

Brief Overlook on the Occupational Accidents Occurring During the Geotechnical Site Works

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Abstract. The aim of this paper is to evaluate occupational accidents reported in geotechnical site works. Variables of the accidents are categorized as the year and month of accidents, the technical codes used for defining the scope of work trades, end use and project type and cost, nature and cause of accidents, occupation of the victims and finally the cause of fatality. As a result, it is seen that the majority of victims were construction laborers or in special trade constructors who were working on a new project or new additions to an existing project. The geotechnical phase of the projects was whether excavation, landfill, sewer-water treatment, pipeline construction, commercial building or road construction. As the outcomes of the study it is evaluated that excavation, trenching and installing pipe or pile driving were the main causes of the accidents while trench collapse, struck by a falling object / projectile and wall collapse were the main causes of fatality. Moreover, it is established that more than half of the fatalities were due to asphyxia followed by fracture. These findings show that accidents occurred in geotechnical works do not only have high frequency but also high severity. This study emphasizes project specific countermeasures should be taken regarding the nature, cost and importance of the project and the occupation variabilities working on the project.

1. Introduction

There is an increasing trend among researchers and private company specialists considering the effects and results of occupational accidents. This positive awareness is still somehow limited in research, especially dealing with the details of accidents. The construction industry is globally in the top three industries that is under the risk of occupational accidents [1-3]. For this reason, every process of construction needs to be investigated separately to provide continuous occupational safety in site works [4].

The construction industry consists of different branches of civil and environmental engineering works. Among them geotechnical site works constitute the first step regardless of the end use of the newly built structures. Besides, alteration, renovation, and maintenance or repair of structures also need the geotechnical processes to be applied for safe and economical solutions [5]. Geotechnical site works are comprehensive, therefore the potential risk of accidents show diversity from project to project [6,7].

Whilst each geotechnical construction process will entail specific hazards, some generic hazards common to many processes can be listed [8]:

- Exposure to dangerous substances, noise or vibration - fluids used by processes and those in the ground as contaminants or services
- Manual handling
- Interactions with heavy plant - this may be in circulation around the site or in the process itself, may be struck by or trapped by the machinery



- Poor access to or organization of the workplace - working in confined spaces or in poor conditions underfoot
- Workplace stability - excavations or near temporarily unstable structures or machinery
- Falls from height - whether into excavations or working in excavations
- Falling objects or debris

During the early stages of this study, it was detected that although there has been several accidents ended up with fatalities and injuries, the scope of reporting was scarce and reaching the required information was quite difficult in geotechnical works as the previous regulations did not obligate to report the detailed features of the incidents. In order to fulfil the gap in this topic, it was aimed to perform sufficient and accurate data mining of Geotechnical site works and to analyze datasets for investigating the root causes of accidents.

2. Methodology

The Occupational Safety and Health Administration, more commonly known by its acronym OSHA, is responsible for protecting worker health and safety in the United States [9]. OSHA's mission is to assure safe and healthful working conditions for working people by setting and enforcing standards and by providing training, outreach, education and assistance [10]. This administration provides detailed information for each case and right to know for academic purposes with a wider data range varying from 1984 to 2017. OSHA updates and develops its own reporting system regularly. The requirements are revised acutely for recording and submitting records of workplace injuries and illnesses specifically in 80's [11-13]. For this reason, Occupational Safety and Health Administration was chosen from the available databases as a source of research. The Standard Industrial Classification System was used as a limitation of data mining. The Standard Industrial Classification (SIC) is a system for classifying industries by a four-digit code [14]. The SIC codes can be grouped into progressively broader industry classifications: industry group, major group, and division (Table 1). Within the scope of the study, SIC codes, related with construction were used. Furthermore, cases occurred during geotechnical works were selected. A severe elimination of accident cases was performed to achieve accurate and reliable data that is free from bias. Finally, 133 cases that resulted with fatalities have remained to consist the database of accidents occurred in geotechnical construction works.

Table 1. The Standard Industrial Classification (SIC).

Range of SIC Codes	Division	Selected SIC Codes
0100-0999	Agriculture, Forestry and Fishing	0181
1000-1499	Mining	
1500-1799	Construction	1521, 1542, 1611, 1622, 1623, 1629, 1771, 1794, 1795, 1799
1800-1999	Not used	
2000-3999	Manufacturing	3731
4000-4999	Transportation, Communications, Electric, Gas, and Sanitary service	
5000-5199	Wholesale Trade	
5200-5999	Retail Trade	
6000-6799	Finance, Insurance and Real Estate	
7000-8999	Services	
9100-9729	Public Administration	8511
9900-9999	Nonclassifiable	

On the vast majority of the construction safety literature, the findings are based on univariate analysis and it is aimed to shed light on problematic areas in this field, especially for accident causes [15-17]. Univariate analysis is adapted for two purposes. The first part is for data screening purposes; and the

second part is to understand what is accumulated and to choose the right variables for bivariate data analysis. Similarly, data analyses for this study relied on univariate analysis for data overview and classification. Frequency tables were utilized for reporting findings of univariate analysis in this paper.

