

Article

Factors Impacting Occupational Safety among Women Engineers

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Abstract: On the one hand, in the present era, construction companies are one of Egypt's fastest-growing industries and provide significant economic returns. On the other hand, construction industries significantly put individuals in danger of accidental death. In this study, the researchers examined the factors that affect Occupational Safety (OCS) measures among women engineers working in Egypt's construction industries. This is a quantitative study that used cross-sectional data, and the researchers used 376 usable samples. By applying Structural Equation Modeling (SEM), this study's findings demonstrate that the Work Environment (WEN), Personal Protection (PP), Training and Education of Safety Skills (TESS), Familiarity with Safety Regulations (FSR) and Safety Commitment (SCT) influence OCS. This study's findings will help policymakers and planners design effective safety policies on construction sites. This study's findings about adopting precautionary and safety measures will help reduce the death rates on Egypt's construction sites. Finally, particularly in developing countries, this study's findings will contribute to the health and safety and environment and health literature.

Keywords: occupational safety (OCS) measures; work environment (WEN); safety commitment (SCT); personal protection; safety measures; construction industry; women engineers



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1. Introduction

In the present era, 2.8 billion workers are working at their workplaces globally [1]. Out of these workers, one third are employed in developing countries. Unfortunately, workers face two occupational hazards, namely traditional and multifaceted work settings due to rapid technological advancements and, in recent years, industrialization and globalization. These circumstances have increased the risks of workers' accidents, whereby they injure themselves and possibly lose their lives. In this regard, taking care of workers and maintaining their safety is a prerequisite for every industry or workplace to lessen the likelihood of their employees suffering from accidents. More specifically, in developing contexts, health and safety precautions must be maintained where more incidents occur due to fewer initiatives or measures of safety. Safety is considered the sustainable means of protecting the workers' health and well-being and those of their families, the company's management, customers and other stakeholders [1].

A company must motivate its employees through various methods to foster a safe and healthy Work Environment (WEN). To ensure these safety requirements, Occupational Safety (OCS) programs are the most helpful when it comes to making a secure and healthy workplace where safety is the main priority. The OCS system includes Occupational and Nonoccupational Safety management [2], which benefits individuals, organizations and employee motivation, which ultimately enhances positive outcomes [3].

Against this background, construction industries are significant in that workers often experience the risk of death when carrying out their duties [4]. However, Egyptian construction companies are one of the nation's fastest-growing industries and significantly contribute to the country's economy. This is one of the most dangerous and accident-prone industries, and its workers are incredibly prone to severe injury or death [5]. It is recognized that construction workers face vast risks of fatal injuries [6]. Egypt's construction industry accounts for nearly 13% of fatal accidents and 18% of work-related illnesses [7].

Several types of accidents occur due to a failure to de-energize electrical systems, the negligence of safe distances, inappropriate use of precautionary equipment, inappropriate work practices, accidental contact with unprotected electrical parts, nonfunctional safety devices and an unsafe environment [8]. As a result of these issues, women engineers need to keep themselves safe, secure and sound. More specifically, on construction sites, women engineers are valuable individuals whose presence can help to generate a safe and secure favor environment. Therefore, bearing this in mind, the researchers aimed to answer the following research question:

What Safety-Related Factors Affect Women Engineers' Occupational Safety on Construction Sites?

This study's findings aim to provide guidelines to construction industries' authorities and contractors to uphold the construction laws and regulations to protect the safety of women engineers on construction sites and, more predominantly, in Egypt. This study's findings may help develop a conducive environment that considers women engineers' safety and calculates the risk factors. Finally, the paper comprises the following sections: Section 1 is the introduction. Section 2 is the literature review and conceptualization, which underlines the safety-related factors and the development of hypotheses. Section 3 explains the methods used in this study. Section 4 is the data analysis and results. Section 5 is the discussion and conclusion. Finally, Section 6 is this study's limitations, novel contribution and recommendations for future research studies.

2. Literature Review and Conceptualization

2.1. Safety-Related Factors

2.1.1. Work Environment

In the organizational safety climates, employee attitudes regarding the maintenance of safety protocols in the WEN significantly reduce workplace hazards. Additionally, individual accountability is also favorable and crucial to maintain safety levels to eliminate maximum workplace danger in organizations [9]. In fulfilling the WEN, smart technology has the potential role to boost worker productivity with minimal workplace accidents [10]. The enablers, such as workplace discipline and the WEN, positively and significantly influence occupational health and safety [11]. From the industrial health and safety perspective, calculating workplace risks is better for organizations. These risks occur due to electricity and related hazards in the workplace [12]. This risk elimination is possible through an advantageous WEN [13].

2.1.2. Safety Equipment

In terms of safety equipment, Personal Protection (PP) ensures health and safety [14]. There is a clear correlation between firefighter safety and safety-specific revolutionary leadership and a positive correlation between the use of PP equipment and the motivation to be safe [15]. The favorable effects of the safety climate and risk perceptions substantially affect attitudes towards wearing PP equipment [16]. A good safety environment influences the perceived use of PP. Sensitivity to noise significantly influences how healthy employees perceive the effects of noise and how they behave towards their physical protection. In addition, the safety environment can substantially benefit employees' perceptions of risk, and their expectations and values and can also directly affect PP behavior. At the same time, perceptions of risk, anticipation and valuation are different mediating factors that do not interfere with one another [17]. During the COVID-19 pandemic, PP equipment, such as masks and sanitizer, has remained effective at resisting COVID-19 [18]. The

organizational risks and emotional fatigue are associated with workplace satisfaction, whereas psychosocial risks are significant predictors of burnout. Nevertheless, by initiating PP steps, these impacts are reduced [19].

