J Inno Sci Eng, 2024, 8(2):132-145
https://doi.org/10.38088/jise.1400605

JISE

Research Article

Occupational Health and Safety Practices in Small and Medium-Sized Enterprises in The Construction Sector and A New Model Proposal

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Cite this paper as:
Altuntas, F., Ghasemlounia, R. (2024). *Occupational Health and Safety Practices in Small and Medium-Sized Enterprises in The Construction Sector and A New Model Proposal.*Journal of Innovative Science and Engineering. 8(2): 132-145

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Received Date: 26/12/2023
Accepted Date: 11/08/2024

Abstract

The aim of the study is to create a model that examines the average occupational safety performance level by considering both occupational health and safety performance in the workplace and occupational health and safety management system performance to improve the level of occupational health and safety in small and medium-sized construction companies. For this purpose, 34 small and medium-sized construction companies located in various cities in the Marmara Region constitute the sample group of the study. The data obtained from the sample group were analyzed using factor analysis and descriptive analysis in the SPSS program and the fuzzy logic method in the MATLAB program. With the fuzzy logic approach, two input variables and one output variable were created and defined with five parameters each. Subsequently, with 25 rules created using the fuzzy approach, the calculated average safety index was obtained at 5.69. It is observed that 18 construction companies, constituting 52.8% of the examined 34 small and medium-sized construction companies, have low safety performance, while 16 construction companies, constituting 47.2%, exhibit high performance.

Keywords: Occupational safety performance in SMEs, Fuzzy logic, Average safety management index in SMEs.

1. Introduction

The construction sector, being a highly comprehensive industry, holds significant importance in terms of employment and economic value. With its characteristics, it serves as a lever in both our country and economies worldwide. Today, the construction sector is not only considered for building construction but also as a comprehensive set of activities contributing to all levels of social life, such as maintenance and repair. From this perspective, the construction sector is regarded as a product carrying investment value that manifests itself in all fields of activity [1].

However, the construction sector is recognized as one of the most hazardous industries, both globally and in our country, due to work accidents resulting in fatalities and injuries. It is observed that a significant portion of these fatalities and injuries occur in small and medium-sized construction firms. When the literature is examined, it is evident that occupational health and safety practices in large construction enterprises are better managed compared to small and medium-sized construction firms [2]. The lack of a corporate structure in construction small and medium-sized enterprises (SMEs), the seasonal and fast-paced nature of activities, and the interruptions in education and inspection mechanisms within a rapid structure are cited as some of the risks faced by construction sector workers in terms of occupational health and safety [3].

Research indicates that the low safety performance observed in small and medium-sized construction firms is closely related to a lack of knowledge in occupational health and safety and shortcomings in management system practices [4]. Additionally, it is emphasized that the implementation of a management system is of great importance in meeting occupational health and safety requirements in small and medium-sized construction firms [5]. The current study aims to examine the occupational health and safety performance of construction SMEs, assess occupational health and safety management performance, and create an average safety performance index by evaluating both performance aspects together.

In the literature review conducted, it was observed that the majority of risk assessment studies in the construction sector focus on large-scale construction firms, and studies on construction SMEs are limited. Therefore, this study holds significance in using fuzzy logic to create an average safety performance index for the evaluation of risks in occupational health and safety in small and medium-sized construction enterprises, providing decision support to users. This study, conducted in small and medium-sized construction firms that constitute a significant portion of the Turkish construction sector, is expected to contribute to the literature by proposing a new methodology that determines the average safety performance using fuzzy logic, aiming to enhance occupational safety levels in these firms.

1.1. Occupational Health and Safety in the Construction Sector

The construction sector, encompassing various sub-industries, inherently faces several challenges. One of these challenges is expressed as occupational health and safety (OHS) in the construction sector [6]. In Turkey, the construction sector stands out as one of the industries where work accidents and occupational diseases occur most frequently [7]. Statistical data on work accidents in our country reveals that approximately 35% of those who lose their lives due to work accidents are employed in the construction sector [8].

One of the reasons for this situation is the unique working conditions and certain risky tasks associated with the construction sector. In Turkey, the number of work accidents is higher compared to developed countries, and fatal work accidents are predominantly observed in the construction sector [9]. Each year, numerous accidents, both large and small in scale, occur on construction sites, emphasizing the need for careful attention to the protection of the health and safety of workers [10]. International Labor Organization (ILO) data indicates that workers in the construction sector in developed countries face a 3 – 4 times higher risk of work accidents compared to workers in other sectors, and this ratio can increase to 5 – 6 times in developing countries [11]. According to the ILO, a work accident is defined as an unforeseen event that is not pre-planned, resulting in specific damage or injury. According to the World Health Organization (WHO), personal injury, damage to machinery, vehicles, equipment, and similar incidents, as well as disruptions in production activities, are considered accidents. When examining accident theories in the literature, system, combination and epidemiology are considered. According to the accident chain theory, accidents are analyzed with five basic factors sequentially listed, as seen in the figure. It is emphasized that if one of the conditions does not occur, the next step will not take place, and the accident and injury will not occur until the chain is completed [12].