Univariate statistical analyses, including the numerical outcomes were performed to discuss the created variables such as; end use, project type, the cost of a project, the nature of the accident, occupation of the victim, the cause of an accident and the cause of fatality.

3. Results and discussions

In this section above mentioned methodology is carefully applied and the outcomes of this research is briefly discussed. SIC codes that come forward relate to heavy construction works in the field, excavation works and bridge tunnel and elevated highway construction. Heavy construction cases involved in this research included caisson drilling, clearing of land, cofferdam construction, dam construction, drainage construction, draining project construction, earthmoving, land levelling, land reclamation, pier construction, pile driving, rock removal and trenching while excavation works included foundation, excavation, and grading excluding the grading works for highways, streets, and airport runways-contractors (Table 1).

The accidents occurred between 1984 and 2013 were analyzed. According to the findings majority of the reported accidents occurred in 1994 and 2006. June and November were the peak months where the accidents mostly repeated in the selected time range (Figures 1-2).

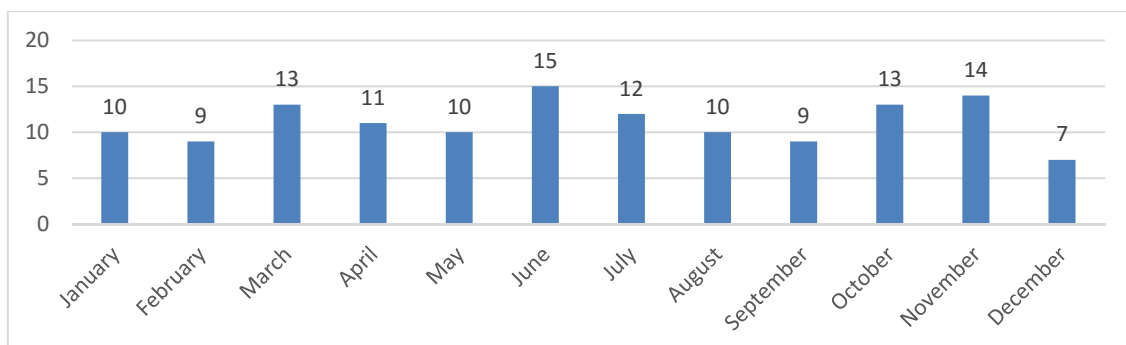


Figure 1. Distribution of fatal accidents by month.

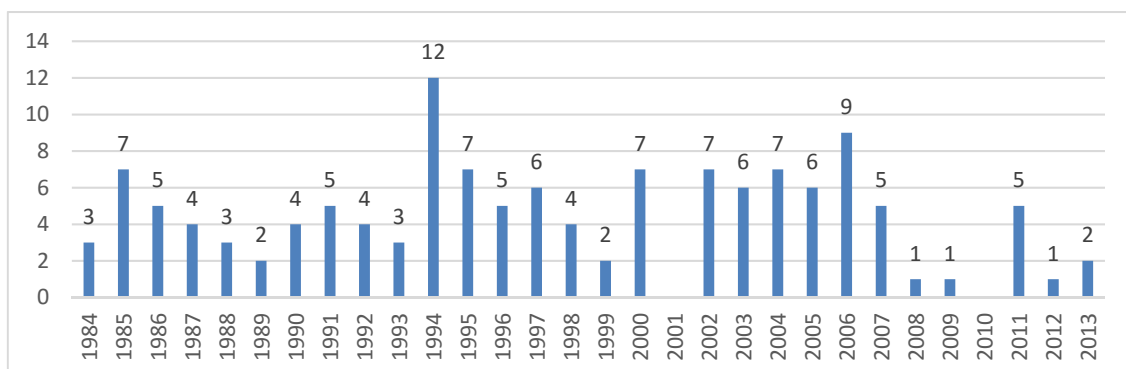


Figure 2. Distribution of fatal accidents by year

A percentage of 49 (%) of the victims were working on a new project or new additions to an existing project. The geotechnical phase of the projects was whether excavation, landfill, sewer-water treatment, pipeline construction, commercial building construction or single family or duplex dwelling works in the end use variable. It is observed that projects with less than 500000\$ budget was more likely to end

up with occupational fatal accidents. Limited budgeted projects were mostly held by small and medium sized contractor companies which might have given less importance to occupational safety and health measures compared to corporate companies (Table 2).