2.1.3. Safety Training and Knowledge

Safety instruction is the most significant factor that influences success in terms of safety. A safety mindset and understanding are the best ways to mediate this relationship. Effective safety instruction is another safety management technique that can help to create a successful safety strategy [20]. Training in safety skills reduces the chances of individual injuries from organizational incidents [21].

2.1.4. Need of Women

The top four viable tactics in construction are recognized to provide women with adequate sanitary facilities in the workplace [22]. Given the demanding positions and opportunities for their professional development, there is a need to provide women, as role models, with a flexible organizational culture. However, women face several existing workplace challenges due to their nature, organizational structures and surroundings. In addition, women encounter sexual harassment, stress and gender discrimination. Additionally, the absence of daycare services, paid absences and flexible work arrangements (such as maternity leave) create unnoticed difficulties that limit women's professional potential. Often, these are acknowledged as the major obstacles facing women in the construction industry [23]. Similarly, the findings of [24]'s review confirm that the USA, South Africa, Australia and Japan are leading the advancement of research in women's health and safety. In addition, biologically associated dangers were found to be the main stresses or hazards encountered by women in the construction industry. In many countries, the construction industry is faced with skill shortages. When compared to men, women experience lower incidence rates in both professional and manual or trade occupations. Women who work in construction and plumbing and operate earthmoving equipment are more likely to sustain injuries that leave them permanently disabled. Among female employees, fractures, soft tissue injuries, deafness, anxiety, stress and depression cause permanent incapacities. Finally, falls from the same height, muscle strain from handling items, prolonged sound exposure, job stress, workplace harassment and bullying lead to incapacitating injuries that cannot be cured [25]. When working in sweltering weather, employees with a medical problem such as hypertension are more likely to experience adverse effects on their health. Female workers have more heat-related illnesses [26]. Attracting women into a profession that emphasizes conflict and aggression is difficult [27]. Consequently, the construction industry is working hard to alter its reputation and culture and professional organizations, and labor unions and colleges are supporting their efforts. In the construction industry, an accident happens when electrical systems are not de-energized, safe distances are not maintained, PP equipment are inappropriately used, poor work practices lead to unintentional contact with exposed electrical parts, broken tools and equipment are used, there is a lack of functional safety devices or a hazardous environment, and preventative actions (safe work practices, insulation, guarding, grounding and electrical protective devices) are not taken [8]. Due to their character, organizational structure, and surroundings, women engineers, in particular, encounter several employment problems. They face many difficulties, including sexual harassment, stress and gender discrimination, particularly in construction sites.

2.1.5. Occupational Safety of Women Engineers

The behavior factor is more effective when preventing rather than setting habitual risk taking and making repetitive warnings. In addition, it is essential to determine the ideal intensity of intervention (such as scheduling and regularity) that will reduce or delay the development of hazardous behaviors [28]. Designs, which include safety measures, significantly improve construction OCS and workers' health and create a favorable environment for safe learning, continuous engagement in education and training, and designs

for lifelong organizational safety [29]. The factors presenting the most significant barriers are the expense of adopting COVID-19 pandemic safety precautions, a lack of cooperation and misinformation [30]. However, fewer respondents mentioned superstitions, a shortage of PP equipment and loss of COVID-19 materials [31]. To ensure the safety management system, several industries possess legal safety management system standards that emphasize a safety culture, and their work includes safety culture components such as reporting/a just culture, continuous development and involvement [32–34]. Although there have been significant advancements in workplace Occupational Safety and health regulations throughout the years, there continues to be many injuries, deaths and incidents of health and safety illnesses [35].

2.1.6. Safety Culture and Commitment

SCT is a crucial factor when determining the stability of miners' safe behaviors. The thoughtful leaders mirror the workgroup's dedication to safety. However, when opinion leaders and group chiefs are different, opinion leaders rather than group chiefs prove to have a more outstanding commitment to safety. There are consistent correlations between cluster subgroups' safety traits and the overall workgroup's degree of dedication to safety [36]. While the SCT attributes of the employees' calculative leader relate only to reducing levels of employee compliance, the SCT attributes of the emotional leader are linked to employee safety behaviors. However, there is no association between employees' self-reported safety behaviors and the conventional SCT attributes of their boss [37]. A lower perceived SCT relates to reduced involvement and compliance with safety measures [38]. A safety culture focusing on managers' and workers' commitment to safety means having leaders and managers foster a secure workplace environment by demonstrating their dedication to safety [32]. They have greater power to ensure all activities are carried out safely within the company [39].

2.1.7. Safety Sustainability

A program that uses safety as a starting point to operationalize sustainability should ideally place stress equally on the advantages of safety for people and the business aspects of pursuing safety measures [40] through mediators and social-sustainability practices, such as the work settings, working conditions, health and safety education and training, and the benefit of the couriers' employment satisfaction during the COVID-19 pandemic (psychological safety and perceived fairness) [41]. Programs for OCS and health help lure in and keep talent, which enhances the effectiveness of these organizations' internal operations. Total quality management practices positively and significantly impact the OCS and health performance of organizations [42].