When evaluating work accidents that occurred between 2008 and 2010 in Turkey, it is observed in Table 2.1 that work accidents in the construction sector constitute 9% to 11% of all accidents [13]. Some of the risk factors causing accidents in the construction sector include noise, vibration, temperature, biological factors, chemicals, and ergonomic issues. The frequently encountered occupational diseases in this sector are listed as musculoskeletal disorders, asbestos-related diseases (asbestosis, mesothelioma), dermatitis, vibration-related issues, and hearing loss [14].

2. Materials and Methods

2.1. Title Data Collection Tools

Some of the risk analysis methods frequently used in the literature include Failure Mode and Effects Analysis, Control Checklist, Fault Tree Analysis, Event Tree Analysis, Cause and Effect Analysis, Fine Kinney Risk Analysis, Hazard, and Operability methods. When examining these risk assessment methods, it is observed that methods emphasizing ease of use, applicability to small and medium-sized construction SMEs in the sector, adaptability to the changing and diverse structures of construction sites, and consideration of disadvantaged processes and situations caused by various uncertainties stand out [15]. Therefore, in the conducted study, the aim was to identify hazards at the construction site using the control checklist method, and the control checklist method developed by Jannadi and Assaf [16] was employed. This method complies with the current OHS legislation in our country and includes criteria for ensuring occupational health and safety in small and medium-sized construction firms. The criteria in the control checklist are organized as follows: Fire prevention, organization, scaffolding, excavation works, formwork, health and comfort, electrical works, pressurized gas cylinders, mobilization, isolation, screed and plastering works, lifting equipment, personal protective equipment and falling from heights. The control checklist used as one of the data collection tools in the study consists of 13 sections and 59 items. It was implemented to assess the OHS performance of 34 small and medium-sized construction firms operating in the Marmara Region (Table 1).

Table 1: Safety control checklist.

Safety Section
1. Fire Prevention
• Adequate portable fire extinguisher
• Sufficient number of portable fire extinguishers
• Proper placement of fire extinguishers
• Proper storage of flammable/combustible materials
• Open flame operations
• Proper display of emergency contact information
2. Organization
• General condition and order
• Daily cleaning
• Direction signs
• Unauthorized access to the work area
• Unrestricted access paths within the construction site
• Proper storage of waste, debris, etc.
• Proper material stacking on the construction site
3. Scaffolding
• Installation and dismantling of scaffolding by qualified and authorized personnel according to relevant regulations
• Is the ground on which the scaffold is erected solid?
• Is the scaffold fully fixed to the surface or facade?
• Is there a safe ladder to access the scaffold and work area?
• Is the scaffold securely fixed to the ground?
• Is the scaffold properly grounded?
• Are scaffold connection points periodically checked?
4. Electrical
• Double insulation and grounding in electric hand tools
• Electrical installation compliance report
• Portable cables kept away from water puddles
• Residual current device
• Portable cables in spiral pipes
5. Excavation Works
• Operator's professional qualification certificate
• Controlled access to excavation areas
• Fall prevention measures in the excavation area
• Are warning signs present in the excavation area?
6. Formwork
• Adequate strength of timber
• Side slope support
• Proper formwork release agent
• Suitable ladders for formwork operations
7. Health and Comfort
• Dining area
• Shelter
• Smoking area
• Shower and sink
• Toilet
8. Personal Protective Equipment
• Compliance of PPE Materials with standards
• Proper use of PPE Materials
9. Pressurized Gas Cylinders
• Cylinders transported in accordance with regulations
• Cylinders stored in accordance with regulations
• Use of recoil and leak valve
• Periodic inspection of cylinders
10. Mobilization
• Marking of vehicle and pedestrian paths
• Direction signs
• Warning signs
• Reverse alarms
11. Roof Covering
• Elevator shaft openings
• Snagging and falling
• Welding operations
• Falling from height, material falling
12. Lifting Equipment
• Periodic inspection report
• Operator's professional qualification certificate
• Safety latches
13. Falling from Height
• Lifeline
• Proper guardrails
• Safety harness
• Suitable anchorage

Businesses conduct a series of activities aimed at improving the OHS performance of the enterprise by developing and implementing OHS policies to manage hazards and risks. The management system activities carried out in an integrated manner can be generally expressed as a combination of program elements such as planning, review, management participation, organizational arrangements [17]. Some of the nationally and internationally implemented and accepted OHS management system practices over the years include ISO 45001 (2018), BSI 8800:2004 (2004), 89/391/EEC OHS Framework Directive (1992), ILO OHS 2001 (2009), 92/57/EEC Council Directive (1992), Construction Works OHS Regulation (2018), TS OHSAS 18001 (2015), Occupational Health and Safety in Construction Projects (1993), TS IEC 62198 (Project Risk Management) (2003), Guidelines for the Civil Construction Industry (2009).

