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Safety Climate in Small and Medium Construction Enterprises

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Abstract

Construction is characterized in a highly hazardous and complex work environment, materializes in a high fatality rate, and a need for development of designated methods and tools for the branch. One of the pitfalls of the construction sector is small and medium enterprises (SMEs), often characterized by loose commitment to safety. The level of adherence of small and medium enterprises to safety and occupational health is not adequate due to many hindering factors such as: multiple small projects, lack of administrative critical mass on site, budget constraints, etc. This research examines the core parameters of safety climate in small and medium enterprises through a model of the fish bone diagram, which divides the safety climate into four core domains: workers, equipment, management, and environment. A field survey that includes 42 questions, aligned with the model was distributed, in 20 construction sites in Eilat, Israel. workers received an average rating of 3.7, equipment 4.2, management 3.6 and environment 4.1 (all rating are on a 5-point Likert scale). The sample results indicate marginal safety climate which is expressed in multiple light and moderate accidents, and in partial assimilation of safety protocols, control and training. The research results were validated by statistical inference using a T test to examine the results. The model significance was found to be significant at a level of $\alpha<0.05$. Furthermore, a case study carried out on the best and worst projects. The case study indicates that the model predicts in a good significance the safety climate performance and that its implementation is a tool for assurance of safety climate. Finally, the results of the model were examined and validated by comparing subgroups, as well. Correlation between the project scope and safety climate was tested. recommendations and conclusions for further research deduced.

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Keywords: Construction, environment, management, safety climate, small and medium enterprises (SMEs)

1. Introduction

The construction industry contributes significantly to the global economy. The expected expense on construction in 2025 will be 9 trillion dollars (Al Mawli et al 2021). The construction industry is considered as one of the most dangerous industry branches with high, frequent and various occupational risks. The common practice is that construction enterprises avoid certain safety activities in order to elude from getting the projects delayed, a step which is not beneficial for safety and might cause accidents and as a result would bring additional costs.

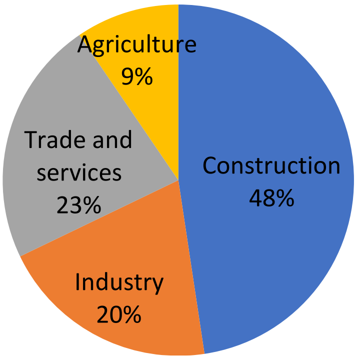

Figure 1: division of fatalities due to work accidents (2019 report, Israeli safety administration)

It is possible to see in the Figure 1, that the share of construction in fatalities due to work accidents is almost half, even though its share in the worker's number and economic size of the branch is much lower. The frequent changes in the construction site, the dusty environment, the hard conditions of working in the height, the mechanical equipment and more, make the construction work environment dangerous.

Safety climate is a relatively new approach, by which the management of an organization takes a proactive approach for promoting project and organizational safety culture and allocates resources for that purpose on different layers (guidance, control, equipment and safety encouragement). The management should encourage the workers to report safety events and reward them for initiating and assimilating processes for safety improvement. Safety climate encourages organizations to report on impairments in processes that might cause failures and work accidents, and assures the personal safety of the reporters on such impairments. Instead of an investigation committee, a friendlier version would be appointed, which its role is to analyze and explain the circumstances of the safety event, with an emphasis on processes for improvement of the work environment and for the creation of work conditions that will assure safety, hygiene and also efficiency of the working process. Organizational safety climate is defined as common conceptions among managers and workers relating to what is rewarded, expected, valued and is getting reinforcement in the workplace when it comes to safety (Zohar, 1980).

A research from Ghana (Kheni, Gibb, & Dainty, 2010), compared the matter of occupational health and safety (OH&S) between large construction enterprises and small and medium ones. According to the research, the larger the enterprise is, the frequency of injuries as a result of work accidents goes down. The small and medium enterprises usually have less resources, a thing that makes it harder to manage safety and hygiene. The major care of these companies is to survive, and therefore not enough attention is given to safety. Since the safety of the workers depends on the safety cost, there are many times conflicts of interest between safe conduct and environment and safety investments in projects (Khoshnava et al. 2020).