2.1.8. Knowledge Gaps

Consequently, there remains significant gaps in the existing literature mentioned above, which need to be filled. First, several scholars tested factors such as working conditions, health and safety, education, training, employment happiness, psychological safety, perceived fairness, total quality management practices, PP, health performance, FSR, workers' commitment, SCT, TESS and managerial dedication. They examined the OCS, safety measures and health occupation [32,39–42]. However, the literature does not include a model to investigate the integrated contribution made by the WEN, PP, TESS, FSR and SCT towards OCS. Second, particularly among women in the construction industry as units of analysis and, more specifically, in the construction industry, there remains a massive gap in the literature. Finally, the literature contains no similar findings about investigations on Egypt's construction sites [21,43–45]. After considering these existing gaps and the positive associations in the literature, the researchers developed a model (see Figure 1) to investigate women engineers working on Egypt's construction sites.

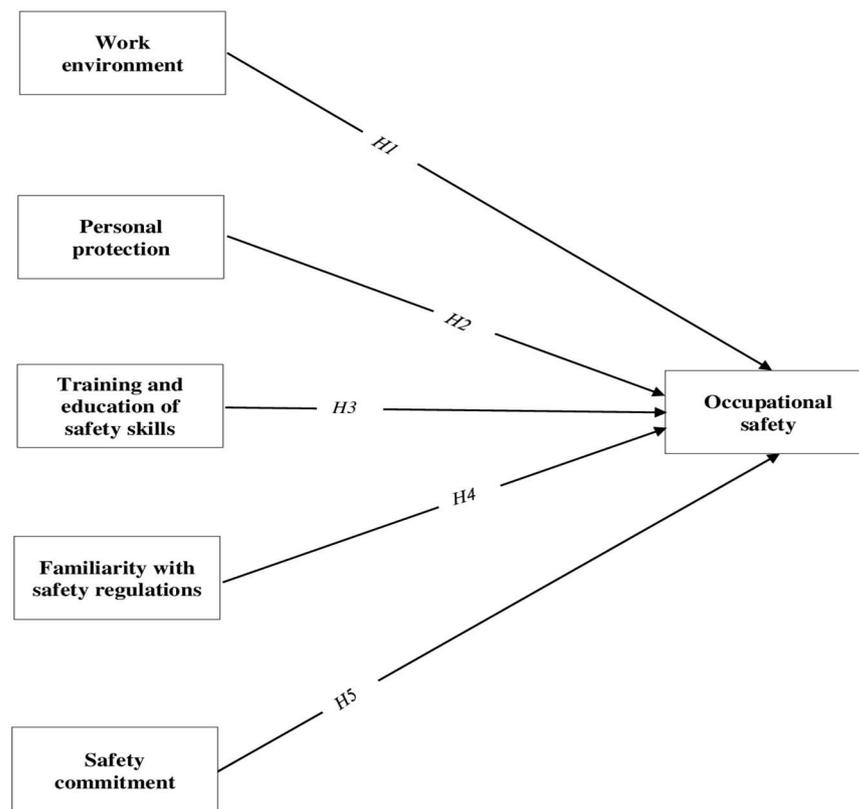


Figure 1. Conceptual model of the study. Source: authors' own conceptualization.

2.2. Work Environment (WEN) and Occupational Safety (OCS)

Workplace safety, health, the environment and sustainable development represent the key unifying factors of the highly divisive ideas. However, these ideas are connected [46]. According to review-based research, the WEN and work ethics impact OCS and health. In comparison, occupational wellness impacts OCS [11]. Monitoring nurses' working circumstances enhances the hospital culture which, in turn, improves employee safety and increases hospital revenue through better system results (such as a lower turnover of employees) [47]. A changing work setting impacts safety and workplace accidents. This suggests an underlying mechanism based on organizational variables to further understand these impacts and the effect of a disability attributed to a workplace accident on an individual's lifespan [48]. The job processes connected to infrastructure and construction significantly impact the WEN [49]. There is a need to learn how nurses view their WEN and workplace safety and the sociodemographic factors and employment requirements that affect these factors. Their workplace is of average standard, with inadequate job safety [50]. Ref. [51]'s findings indicate that the effect on the Spanish industry will improve working conditions. From an academic perspective, workplace health and safety integrate environmental, societal and corporate variables. Healthy workers, a safer workplace, lower costs due to fewer accidents, a controlled atmosphere, managed workplace incidents and enhanced workplace safety information contribute to sustainable development [52]. Water utility sector workers are subject to dangers and hazards. Workplace safety and health risks affect this sector's working conditions [53]. Ref. [54]'s findings show that innovation is crucial for any country's long-term growth. Workplace innovation drastically alters the employees' WEN. In a similar dimension, the quality of the WEN predicts the OCS [55]. Safety communications, management's dedication to safety, and workplace safety training are the variables that affect if workers are successful in terms of safety. An improvement in safety efficiency is linked to a reduction in workplace accidents. When reducing the number of accidents and near misses, safety communications are the most critical aspect of a safe WEN [56]. It is essential to prioritize workplace safety to motivate a company's

workers in various ways. A secure, safe and healthy work setting, non-OCS and safety for tasks performed outside of the workplace are all goals of the OCS system [2].

