safety

MDPI

Article

# Work Accidents Correlation Analysis for Construction Projects in Northern Greece 2003–2007: A Retrospective Study

**Sotiris Betsis, Maria Kalogirou, Georgios Aretoulis * and Maria Pertzinidou**

Department of Transport and Project Management, Faculty of Engineering, School of Civil Engineering, Aristotle University of Thessaloniki, 54124 Thessaloniki, Greece; sotirismpetsis@gmail.com (S.B.); kalogimariad@gmail.com (M.K.); pertz3@hotmail.com (M.P.)

* Correspondence: garet@civil.auth.gr; Tel.: +30-2310-994564

Received: 10 March 2019; Accepted: 6 May 2019; Published: 27 May 2019


**Abstract:** Construction project related accidents are critical events and it is imperative that they are analyzed in order to understand and identify their root causes. Therefore, the present study analyzes work accidents on construction projects in northern Greece. The methodological approach firstly includes the collection of accident related data from the "Greek Work Inspection Organization", which is followed by a descriptive analysis and corresponding codification of available data. The next step includes the creation of an appropriate database in SPSS to accommodate all relevant data and subsequent correlation analysis that aims to identify potential trends and tendencies within the accidents' sample. The findings highlight the most frequent occurrences regarding construction work related accidents and at the same time identify correlations among the various parameters associated with them. The majority of accidents include inexperienced personnel and workers in the age range of 24–44 years old. Moreover, most accidents occur during the summer and are not fatal. Falls are by far the dominant type of accident, and as a consequence, fractures are the most frequently occurring type of injury. Finally, most accidents occur in the morning, with injuries focusing on the lower parts of the body, and in the presence of general use equipment. The current paper also identified associations among various accident characteristics. These findings could help towards reducing the number and severity of work-related accidents. Improved construction site organization, accompanied by the dedication of management towards health and safety and more frequent inspections, could decrease the number and severity of accidents.

**Keywords:** work accidents; correlation analysis; type of accident; accident causes; worker characteristics; construction industry

## 1. Introduction

Health and safety in the construction industry is a major issue in Greece. As seen from the Hellenic Labor Inspectorate's reports, the building construction sector had the highest record of ratifications to inspections made (115.34%) in the year 2013 [1]. The contribution of the construction industry to the occurrence of fatal accidents every year is also a major concern. Out of 189 fatal accidents reported from 2010 to 2013 in Greece, 77 (40.7%) occurred in the construction sector [1].

It should be emphasized that the actual numbers from research aimed at improving the health and safety performance of the industry are seldom published in Greece. This motivated the authors of this paper to focus on research that will help to improve the quality of the construction sector's health and safety practices in the country. The research findings highlight the situation regarding construction accidents in a period (2003–2007) that the construction sector in Greece was operating under "normal"

conditions. Since this time period, no significant changes in legislation have taken place. The research findings are useful for international research and contribute towards a better understanding of the conditions and causes of accidents. Thus, the main goal was to understand the "mechanisms" behind each accident and suggest prevention measures. This, hopefully, will reduce the number of accidents and their severity, thus creating a safer environment for the people working on construction projects. International literature offers a plethora of quality research on the matter and papers such as those by López Arquillos, Rubio Romerro, and Gibb [2], Camino López, Ritzel, Fontaneda, and González Alcantara, [3], Haslam et al., [4], Chi and Han [5], and others presented in the literature review provide an excellent benchmark for this research. The international literature review helps to better understand this paper's findings by relating and comparing them to research made by others.

The current paper firstly presents a detailed literature review along with the parameters considered in order to collate all the available information in an organized manner. Then follows the research methodology, which highlights all the steps taken in order to analyze the data and provide useful information regarding the causes of accidents. The results and discussion, along with conclusions and suggestions for future work, complete the current research study.

## 2. Literature Review

### *2.1. Literature Review Methodology*

A literature review on an international basis was conducted in order to record similar research completed in the past. Based on the Scopus, Science Direct, and Google scholar databases and using the keywords "workplace accidents" or "construction accidents" and "construction safety", a significant number of papers were found matching the review criteria. Studies were selected based on the following criteria:

(a) the study was empirical with a substantive focus on identifying factors and variables related to construction accidents,
(b) data involved construction employees, unsafe behaviors, and work-related accidents,
(c) was published between 2000 and 2017,
(d) was available online,
(e) was published in a refereed journal, and
(f) was written in English.

The results of the relevant studies were then compared with the data produced on the basis of this review.

### *2.2. Literature Review*

A number of relevant research papers are listed below. The aim is to firstly identify the type and classification method of data and then compare the results of the presented papers with the findings of the current research. The first study highlights the time of accident. More specifically, a study conducted in Spain of 2,155,954 cases of construction accidents from the year 1990 to 2000 [6] found that 57.3% of the total number of accidents occurred between 09:00 and 12:59, followed by 18.2% between 13:00 and 16:59. The majority of fatal accidents (38%) also happened between 09:00 and 12:59, followed by 29% occurring between 13:00 and 16:59.

The next study sheds light on fatal falls. In this context, the study by Chi, Chang, and Ting, which analyzed 621 cases of fatal falls during 1994–1997, found that 92.1% of the workers involved in the accidents were men, and the remaining 7.9% were women. In 29.1% of cases, the workers' age falls in the range 35–44 years, followed by 22.2% for 25–34-year-old workers, and finally, 18.5% of the cases concern workers in the age group 45–54 years. The majority of fatal falls, 80.5%, involved workers with less than one year's experience [7].

The type and cause of accidents is the focus of the next research paper. Jabbari and Ghorbani [8] found that the most frequently occurring type of accident was falling to a lower level, which occurred in 57% of the cases. The second most common type of accident was injury due to falling objects with 20%. This was followed by contact with hazardous materials, which occurred in approximately 12% of the cases. The main cause of occupational accidents is attributed to working at height or open edges without using fall-protection systems (33% of the cases) followed by accidents associated with working on unsafe scaffolding, during erecting or unfolding scaffolding and contact with power lines, gas pipelines and electrical systems, each representing 10% of the cases.

Similarly, Goh's and Ubeynarayana's study sheds light on [9] the types of accidents in construction sites. Their study analyzed 1000 cases of construction accidents and found that: 23.6% of the accidents were falls, 21.2% are related to objects collapsing, 13,4% were strikes by falling objects and 10.8% were electrocutions.

Accidents related to subway construction are presented in the next paper. The suggested study, which was published in 2014, was based on a database of 241 incidents and showed that the type of accident that occurred most is "collapse", accounting for 40% of the cases. Second comes "struck by object" (12% of the cases) while "falls" come third with 10% [10].