According to Predo (Predo, 2020), Organizations with safety climate attribute importance to: Showing managerial commitment, Assimilation and combination of safety as a value with importance to the organization's activity, Assuring of all employees being held responsible in all levels of the organization, Improvement of safety leadership on work sites, empowering workers and increasing involvement, Improvement of communication, training in all levels and encouragement of owners / client involvement. Following these principles of safety help to achieve good safety outcomes.

In the research of Rahamim Bachar from Ben Gurion University (Bachar and Shohet, 2021) focused on the parameters for investment in safety in small and medium projects. This research investigated optimal level of resource of resource allocation in construction safety, using empirical data gathering and simulation. The optimal level was found to be 1% of the project scope. However the research focused on the entire population of construction projects, primarily big, mega and medium projects. It was recommended to elaborate the research to SME's. It was found that in projects where the safety investment is higher, there were less accidents and the safety climate was significantly better.

Another finding of the research is that the ideal minimum for safety investment ratio in small projects is at about 3.8% of the project scope. The investment ratio required in small projects is much higher than what is needed is large projects.

In industry branches such as marine drilling, chemistry and aviation reports of near miss events are being used for a relatively long period. In the drilling industry it was found that a report rate of 50% reduces by 75% the number of safety events (mostly the light ones). The thing is not the same in the construction branch, where near miss events reporting is not common.

An article from Alabama university (Awolusi et al., 2016) introduced an advanced model of near miss events management program as a basic methodology for safety managers in construction sites for collecting, analyzing and making an efficient use of safety data. The model includes identification of the event, reporting it, preforming a root cause analysis, determining a solution, and decision making.

2. Methodology

The SMEs safety climate model developed in the research divides the safety factors into four core domains: (1) workers, (2) equipment, (3) management and (4) environment, which lead to safe or rather unsafe conduct.

The SMEs safety climate model's components:

1. **Equipping the construction site with the necessary safety measures –** The construction site should be safe for the workers.
2. **Moral and physical support to the workers –** this component includes matters that relate to managerial support in the workers, communication, cooperation between colleagues and medical insurance policy.
3. **Healthy work environment –** this component emphasizes the importance of a work environment with comfortable conditions for the workers.
4. **Assuring the safety of the construction site from falling objects and workers falling from the height –** This component relates to the component emphasizes the importance of executing actions and using measures for preventing the falling of workers from height (scaffolding, ladders, temporary structures) and to the fall of objects.
5. **Proactive activity for accidents prevention –** this component includes steps that assist in preventing accidents, as well as willingness of the company to receive safety complaints and feedbacks from workers and to manage a data-base of the accident's history of the company.
6. **Supply of equipment and zones for safety and comfortability of the workers –** one of the basic elements of worker's safety is the supply of personal protection equipment (PPE). Moreover, allocation of safe storing zones has a major influence on safety conditions and worker's safety since it keeps hazardous materials in safe places.
7. **Avoidance of mental and physical overexertion of workers –** this component gives attention to the action of overloaded employees who are working beyond their capacity. Tired workers tend to compromise safety.
8. **Fire and heat hazards –** this component is meant to prevent the risk of fire by supplying fire extinguishing systems.
9. **Knowledge and skills –** It is necessary to assure that safety procedures are the first issue that a worker is exposed to when he starts to work on the site.
10. **Safe conduct** – this component checks the probability for negligence and mistakes in judgement by the workers.

11. **Safety control** – this component is meant to check the level of control and inspection of equipment and of the work conditions in the site, since many accidents occur due to impaired equipment.
12. **Hazards assessments and risk factors** – the enterprise is required to execute hazards and risk factors assessments as a routine, and also in the different stages of construction.
13. **Adjustments for workers** – age and experience are highly important constituents in the conception of safety climate among workers.