Consequently, the above literature demonstrates the WEN's predictive and positive effect on OCS. However, this association still needs further investigation among Egyptian women engineers on construction sites. Accordingly, the researchers formulated the following hypothesis:

Hypothesis 1 (H1). *WEN has a positive and significant effect on OCS.*

2.3. Personal Protection (PP) and Occupational Safety (OCS)

Human behaviors make a tremendously significant contribution to restricting OCS. With the employees' involvement and a specific pattern of behavior as crucial criteria required to alter employees' behaviors, the safety problem can be addressed effectively [57]. Using PP equipment in such a way is more helpful in reducing accident rates [58]. Due to the deficient use of PP equipment, employees in small-scale businesses are subjected to a wide range of physical, chemical and accidental dangers [59]. PP equipment effectively reduces work illnesses, accidents and other hazards that would otherwise cause significant losses in human capital and resources in small-scale industries. To ensure a safe and healthy WEN, there is a need to provide employees with appropriate and timely safety training and sophisticated safety equipment for everyday activities [60]. Ref. [61]'s findings demonstrate that preserving and safeguarding employees' health and safety helps avoid illnesses and injuries and improves workers' living standards. Additionally, it helps to engage in "low awareness activities" such as training and development, human resource management and environmental concerns. The pollution-avoidance techniques used by employees of the Mexican car refinishing industry affect the communities, the WEN and public health [62]. More particularly, working in elevated areas without safety precautions, losing equilibrium while moving, failing to use safety equipment, having bad experiences and meeting unsafe structures can all lead to accidents [63]. The development of workplace safety and health in the production sector includes exposure to physical and chemical factors, technical controls use and working medical services [64]. Consequently, the PP's role in the workplace remains both robust and constructive. To gauge its role among women engineers on construction sites, the researchers formulated the following hypothesis:

Hypothesis 2 (H2). *PP has a positive and significant effect on OCS.*

2.4. Training and Education of Safety Skills (TESS) and Occupational Safety (OCS)

The use of training is one such intervention used in the industrial and building sectors to address the issue of construction-related workplace health and safety. It provides a better understanding of the human factors affecting the actions of those responsible for accidents on building sites. The inadequate training and education given to new employees on building sites, inappropriate behaviors and a lack of communication make it difficult for project managers to encourage "learning by doing." [65]. While most of the questioned contractors offered health and safety training, few quantified their programs' effectiveness in reducing risky behaviors or exposures, elevating work satisfaction or improving productivity [4]. The prevalence of occupational illnesses and injuries has dropped since the advent of health and safety management systems. However, these systems are only effective with a strong workplace safety ethic [66]. It is essential to note that the following information is based on the most recent available data [20]. Practical safety training helps to develop a well-functioning safety policy. Likewise, in construction projects, the accident rate is higher than the average of other industries. OCS and health standards must catch up to enable developing countries' economies to grow. The authors of [67] demonstrated that the new feedback safety measures, based on goal setting and collaborative follow up, appear to increase the safety and progress of building work

significantly. The experts claim that improving safety performance is possible through education/training [68].

Similarly, more than ever before, employees can benefit from comprehensive workplace health and safety training due to national skill requirements [69]. These offer safety educators and industry experts helpful information on creating efficient indicators of danger and receptor training programs to enhance the safety performance of building sites. Based on the vigorous review of the literature, ref. [70]'s findings showed that, as crucial elements of successful training programs, adult-learning cognitive processes are needed to create a solid foundation for the instruction and dissemination of safety information. There is also a need to use the socioecological paradigm in education and develop novel strategies to avoid workplace injuries in young employees. Youth-related incidents decline as workplace health and safety programs and career training programs improve [71,72]. Consequently, TESS is meaningful at ensuring health and safety precautions are taken. To provide further confirmation among women engineers, the researchers formulated the following hypothesis:

Hypothesis 3 (H3). *TESS has a positive and significant role in ensuring sustainability in OCS.*

2.5. Familiarity with Safety Regulations (FSR) and Occupational Safety (OCS)

The researchers identified the variables that included the improper use of PP, a lack of stringent safety regulations, incentives and insufficient management support [73]. The cognitive sign characteristics of familiarity, concreteness, simplicity and meaningfulness have an anticipated influence on understanding ratings. A lack of adherence to health and safety work regulations has led to a disproportionately higher rate of building accidents in developing countries such as Pakistan. According to the findings of previous studies, the two most neglected factors are employees' participation and the absence of OCS and health instruction in contract papers [74]. Safety awareness and citizenship behaviors among Chinese building employees are important constructs that can significantly improve personnel safety [75]. A lack of knowledge and carelessness or intentional breaches improve attitudes towards using safety precautions. The beliefs about mistakes, taking risks, accidents and how they interact with rules and regulations eventually promote the use of workplace safety measures [76]. At the organizational level, a positive and significant association exists between high-performance work systems and OCS [77]. The formulation, implementation and monitoring of safety rules and laws are subject to lax procedures, and most building sites need to employ safety-management systems [78]. Effective safety regulation remains an indefinable goal for many industrializing countries. FSR ensures fewer incidents [79]. Management system certification impacts the connection between the chemical industry's safety management and safety performance and has resulted in significant levels of accidents. The safety management methods anticipate safety behaviors. However, safety policies and protocols have become frequent indicators of specific behaviors [80]. Similarly, Ref. [29]'s findings demonstrated that the design of safety measures improves the construction industry's OCS. Although usually regarded as practical, the partnership between service providers and clients regarding safety measures relies on the partner. The provision of safety cooperation includes, among other things, instruction, direction and risk analysis [81]. From the existing literature, it is crystal clear that FSR plays a pivotal role in implementing safety measures. To confirm this role, the researchers developed the following hypothesis:

