costs) it is concluded that:

- the number of first aid accidents given by ECO case or the HSE (1993) study are realistic, whilst only five incidents are given in K1-K4 case and none in PPC case;
- the ECO case average first aid cost provides a figure equal to the mean value of the figures given by HSE (1993) and HSE (2002).

[11] Current work being undertaken by the European Agency for OSH has not been reviewed here as it is still in preparation.

- in the HSE (1993) study, the cost of accidents to the main contractor was 3.12% of the tender price. In the three projects the accident cost ranges from 0.03% (K1-K4) to 0.37% (PPC). But HSE (1993) included all damage costs where the accident did not necessarily involve the potential to cause harm to people. The injury cost accounts for only 0.18% of the damage costs in the HSE (1993) study;
- there is a substantial difference between the average cost of various types of accidents amongst the three projects and when compared with the other studies. This is partially is explained by the small number of accidents in the K1-K4 and PPC cases. For instance the average cost of damage only incidents for K1-K4 and ECO results from one incident only in each case. Additionally, the inherent risk of a project plays a significant role in the cost of prevention and cost of accidents as in a road building the overall risk is lower than the PPC site where much of the work was at heights. There are areas of agreement: the K1-K4 2,407 Euros average cost for over 3-days accident is close to the HSE (2002) figure of 3,142 Euros; the ECO 195 Euros average cost for damage only incident is very close to the HSE (2002) figure of 212 Euros; Also the K1-K4 295 Euros average cost for damage only incident is relatively close to the HSE (2002) figure of 212 Euros.

It should be noted that:

- HSE (1993) was an 18 weeks intensive survey in one single 14-month project, covering a specific stage of construction. Moreover the report is very superficial, with many unanswered questions;
- HSE (2002) provides an average for all employment and does not give any further details for survey duration, number of incidents etc;
- the present work covers a total of 27 months in three projects;
- the capture of first aid accidents and damage only accidents was probably better generally in the HSE (1993) study.

9.6 Review

This work presents a rigorous, transparent and comprehensive methodology for calculating the cost of safety. The methodology is supported by an Excel® data base that allows safety professionals and those taking decisions to run various scenarios in order to optimise safety cost and safety performance, based on monetary grounds. The methodology also supports the quantification of soft costs such as company reputation, moral issues and human pain. Finally, the methodology can be replicated and adapted by any accounting system, country or other economic sector.

The methodology has been tested in three projects with a total length of 27 months and it worked satisfactorily despite difficulties in generating and gathering the required data.

Entering data based on the assumptions made, unit cost rates, local currency and units occurring, the spreadsheet gives in real time the cost of safety. The spreadsheet calculates costs in percentages of the project value to provide information also for costing at a tender stage.

The methodology allows further analysis of the findings based on realistic scenarios. This enables safety professionals and decision makers to run scenarios that they are consider realistic and to examine safety impacts in project budgeting.

9.7 Further work

As a first step of further work I would suggest the further application of the methodology in a number of construction projects where a strong management system is in place. The methodology should be applied in real time[12] in order to reveal statistically accepted (for samples of good size) safety costing figures. Working out various scenarios could then justify any changes in safety and thus the economic case could be explored in more depth.

A further development of the methodology and supporting elements would be:

- quantification of the safety level via risk assessments;

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[12] MANAGEMENT FORCE has been committed to apply the methodology in all their new contracts in construction from November 1, 2004 onwards, providing that there is a full time site safety function. Application planned for November 2003 but due to contractors overload because of the Olympics 2004 in Athens, contractors suggested application a year later.

- correlation of the safety level with average expected cost of accidents;
- correlation of the safety level with average expected management failures with-no-accident costs;
- correlation of the safety level with prevention cost optimisation;
- adding to the costing data-base the safety features of some operational costs;
- to calculate accident rates (per person employed);
- to improve the evaluation of image costs.

Quantification of the safety level, based on risk assessment, would allow a net correlation of the safety level with the average expected management failures (with and with-no-accidents) cost and thus the average expected cost of safety would be calculated. The quantification of the safety level would also allow for an optimisation of the prevention cost, by spending on prevention based on a consequences hierarchy, in monetary terms.

Finally any improvement in quantifying or factorised the image cost would allow a more secure approach in monetary terms.

For the software, I believe that there should not be any major changes in regard to the required features and outcomes, but it is possible that a bespoke data base application would facilitate data entry and analysis.

Finally, the business case for safety might best be evaluated by costing two (or more) projects carrying out comparable work (for example motorway construction) where the overall risk levels are similar. Evidence from such a study would reveal with greater certainty the relationship between prevention costs, accident costs, and the overall cost of safety.

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