In the conducted study, an Occupational Health and Safety Management Index (OHSMI) was created to assess the elements and activities of the OHS management system. An OHS management system survey was developed for construction SMEs, considering some of the criteria of the OHS management systems mentioned above. The survey consists of 14 OHS management elements and 52 sub-components. The survey is designed with response options such as "Agree," "Partly Agree," "Disagree," "Partly Disagree," and "Strongly Disagree," and is scored on a scale of 5, 4, 3, 2, 1, respectively. The components constituting the OHS management system survey are grouped under the headings of health and safety plan, employee participation, hazard analysis, risk prevention and control, emergency plan, training, general ohs at the construction site, ohs in terms of duty, responsibility, accountability, suitability for the job, internal audit, first aid, accident investigation, documentation and reporting, contractor, and subcontractor.

2.2. Data Analysis

2.2.1 OHS Control Checklist Data Analysis

In the control checklist method developed by Jannadi and Assaf [16], the safety performance index (SPI) is obtained by multiplying each "yes" response by 100 and each "no" response by 0, summing them up, and then dividing by the total number of items, as shown in the formula below (1).

$$\text{Safety Performance Index (SPI)} = \left(\frac{\sum(\text{Number of Yes" x 100+Number of "No" x 0})}{\text{Number of applicable items}}\right) \tag{1}$$

If there are elements in the analyzed work area that are not covered by the examined checklist criteria, they are not taken into account. The obtained SPI is evaluated as shown below (Table 2).

Table 2: Safety performance index evaluation.

Score (%)	Status
0-59	Insufficient
60-69	Adequate
70-79	Proficient
80-89	Excellent
90-100	Outstanding

2.2.2 OHS Management System Survey Data Analysis

To determine the safety index (SI) in terms of occupational health and safety in construction SMEs, the equation below has been utilized (2).

$$\text{Safety Management Index (SMI)} = \left(\frac{\sum(\text{Likert Scale Points})}{\text{Number of applicable items}}\right) \text{ x } 2 \tag{2}$$

In the study, the average values of the safety management system for construction companies, as seen in Table 3, range between 4.38 and 3.35. When the elements of the management system listed in the table are ranked, the top five elements with the highest values are, in order: training with an average of 4.38, first aid with an average of 4.17, general OHS at the construction site with an average of 4.14, and health safety plan with an average of 4.08. The elements with the lowest values are, in order: risk prevention and control with an average of 3.35, hazard analysis with an average of 3.62, employee participation with an average of 3.65, emergency plan with an average of 3.70, and documentation and reporting with an average of 3.82.

Table 3: Average value of elements constituting the safety management index.

1.	Training	4.38
2.	Duty, Responsibility, Accountability in Terms of OHS	4.29
3.	First Aid	4.17
4.	General OHS at the Construction Site	4.14
5.	Health Safety Plan	4.08
6.	Suitability for the Job	4.02
7.	Internal Audit	3.96
8.	Contractor, Subcontractor	3.95
9.	Accident Investigation	3.83
10.	Documentation and Reporting	3.82
11.	Emergency Plan	3.70
12.	Employee Participation	3.65
13.	Hazard Analysis	3.62
14.	Risk Prevention and Control	3.35

2.3. Fuzzy Logic Concept

Fuzzy sources are generally characterized as complex, uncertain, and imprecise information sources that appear in various forms [18]. The concept of fuzzy logic, first introduced by Zadeh in 1965, is described as the ability to think with uncertain statements [19]. While classical logic categorizes a proposition as true or false, fuzzy logic creates the flexibility needed in everyday life uncertainties [20]. Fuzzy logic analyzes uncertainty in natural language and certain applications by gradually addressing the concepts of truth and falsehood, allowing for better solutions through the tolerance of sub-optimality and uncertainty [21].

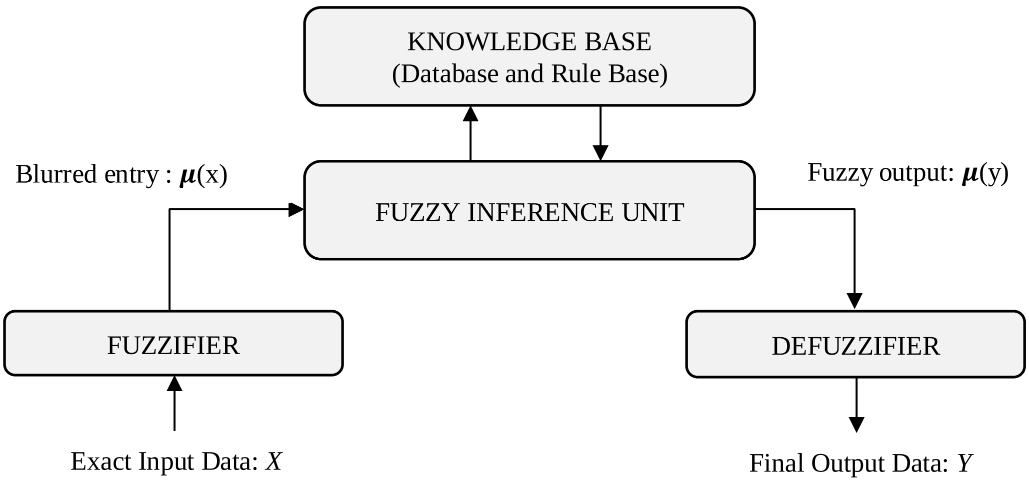

Figure 1: Fuzzy logic Structure.