Hypothesis 4 (H4). *FSR plays a positive and significant role in affecting OCS.*

2.6. Safety Commitment (SCT) and Occupational Safety (OCS)

There is a positive and strong correlation between employee safety behaviors and a perceived corporate dedication to supporting safety measures. Employees' safety behaviors are more susceptible to perceived corporate commitment and support for safety in general

industries and developed regions rather than in high-risk sectors and emerging areas [82]. There is a positive and significant correlation between OCS management and emotional, normative and continual dedication. In addition, workplace health and safety impact favorably on continued behaviors and normative commitment [83]. Healthy workers, a safer workplace, lower costs due to fewer accidents, a controlled atmosphere, managed workplace incidents and enhanced workplace safety information contribute to sustainable development [52]. Ref. [84]'s findings showed that health and safety results can be improved only if systems satisfy strict requirements for top management commitment, efficient workforce participation and program integration. There are negative correlations between workplace health and safety management dimensions and attributed purpose, safety leadership, oversight, safety buildings and equipment and safety processes. The safety leadership and building strongly predict the desire to leave. In addition, the dedication of safety leadership to ensuring the successful formulation of policies and the oversight of occupational health and safety in the workplace positively impacts the employees' desires to leave their jobs [85].

Consequently, the existing literature indicates that SCT is a favorable factor that enhances and encourages several organizations to implement OCS. However, in view of the need for the further endorsement of women engineers in construction companies, the researchers formulated the following hypothesis:

Hypothesis 5 (H5). *SCT has a positive and significant effect on OCS.*

3. Methods

3.1. Survey Instruments and Units of Analysis

The researchers used a questionnaire to collect this study's data. To be consistent with the previous literature, we used an English questionnaire. Before collecting more extensive samples, we conducted a mini version (pilot study) to assess the questionnaire's fundamental presumptions, namely its reliability and validity. We used preliminary research to gather 15 samples to verify these assumptions. We used Cronbach's alpha (α) to verify the questionnaire's reliability.

Turning to the instrument's validity, we verified its outward look with the help of academics who were very knowledgeable about the most recent trends and methods used in quantitative studies. Finally, after making a few minor adjustments, the researchers used an accurate and valid questionnaire to collect the data from a larger sample of participants. The overall alpha was 0.789, and the reliability of each component was above 0.60; this was considered adequate [86].

Regarding the respondents/units of analysis, the researchers targeted women engineers who worked in Egypt's construction industries and on their sites. We selected the construction industry because, when compared to other sectors, it had the third-highest death rate [4]. Many factors contribute to such high death rates because little is known about the character and quality of the safety and health training, human behaviors, the challenging WEN and inadequate safety management [4,87,88]. However, in the construction industry, women face social protection challenges, health and safety challenges and meaningful compensation [89]. The Egyptian construction industry is one of the country's fastest-growing industries and significantly contributes to the economy.

On the one hand, it is driven by Egypt's massive infrastructure initiatives and, more particularly, by the housing market's ongoing growth [5,90]. On the other hand, it is one of Egypt's most dangerous and accident-prone industries, which can result in employees suffering severe injuries or even losing their lives [5]. Evidence demonstrates that, compared to other workers, Egypt's construction workers face higher risks of fatal and nonfatal injuries [6]. In Egypt, construction employees comprised about 13% of those who died at work and 18% of those injured at work [7]. Therefore, the researchers confirmed the OCS among women engineers working on Egypt's construction sites.

3.2. Approach Applied in the Study

The researchers used a quantitative descriptive method and applied it with statistical data to significantly reduce the time and resources needed for this study [91]. We selected the quantitative approach because it used numbers and figures in the data analysis. This is a solid approach (quantitative technique) [92,93]. Notably, this approach's use of empirical data makes it possible to apply the findings [94]. Moreover, previous researchers, such as [21,32,34,39,41–45], applied quantitative techniques to explore the OCS measures and the several factors associated with safety.

3.3. Data Collection and Respondents' Ethics

The researchers gathered the data by applying both personal and email services. Before seeking their responses, we obtained the respondents' consent to participate in this study. We explained the goals and purpose of the data collection in an email to the respondents, who were also instructed to return their completed questionnaires. The researchers used a convenience sampling method to select the interviewees. We based this study's findings on 376 samples. Finally, the researchers chose only women as this study's participants. Characteristically, in terms of job function, 43.09% (n = 162) were working in civil engineering, 35.11% (n = 132) were in architectural engineering, 12.23% (n = 46) were in middle-level management and 9.57% (n = 36) held other positions. Likewise, in terms of job title, most respondents (27.66% or n = 104) were managers, 25.53% (n = 96) were supervisors, 17.55% (n = 66) were designers and 13.30% (n = 50) were instructors. Furthermore, 10.64 % (n = 40) were doing practical apprenticeships and 5.32% (n = 20) were doing other tasks.