Cheng, Leu, Lin, Fan, and Chihhao [11] associate the severity of accidents with the size of the firm. They found that most construction related accidents that cause death or injury occur in small firms. Between 2000 and 2007, 800 out of 1546 accidents, happened in enterprises with 10 or less employees, while firms with 500 or more employees had only 54 incidents over the same time period.

Hale, et al. [12] aimed at understanding the underlying factors of accidents. In their study, which focused on 26 cases of workplace accidents that led to 28 fatalities, they identified the following factors: in 23 cases of accidents, a violation had occurred and 21 errors were observed. In 25 cases, the factor of "Planning and Risk control" appeared. In 24 cases, "Hardware and workplace ergonomics/usability/hazards" appeared to be the factors that caused the accident while in 15 cases, the factor "Competence and suitability" appeared.

Ale et al. [13] focused on types and causes of accidents in the Netherlands. Out of 2424 cases of accidents, 1330 were falls from height (roof/floor, scaffold, ladder), 472 were caused due to contact with falling objects, while 311 were caused due to contacts with moving parts of machines. Out of 559 "Falls from roof/floor", the main cause was "Roof edge protection failure" (48%), followed by "User ability failure", accounting for 30% of the incidents. In the "Contact with falling objects" type of accident, the main causes were "Safe zone failure" in 48% of the cases, followed by "Connection/Anchorage failure" in 42% of the cases [13].

The factors influencing unsafe behavior were the focus of Khosravi et al. [14]. More specifically, Site condition, Organization, Project management and Individual factors are the most common factors that influence unsafe behaviors which lead to accidents in the construction industry. Camino Lopes, Ritzel, Fontaneda, and Gonzalez Alacantara [3] analyzed in their study construction accidents in Spain from 1990 to 2000. Some of the highlights included the following findings and observations: the most serious and fatal accidents occurred in the age group of 30 to 39 years, accounting for 27.7% of the total accidents, followed by the age group of "40 to 49" years, with 18.5%. The age groups of "20 to 24" and "24 to 29" years came in third place with 17.7%. Most accidents seemed to occur amongst workers with experience of "3 to 6 months" with 17.5%, followed by workers with experience "6 months to 1 year" with 16.4% of the cases. The type of accident that occurred the most was "Overworking", appearing in 20.9% of the cases and closely followed by "Struck by objects and tools", which occupied 20.5% of the sample. "Falls" from the same or different levels came third, with 19.9% of the cases having been caused by them.

Age, experience and accident severity are the focus of the analysis by Aquillos, Romerro, and Gibb regarding Spain, which was published in 2012. Their research concerned the time period from 2003 to 2008. One of the most significant findings, in this study included the fact that the severity of an accident tends to rise with the age. More specifically, the age group from 60 to 65 years had more than

double the chance of being involved in a fatal accident (5.94%) rather than in a less serious one (2,10%). In lower age groups the opposite was true. In the group "20 to 24" the probability of a less severe accident occurring is 15.94% and the probability of a fatal one occurring dropped to 8.48% [2]. The highest difference between the "Total Accident Rate" and the "Fatal Accident Rate" regarding previous experience was associated with the 4 to 12 months of experience group with a difference of +4.27% (TAR-FAR) and the lowest in the 5 to 10 years of experience group with a difference of −3.19% [2]. The most frequent type of injury in the sample was "Dislocations, sprains and strains", accounting for 40.82% of the sample, then followed by "Wounds and superficial injuries" in 38.8% of the cases. Although those types of accidents were abundant, their fatality rate was negligible, with 0.46% and 0.29% correspondingly of the cases being fatal. "Multiple lesions", on the other hand, occupy only 1.28% of the sample but account for 46.28% of the fatal accidents followed by "Heart attacks and strokes", which appeared in 0.11% of the cases, while they produced 16.56% of the total fatalities [2]. In the same context, Zhipeng, Irrzarry, and Li, [10] report that in 115 out of 241 accidents were fatal.

Similarly, the relation between age and accident rates was the focus of Salmien in the year 2004. His literature review investigated the accident rates of younger workers (under 25 years of age) versus workers of greater age. More specifically, in 56% of the published studies young workers had the highest chance of being involved in a non-fatal accident, 27% of the studies showed no difference between younger and older workers, while in 17% of the papers, older workers seemed to have a higher chance of causing a nonfatal accident. Concerning the fatal accidents, in 64% of the studies, younger workers had a lower chance of being fatally injured than older ones, while 16% of the studies stated the opposite [15].

Yi, Kim, Kim, and Koo, [16] investigate the types of accidents and the age groups that are involved in them in construction worksites. They found that, in 92.292 accidents recorded from 2004 to 2008 in Korea, 32.7% were "Falls to a lower level", 16.7% of the cases were related to "Overworking", 11,7% of the cases were "Falls to the same level" and 11.3% were "Strikes by falling objects". Out of 3318 cases of fatal accidents in the same period 46.7% were caused by workers of over 50 years of age and 32.5% by the "40–49" year old group.

A study published in 2017 by Hola and Szóstak, consisting of 130 work accidents that occurred in the construction industry in Lower Silesia, between 2008 and 2012, concluded that an accident occurred more frequently when the affected person was moving. The causes of those accidents were slipping, tripping, falling onto a lower level or falling over at the same level, with vertical collision with fixed objects being next on the list. As a result, the most common type of injury was bone fractures [17].

Heatwaves, age and experience were examined as potential factors that contribute to accidents. A study was conducted in Australia by Rameezdeen and Elmualim and the following was concluded: workers that had more accidents during heat wave periods fell in the 25 to 34 years old age group in 25.6% of the cases, followed closely by the 35 to 44 years old group in 24% of the cases. Accidents seemed to occur mostly on among experienced workers (over 1 year of experience) in 79.1% of the cases rather than inexperienced ones. The percentages mentioned are kept relatively steady in the normal (non-heat wave) period [18].

A difference in the accidents' frequencies between skilled and unskilled workers was also discovered. In the study published in 2005, which analyzed a sample of 100 accidents the authors found that, in 60 cases of accidents skilled workers/operatives were involved, while unskilled workers seemed to be involved in 27 cases [4].

Safety risk attributes and models for accident probability forecast were the subject of the research carried out by Esmaeili, B., Hallowell, M., and Rajagopalan, B. [19,20]. Their study included content of a large, representative, and reliable national database of 1812 injury reports of struck-by incidents. In total, 22 safety risk attributes that led to struck-by incidents were identified and their relative risks were quantified. Then a number of models were proposed which can be used by safety managers in order to skillfully forecast the probability of a safety incident happening, given identifiable characteristics of planned work.