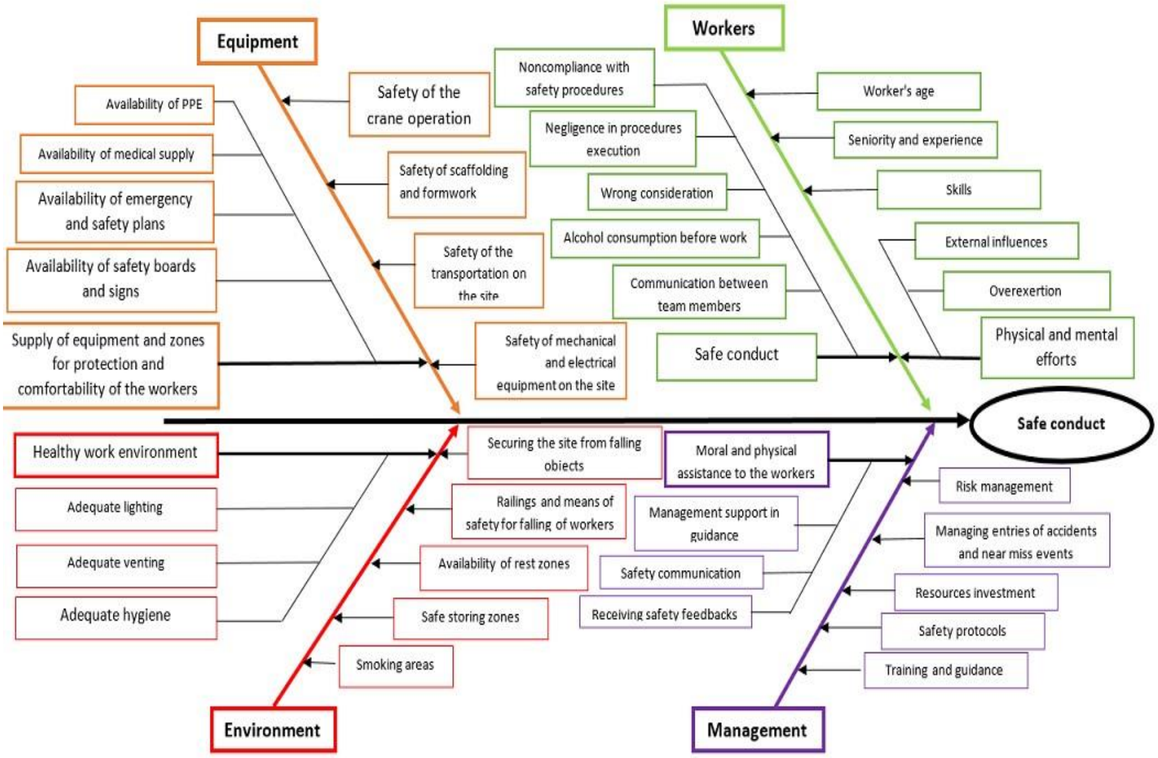

Figure 2: model of safety climate in small and medium construction enterprises

The research methodology encompasses field survey of 20 sites covering 42 parameters and variables of the model, allowing to assess the safety climate on a representative sample, inferential statistics, case study and conclusions.

3. Results and discussion

The field survey results are summarized in Table 1 below, the survey was carried out with the Likert 5-Point ranking scale and the core variables of the SMEs safety climate model were categorized into four categories: A – Equipment, B – Management, C - Employees, and D – Environment.

Table 1 defines the safety performance variables and delineates the means and Standard Deviations. In average four accidents in a project, 3.1 light, 0.9 moderate and 0.1 severe. No fatal accident reported. And the average nears-miss events reported is 0.9, indicating low level of reporting. Table 2 and Figure 3 depicts the SMEs safety climate mode equipment core which shows that this core is relatively at sufficient level safety climate adherence except the adoption of emergency and emergent safety plans. Table 3 and Figure 4 indicate the SMEs safety climate at the management level – it is apparent that most management component are at mediocre or low implementation particularly: B4 – Exposure of workers to safety records, B5 –