3.4. Measures

When devising the questionnaire, the researchers adopted all the factors from the previous literature. As adapted from [95], we used three items to measure the WEN factor. Likewise, we adapted five items from [95] to measure the PP factor. In the same vein, the researchers used three items from [96] to measure the SCT and three items from [97] to assess FSR. As adopted from [97], we used three items to evaluate the TESS factor. Finally, we used seven items from [72]'s study to measure OCS. Finally, we applied a five-point Likert scale that included strongly agree (1), agree (2), neutral (3), disagree (4) and strongly disagree (5) options. Table 1 details the entire questionnaire.

Table 1. Survey instrument.

| Factor | Item Description | Source |
|--|--|--------|
| Work Environment (WEN) | (wen1). It is better for women to work in the construction company. (wen2). I feel safe at work. (wen3). The construction company makes provision for rehabilitation in case of accidents at work. | [95] |
| Personal Protection (PP) | (pp1). My personal protective equipment is enough. (pp2). I have sufficient information given about their proper use. (pp3). There is an occupational health and safety board at the construction site. (pp4). The occupational health and safety trainings are provided at our construction site. (pp5). There are periodical control and maintenance of work equipment and hand tools. | [95] |
| Training and Education of Safety Skills (TESS) | (tess1). I think it is necessary to attend training and education on workers safety knowledge. (tess2). I usually participate in safety-related skills training and education on my own initiative. (tess3). I think the training of safety skills is useful and has considerable meaning for practical application. | [97] |

Table 1. *Cont.*

| Factor | Item Description | Source |
|---|--|--------|
| Familiarity with Safety Regulations (FSR) | (fsr1). I often read and study the construction laws and regulations. (fsr2). I know more than four construction laws and regulations (such as the Convention on Safety and Health in the Construction Industry, the Building Law, etc. (fsr3). I always ask myself “Is my behavior in line with the rules?” during the works. | [97] |
| Safety Commitment (SCT) | (sct1). Management places high commitment on safety. (sct2). Management gives importance to safety initiatives. (sct3). Safety is important to company. | [96] |
| Occupational Safety (OCS) | (ocs1). There is an occupational physician on the construction site. (ocs2). There is an occupational physician on the construction site. (ocs3). There is a workplace health and safety unit on the site. (ocs4). There are risk assessment practices carried out on the construction site. (ocs5). There are emergency plans at the construction site. (ocs6). There are fire-fighting and evacuation exercises are done on site. (ocs7). I know how to report an occupational accident. | [72] |

4. Data Analysis and Results

For the data analysis, the researchers applied the Analysis of Moment Structures (AMOS) version 26 since this was the best software for interpreting the quantitative values and providing meaningful findings [98,99].

4.1. Measurement Model

Table 2 details the evaluation of the measurement model with the internal arrangement of the connection of the items. In terms of factor loadings, this study’s findings showed that, except for ocs5 and pp3, which had values lower than 0.70 [100], most items contained acceptable values (>0.70). Therefore, the researchers took both these items from the study [86]. In the same vein, we continued the analysis by ensuring the Composite Reliability (CR) by ensuring that all the model’s factors ranged from 0.766 (PP) to 0.838 (FSR) and were thus greater than 0.70 as this is the acceptable range [101]. In addition, the researchers assessed the Average Variance Extracted (AVE) values, and these ranged from 0.719 (SOCS) to 0.823 (TESS). These were greater than 0.50, which is the recommended benchmark for AVE values [100]. Finally, we used Cronbach’s alpha among the items to gauge internal consistency. Consequently, this assumption fell within the acceptable ranges (>0.60), i.e., 0.739 (FSR) to 0.886 (WEN) [100].

Table 2. Measurement model.

| Factors | Item Code | Loading Score | CR | AVE | Cronbach’s Alpha (α) Reliability |
|---------------------------|-----------|---------------|-------|-------|----------------------------------|
| Work Environment (WEN) | wen1 | 0.876 | 0.832 | 0.782 | 0.886 |
| | wen 2 | 0.857 | | | |
| | wen3 | 0.841 | | | |
| Occupational Safety (OCS) | ocs1 | 0.860 | 0.809 | 0.719 | 0.823 |
| | ocs3 | 0.856 | | | |
| | ocs2 | 0.833 | | | |
| | ocs4 | 0.828 | | | |
| | ocs7 | 0.818 | | | |
| | ocs6 | 0.764 | | | |
| Personal Protection (PP) | pp1 | 0.869 | 0.766 | 0.801 | 0.780 |
| | pp2 | 0.854 | | | |
| | pp5 | 0.831 | | | |
| | pp4 | 0.805 | | | |

Table 2. Cont.

| Factors | Item Code | Loading Score | CR | AVE | Cronbach's Alpha (α) Reliability |
|--|-----------|---------------|-------|-------|----------------------------------|
| Safety Commitment (SCT) | sct1 | 0.886 | 0.831 | 0.779 | 0.829 |
| | sct2 | 0.856 | | | |
| | sct3 | 0.816 | | | |
| Familiarity with Safety Regulations (FSR) | fsr1 | 0.867 | 0.838 | 0.799 | 0.739 |
| | fsr3 | 0.842 | | | |
| | fsr2 | 0.803 | | | |
| Training and Education of Safety Skills (TESS) | tess1 | 0.833 | 0.833 | 0.823 | 0.847 |
| | tess2 | 0.829 | | | |
| | tess3 | 0.786 | | | |

Note(s): CR = Composite Reliability; AVE = Average Variance Extracted; α = Cronbach's alpha.