Finally, Carrillo-Castrillo, Trillo-Cabello and Rubio-Romero, [21] and similarly Abdelhamid and Everett [22] managed to identify the most frequent causes of accidents in the construction sector, in order to help safety practitioners with the analysis of official accident investigation reports. Their research revealed important associations of the types of accident causes with accident mechanisms and construction stages.

## 3. Research Methodology

The methodology of the following research briefly included data collection on accidents, creation of an SPSS database to include all available data, sample descriptive statistics and finally correlation analysis. More specifically, the methodological approach is described in the following sub-sections.

### *3.1. Work Related Accidents' Data Collection*

The accidents' data was provided by the "Greek Work Inspection Organization" of the region of Central Macedonia, in the form of accident reports, which are kept for every work accident that has taken place. The choice of this source and approach was made taking into consideration that the "Work Inspection Organization":

1. Oversees the implementation of work legislation in all public and private enterprises.
2. Is responsible for registering all work-related accidents.
3. Investigates the causes that led to a work-related accident.

The aforementioned facts make this organization the most competent and reliable body regarding work related accidents. The sample consists of 413 reported cases of construction accidents that occurred in the region of Thessaloniki and Kilkis (Northern Greece) from 2003 to 2007. This time frame was selected because in 2008, financial crisis broke in Greece, and as a result, private and public construction were halted. The study findings successfully illustrated the circumstances under which construction accidents occurred in the selected period. At this specific time period, the construction sector in Greece used to function under "normal" conditions. Since then, no significant changes in legislation have taken place. Therefore, the results of the following research would be useful for international research and contribution towards a better understanding of the conditions and causes of accidents. As far as the workers are concerned, their age ranged from 16 to 64 years old and their experience in the field from 0 to 370 months. In 87% of the cases the accidents were non-fatal, while 54% of them are defined as falls (either to the same or to a lower level). In the case of a work- related accident occurring, the Greek Work Inspection Organization visited the location where the accident took place and filled out standard forms, with details regarding the accident.

### *3.2. Creation of the SPSS Database*

Variable definition and creation of data parameters were necessary for the implementation of the SPSS database. Two types of variables were defined: those related to the worker as an individual and those related to the accident as an event. The individual-related variables included: Age, Previous Work Experience, Gender, Specialization and Nationality. The incident- related variables were: Time and Date, Mortality, Type of Accident, Type of Injury, Injured Body Part, Dangerous Situation (circumstances just before the accident) and Material Factor (object associated with the accident). All the variables, except Age and Experience, were qualitative variables by nature. Age and Experience were quantitative variables. After creating classes for both of these variables, they were introduced as qualitative ones in the database. The variables of Age, Experience, Time of Accident and Month of Accident had a wide range of values. This fact did not facilitate the identification of statistically significant correlations related to them. Following the suggestions of the research by Chi, Chang, and Ting [7] and Camino López, Fontaneda, González Alcantara, and Ritzel [6], the values were grouped, as shown in Table 1. After defining the variables and their parameters, all their values were incorporated

into an SPSS database. For these quantitative variables, every possible value per variable was assigned a corresponding number. This codification is presented in Table 1.

**Table 1.** Grouping of the variables.

| Age (Years) | Prev. Exp. (Months) | Time of Accident | Month of Accident |
|---|---|---|---|
| <24 | <12 | until 12:00 p.m. | Dec., Jan. and Feb. |
| 24–34 | 12–60 | 12:01 p.m.–04:00 p.m. | March, April and May |
| 35–44 | 61–120 | past 04:01 p.m. | June, July and Aug. |
| 45–54 | 121–180 | | Sept., Oct. and Nov. |
| >54 | >180 | | |

### *3.3. Sample Descriptive Analysis*

The results of the descriptive analysis were derived from the finalized SPSS database, (after defining the data parameters and grouping the values). Results are presented in Tables 2 and 3. Table 2 incorporates the results for the variables related to the individuals, while Table 3 presents the results for the accident—related variables. A comparison was made with the findings of the literature review aiming to evaluate the similarities.

**Table 2.** Details of individuals involved in the accident.

| Variable | Category | % |
|---|---|---|
| Age (years) | <24 | 10% |
| | 24–34 | 26% |
| | 35–44 | 26% |
| | 45–54 | 18% |
| | >54 | 20% |
| Gender | Male | 98% |
| | Female | 2% |
| Worker Specialization | Unskilled worker | 37% |
| | Machine operators | 14% |
| | Skilled workers | 46% |
| | Specialists and Technicians | 1% |
| | Office employees | 1% |
| | Executives and Administrators | 1% |
| Nationality | Greek citizen | 65% |
| | E.U. citizen working in Greece | 2% |
| | Non E.U. citizen | 33% |
| Work Experience (in months) | <12 | 68% |
| | 12–60 | 22% |
| | 61–120 | 5% |
| | 121–180 | 2% |
| | >180 | 3% |

**Table 3.** Accident event details.

| Variable | Category | % |
|---|---|---|
| Month | Dec., Jan. and Feb. | 26% |
| | March, April and May | 22% |
| | June, July and Aug. | 31% |
| | Sept., Oct. and Nov. | 21% |
| Mortality | Fatal | 13% |
| | Non-fatal | 87% |

**Table 3.** *Cont.*

| Variable | Category | % |
|---|---|---|
| Type of accident | Falls | 54% |
| | Struck by falling objects | 21% |
| | Walking or hitting on objects | 6% |
| | Compression in/between | 10% |
| | Overworking | 2% |
| | Exposure to high temperature | 1% |
| | Contact with electricity | 3% |
| | Exposition to harmful substances or radiation | 1% |
| | Other | 2% |
| Type of injury | Fractures | 43% |
| | Concussions, internal injury | 12% |
| | Dislocations | 2% |
| | Sprains | 4% |
| | Amputations | 2% |
| | Superficial injuries | 4% |
| | Bruises | 7% |
| | Burns | 2% |
| | Poisoning | 1% |
| | Asphyxiation | 1% |
| | Electric shock effects | 3% |
| | Multiple lesions | 2% |
| | Undefined | 2% |
| | Other injuries | 15% |
| Dangerous situation | Unsuitable workplace | 7% |
| | Floors, corridors, fixed ladders, emergency exits | 15% |
| | Work positions | 34% |
| | Arranging | 2% |
| | Machinery, facilities, tools and equipment | 6% |
| | Organization and safety management | 35% |
| | Work environment | 1% |
| | No dang. Situations | 0% |
| Time of accident | Until 12:00 p.m. | 53% |
| | 12:01 a.m.–04:00 a.m. | 40% |
| | Past 04:01 a.m. | 7% |
| Injured body part | Head | 19% |
| | Core | 14% |
| | Lower body | 25% |
| | General injuries | 1% |
| | Neck | 1% |
| | Upper limbs | 23% |
| | Multiple injuries | 15% |
| | Non specified | 2% |
| Material Factor | Means of transport and lifting equipment | 15% |
| | General equipment | 37% |
| | Materials, substances, radiation | 7% |
| | Work environment | 30% |
| | Machinery | 10% |
| | Other | 1% |

