Development of an Internal Safety Evaluation Program for Ready Mixed Concrete Producers

Özge AKBOĞA KALE

ABSTRACT

The aim of this study is to assist the safety specialists and departments in ready mixed concrete (RMC) industry by preparing an internal safety evaluation program (ISEP). To constitute an ISEP the 287-item control list was created and grouped as negligible, moderate, and critical. The control list was applied to thirteen RMC plants which belongs to one RMC company. It is found that even the same company cannot ensure stability in terms of OHS between its plants, none of the plants had an approved OHS policy, emergency action plan and a plant entrance OHS warning sign. OHS training was mostly missing in plants.

Keywords: Construction industry, risk identification, control list, risk assessment, safety management system.

1. INTRODUCTION

Work-related accidents in the construction industry lead to major problems in many countries [1]. Occupational health and safety (OHS) assurance remains a major challenge because of the diverse and complex nature of this industry. In various studies, researchers have demonstrated that a high percentage of work-related injuries is attributed to construction work, [2-22]. Moreover, the construction industry ranks higher in fatal occupational injuries than in other industries [23-30]. To refuse this high percentage it is necessary to investigate every construction process (excavation works, pile driving, rough construction works, fine construction works, etc.) and sub-sectors (ready mixed concrete industry, prefabricated construction industry, brick plants, etc.) separately because production processes are unique and have differences. Therefore, potential hazards and precautions should be identified for improvement.

The construction industry’s single most important material is concrete. Ready mixed concrete (RMC) industry as a producer of the primary material required for buildings and public infrastructure work is one of the most essential sub-sectors of today’s construction industry with some specific advantages. Advantages of RMC in high-level can be listed as; producing
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crime under controlled conditions, easily placing and transportation, reducing dust pollution, noise and air pollution, high speed of construction, saving on labor employment, an overall reduction in cost, etc. [31]. Due to the advantages mentioned this product is increasingly being preferred, especially in modern construction, and most of the developed countries prefer to use RMC instead of conventional concrete production. The United States (274 million m³), Turkey (100 million m³), and Japan (84.8 million m³) are the top three largest producers according to 2018 statistics [32]. In Turkey, second largest RMC producer, there has been tremendous growth in RMC production. RMC production was 100 million m³ with 495 RMC companies in 2018 [32].

Academic studies on RMC are abundant. Numerous studies have been conducted to develop ready mixed concrete technology, which is so widespread in use. However, current studies mostly focus on quality control [33-34], scheduling [35-36], waste management [37-38], delivery problems [39-40], and so on. Since safety and health is a rather new topic in RMC industry, statistical and academic studies are rarely found and limited [41]. Research studies on the subject are not abundant not only in Turkey but also in other countries. However, when the complex and unique operating system with more component of the industry is taken into consideration, the importance of OHS emerges once again. Publications aim to build safety awareness are still limited guidelines and manuals printed by associations such as Occupational Safety and Health Administration (OSHA), American Concrete Pumping Association (ACPA), National Ready Mixed Concrete Association (NSCSA) [42-44]. Besides, there is a high demand for training and consultation regarding occupational safety by RMC companies.

To fill this gap, the study adopted the Internal Safety Evaluation Program to the ready-mixed concrete industry, which was not applied before. The Internal Safety Evaluation Program (ISEP) provides a structured, documented method of establishing and promoting a system of continual improvement through quality and safety management. ISEP also measures performance and the effectiveness of risk control. The objective of this safety program is to correct non-conformities with risk controls within each specific department’s operational processes and to improve the performance of ineffective risk controls [45]. A study on how RMC companies will conduct their ISEP will guide them and contribute to the development of OHS policies. To prepare an internal safety evaluation program, it is necessity to consider the functioning of the process in terms of occupational safety and health (OHS).