For instance, fuzzy logic aims to resemble expressions comprising variables like hot-cold, low-high, fast-slow in the crisp world by using more flexible expressions such as slightly cold, slightly hot, slightly fast, slightly slow, slightly high, and slightly low [22]. In evaluating complex systems with limited accessible numerical data and uncertainties, fuzzy logic allows us to gain insights into the behavior of the system through transformation based on specific rules between fuzzy input and output data [23]. The fuzzy inference system editor in the fuzzy logic module of the MATLAB program enables users to determine their own rule and membership function styles.

The linguistic variables for the Average Safety Performance Index (ASPI) membership function, sequentially determined as very low, low, medium, good, very good, were assigned parameters (0,1,2,3), (2,3,4,5), (4,5,6,7), (6,7,8,9), (8,9,10), and the fuzzification process was performed in the MATLAB program. After defining the input variables Safety Performance Index (SPI) and Safety Management Index (SMI) and the output variable ASPI, the rule base was created using the Rules tab. Since the rule base in the fuzzy logic system defines the output variables (ASPI) based on the input variables (SPI and SMI), the relationship between the input and output variables defined by linguistic variables was established. The rule window that opens when the VIEW tab is clicked is also shown in Figure 2. The created rules are presented in Table 4.

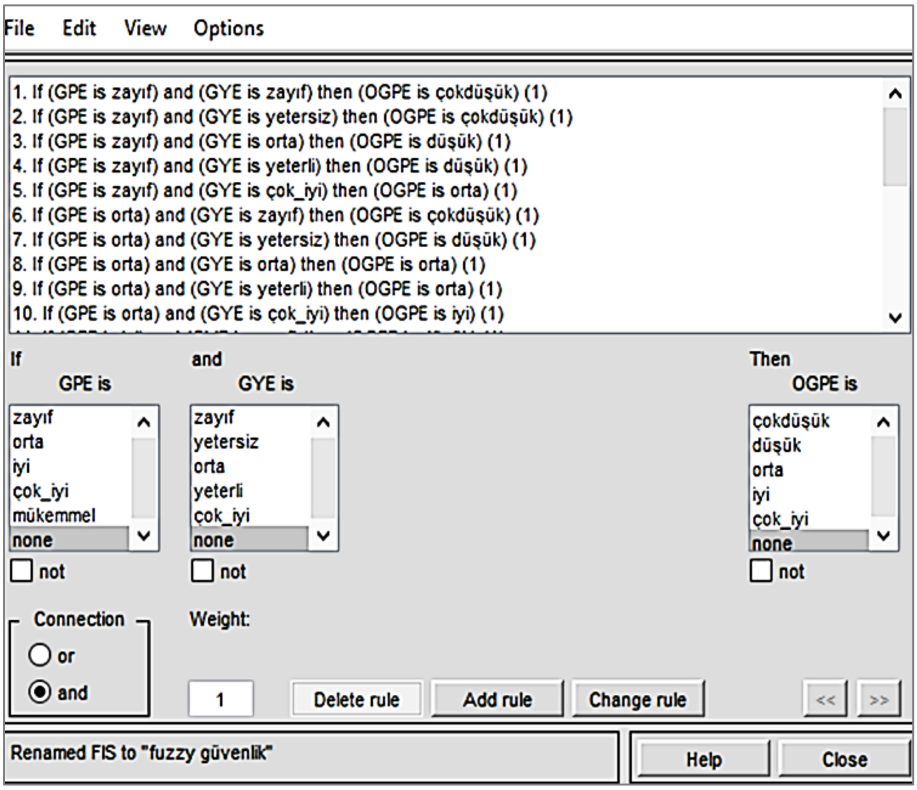

Figure 2: Mamdani fuzzy logic rule writing editor.

3. Findings

3.1. Findings Related to The OHS Control List

The findings resulting from the observation and control list assessment conducted in the construction sites of 34 small and medium-sized construction companies located in the Marmara region, which constitute the sample group of the study, are presented in Table 5.

Table 4: Fuzzy logic rule chart.