### *3.4. Correlation Analysis*

This study's main aim is to find correlations between the various factors and conditions occurring during an accident. The crosstabs procedure from the descriptive statistics analysis, within SPSS, was applied. "Chi-square" was chosen in the "statistics" tab and the display of "adjusted standardized

residuals" in the display cells. The 2-sided "Asymptotic Significance", which is derived as a function of the Pearson Chi-Square, was used to define the existence of a correlation between the two considered variables. For values of "Asymptotic Significance" (most commonly known as *p*-values) lower than 0.05 a definite correlation was assumed, but if the value fell in the 0.05 to 0.06 range a tendency was assumed. Only tables containing correlations or tendencies based on the criteria listed above are presented in this paper. The adjusted residuals are used to determine if deviation of from the mean is significant. For values of the "Standardized Adjusted Residual" higher than |1.96| the deviation is considered significant.

## 4. Descriptive Analysis' Results and Discussion

### *4.1. Sample Descriptive Results*

The results of the descriptive analysis of the sample are given in the two Tables bellow. Table 2 depicts the characteristics of the individuals involved in the accidents and their distribution, while Table 3 presents the accident as an event and descriptively analyses its details. Groupings of the available data in the presented Tables follow the approach of corresponding international scientific studies, in order for the results and findings to be easily and readily compared. Based on these two Tables (Tables 2 and 3) a number of findings regarding the context of the accident occurrence could be identified.

#### 4.1.1. Worker Age Factor

Concerning the age of the workers a more even distribution of cases is observed. A peak appears in the 24 to 34 and 35 to 44 years old age groups in each case representing 26% of the cases. The age group of workers over 54 years old follows with 20% of the total cases. The aforementioned findings could be explained by the fact that, due to their relatively young age, these age groups tend to be more dynamically involved in construction site work and therefore are more exposed to danger.

#### 4.1.2. The Gender Factor

Another observation is the domination of males in the sample, as they occupy 98% of the workers in the sample. A reason that females show such a small frequency of accidents may be credited to the fact that females are rarely employed in jobs with extreme working conditions [23].

#### 4.1.3. Worker Skill Factor

In 46% of the cases, workers involved in an accident are skilled workers, followed by unskilled workers in 37% of the cases, and the third group being machine operators occupying 14% of the sample. Skilled workers are more abundant in a construction worksite and they more often tend to undertake more "demanding" activities. This may explain why skilled workers are mostly engaged in accidents.

#### 4.1.4. Worker Nationality Factor

Although the majority of workers in the construction industry in Greece are Non E.U. citizens, mostly originating from countries in the Balkan region, this nationality group seems to have less reported accidents than the other. It should be mentioned that there are a significant number of reports concerning "personal accidents".

#### 4.1.5. Experience as an Accident Factor

The fact that accidents occur to inexperienced individuals new to construction, in 68% of the cases, indicate amongst others that educating individuals relating to the safety threats within the construction industry should be further promoted in Greece. Workers who do not have sufficient training or knowledge about their tasks should not be expected to identify all unsafe conditions surrounding their work. According to Abdelhamid and Everett [22] inexperienced workers often try to explain that the

usage of safety measures and barriers, especially the personal protection equipment, decrease their performance. This is a matter that calls for additional safety training and management alertness.

#### 4.1.6. Month of Accident Factor

A spike in accident occurrence is observed during summer (June, July and August). Accidents seem to appear in these months in 31% of the cases. Construction activity in general and at the same time specific types of activities, also tend to spike during summer in Greece and, combined with harsh work conditions created by common heat waves, produce an increased accident rate. Winter months follow in 26% of the cases.

#### 4.1.7. Fatality as a Factor

Most of the accidents are not fatal, more specifically, 87% of them were non-fatal. Some of the accidents were not immediately fatal but developed into fatal accidents after some time. The various time periods differ in which an accident could be declared as fatal in different countries, as follows: In the Netherlands, an accident is registered as fatal if the victim's loss of life occurs on the day of the accident, in Germany, if death occurs within 30 days of the accident, in Spain, if the victim dies within 1.5 years, in Poland, if the victim dies within 6 months of the date of the incident [24]. Other studies seem to show different results regarding the time period. In Greece, an accident is considered as fatal, if a person loses their life within a month from the event, according to the Greek work legislation.

#### 4.1.8. Type of Accident Factor

The majority of accidents (54%) are categorized as "Falls" either to the same or a different level. This could be related to the second most frequently appearing dangerous situation related to "Work Positions", as workers neglect using safety barriers/equipment when working in a dangerous location/environment. The second most frequent type of accident, "Struck by falling object", can be also attributed to the lack of protective measures either to secure an object from falling down or to minimize the consequences of a falling object striking an individual. Two kinds of barriers should be used. Barriers that prevent an accident before a specific initiating event takes place, such as reinforcement and railings on the scaffolds, and barriers that work after a specific initiating event has taken place to serve as means of protection, such as safety belts and helmets [25].

#### 4.1.9. Injury Type Factor

The most reoccurring type of injury is fractures in 43% of the cases, followed by other type of injuries (that include cuts, head injuries, bruises with cuts or nail or ear loss) accounting for 15% of the sample. Third come concussions and internal injuries in 12% of the cases.

#### 4.1.10. Factors Influencing Dangerous Situations

"Organization and safety management" appears as a factor that creates dangerous situations in 35% of the cases, closely followed by "Work positions" in 34% of the cases. Parameters and factors influencing accident causation are either produced higher in the hierarchy of a company (by lacking management or organization and inability to determine dangerous situations) or by the worker being involved in the accident. In order to respond to the aforementioned facts companies should introduce various interventions such as the implementation of safety management standards, behavioral observation or the design modification of workplaces [26].

#### 4.1.11. Accident Time of Day Factor

Most construction accidents seem to occur during the morning hours until 12:00 in 53% of the cases. This time of the day includes the highest volume of work with multiple workers coexisting in the often confined, space of the worksite, often lacking sufficient coordination and supervision. Combined

with the time group of 12:01 to 16:00, which occupies 40% of the sample, the two time groups account for 93% of the cases.