Encouragement of senior management to report near miss events, and B9 - Conduct if daily risk assessment surveys. Table 4 and Figure 5 depicts the Workers core variables of the SMEs safety climare model – it is indicated that the workers safety climate adherence is relatively low (3.7), particularly, C2 – Workers at work oveload, C3 – insufficient cinsideration of exterior factors affecting the work conditions (extreme hot weather in Eilat city are), and C10 - Capability of workers to assess fall from height hazards, Electrocution, Heat hazards and excavations hazards, Table 5 and Figure 6 depicts the SMEs safety climate environment factors inicating the this core of the SMEs safety climate is at aaceptable average level of 4.1 with exception of ventilation conditions at the work station and the hygiene and sanitary contions which are both below expected levele (4).

Table 1: Construction safety performance

Variable	Mean	Std. Dev.
No. of light work accidents	3.1	1.61
No. of moderate accidents	0.9	0.68
No. of severe accidents	0.1	0.30
No. of fatal accidents	0.0	0.00
No. of Near miss events reported	0.9	2.39

Table 2: SME safety climate model equipment variables (A)

Variable	Symb.	Mean	Std. Dev.
Availability medical equipment and first-aid	A1	4.2	0.96
Availability of emergency and safety plans at site.	A2	3.9	0.89
Site safety signage	A3	4.2	0.73
Prevention of falling of objects from height	A4	4.3	0.56
Inpection of safety equipment (scaffoldings, harnesses, crane)	A5	4.6	0.67
Mean		4.2	0.76

Table 3: SME safety climate model management variables (B)

Variable	Symb.	Mean	Std. Dev.	Remark
Encouragement of safety climate by the company management	B1	4.1	0.77	
Safety information tranfer into the site	B2	3.8	0.68	
Safety climate feed-back initiated by management	B3	3.7	0.96	
Exposure to safety records history	B4	2.7	1.62	
Encouragement to report mear-miss events	B5	2.1	0.89	
Allocation of safety climate resources by management	B6	3.9	0.99	
Clearity of safety protocols and regulation	B7	4.7	0.56	
Conduct of safety supervision at site	B8	3.7	0.64	
Conduct if daily risk assessment surveys	B9	3.4	1.02	
Update of safety regulations according to project progress	B10	3.9	0.77	Frequently carried out only once at beginning of project
Safety risk assessment by the company management	B11	3.6	0.86	
Mean		3.6	0.89	

Table 4: SME safety climate model employee's variables (C)

Variable	Symb.	Mean	Std. Dev.	Remark
Encouragement of safety climate by the peers	C1	3.8	0.75	
Work overload on your peers	C2	3.2	1.01	
Extrior factors affecting safety	C3	3.4	0.79	Hot weather condions affect safety equipment
Clarity of safety protocols and regulations	C4	4.7	0.57	
Sufficiency of training sessions (Work and the height, safety general, electricity, Work in Hot conditions)	C5	4.1	0.44	
Workers qualified for their tasks	C6	3.8	0.70	
Implementation of safety regulations	C7	3.7	0.57	
Do you feel qualified for risk assessment at marginal conditions such as heavy loads lifting, work at height, heavy earthmoving mechnical equipment, etc.	C8	4.3	0.43	
Peers consuming alcohol during work	C9	4.4	0.97	
Capability of workers to assess fall from the height hazards, Electrocution, Heat hazards and excavations hazards	C10	3.2	0.75	
Mean		3.7	0.69	

Table 5: SME safety climate model environment variables (D)

Variable	Symb.	Mean	Std. Dev.	Remark
Sufficient light conditions at work station	D1	4.1	1.08	
Sufficient ventilation of work station	D2	2.4	0.86	
Sufficient hygiene conditions	D3	3.5	1.12	
Safety measure for fall of workers from the height	D4	4.4	0.49	
Protection from Electrocution	D5	4.7	0.46	
Sufficient rest areas in the site	D6	4.8	0.54	
Storage areas are well fenced signed accessibke	D7	4.3	1.14	
Smoking areas exist	D8	4.3	1.10	Most workers smoke during work
Fire protection at the site	D9	4.7	0.56	
Mean		4.1	0.82	