It was necessary to test the model fitness of the data before further assessing this study's hypotheses or investigating the relationships. Therefore, the researchers applied multiple model fit indicators to confirm the model fitness with the data. Table 3 and Figure 2 show all the model fit indices, such as the Normed Fit Index (NFI), Comparative Fit Index (CFI), Goodness of Fit Index (GFI), Root Mean Square Residual (RMR), Adjusted Goodness of Fit Index (AGFI) and Root Mean Square Error of Approximation (RMSEA), are within the acceptable ranges and consistent with the previous literature [99,102,103].

Table 3. Model fit indices.

| Model Fit | GFI | AGFI | CFI | NFI | RMR | RMSEA |
|-------------------|-------|-------|-------|-------|-------|-------|
| Occurred values | 0.907 | 0.857 | 0.933 | 0.929 | 0.036 | 0.026 |
| Recommended value | ≥0.90 | ≥0.80 | ≥0.90 | ≥0.90 | ≤0.08 | ≤0.08 |

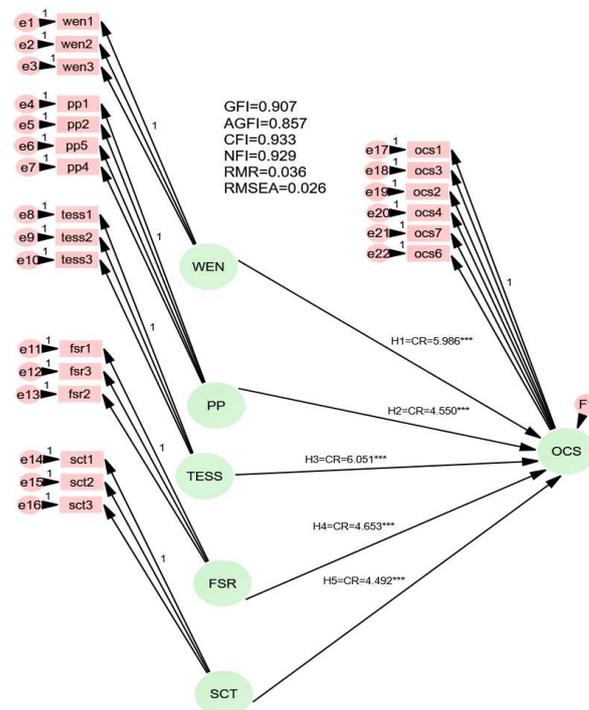


Figure 2. Structural equation model. Source: estimated by the authors. Note: CR = critical ratio, *** $p < 0.001$; WEN = Work Environment; PP = Personal Protection; TESS = Training and Education of Safety Skills; FSR = Familiarly with Safety Regulations; SCT = Safety Commitment; OCS = Occupational Safety; GFI = Goodness-of-Fit Index; AGFI = Adjusted Goodness-of-Fit Index; CFI = Comparative Fit Index; NFI = Normed Fit Index; RMR = Root Mean Square Residual; RMSEA = Root Mean Square Error of Approximation.

4.2. Structural Model

As presented in Table 4 and Figure 2, the researchers used the latest structural equation model (SEM) technique to confirm the proposed relationships. Regarding hypothesis H1 (WEN → OCS), the analysis showed that WEN had a positive and significant effect on OCS (H1 = SE = 0.096; CR = 5.986 ***). Therefore, hypothesis H1 was accepted. Likewise, the findings showed that PP positively and significantly impacted OCS (PP → OCS) (H2 = SE = 0.076; CR = 4.550 ***). Consequently, hypothesis H2 was accepted. Similarly, a positive and significant association existed between TESS and OCS (TESS → OCS) (H3 = SE = 0.089; CR = 6.051 ***). Therefore, hypothesis H3 was accepted. Furthermore, the findings showed that FSR had a positive and significant predictive effect on OCS (FSR → OCS) (H4 = SE = 0.074; CR = 4.653***). Therefore, in line with the researchers' expectations, hypothesis H4 was accepted. Finally, as the SEM analysis showed, SCT was the positive and significant analyst of OCS (SCT → OCS) (H5 = SE = 0.058; CR = 4.492 ***). Consequently, hypothesis H5 was accepted.

Table 4. SEM Estimations.

| S. No. | Relationships | Estimate | SE | CR | p-Value | Decision |
|--------|---------------|----------|-------|-----------|---------|----------|
| H1 | WEN → OCS | 0.309 | 0.096 | 5.986 *** | 0.001 | [√] |
| H2 | PP → OCS | 0.339 | 0.076 | 4.550 *** | 0.000 | [√] |
| H3 | TESS → OCS | 0.179 | 0.089 | 6.051 *** | 0.002 | [√] |
| H4 | FSR→OCS | 0.339 | 0.074 | 4.653 *** | 0.000 | [√] |
| H5 | SCT → OCS | 0.266 | 0.108 | 4.492 *** | 0.004 | [√] |

Source: calculated by the authors. Note: CR = critical ratio, *** $p < 0.001$, WEN = Work Environment; PP = Personal Protection; TESS = Training and Education of Safety Skills; FSR = Familiarly with Safety Regulations; SCT = Safety Commitment; OCS = Occupational Safety; [√] = Accepted.