#### 4.1.12. Injured Body Part Factor

This factor examines the part of the body that suffers the injury. Lower body parts seem to be the ones that suffers most injuries, followed by upper limbs and head. Next appear multiple injuries and injuries to the body core. Neck injuries are among the rarest.

#### 4.1.13. Material Factor

Regarding the material factor, 37% of accidents are associated with "general equipment" and, secondly, with "work environment". The third place is occupied by "means of transport and lifting equipment". In the last places appear "machinery", followed by "materials, substances and radiation".

## 5. Correlation Analysis Results and Discussion

The results of the correlation analysis of the sample are presented in the following Tables (Tables 4–13), which only show the pairs of variables that are correlated. It should be emphasized that the identified correlations are developed among the following parameters:

- Mortality and Age
- Age and Type of Accident
- Age and Type of Injury
- Age and Dangerous Situation
- Fatality and Work Experience
- Work Experience and Material Factor
- Time of Accident and Dangerous Situation

**Table 4.** Correlation between mortality and age factor.

| **Mortality:** | **Age:** | **25 to 34 Years Old** | | **>54 Years Old** | |
|---|---|---|---|---|---|
| **AS (Asymptotic Significance), AR (Adjusted Residual)** | | **AS** | **AR/Count** | **AS** | **AR/Count** |
| **Fatal accidents** | | | | 0.028 | 2.7/18 |
| **Non-Fatal accidents** | | 0.028 | 2.6/102 | | |

**Table 5.** Correlation between age and type of accident.

| **Age:** | **Type of Accident:** | **Walking or Hitting on Objects** | | **Compression In/Between** | | **Overworking** | | **Exposition to Harmful Substances or Radiation** | |
|---|---|---|---|---|---|---|---|---|---|
| **AS (Asymptotic Significance), AR (Adjusted Residual)** | | **AS** | **AR/Count** | **AS** | **AR/Count** | **AS** | **AR/Count** | **AS** | **AR/Count** |
| <24 years old | | 0.01 | 2.2/5 | | | 0.01 | 3.5/4 | | |
| 25 to 34 years old | | | | | | | | 0.01 | 3.4/4 |
| 45 to 54 years old | | | | 0.01 | 2.0/11 | | | | |

**Table 6.** Correlation between age and type of injury.

| **Age:** | **Type of Injury:** | **Fractures** | | **Amputations** | | **Burns** | | **Poisoning** | | **Asphyxiation** | | **Multiple Lesions** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **AS (Asymptotic Significance), AR (Adjusted Residual)** | | **AS** | **AR/Count** | **AS** | **AR/Count** | **AS** | **AR/Count** | **AS** | **AR/Count** | **AS** | **AR/Count** | **AS** | **AR/Count** |
| <24 years old | | | | 0.00 | 2.4/3 | | | | | | | | |
| 25 to 34 years old | | | | | | 0.00 | 2.4/5 | 0.00 | 3.8/5 | | | | |
| 35 to 44 years old | | | | | | | | | | 0.00 | 3.0/3 | | |
| 45 to 54 years old | | 0.00 | 3.0/41 | | | | | | | | | | |
| >55 years old | | | | | | | | | | | | 0.00 | 2.4/4 |

**Table 7.** Correlation between age and dangerous situation.

| Age: | Dangerous Situation: | Unsuitable Workplace | | Floors, Corridors, Fixed Ladders, Emergency Exits | | Arranging | | Organization and Safety Management | | Work Environment | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AS (Asymptotic Significance), AR (Adjusted Residual) | | AS | AR/Count | AS | AR/Count | AS | AR/Count | AS | AR/Count | AS | AR/Count |
| <24 years old | | | | | | | | 0.009 | 2.0/18 | | |
| 25 to 34 years old | | 0.009 | 2.7/13 | | | | | | | | |
| 35 to 44 years old | | | | | | | | | | 0.009 | 2.4/2 |
| 45 to 54 years old | | | | 0.009 | 2.0/15 | 0.009 | 2.1/3 | | | | |

**Table 8.** Correlation between fatality and work experience and actual number of fatal accidents.

| Experience | Number of Fatal Accidents | AS (Asymptotic Significance), AR (Adjusted Residual) |
|---|---|---|
| <12 Months | 30 | |
| 12 Months–60 Months | 8 | |
| 61 Months–120 Months | 13 | 0.00 (AS)/6.7 (AR) |
| >181 Months | 1 | |
| Total | 52 | |

**Table 9.** Correlation between work experience and material factor.

| Work experience: | Material Factor: | Machinery | | Means of Transport and Lifting Equipment | | General Equipment | | Work Environment | |
|---|---|---|---|---|---|---|---|---|---|
| AS (Asymptotic Significance), AR (Adjusted Residual) | | AS | AR/Count | AS | AR/Count | AS | AR/Count | AS | AR/Count |
| <12 months | | | | | | 0.022 | 2.3/106 | | |
| 61–120 months | | 0.022 | 2.2/5 | | | | | | |
| 121–180 months | | | | 0.022 | 2.1/3 | | | | |
| >181 months | | | | | | | | 0.022 | 3.4/9 |

**Table 10.** Correlation between time of accident and dangerous situation.

| Time of Accident: | Dangerous Situation: | Unsuitable Workplace | | Floors, Corridors, Fixed Ladders, Emergency Exits | | Machinery, Facilities, Tools and Equipment | | Organization and Safety Management | |
|---|---|---|---|---|---|---|---|---|---|
| AS (Asymptotic Significance), AR (Adjusted Residual) | | AS | AR/Count | AS | AR/Count | AS | AR/Count | AS | AR/Count |
| Until 12:00 p.m. | | 0.003 | 2.7/21 | | | 0.003 | 2.0/15 | | |
| 12:01 a.m.–04:00 a.m. | | | | | | | | 0.003 | 3.0/59 |
| past 04:01 a.m. | | | | 0.003 | 2.0/6 | | | | |

**Table 11.** Correlation between type of accident and material factor.

| Type of Accident: | Material Factor: | Machinery | | Means of Transport and Lifting Equipment | | General Equipment | | Materials, Substances, Radiation | | Work Environment | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AS (Asymptotic Significance), AR (Adjusted Residual | | AS | AR/Count | AS | AR/Count | AS | AR/Count | AS | AR/Count | AS | AR/Count |
| Falls | | | | | | 0.00 | 4.3/92 | | | 0.00 | 6.7/88 |
| Struck by falling objects | | 0.00 | 2.6/13 | | | | | 0.00 | 6.2/17 | | |
| Walking on objects | | 0.00 | 4.0/7 | | | | | | | | |
| Compression in/between | | 0.00 | 2.2/7 | 0.00 | 4.7/15 | | | | | | |
| Overworking | | | | | | | | 0.00 | 3.4/3 | | |
| Exposure to high temperature | | | | | | | | 0.00 | 5.0/3 | | |

