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Letter to Editor

Risk Estimation in the Greek Constructions' Worksites by using a Quantitative Assessment Technique and Statistical Information of Occupational Accidents

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Abstract

The risk estimation is a very crucial part of the whole procedure of evaluating hazards in the work. We can consider the risk as a quantity, which can be measured and expressed by a mathematical relation, under the help of occupational accidents' data. In this paper, we analyze a quantified risk estimation technique and apply on the constructions' worksites by using occupational accidents' statistical information of SEPE Service (Ministry of Employment) and IKA Social Insurance Institute (Ministry of Health). The outcome result of the risk value R has been estimated to be higher than 200 (in the risk gradation scale of 0-1000), for the time period 2000-2003, and proves that actions must be done earlier than 1 year, to degrade the likelihood of arising fatal accidents.

Keywords: risk analysis, risk estimation, risk assessment, quantitative risk assessment, quantified risk evaluation, construction worksite, occupational accident

1. Introduction

Risk has been defined as "the chance that someone or something that is valuated will be adversely affected by the hazard" [1]. A hazard is any unsafe condition or potential source of an undesirable event with potential for harm or damage [2]. Risk analysis is an essential tool for the safety policy of a company, and the risk estimation is the most important part of the whole procedure of hazards' evaluation in the work, and especially in the constructions' worksites, where the work conditions are unstable. In this paper, we analyze a quantified risk estimation technique and apply on the Greek constructions' worksites by using occupational accidents' statistical information of SEPE Service (Ministry of Employment) and IKA Social Insurance Institute (Ministry of Health), concerning years 2000-2003.

2. Quantitative Assessment of Risk

We can quantified the risk and consider it as a quantity, which can be measured and expressed by a mathematical relation [3], under the help of real accidents' data.

The quantitative calculation of the risk (or quantified risk evaluation) can be given (see [3], [5], [6], [7]) by the following relation:

$$R = P \cdot S \cdot F \qquad (2.1)$$

where:

R: the Risk
P: the Probability Index
S: the Severity of Harm Index
F: the Frequency Index

Each factor in equation (2.1), takes values in the scale of 1-10 according to Tables 1, 2, 3, so that the quantity R can be expressed in the scale of 1-1000 (see [3], [4]). Concerning the gradation of probability index (P), the value P=1 corresponds to probability of 0.1 or 10%, P=2 to probability of 0.2 or 20%, etc. We note the possible existence of intermediate values, as a result of linear interpolation e.g. the value P=4.2, corresponds to probability of 0.42 or 42%.

We can use Table 4 to associate the gradation of the risk value R with the urgency level of required actions. To develop Table 4, we give values to Probability and Severity of Harm factors so that the Frequency (or Exposure) Factor could determine the urgency level of the required actions [3].

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Table 1
Gradation of the Probability Index in association with the undesirable event

Probability Index (P)	*Description of Undesirable Event*
10	*Unavoidable*
9	*Almost assured*
8	*Very Probable*
7	*Probable*
6	*Probability slightly greater than 50%*
5	*Probability 50%*
4	*Probability slightly less than 50%*
3	*Almost improbable*
2	*Very improbable*
1	*Improbable)*

Table 2
Gradation of the Severity of Harm Index in association with the undesirable event

Severity of Harm Index (S)	*Description of Undesirable Event*
10	*Death*
9	*Permanent total inefficiency*
8	*Permanent serious inefficiency*
7	*Permanent slight inefficiency*
6	*Absence from the work >3 weeks, and return with health problems*
5	*Absence from the work >3 weeks, and return after full recovery*
4	*Absence from the work >3 days and <3 weeks, and return after full recovery*
3	*Absence from the work <3 days, and return after full recovery*
2	*Slight injuring without absence from the work, and with full recovery*
1	*No one human injury*

Table 3
Gradation of the Frequency Index in association with the undesirable event

Frequency Index (F)	*Description of Undesirable Event*
10	*Permanent presence of damage*
9	*Presence of damage every 30 sec*
8	*Presence of damage every 1 min*
7	*Presence of damage every 30 min*
6	*Presence of damage every 1 hr*
5	*Presence of damage every 8 hr*
4	*Presence of damage every 1 week*
3	*Presence of damage every 1 month*
2	*Presence of damage every 1 year*
1	*Presence of damage every 5 years*

Table 4
Gradation of the Risk Value in association with the urgency level of required actions

Risk Value (R)	*Urgency level of required actions*
800 - 1000	*Immediate action*
600 - 800	*Action during 7 days*
400 - 600	*Action during 1month*
200 - 400	*Action during 1 year*
<200	*Immediate action is not necessary but it is required the event surveillance*

3. Risk Estimation in the Constructions' worksites

We proceed to the calculation of risk value R on the Greek constructions' worksites, by using the quantitative technique of equation (2.1) and occupational accidents' statistical information of SEPE Service (Hellenic Ministry of Employment) and IKA (Hellenic Ministry of Health), concerning the year 2002 (see Tables 5, 6) and the time period 2000-2003 (see Tables 7). Moreover Table 8 presents the calculation results of the total value R in the Greek constructions worksites for the period 2000-2003.