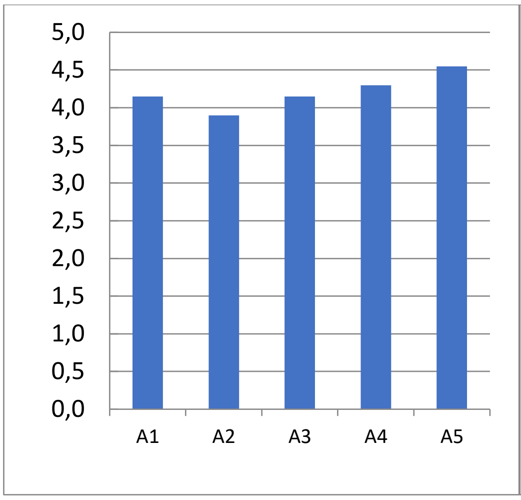

Figure 3: Equipment category ranking

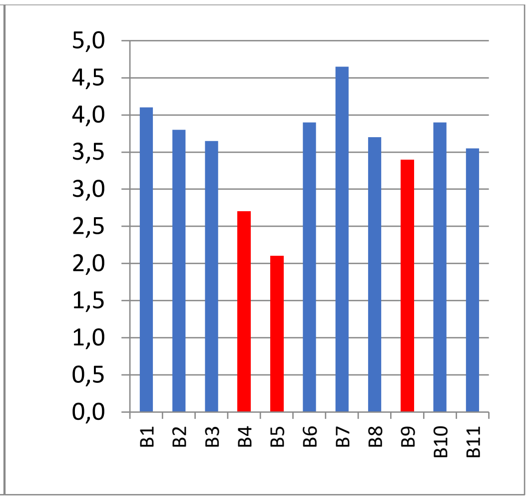

Figure 4: Management category ranking

(in red – low safety)

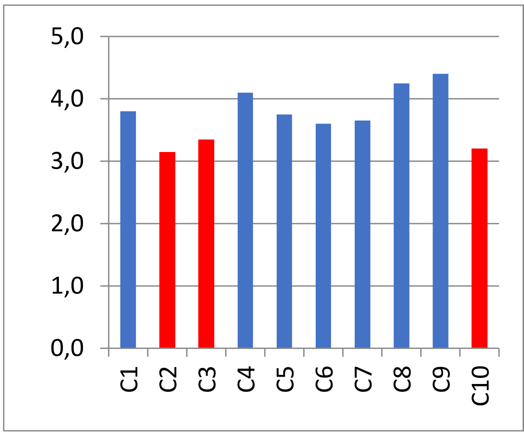

Figure 5: Employee category ranking

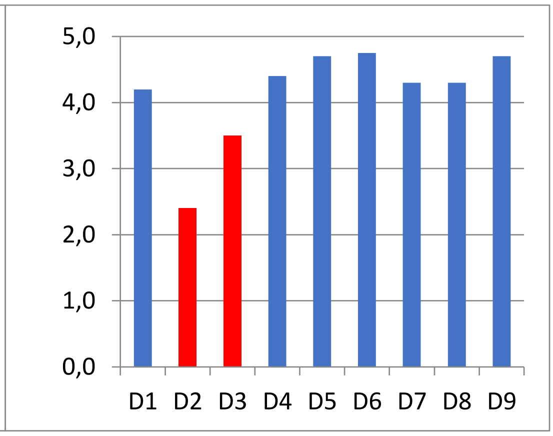

Figure 6: Environment category ranking

The foremen thought that the equipment category is the best with an average rating of 4.2, while in the management domain the rating was the lowest with 3.6 and the highest standard deviation of 0.89 which indicates on big variance between some projects with good and some with poor safety. The workers category had medium rating of 3.7, and in the environment category there was a relatively high rating of 4.1.

It appears that the lower rated categories are the ones related to the manpower – both management and workers.