**Table 12.** Correlation between type of accident and type of injury.

| Type of Accident / Type of Injury | Fractures | | Dislocations | | Sprains | | Concussion, Internal Injuries | | Amputations | | Other Injuries | | Burns | | Poisoning | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **AS (Asymptotic Significance), AR (Adjusted Residual** | **AS** | **AR/Count** | **AS** | **AR/Count** | **AS** | **AR/Count** | **AS** | **AR/Count** | **AS** | **AR/Count** | **AS** | **AR/Count** | **AS** | **AR/Count** | **AS** | **AR/Count** |
| **Falls** | 0.0 | 6.8/118 | 0.0 | 3.0/9 | | | 0.0 | 2.9/32 | | | | | | | | |
| **Walking on objects** | | | | | | | | | 0.0 | 3.9/3 | | 4.7/10 | | | | |
| **Compression in/ between** | | | | | | | | | 0.0 | 3.8/4 | 0.0 | 4.0/13 | | | | |
| **Overexertion** | | | | | 0.0 | 2.8/2 | | | | | | | | | | |
| **Exposure to high temperature** | | | | | | | | | | | | | 0.0 | 14.3/4 | | |
| **Exposure to harmful substances or radiation** | | | | | | | | | | | | | | | 0.0 | 18.1/4 |

**Table 13.** Correlation between type of accident and dangerous situation.

| Type of Accident: / Dangerous Situation: | Floors, Corridors, Fixed Ladders, Emergency Exits | | Work Positions | | Arranging | | Machinery, Facilities, Tools and Equipment | | Organization and Safety Management | |
|---|---|---|---|---|---|---|---|---|---|---|
| **AS (Asymptotic Significance), AR (Adjusted Residual** | **AS** | **AR/Count** | **AS** | **AR/Count** | **AS** | **AR/Count** | **AS** | **AR/Count** | **AS** | **AR/Count** |
| **Falls** | 0.00 | 7.3/53 | 0.00 | 3.9/82 | | | | | | |
| **Struck by falling objects** | | | | | | | | | 0.00 | 3.0/35 |
| **Walking on objects** | | | | | 0.00 | 3.2/2 | 0.00 | 2.8/4 | | |
| **Compression in/between** | | | | | | | | | 0.00 | 5.5/26 |
| **Overworking** | | | | | | | | | 0.00 | 2.4/6 |

In each Table, the correlated variables are presented, along with the asymptotic significance (*p*-values), adjusted residual and the number of correlated cases (count).

### *5.1. Correlation Between Mortality and Age Factor*

In Table 4, it is highlighted that the age group over the age of 54 tends to be fatally injured more often than other age groups. This could be explained by the worse physical condition of older age groups, unlike the younger ones.

### *5.2. Correlation Between Age and Type of Accident*

Table 5 shows that, under the age of 24, there is an increased occurrence of accidents involving overworking and walking or hitting on dangerous objects. The age group from 25 to 34 years old tends to suffer accidents that are related to exposure or contact with harmful substances or radiation and the age group of 45 to 54 tends to suffer accidents that are related to compression in or between objects.

### *5.3. Correlation Between Age and Type of Injury*

According to the following table (Table 6), employees under the age of 24 appear to be more frequently amputated than employees that belong in the other age groups. In addition, the age group from 25 to 34 has an increased tendency for burns or poisoning and the group from 35 to 44 has an increased tendency to suffer asphyxiation-related accidents. For workers aged from 45 to 54 years, the tendency for injuries in the form of fractures appears increased. Also, the age group over the age of 54 tends to suffer multiple lesions of various causes.

### *5.4. Correlation between Age and Dangerous Situation*

The following table (Table 7) shows that workers under 24 years old are related to accidents in which the dangerous situation is considered the organization and safety management. In the group of 25 to 34, there is an increased tendency for accidents related to unsuitable workplaces such as narrow spaces, poorly maintained buildings, etc. Ages 35 to 44 appear to be related to the work environment factor (Insufficient or inappropriate lighting and aeration, high temperature, etc.). Employees aged 45 to 54 appear to have an increased tendency to suffer accidents related to factors such as floors, corridors, fixed ladders, emergency exits, etc., as well as arranging.

### *5.5. Correlation between Fatality and Work Experience*

According to Table 8, in the group of 61 to 120 months of working experience, there is a tendency for increased mortality, despite the low percentage of accidents.

### *5.6. Correlation between Work Experience and Material Factor*

Table 9 shows that the group with the shortest work experience (under 12 months) appears to be related to accidents, the material factor of which is the equipment of the construction site. In the group with 61 to 120 months of experience appears an increased tendency for accidents involving machinery. Employees with a work experience between 121 and 180 months and the means of transport and the lifting equipment are also correlated. Workers with more than 180 months of experience, have a tendency to suffer work environment-related accidents. (Floor and side wall openings, work surfaces, staircases, weather, noise, temperature, etc.)

### *5.7. Correlation between Time of Accident and Dangerous Situation*

According to Table 10, there is an increased tendency for accidents related to unsuitable workplaces as well as to Machinery, facilities, tools and equipment in the morning. At noon, accidents are mostly related to the organization and safety management. Both tendencies can be explained by the loads of work and the simultaneous parallel tasks at this time, combined with possible lack of good coordination.

### *5.8. Correlation between Type of Accident and Material Factor*

As Table 11 shows, falls have an increased tendency to have a relation to the work environment (work surfaces, floor and side wall openings, steps, etc.) and the general equipment. Additionally, on struck by falling objects seems to be highly related to the machinery and various materials. Compression in/between objects is mostly related to the machinery and the means of transport and lifting equipment. As expected, overworking and exposure to high temperature are both highly related to materials, substances and radiation.

### *5.9. Correlation between Type of Accident and Type of Injury*

According to Table 12, falls have an increased tendency to cause fractures, dislocations and concussions while walking on objects is more related to amputations. Finally, as expected, high temperature exposure and exposure to harmful substances or radiation have a strong correlation with burns and poisoning respectively.