Rule #1.	If GPE is Poor and GYE is Poor then OGPE is Very Low Safety
Rule #2.	If GPE is Poor and GYE is Inadequate then OGPE is Very Low Safety
Rule #3.	If GPE is Poor and GYE is Average then OGPE is Low Safety
Rule #4.	If GPE is Poor and GYE is Adequate then OGPE is Low Safety
Rule #5.	If GPE is Poor and GYE is Very Good then OGPE is Average Safety
Rule #6.	If GPE is Average and GYE is Poor then OGPE is Very Low Safety
Rule #7.	If GPE is Average and GYE is Inadequate then OGPE is Low Safety
Rule #8.	If GPE is Average and GYE is Average then OGPE is Fair Safety
Rule #9.	If GPE is Average and GYE is Adequate then OGPE is Average Safety
Rule #10.	If GPE is Averagea dequate and GYE is Very Good then OGPE is Average Safety
Rule #11.	If GPE is Good and GYE is Poor then OGPE is Low Safety
Rule #12.	If GPE is Good and GYE is Inadequate then OGPE is Low Safety
Rule #13.	If GPE is Good and GYE is Average then OGPE is Average Safety
Rule #14.	If GPE is Good and GYE is Adequate then OGPE is Good Safety
Rule #15.	If GPE is Good and GYE is Very Good then OGPE is Good Adequate
Rule #16.	If GPE is Very Good and GYE is Poor then OGPE is Fair Safety
Rule #17.	If GPE is Very Good and GYE is Inadequate then OGPE is Average Safety
Rule #18.	If GPE is Very Good and GYE is Average then OGPEis Average Safety
Rule #19.	If GPE is Very Good and GYE is Adequate then OGPE is Adequate
Rule #20.	If GPE is Very Good and GYE is Very Good then OGPE is Adequate
Rule #21.	If GPE is Perfect and GYE is Poor then OGPE is Average Safety
Rule #22.	If GPE is Perfect and GYE is Inadequate then OGPE is Average Safety
Rule #23.	If GPE is Perfect and GYE is Average then OGPE is Good Safety
Rule #24.	If GPE is Perfect and GYE is Adequate then OGPE is Very Good Safety
Rule #25.	If GPE is Perfect and GYE is Very Good then OGPE is Very Good Safety

Table 5: Results of the control list assessment.

No	Security Department	Average Score (%)	Status
1	5. Fire	91.66	Outstanding
2	6. Excavation Works	90.68	Excellent
3	3. Mold Works	73.01	Proficient
4	7. Health and Guidance	72.35	Proficient
5	1. Personal Protective Equipment	66.16	Adequate
6	8. Layout	65.12	Adequate
7	2. Mobilization	63.23	Adequate
8	11. Lifting Tools	60.76	Adequate
9	9. Compressed Gas Cylinders	59.55	Insufficient
10	4. Electricity	58.58	Insufficient
11	12. Pier	58.39	Insufficient
12	10. Roofing	57.35	Insufficient
13	13. Falling from a Height	55.14	Insufficient
	Overall Security Performance	**67.09**	Adequate

When Table 5 is examined, it is observed that the safety performance index (SPI) average of the 34 small and medium-sized construction companies involved in the study is 67.09%, corresponding to a score of 6.70 on a scale of 10. Therefore, it can be seen that the occupational health and safety SPI value of the 34 small and medium-sized construction companies constituting the sample group is at a moderate level with an average score of 6.70. Table 6 presents the mean, variance, and standard deviation values of the control list items. According to the findings obtained from the conducted study, as seen in Table 5, the factor of falling from heights ranks first in terms of hazards and risks in small and medium-sized construction companies.

This finding aligns with the results obtained from a literature review. In a study, it was revealed that 67% of fatal workplace accidents in the construction sector occurred due to falls from heights [24]. Another of the five elements with the lowest averages is identified as the scaffolding component. This finding is consistent with a study on workplace accidents in the construction sector, indicating that accidents related to scaffolding have the highest average and highlighting the need to enhance the education and awareness levels of workers [25].

In the conducted study, one of the elements with the lowest average among the control list items was the electrical factor. This finding aligns with a study on accident patterns, revealing that 7.9% of accidents on construction sites are caused by electrical accidents [26]. The factor of fire, which is among the risks and hazards causing workplace accidents and injuries, was observed to have the highest safety level in the study. This result is similar to the finding that fires are infrequently observed in small and medium-sized construction companies, possibly due to employees' perception of fires and longer reaction times [27].

Table 6: Average, variance, and standard deviation of the safety index.

Average	Variance	Standard Deviation
67.09	143.43	11.97

3.2. Findings on OHS Management System

Table 7 shows the average value of elements constituting the safety management index.

Table 7: Average value of elements constituting the safety management index.