5. Discussion and Conclusions

In this study, the researchers aimed to examine the enablers that affect sustainability in occupational health measures among women engineers working in Egypt's construction industry. Based on the conceptualizations and with the support of the existing literature, the researchers developed a model and five hypotheses. The findings showed that WEN had a positive and significant effect on OCS (therefore, hypothesis H1 was accepted). These findings are consistent with those of previous studies such as [2,4,11,47,51,56]. These findings highlight that women engineers feel better when employed by an Egyptian construction company. In such circumstances, women engineers feel safe in the workplace and believe that their company provides rehabilitation in case of workplace accidents.

Moreover, as reinforced by the literature [57–64], the analysis findings showed that PP had a positive and significant effect on OCS. These positive connections indicate that the women engineers believed their workplace PP equipment was enough and the equipment and hand instruments used in their work were periodically inspected and maintained. They have received adequate knowledge about how to use the equipment. At the building's location, there was a board explaining OCS. They received occupational health and safety training in the workplace.

Similarly, the study's findings showed that TESS positively and significantly affected OCS. These findings are consistent, also, with those of previous studies such as [20,65,66,68,71,72]. These findings demonstrated that women engineers believed it was essential for them to receive workplace health and safety education and training. Typically, they took the initiative in safety-related skill training and education.

Furthermore, the analysis highlights a positive and significant contribution between FSR and OCS (therefore, hypothesis H4 is accepted). These positive and meaningful connections were consistent with those of previous studies such as [29,73,74,78,81]. These findings also showed that those women engineers frequently read and researched building legislation and regulation and were familiar with more than four of Egypt's building laws and rules, including the Building Law and the Convention on Safety and Health in

the construction industry. They checked to see if their workplace actions complied with the guidelines.

Finally, the findings showed that SCT had a positive and significant impact on OCS. These findings were consistent with those of previous studies such as [52,82,83,85]. The results also demonstrated that management had a strong commitment to workplace safety and prioritized safety initiatives since these were very important for their companies. The companies employed specialists in job safety and, more specifically, a doctor of industrial medicine who cared for the women working on each construction site. On-site, there was a fully functional health and safety center. Risk evaluation procedures were followed, with each construction site having emergency measures in place, including on-site firefighting and escape drills. The employees were aware of how to disclose a workplace accident.

In maintaining international health and safety rules as suggested by the Health and Safety Executive (HSE), women engineers adopted workplace health and safety, which intends to prevent workplace accidents, injuries and deaths. On construction sites, most of the regulations, which the HSE enforces, were based on risk assessments to determine the most acceptable methods of risk management based on importance and reasonableness. Consequently, since most private companies are legally required to comply with the Occupational Safety and Health Administration (OSHA), the researchers recommend that Egypt's construction industry does so by providing workers with protection from on-the-job hazards. The companies may fulfil the OSHA requirements by making health and safety education and training a part of their best practices. To prevent accidents at work, companies should ensure that all their employees are doing their tasks properly and are fully aware of the risks and how to manage them. The employees must thoroughly understand the equipment and supplies needed to carry out their duties safely. In maintaining safety issues, a doctor of industrial medicine must be available for women on the construction site. The doctor may deal with various work-related illnesses, with the prevalence varying depending on incidents and conditions, i.e., epidemiology of noise-induced hearing loss, nosocomial infections, skin-related disorders and work-related malignancies.

In summary, this study's findings showed that factors such as WEN, PP, TESS, FSR and SCT are the essential enablers that encourage OCS initiatives for women engineers working on Egypt's construction sites. These findings showed that adopting WEN, PP, TESS, FSR, and SCT reduces the number of workplace accidents and saves the precious lives of women engineers. In such a context, this study's findings encourage women engineers to create a favorable WEN where they can keep themselves safe, secure and sound. These findings support the need for Egypt's construction industry authorities and contractors to maintain the construction laws and regulations to ensure the safety of women engineers on construction sites. Finally, from women engineers' perspectives, these findings contribute to the existing evidence about workplace health and safety education and training.

6. Limitations, Novel Contribution and Future Research Studies

The main limitation of this quantitative study is that the researchers used only cross-sectional data obtained from a questionnaire completed by women engineers in Egypt's construction industry. Additionally, the researchers did not use any concerned theory to underpin the model and based this study's findings on a sample of 376 completed questionnaires. We recruited only women engineers as the participants. Finally, the researchers only applied a single source (survey questionnaire) for data collection.

This study's findings offer a novel contribution to developing a conducive WEN, which may support more women in the workplace and ensure their safety. These findings help to reduce the number of workplace accidents by encouraging the use of workplace PP equipment to keep workers safe and sound. These findings also provide sufficient information on the use of OCS on construction sites. In addition, these findings should inspire the companies' management to demonstrate a high level of SCT by maintaining the Egyptian laws and regulations concerning OCS and safety initiatives on the country's construction sites. Furthermore, this study's findings provide a novel contribution by

offering a model that provides valuable insights into the OCS assumptions that have been empirically validated among women engineers working on Egypt's construction sites. Finally, particularly in developing countries, these findings contribute to the existing environmental, health and safety and risk assessment literature.

Regarding future studies, the researchers recommend that researchers use this study's model but apply longitudinal data to assess the OCS. We also recommend using concerned theories to underpin the conceptual framework and the formulation of the hypotheses. Such studies may also apply other constructs such as attitudes, intentions, risk assessment and built environmental behaviors towards OCS. Finally, the researchers recommend that future studies focus on men rather than women.

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