### *5.10. Correlation between Type of Accident and Dangerous Situation*

The following table (Table 13) shows that falls have a strong correlation with factors such as floors, corridors, fixed ladders, emergency exits and work positions (spots without adequate protection against falling onto another level, spots with poor visibility, narrow spaces). Struck by falling objects is highly related to the organization and safety management in the field and walking on objects has a tendency of being related to arranging and machinery, facilities, tools and equipment. In the end, compression in/between and overworking are both strongly correlated with the organization and safety management. All these findings are anticipated, as international scientific literature agrees with the findings of the current study.

## 6. Discussion

It was observed by the descriptive analysis of the sample that the majority of accidents include inexperienced personnel (68%) and workers with an age ranging between the age groups of 24–34 (26%) and 35–44 (26%) years old. Furthermore, most accidents occur during summer time (31%) and they are not fatal (87%). Falls are by far the most dominant type of accident with a percentage of 54%, and as a consequence, fractures are the most frequently occurring type of injury (43%). Morning hours are the ones associated with most of the accidents (53%), with the injuries focusing on the lower body part (25%). Additionally, the majority of accidents are related to the use of general equipment (37%).

The main findings which originated by the correlation analysis of the sample suggest that workers over the age of 54 tend to be fatally injured unlike younger ones. In addition, it was observed that workers under the age of 24 have an increased tendency for accidents due to overworking and walking or hitting on dangerous objects, and that the age group of 45 to 54 tends to suffer accidents that are related to compression in or between objects. Furthermore, it became evident that employees under 24 years old tend to suffer from amputation, while the age group from 25 to 34 tend to suffer from burns and poisoning. As far as the age group 35 to 44 is concerned, it has an increased tendency for asphyxiation-related accidents, while the age group 45 to 54 tends to suffer from fractures. It is also remarkable that workers who are older than 55 years old appear to suffer multiple lesions. Moreover, the correlation between age and the dangerous situation, suggested that workers under 24 years old are commonly associated with accidents, in which the organization and safety management were not properly planned or followed. Furthermore, the age group of 25 to 34 tends to get involved in accidents that are related to unsuitable workplaces, while the age group of 35 to 44 appears to be related to the work environment factor (Insufficient or inappropriate lighting, high level noise, inadequate ventilation). Employees from 45 to 54 years old appear to have an increased tendency to suffer accidents related to factors such as floors, corridors, fixed ladders, emergency exits, as well as arranging. Additionally, the correlation between fatality and work experience showed that in

the group of 61 to 120 months of experience, there is a tendency for increased mortality, despite the low percentage of accidents. An also important finding is that the group of lowest work experience (under 12 months) appears to be related to accidents which arose from the use of the equipment on the construction site. The groups with 61 to 120 and 121 to 180 months of work experience have an increased tendency for accidents involving machinery and means of transport-lifting equipment, respectively. Workers with more than 180 months of experience, have a tendency to suffer from accidents related to the work environment (floor and side wall openings, work surfaces, staircases). According to the correlation between the time of accident and the dangerous situation, there is a tendency for accidents related to unsuitable workplaces as well as to machinery, facilities, tools and equipment happening until 12:00. Moreover, at noon (12:01 –. 16:00) accidents are usually related to the organization and safety management. Furthermore, the analysis showed that the most common type of accident which is "Falls", is highly related to the work environment (Floor and side wall openings, work surfaces, staircases, etc.) and the general equipment. An also significant highlight is that falls have a strong correlation with factors such as floors, corridors, fixed ladders, emergency exits and work positions (spots without adequate protection against falling onto another level, with poor visibility, narrow spaces). Finally, it was observed that organization and safety management are strongly correlated with several types of accidents such as "struck by falling objects", "compression in/between" and "overworking".

## 7. Conclusions and Further Research

Health and safety in construction are very critical issues that require the devotion and commitment of all people involved towards preventing accidents from happening and improving the working conditions within construction sites. It is true to say that construction projects' accidents are critical events that should be provided with the utmost attention and care. The aim of the current study was to analyze accidents during work, with emphasis on construction related projects in northern Greece. In order to do so, reliable data on accidents was collected and then followed by a descriptive analysis and corresponding codification of all available data. An appropriate database in SPSS was created to accommodate all relevant data and subsequent correlation analysis identified potential trends and tendencies. The findings highlighted the most frequent occurrences regarding construction work related accidents and at the same time identified correlations among the various parameters associated with work accidents. It should be mentioned that, among the identified correlations, the most frequently appearing variable/factor was age. Furthermore, the current paper identified associations among various accident characteristics. These findings can help all stakeholders to take preventive measures in order to minimize the risk of accidents in construction and as a result to improve the safety conditions in the worksite and optimize the project performance.

The results of the current study seem to agree with the findings of relevant international literature. More specifically, common findings include the following:

- The majority of the accidents involves inexperienced personnel
- "Falls" are identified as the dominant type of accidents
- Summertime is associated with most accidents due to heatwaves that influence performance
- Most accidents appear during morning hours
- Mostly men suffer fatal injuries in comparison to women
- Finally, current research identified the age group 24-34 as the one most frequently involved in accidents. In other international studies the specific group is ranked in the second place based on the number of accidents

It should be noted that the sample of the examined accidents originates from a specific district/location in Greece and for a specific time range, covering 5 years (2003–2007). As far as future work is concerned, a greater sample could be collected covering other districts in Greece. At the same time, additional analyses could take place in order to shed more light on the causes and prevention

measures of accidents. Additionally, effort will be made to classify the findings from international literature in order to identify the potential trends. Finally, models that could predict the possibility or risk of accidents could be developed based on artificial intelligence, given the existence of reliable data on accidents.

Regarding suggestions that could further improve health and safety in construction sites, these could include but are not limited to the following:

Better organization and further development of the forms and reports for recording construction accidents.

- More experienced people should be hired by the government to inspect work sites
- Legislation could become stricter regarding the health and safety.
- Management should promote training and education regarding health and safety.
- Individual protection gear should be enforced by the management, otherwise workers would not be allowed to proceed to their workstations.
- Scheduling applications and software regarding construction site allocation should also consider the health and safety parameter. Multiple activities running at the same time and at the same location or part of the project should be avoided. At the same time, another very important factor that could potentially prevent severe accidents is the scheduling of heavy construction equipment activities adjacent work crews. All these events could be prevented by improved scheduling and better construction site administration.
- The period considered for the recording of a fatal accident should be increased. It should be noted that currently in Greece, the period in which an accident could be developed and recorded as fatal is a single month. An increase in this duration may possibly lead to an increase in the number of fatal accidents. Each country has adopted a different time frame in order to identify a fatal accident. These various views in the considered period create a lot of differences in the number of fatal accidents among countries. It is useful to suggest that countries should adopt a standard time frame for considering an accident as fatal. This way, the reported data would be comparable.