1.	Training	**4.38**
2.	Duties, Responsibilities, and Accountability in terms of OHS	**4.29**
3.	First Aid	**4.17**
4.	General OHS at the Construction Site	**4.14**
5.	Health Safety Plan	**4.08**
6.	Fitness for Work	4.02
7.	Internal Audit	3.96
8.	Contractor, Subcontractor	3.95
9.	Accident Investigation	3.83
10.	Documentation and Reporting	**3.82**
11.	Emergency Plan	**3.70**
12.	Employee Participation	**3.65**
13.	Hazard Analysis	**3.62**
14.	Risk Prevention and Control	**3.35**

As seen in Table 7 for the construction companies involved in the study, the average values of the safety management system range between 4.38 and 3.35. When the elements of the management system in the table are ranked, the top five elements with the highest values are, in order: training with an average of 4.38, first aid with an average of 4.17, general OHS at the construction site with an average of 4.14, and health safety plan with an average of 4.08. The elements with the lowest values are, respectively: risk prevention and control with an average of 3.35, hazard analysis with an average of 3.62, employee participation with an average of 3.65, emergency plan with an average of 3.70, and documentation and reporting with an average of 3.82.

Table 8 examines the relationship between the SMI and SPI values of the construction sites constituting the sample group of the study.

Table 8: SMI, SPI, and average values of the sample group construction sites.

Company	Averages														SMI	SPI
	SGP	RD	KA	RÖK	ADP	EĞT	ŞGİSG	İY	İU	İD	GSVH	TA	ÇK	YA		
1	4.67	3.75	3.33	3.50	3.80	3.75	4.50	4.25	5.00	3.33	4.50	3.75	4.33	4.33	**8.07**	**8.71**
2	4.33	3.75	3.67	3.83	3.80	4.00	5.00	3.50	5.00	5.00	5.00	4.00	4.33	4.33	**8.50**	**7.85**
3	5.00	3.50	3.00	2.83	3.40	4.00	3.25	3.75	2.50	3.33	3.25	3.00	3.67	3.33	**6.83**	**5.93**
4	4.33	5.00	4.33	3.50	4.40	4.50	4.50	4.00	4.00	4.33	4.50	3.50	3.67	4.00	**8.36**	**3.75**
5	3.67	3.25	3.33	3.67	3.40	4.50	5.00	4.50	4.50	4.33	5.00	3.00	5.00	5.00	**8.3**	**9**
6	4.67	4.75	4.67	4.00	4.60	5.00	4.50	4.75	4.00	3.67	4.50	2.75	4.00	4.33	**8.58**	**4.12**
7	3.33	3.50	3.33	3.00	3.20	3.75	4.25	3.25	5.00	3.33	4.25	2.25	2.00	4.00	**6.92**	**5.92**
8	4.33	3.25	4.33	3.67	3.80	4.75	4.50	4.50	5.00	4.67	4.50	3.75	3.33	3.33	**8.24**	**6.18**
9	4.00	4.00	4.33	3.50	4.20	4.75	3.00	4.25	5.00	3.00	3.00	2.25	3.00	3.67	**7.42**	**6.83**
10	3.33	3.50	3.67	2.67	3.00	4.00	3.75	3.50	3.50	3.33	3.75	2.00	2.00	3.33	**6.42**	**5.57**
11	4.33	4.00	4.33	3.50	4.80	4.75	2.25	3.50	3.50	2.33	2.25	3.25	3.33	3.33	**7.08**	**4.43**
12	4.33	3.25	3.33	3.50	3.20	4.50	5.00	4.25	4.00	3.67	5.00	3.00	3.00	3.67	**7.68**	**5.57**
13	4.00	3.25	5.00	3.50	3.60	4.75	3.25	4.25	4.00	3.00	3.25	3.25	3.00	3.67	**7.4**	**7.66**
14	4.00	4.00	4.00	3.50	4.40	4.75	4.00	4.00	4.00	3.33	5.00	3.50	3.67	4.00	**8.02**	**4.66**
15	3.33	3.50	2.33	2.50	2.80	5.00	3.75	3.75	4.00	3.67	3.75	4.00	3.67	4.67	**7.08**	**5.28**
16	5.00	5.00	5.00	4.67	4.80	4.75	5.00	5.00	5.00	5.00	5.00	4.75	4.00	4.67	**9.68**	**8.1**
17	3.00	3.75	3.67	3.50	3.80	5.00	3.25	4.50	5.00	4.33	3.25	2.50	4.00	4.00	**7.62**	**3.8**
18	4.00	4.00	4.33	3.50	3.40	3.75	4.00	3.00	4.00	4.33	4.00	3.25	4.00	4.00	**7.62**	**8.8**
19	4.00	3.75	3.67	3.83	3.40	4.00	4.25	3.50	4.50	4.00	4.25	3.50	3.33	4.00	**7.68**	**5.64**
20	4.33	3.50	4.33	3.50	4.00	4.75	4.50	4.00	5.00	4.00	4.50	3.50	3.67	4.00	**8.24**	**7.25**
21	5.00	3.75	4.00	2.83	3.40	5.00	3.75	4.00	4.00	3.67	3.75	4.25	3.67	3.67	**7.84**	**8.72**
22	4.00	3.75	3.67	3.17	3.60	3.75	5.00	4.50	5.00	4.33	5.00	4.25	4.00	4.33	**8.3**	**8.16**
23	3.67	4.00	3.33	3.67	3.20	3.75	5.00	4.25	5.00	4.33	5.00	4.25	4.00	4.33	**8.2**	**4.64**
24	4.00	4.00	3.67	2.50	3.40	5.00	4.25	4.00	4.50	4.33	4.25	3.25	3.00	4.00	**7.7**	**8.22**
25	4.00	2.75	4.00	3.00	4.20	4.50	5.00	5.00	5.00	5.00	5.00	4.00	3.33	4.00	**8.42**	**2.87**
26	4.00	3.75	4.00	4.33	3.40	4.00	4.00	3.75	3.50	3.67	4.00	4.50	4.33	3.67	**7.88**	**6.35**
27	4.00	3.00	3.33	3.67	3.40	4.00	4.75	4.00	5.00	5.00	4.75	5.00	5.00	5.00	**8.44**	**9.1**
28	4.33	4.50	5.00	3.83	4.20	4.75	3.00	4.50	4.00	2.67	3.00	5.00	4.00	4.00	**8.12**	**8.6**
29	3.00	3.25	2.00	1.83	3.60	2.25	3.50	2.50	4.50	4.00	3.50	4.00	3.00	3.00	**6.28**	**8.18**
30	3.33	5.00	4.33	2.33	3.40	5.00	4.00	3.00	4.00	4.00	4.00	5.00	3.67	3.33	**7.84**	**8.16**
31	5.00	3.25	4.67	3.83	3.60	4.00	3.75	4.50	3.50	4.33	3.75	4.25	4.33	4.33	**8.1**	**6.88**
32	4.67	4.75	4.67	3.33	3.60	4.50	4.50	4.00	3.50	3.33	4.50	4.75	5.00	5.00	**8.46**	**4**
33	3.33	3.75	1.33	2.17	3.40	4.50	4.50	4.00	4.00	5.00	4.50	3.00	3.00	3.00	**7.14**	**7**
34	4.67	4.25	4.33	4.00	3.80	5.00	4.50	5.00	4.00	5.00	4.50	3.00	3.00	3.00	**8.46**	**6.68**
Average	**4.08**	**3.82**	**3.83**	**3.35**	**3.70**	**4.38**	**4.14**	**4.02**	**4.29**	**3.96**	**4.17**	**3.62**	**3.65**	**3.95**	**7.85**	**6.54**
Variance	**0.32**	**0.33**	**0.68**	**0.38**	**0.24**	**0.34**	**0.49**	**0.34**	**0.41**	**0.51**	**0.51**	**0.67**	**0.51**	**0.31**	**0.47**	**3.22**
SD	**0.57**	**0.57**	**0.82**	**0.61**	**0.49**	**0.58**	**0.70**	**0.58**	**0.64**	**0.71**	**0.71**	**0.81**	**0.71**	**0.55**	**0.68**	**1.79**