The Probability Index (P) can be calculated (in column C of Tables 5, 6) for various undesirable events (Column A) by using the corresponding number of accidents (Column B) and the following equation:

$$P = \frac{\text{Number of accidents or undesirable events}}{\text{Total number of accidents}} \times 10 \qquad (3.1)$$

The Severity of Harm Index (S) is estimated (in column D of Tables 5, 6) for the worst case by using the gradation scale of Table 2.

The Frequency Index (F) shows the number of accidents during a definite time period. In order to calculate the accidents' frequency (per day), we use data for ***1 year*** time period (i.e. with 48 working weeks and each working week with 5 working days) in the relation:

$$\text{Accid. Frequency} = \frac{\text{Number of accid. per event}}{48 \bullet 5} \qquad (3.2)$$

Then the Frequency Index (F) is calculated (in column E of Tables 5, 6) by the combination of equation's (3.2) result, and the gradation scale of Table 3. Eventually, the risk value R for year 2002, is depicted in Column F of Tables 5, 6. Comparing tables 5, 6 (column F) we realize that the results for R are different. The reason is that these tables have been produced by two separated data-bases: Table 5 from the SEPE data-base, and Table 6 from the IKA one.

Furthermore, by using the above explained quantitative risk assessment technique, expressing by equations (2.1), (3.1), (3.2) and the accidents' data of SEPE in Table 7 (concerning years 2000-2003) we have calculated in Column E of Table 8, the total risk value R in the Greek constructions' worksites and Public Works. Furthermore, Table 7 represents the sample space, or in other words the set of all possible outcomes (i.e. undesirable events or accidents) for the Greek constructions worksites and Public Works, and it is used to calculate the probability index P. For example, as far as concern the year 2000, by using equation (3.1), and Table 7, where the number of accidents in the constructions worksites is N_{CW}=66 and the total number of accidents in the Greek worksites is N_T=127, we have the result of P=(66/127)x10=5.2. To take into account the worst case, we give the maximum value S=10 to Severity of Harm Factor (S), while the Frequency Index (F) has been calculated by the usage of equation (3.2) and the gradation scale of Table 3, so that 66/48=1.375 accidents per working week, which corresponds to F=4.1 (according to Table 3 and in association with the using of linear interpolation for the intermediate values).

4. Discussion – Results - Comclusions

The risk estimation is a very crucial part of the whole procedure of evaluating hazards in the work. We can consider the risk as a quantity, which can be measured and expressed by a mathematical relation, under the help of occupational accidents' data. In this paper, we analyze a quantified risk estimation technique (QRET) and apply on the Greek constructions' worksites by using occupational accidents' statistical information of SEPE Service (Ministry of Employment) and IKA Social Insurance Institute (Ministry of Health).

To develop the above referred quantitative risk assessment technique, we used but improved specific points (like gradation scales, equations, and estimated factors) of other works included in the scientific literature [e.g. the papers of Fine and Kinney (1971), Hammer (1972), and Marhavilas and Koulouriotis (2008)].

The outcome results of the risk estimation R for year 2002, according to the *QRET technique* (Table 6, column F) show that the most important hazard source in the Greek Constructions' Worksites and Public Works, according to IKA data-base, is the **"***Impacts on stable objects, hits by moving objects***"** (with R=215.7>200) and proves that required actions must be done earlier than 1 year, to degrade the likelihood of arising fatal accidents.

Moreover, the maximum outcome result of the risk value R in the Greek constructions' worksites and Public Works, according to SEPE data-base, which concerns the period of years 2000-2003, is R=228.8>200 (Table 8) and proves that actions must be done earlier than 1 year, to degrade the likelihood of arising fatal accidents.

Comparing tables 5, 6 (column F) we realize that the results for R are different. The reason is that these tables have been produced by two separated data-bases: Table 5 from the SEPE data-base, and Table 6 from the IKA one.

The contribution and merit of this work to the health and safety science, could be focused on the following points:

On the risk prediction and prevention: The use of the above-presented new quantitative risk assessment technique could help the responsible persons of a work-site (directors, safety managers/engineers, etc) to predict hazards, unsafe conditions and undesirable events/situations, and also to prevent fatal accidents.

On the application of this new technique, for the first time on the Greek Constructions' Worksites and Public Works (as a case study), in such a way which makes the new technique useful tool for the quantitative risk estimation.

As a general conclusion, the development of an integrated risk analysis scheme, which will combine a well-considered selection of widespread techniques (including the QRET and others) would enable the safety engineers to achieve more efficient results on risk identification.