**Author Contributions:** Conceptualization S.B. and M.K.; methodology, S.B., M.K. and G.A.; validation, S.B., M.K., G.A. and M.P.; formal analysis, S.B., M.K. and G.A.; investigation, All Authors.; data curation, All Authors; writing—original draft preparation, S.B., M.K., G.A..; writing—review and editing, All Authors; visualization, S.B., M.K., G.A.; project administration, G.A.

**Funding:** This research received no external funding.

**Conflicts of Interest:** The authors declare no conflict of interest.

## References

1. Hellenic Labor, I. *Hellenic Labor Inspectorate's Yearly Report*; Hellenic Ministry of Health and Social Care: Athens, Greece, 2013.
2. López Arquillos, A.; Rubio Romerro, J.C.; Gibb, A. Analysis of construction accidents in Spain, 2003-2008. *J. Saf. Res.* **2012**, *43*, 381–388. [CrossRef]
3. Camino López, M.A.; Ritzel, D.O.; Fontaneda, I.; González Alcantara, O.J. Construction industry accidents in Spain. *J. Saf. Res.* **2008**, *39*, 495–505. [CrossRef] [PubMed]
4. Haslam, R.; Hide, S.; Gibb, A.; Gyi, D.; Pavitt, T.; Atkinson, S.; Duff, A. Contributing factors in construction accidents. *Appl. Ergon.* **2005**, *36*, 401–415.
5. Chi, S.; Han, S. Analyses of system theory for construction accident prevention with specific reference to OSHA accident reports. *Int. J. Proj. Manag.* **2013**, *31*, 1027–1041. [CrossRef]
6. Camino López, M.A.; Fontaneda, I.; González Alcantara, O.J.; Ritzel, D.O. The special severity of occupational accidents in the afternoon: "The lunch effect". *Accid. Anal. Prev.* **2011**, *43*, 1104–1116. [CrossRef] [PubMed]
7. Chi, C.-F.; Chang, T.-C.; Ting, H.-I. Accident paterns and prevention measures for fatal occupational falls in the construction industry. *Appl. Ergon.* **2005**, *36*, 391–400. [CrossRef]

8. Jabbari, M.; Ghorbani, R. Developing Techniques for cause-responsibility analysis of occupational accidents. *Accid. Anal. Preve.* **2016**, *96*, 101–107. [CrossRef]
9. Goh, Y.M.; Ubeynarayana, C. Construction accident narrative classification: An evaluation of text mining techniques. *Accid. Anal. Prev.* **2017**, *108*, 122–130. [CrossRef] [PubMed]
10. Zhipeng, Z.; Irrzarry, J.; Li, Q. Using network theory to explore the complexity of subway construction accident network (SCAN) for promotig safety managemet. *Saf. Sci.* **2014**, *64*, 127–136.
11. Cheng, C.W.; Leu, S.L.; Lin, C.-C.; Fan, C. Charasteristic analysis of occupational accidents at small construction enterprises. *Saf. Sci.* **2010**, *48*, 698–707. [CrossRef]
12. Hale, A.; Walker, D.; Walters, N.; Bolt, H. Developing the understanding of underlying causes of construction fatal accidents. *Saf. Sci.* **2012**, *50*, 2020–2027. [CrossRef]
13. Ale, B.; Bellamy, L.; Baksteen, H.; Damen, M.; Goossens, L.; Hale, A.; Whiston, J. Accidents in the construction industry in the Netherlands: An analysis of accident reprorts using Storybuilder. *Reliab. Eng. Syst. Saf.* **2008**, *93*, 1523–1533. [CrossRef]
14. Khosravi, Y.; Asilian-Mahabadi, H.; Hajizadeh, E.; Hassanzadeh-Rangi, N.; Bastani, H.; Behzadan, A.H. Factors Influencing Unsafe Behaviors and Accidents on Construction Sites: A Review. *Int. J. Occup. Saf. Ergon.* **2015**, *20*, 111–125. [CrossRef]
15. Salminen, S. Have young workers more injuries than old ones? An international literature review. *J. Saf. Res.* **2004**, *35*, 513–521. [CrossRef]
16. Yi, J.-S.; Kim, Y.W.; Kim, K.-A.; Koo, B. A suggested color scheme for reducing perception-related accidents on construction work sites. *Accid. Anal. Prev.* **2012**, *48*, 185–192. [CrossRef]
17. Hoła, B.; Szóstak, M. Methodology of Analysing the Accident Rate in the Construction. *Procedia Eng.* **2017**, *172*, 355–362. [CrossRef]
18. Rameezdeen, R.; Elmualim, A. The Impact of Heat Waves on Occurrence and Severity. *Int. J. Environ. Res. Public Health* **2017**, *14*, 70. [CrossRef]
19. Esmaeili, B.; Hallowell, M.; Rajagopalan, B. Attribute-Based Safety Risk Assessment. I: Analysis at the Fundamental Level. *J. Constr. Eng. Manag.* **2015**, *141*, 04015021. [CrossRef]
20. Esmaeili, B.; Hallowell, M.; Rajagopalan, B. Attribute-Based Safety Risk Assessment. II: Predicting Safety Outcomes Using Generalized Linear Models. *J. Constr. Eng. Manag.* **2015**, *141*, 04015022. [CrossRef]
21. Carrillo-Castrillo, J.A.; Trillo-Cabello, A.F.; Rubio-Romero, J.C. Construction accidents: Identification of the main associations between causes, mechanisms and stages of the construction process. *Int. J. Occup. Saf. Ergon.* **2017**, *23*, 240–250. [CrossRef]
22. Abdelhamid, T.S.; Everett, J.G. Identifying root causes of construction accidents. *J. Constr. Eng. Manag.* **2000**, *126*, 52–60. [CrossRef]
23. Lucas, R.E. The distribution of job characteristics. *Rev. Econ. Stat.* **1974**, *56*, 530–540. [CrossRef]
24. Hola, B.; Szostak, M. Analysis of the state of the accident rate in the construction industry in European Union countries. *Arch. Civil Eng.* **2015**, *61*. [CrossRef]
25. Hollangel, E. Accidents an Barriers. In Proceedings of the European Conference on Cognitive Science Approaches to Process Control (CSAPC), Villeneuve, France, 21–24 September 1993.
26. Swuste, P.; Koukoulaki, T.; Targoutzidis, A. WOS2008, prevention of occupational accidents in a changing work enviroment. *Saf. Sci.* **2010**, *48*, 933–935. [CrossRef]