The Pearson correlation coefficient was calculated as 0.58 at the 0.01 significance level. The interpretation of the relationship level between variables is as follows: if the Spearman correlation coefficient value is between 0 and 0.29, it is considered weak; between 0.30 and 0.64, it is moderate; between 0.65 and 0.84, it is strong; and between 0.85 and 1, it is very strong. In light of this information, it can be concluded that there is no strongly positive relationship between SMI and SPI. The result indicates that although the 34 small and medium-sized companies participating in the study exhibit a high level of safety management performance with an average value of 7.85 (out of 10), this does not fully reflect the occupational health and safety performance demonstrated in the construction site. As a result of factor analysis, the average value of the first dimension named "management participation" is 3.94, and the average of the second dimension named "appropriateness of OHS activities" is 3.91.

The evaluation results suggest that the low value obtained from the SPI analysis can be explained by the second dimension, "appropriateness of OHS activities," being lower than the first dimension, "management participation." These findings highlight the necessity of considering both the SPI and SMI together when assessing the average safety performance (ASPI) of construction sites in small and medium-sized construction companies. It indicates that only through the integration of these two factors can appropriate and sufficient conditions for occupational health and safety be achieved in the construction site fields of small and medium-sized construction companies.

Table 9 presents the average safety performance index and its linguistic equivalent for the 34 small and medium-sized construction companies visited.

Table 9: SPI, SMI, and ASPI values of visited construction sites.