Table 5

Accident's statistical information of Hellenic Ministry of Employment according to report of SEPE of year 2002 (columns A, B), estimation of index S (col. D), and calculation of indices P, F (col. C, E) and risk value R (col. F)

(A)	(B)	(C)	(D)	(E)	(F)
Description of Undesirable Event	Number of Accidents	Probability Index (P)	Severity of Harm Index (S)	Frequency Index (F)	Risk Value (R)
Drops (Slumps from height)	325	3,07	10	5,05	155,1
Downfalls (at the same level)	130	1,23	8	4,43	43,5
Slips, hits by dropping objects	181	1,71	10	4,96	84,9
Impacts on stable objects, hits by moving objects	93	0,88	9	4,23	33,5
Squeezing	111	1,05	9	4,33	40,9
Overworking, hard jobs	25	0,24	7	3,36	5,6
Exposure/Contact in/with extreme temperatures	10	0,09	7	2,94	1,9
Exposure/Contact in/with electric current	27	0,26	10	3,42	8,7
Exposure/Contact in/with harmful substances or radiation	3	0,03	9	2,75	0,7
Other reasons of accidents	153	1,45	-		
Total	1.058	10,00			

Table 6

Accident's statistical information of Hellenic Ministry of Health according to report of IKA of year 2002 (columns A, B, estimation of index S (col. D), and calculation of indices P, F (col. C, E) and risk value R (col. F)

(A)	(B)	(C)	(D)	(E)	(F)
Description of Undesirable Event	Number of Accidents	Probability Index (P)	Severity of Harm Index (S)	Frequency Index (F)	Risk Value (R)
Drops (Slumps from height)	2.141	1,34	10	6,12	81,7
Downfalls (at the same level)	2.561	1,60	8	6,33	80,9
Slips, hits by dropping objects	1.880	1,17	10	5,98	70,1
Impacts on stable objects, hits by moving objects	5.477	3,42	9	7,01	215,7
Squeezing	2.501	1,56	9	6,30	88,5
Overworking, hard jobs	501	0,31	7	5,16	11,3
Exposure/Contact in/with extreme temperat.	311	0,19	7	5,04	6,8
Exposure/Contact in/with electric current	58	0,04	10	4,05	1,5
(Exposure/Contact in/with harmful substances or radiation	245	0,15	9	5,00	6,9
Other reasons of accidents	356	0,22	-	5,07	-
Total	16.031				

Table 7
Statistical information of fatal accidents of Hellenic Ministry of Employment (according to report of SEPE of years 2000, 2001, 2002, 2003) for various categories of financial activities

Code	Description of various financial branches (according to STAKOD-91 coding)	Year **2000**	Year **2001**	Year **2002**	Year **2003**
1	Agriculture-stock farming	5	9	7	0
2	Forestry - woodcutting	2	2	0	0
5	Fishing	2	4	0	0
10	Mines – quarryes	2	3	1	0
14	Other mining and quarrying activities	0	0	1	1
15	Industries of foods and drinks	3	10	9	5
16	Tobacco products	1	0	0	1
17	Textile production	0	0	2	2
18	Production of clothes	0	1	1	0
20	Wood industries	0	1	1	1
21	Production of wood-pulp, paper, cardboard	0	1	1	2
22	Editions, impressions	0	0	1	0
23	Production of oil-products	0	0	2	2
24	Production of chemical substances	1	1	2	1
25	Rubber industries and production of plastic matter	1	1	0	2
26	Industries of non-metallic minerals	9	3	5	9
27	Production of metals	4	4	0	6
28	Manufacture of metallic products (except machines)	3	3	8	5
29 31	Machine and equipment construction	0	3	4	2
32	Production of Radio & TV device	1	0	0	0
34	Car industries and construction of vehicle trailer	0	1	1	1
35	Construction of transportation equipment	3	7	5	3
36	Furniture production	0	2	0	0
40	Supply of electric energy and natural gas	6	3	6	3
41	Companies of water supplying	1	0	0	0
45	Constructions' Worksites – Public Works	66	86	80	79
50	Car commerce, car-bike repairing, fuel station	2	2	1	0
51	Wholesale trade	3	4	4	3
52	Retail trade – Repairing of domestic kinds	2	4	4	2
55	Hotels – Restaurants	2	2	2	0
60	Land Transportations	1	9	1	3
61 62	Water Transportations	0	1	2	1
63	Relative to transportations activities – Storages	0	3	2	1
64	Telecommunications- Posts- Mails	2	4	1	3
71	Machines leasing	0	1	0	0
74	Other enterprising activities	2	2	2	2
75	Public administration - Health insurance	0	3	2	1
80	Education	0	2	0	0
85	Health & Social Care	0	1	0	0
90	Waste disposal	1	3	1	3
92	Entertainment, culture & sport activities	1	0	1	1
95	Other activities of ministration	1	1	0	0
99	Other enterprises	0	1	0	0
	Total	**127**	**188**	**160**	**145**

Table 8
Calculation results of the total risk value R in the Greek constructions' worksites & Public Works, concerning years 2000-2003, by using the quantitative risk assessment technique (equations 2.1, 3.1, 3.2) and occupational accidents' data of SEPE/Hellenic Ministry of Employment of Table 7.

(A)	(B)	(C)	(D)	(E)
Year	*Probability Index* **(P)**	*Severity of Harm Index* **(S)**	*Frequency Index* **(F)**	*Risk Value* **(R)**
2000	5,2	10	4,10	213,2
2001	4,6	10	4,20	193,2
2002	5,0	10	4,20	210,0
2003	5,5	10	4,16	228,8

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