Table 2. Project Characteristics of fatal accidents.

Variables	Categories	Frequency	Valid Percent	Cumulative Percent
End Use	Excavation, landfill	19	16.1	16.1
	Sewer/water treatment	18	15.3	31.4
	Pipeline	17	14.4	45.8
	Commercial building	14	11.9	57.7
	The single family/duplex dwelling	14	11.9	69.6
	Other building	11	9.3	78.9
	Highway, road, street	10	8.5	87.4
	Bridge	6	5.1	92.5
	Multi-family dwelling	5	4.2	96.7
	Other heavy construction	4	3.4	100.0
Project Type	New project or new addition	65	69.9	69.9
	Maintenance or repair	13	14.0	83.9
	Alteration or rehabilitation	8	8.6	92.5
	Other	7	7.5	100.0
Project Cost (\$)	Under 500000	13	18.6	18.6
	50000-250000	14	20.0	38.6
	250000-500000	11	15.7	54.3
	500000-1000000	6	8.6	62.9
	1000000-5000000	12	17.1	80.0
	5000000-20000000	7	10.0	90.0
	>20000000	7	10.0	100.0

According to results; it is seen that the majority of victims were construction laborers (14.3%) or in special trade constructors (8.3%). It should be noted that the occupation of 59% of victims was not reported. The reason of this description lacking is probably due to the negligence of fulfilling of accident notification reports. However, this is an important input to understand which occupational groups are at high risk in geotechnical site works. It is believed that providing of this information by employers should be compulsory in order to take occupation specific precautions in the field. As the outcomes of the study, it is evaluated that excavation, trenching and installing pipe or pile driving were the main causes of the accidents while trench collapse, struck by a falling object / projectile and wall collapse were the main causes of fatality. Moreover, it is established that more than half of the fatalities were due to asphyxia followed by fracture (Table 3).

4. Conclusions

OSHA database related to geotechnical accidents is deeply investigated and 133 cases were determined to be eligible with their sufficient detail and used in this study. Raw data is divided into several variables which can be used to define the accident and put into several statistical analyses. Each variable is interpreted according to its occurrence rate. The variable with the highest occurrence level should be considered as the primary effect, causing the accidents and necessary precautions should be taken before starting to site works.

Table 3. Accident Characteristics of fatal accidents.

Variables	Categories	Frequency	Percent	Cumulative Percent
Nature	Asphyxia	61	45.9	45.9
	Fracture	21	15.8	61.7
	Concussion	8	6.0	67.7
	Bruise/Contus/Abras	6	4.5	72.2
	Electric shock	4	3.0	75.2
	Internal injury	2	1.5	76,7
	Cut/Laceration	2	1.5	78,2
	Other	29	21.8	100,0
Occupation	Occupation not reported	78	58.6	58.6
	Construction laborer	19	14.3	72.9
	Construction trades n.e.c.	11	8.3	81.2
	Supervisors; plumbers, pipefitters, steamfitters	9	6.8	88.0
	Excavation and loading machine operators	7	5.3	93.3
	Welders, cutters and metal workers	3	2.3	95.6
	Miscellaneous material moving equipment operators	3	2.3	97.9
	Sales occupations, other business services	3	2.3	100.0
Cause	Excavation	43	32.3	32.3
	Trenching, installing pipe	40	30.1	62.4
	Pile driving	28	21.1	83.5
	Backfilling and compacting	11	8.3	91.8
	Site grading and rock removal	3	2.3	94,1
	Placing bridge girders, beams and erection of coffer dams caissons	3	2.3	96.4
	Emplacing reinforcing steel	3	2.3	98.7
	Landscaping	2	1.5	100.0
Fatality Cause	Trench collapse	49	36.8	36.8
	Struck by falling object/projectile	32	24.1	60.9
	Wall collapse	22	16.5	77.4
	Collapse of structure	9	6.8	84.2
	Crushed/run-over/trapped of operator by operating	8	6.0	90,2
	Electric shock, other and unknown cause	4	3.0	93.2
	Fall from height	2	1.5	94.7
	Other	7	5.3	100.0

Regardless of the end use and project type of project geotechnical site work is the very first step of construction. This condition emphasizes the importance of occupational safety and health and the need of pre-planning in geotechnical works.

These findings show that accidents occurred in geotechnical works do not only have high frequency but also high severity. This study emphasizes project specific countermeasures should be taken regarding the nature, cost and importance of the project and the occupations working on the project.

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