	SMI	**SPI**	**Fuzzy Logic ASPI**	**Low/High Performance Relative to the Average**	**Linguistic Equivalent of ASPI**
1.	8.07	8.71	8.28	High	28% Very Good, 72% Good
2.	8.50	7.85	7.56	High	100% Good
3.	6.83	5.93	3.38	**Low**	100% Low
4.	8.36	3.75	4.44	**Low**	56% Low, 44% Medium
5.	8.3	9	9	High	50% Good, 50% Very Good
6.	8.58	4.12	4.46	**Low**	46% Medium, 54% Low
7.	6.92	5.92	3.38	**Low**	100% Low
8.	8.24	6.18	4.9	**Low**	90% Medium, 10% Low
9.	7.42	6.83	5.9	High	100% Medium
10.	6.42	5.57	3.38	**Low**	100% Low
11.	7.08	4.43	3.4	**Low**	100% Low
12.	7.68	5.57	3.36	**Low**	100% Low
13.	7.4	7.66	6.6	High	40% Medium, 60% Good
14.	8.02	4.66	3.44	**Low**	100% Low
15.	7.08	5.28	3.34	**Low**	100% Low
16.	9.68	8.1	9	High	50% Good, 50% Very Good
17.	7.62	3.8	3.44	**Low**	100% Low
18.	7.62	8.8	8.15	High	15% Very Good, 85% Good
19.	7.68	5.64	3.36	**Low**	100% Low
20.	8.24	7.25	6.39	High	39% Good, 61% Medium
21.	7.84	8.72	8.3	High	30% Very Good, 70% Good
22.	8.3	8.16	7.74	High	100% Good
23.	8.2	4.64	3.94	**Low**	100% Low
24.	7.7	8.22	7.66	High	100% Good
25.	8.42	2.87	4.39	**Low**	39% Low, 61% Medium
26.	7.88	6.35	4.45	**Low**	45% Medium, 55% Good
27.	8.44	9.1	9	High	50% Good, 50% Very Good
28.	8.12	8.6	8.12	High	12% Good, 88% Very Good
29.	6.28	8.18	6.04	High	4% Good, 96% Medium
30.	7.84	8.16	7.56	High	100% Good
31.	8.1	6.88	5.47	**Low**	100% Medium
32.	8.46	4	4.45	**Low**	45% Medium, 55% Low
33.	7.14	7	5.34	**Low**	100% Medium
34.	8.46	6.68	5.89	High	100% Medium
Average	**7.85**	**6.54**	**5.69**		100% Medium

The table shows that out of the 34 construction sites evaluated in the study, 18 construction companies, constituting 52.8%, exhibited a safety performance below the average value of 5.69. On the other hand, 16 construction companies, constituting 47.2%, demonstrated a high safety performance.

4. Conclusion

SMEs constitute 99% of businesses, provide 80% of employment, and contribute 38% to the total value-added production in our country [28]. The construction sector plays a locomotive role both in the global and national economies due to its share. However, the construction industry stands out as one of the riskiest sectors in terms of the required working conditions. When examining statistical data on workplace accidents in our country, it is observed that 10% of work accidents, 30% of fatal accidents, and 25% of accidents resulting in permanent disability occur in the construction sector. Research indicates that, compared to large-scale construction companies exhibiting a corporate structure, there are deficiencies in occupational health and safety practices in small and medium-sized construction companies [29].

Adverse working conditions in the construction sector, the relatively low level of education of workers in the sector, and a lack of supervision contribute to the increase in workplace accidents. Therefore, the importance given to activities necessary for ensuring occupational health and safety in the work environment is increasing day by day, both due to ethical principles and legal requirements. In this context, risk assessment studies, which have become mandatory in Turkey with the Occupational Health and Safety Law No. 6331, should be conducted with precision.

When examining the literature, it is evident that there are numerous risk assessment methods, and selecting the most appropriate method for the sector and the company is crucial, as shown by various studies [30]. In this study, a method was developed to assess the overall occupational health and safety performance in small and medium-sized construction companies. Comparing the safety performance of construction SMEs, which constitute a significant portion of the Turkish construction sector, with the created index and identifying deficiencies can pave the way for improvement activities. The proposed model demonstrates a structure with the main inputs being the occupational health and safety control list and the safety management system survey, and the output being the average safety performance index.

The safety management system survey consists of elements such as Training, Duties, Responsibilities, Accountability in terms of OHS, First Aid, General OHS at the Construction Site, Health Safety Plan, Fitness for Work, Internal Audit, Contractor-Subcontractor, Accident Investigation, Documentation and Reporting, Emergency Plan, Employee Participation, Hazard Analysis, and Risk Prevention Control. In the study, the checklist created by Jannadi and Assaf [16] was adapted for small and medium-sized construction companies, and deficiencies in construction sites were assessed.

In the conducted study, the Average Safety Performance Index (ASPI) was created by analyzing the SMI and the SPI together using fuzzy logic. In this MATLAB-programmed study, linguistic variables for input data SMI, SPI, and output data ASPI were defined, and membership functions were created. Membership functions were transformed into fuzzy variables ranging from zero to ten, with five parameters assigned. Subsequently, a rule base was formed using linguistic variables defining the output variables based on the input variables and the rule window, and 25 rules were defined. The analysis results indicate that out of the 34 construction sites evaluated in the study, 18 construction companies, constituting 52.8%, exhibited a safety performance below the average value of 5.69. On the other hand, 16 construction companies, constituting 47.2%, demonstrated high safety performance. For future studies, it is considered that revisiting the safety control list and safety management survey by adding or removing new elements based on the characteristics of construction projects and repeating studies with different sample sizes will contribute to the literature.

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