4. Inferential statistics

In the sake of validating the model that was developed in this research, two subgroups of projects, that represent the model characteristics in its both poles (high and poor safety climate) – subgroup A with model variables higher than 4, and a subgroup B with model variables lower than 3.5. subgroup A included 5 projects and its average is 4.26. Subgroup B included 4 projects, and its model variables average is 3.34. both groups characterize in relatively small standard deviations (0.2 and 0.16 in accordance), a datum that allows to perform a T test in a good significance of 0.05.

The safety performance as measured in the survey has a significant and critical influence on the accidents number (Figure 7). The average of the light accidents number in subgroup A, with the good safety executions, is 3, compared to 3.75 in subgroup B. There were 0.8 moderate accidents in subgroup A, compared to 1.5 in subgroup B. there were no severe accidents in subgroup A, while in subgroup B there were 0.25. generally, there were 3.8 accidents in subgroup A and 5.5 accidents in subgroup B, a difference of about 44%.

This data indicate that the model and the survey questionnaire were validated, and show of direct connection between the estimated safety executions and their results.

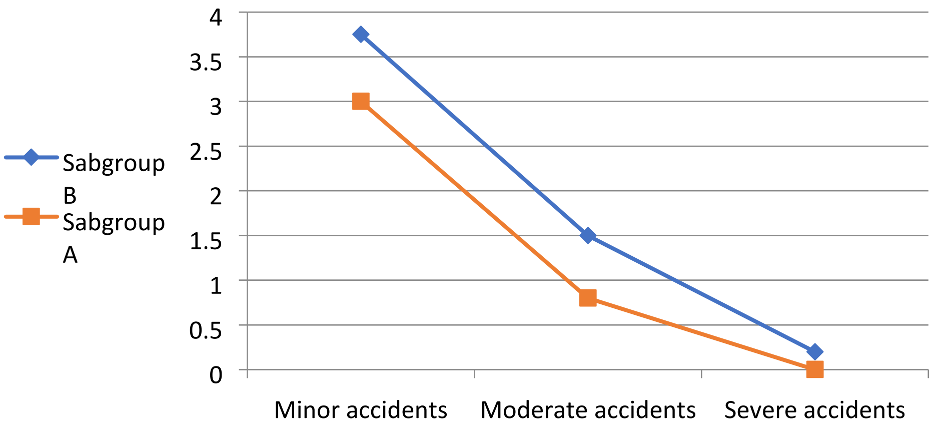

Figure 7: Average accidents in 2 groups according to safety performance

Siginificance of the findings - T test

Comparing the groups averages according to a T test in $\alpha=0.05$ significance it was found that T=8.59 beyond the limit value which is 2.365 and it allows to reject the null hypothesis that the means of both groups of safety climate projects are equal in 0.05 significance. Meaning, it was validated that there is a significant difference in safety performance indicators between projects that the SMEs safety climate model identified as having high safety executions, and ones that were identified as having low safety executions.

Case study

The analysis of the results of two projects, A, with the best results in the survey (avg. rating of 4.54 and a cost of 9.1 million$), and project B, with the lowest results (3.09 avg. rating and a cost of 2.4), is being used here as a mean for validating the research's conclusions.

Project A with the best results in the field survey, had high ratings in almost all parameters, besides factor related to heat. Project B with the lowest results in the survey got low ratings in almost all variables, specifically in the ones that are related to management, communication and control. Between both projects, one invests much in safety and the other one does not. A is much larger and according to the size it is expected to have 3-4 times more accidents – there were no accidents at all at project A, while in project B there were 3 light accidents and one medium.

Correlation between the project scope and safety climate

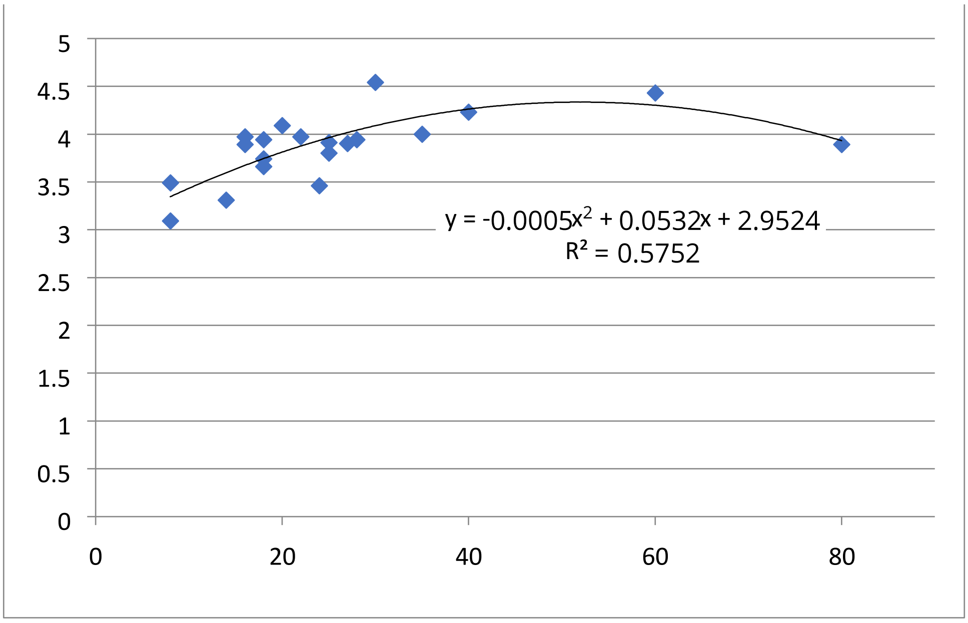

Figure 8: Safety climate Vs. project scope (M ILS)

Pearson correlation coefficient: R^2=0.575. It shows that there is a positive second-order parabolic connection between the project's scope and the safety climate quality, and that The model predicts the safety climate up to a project scope of 80 M ILS (23 M USD).

5. Summary and conclusions

This research examined the safety climate in small and medium construction enterprises. The core of the model was examination of the different components that were presented in the fish bone diagram – workers, equipment, work environment and management, in the different construction enterprises that were surveyed.

The construction sites that were examined are located in Eilat area (in the Israeli desert), and therefore are characterized with an extremely hot and desert climate. The research shows in a clear way the influence of the environment on the safety climate. There is often a loosening in the safety discipline due to the severe heat load that induces fatigue, lack of concentration and giving up on personal protection gear.

Likewise, it is possible to see that foremen are nearly entirely not exposed to historical entries of work accidents and don't keep making risk surveys consistently in all project stages, there are almost no near miss reports and the safety communication was found as impaired.

The importance of this research stems from the fact that it examines the safety climate in small and medium enterprises with no big budget like big enterprises have. In the research, there was found a certain correlation between the project's scope and the safety climate with a coefficient of 0.5. meaning that usually, the bigger the project's scope is, the safety budget is bigger and the safety itself is better.

In the research, there was developed a safety model that is built on four aspects: management, environment, workers and equipment. The model was examined through a survey of project managers and foremen in small and medium construction enterprises. The field survey, that was conducted at the city of Eilat in Israel – that is affected by a desert climate – showed that the safety climate in small and medium construction enterprises is at borderline levels with an average of 3.9 (from 1 to 5), that indicates of medium-borderline safety climate.

The relatively large standard deviations (equipment – 0.76, management – 0.89, workers – 0.69, environment – 0.82) indicate on a large variance between the sites, and on the need for improvement in regulation and inspection in the enterprises operating those sites.

The SMEs safety climate model was validated using inferential statistics on two categories of projects: group A - with high safety climate features, and group B – with medium-low safety features. The test found that the model predicts the safety performance at high level of significance (α=0.05), and that its implementation assures high safety climate and performance indicators.

The questionnaire was handed to foremen in projects, and sometimes their answers are biased by their positions as the safety manager in chief at the site level. it is recommended to conduct future research, in which it is possible to distribute the survey to the workers themselves, then the number of questionnaires would be large, and in addition the answers will be more demonstrative.

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