In addition, it is known that an effective occupational health and safety program contributes to quality management [46]. Total Quality is the handling and development of the management, people, work is done, product and service qualities required to meet customer demands in all works performed in any enterprise within a system approach, by ensuring the participation, goals, and consensus of all employees [47]. The concept of occupational safety integrated with the principles of "Total Quality Management", together with the principles of quality and efficiency, constitutes the triple sheet leg that leads the business to success [46]. For this reason, improvement in occupational safety will also benefit total quality management. As a matter of fact, ISO 45001 Occupational Health and Safety Management System standard adopts ISO 14001 Environmental management system and ISO 9001 Quality management system approaches. Quality assurance systems provide directive provisions for ensuring occupational health and safety. Therefore, new programs in the field of occupational safety should be developed, considering the priorities of the industry [48].
The aim of this study is to assist the safety specialists and departments in the industry in making an assessment of the measures it adopts concerning the safety and health of its employees in all fields of its operations in the production of ready mixed concrete by preparing a comprehensive ISEP. The control list is the largest element in a company’s internal safety evaluation program. When completed thoroughly, it will be used as the foundation for all other areas of the program. For this reason, it was investigated what should be considered for detailed ISEP of the production area of a ready mixed concrete plant and the 287-item control list was created. Afterward, the created control list was applied in 13 ready mixed concrete plants of one company. Consequently, the findings of this study will give an opportunity to provide further precautions for preventing future accidents. It is expected that the findings obtained in the study will guide the producers of the ready-mixed concrete sector, guide the occupational safety departments of the producers, inform the occupational safety experts about the sector and inspire the researchers.

2. METHODS

As organizations move from the early stages to maturity, the focus turns to assure a continuous safe operation. An Internal Safety Evaluation Program (ISEP) is the prescribed pathway for achieving this within a safety management system (SMS) [49]. To have a reliable safety risk assurance under SMS, internal evaluation is a very critical component. ISEP validates the processes, procedures, and controls an organization puts into place and helps ensure they are working as intended. This method also helps verify that risks have been mitigated as low as reasonably practicable [49]. Advantages of ISEP can be listed as; it is possible to discover and correct undetected operational risk, operational efficiencies can be promoted, risks can be mitigated to an acceptable level before an event occurs, sheds light on what is working and what is not and so on. ISEP is used in different fields such as flight safety due to its advantages.

The major objective of this study is to determine how to develop a control list for ISEP that can be used by all producers to understand and improve OHS performance in the production process. A framework for the control list should be developed according to sources of risk factors on the site. Therefore, it is necessary to consider the hazards of the complex and unique operating system (Figure 1).

Main hazards in the operation of an RMC production process can be listed as; trucks, loaders reversing, trapping between conveyor belts in motion and head/tail drums, falls into aggregate loading hoppers, falling from the upper parts of conveyor belts, impacts from lower parts of moving conveyor belts, fall from upper levels when cleaning filters of silos, trapping, amputations by mixing mechanism, electrocution in the main fuse system, trapping in compressor belts and so on. From this perspective, each stage of the production process outlined in Figure 1 should be examined in terms of OHS. This process is similar in most ready mixed concrete companies. Therefore, it can be said to reflect the general. In addition to these mechanic hazards, preparing a control list by considering the administrative deficiencies are very important for the companies in the industry to take the necessary importance. The created control list was based on a comprehensive literature review, legal regulations, and site visits, including mechanical hazards and safety management system principles.
Within the scope of created control list, questions were basically grouped under 6 sections namely general, plant, material storage and production, auxiliary facility, mobile equipment, and laboratory. Afterward, the scope of each group was determined as subsections. Within the scope of the general section, managerial OHS precautions were evaluated. Plant entrance, plant entrance OHS warning sign, on-site traffic plan, and plant lighting were investigated under the plant section. Material storage and production section mainly focused production process. Stockyard conformity, bunker conformity, horizontal conveyors, vertical conveyors, horizontal-vertical conveyor joints, mixing process, truck mixer loading, cement silo safety, silo automation, cement trailer unloading, and admixture tank were determined as subsections. Weighbridge, recycled water reservoir, compressor, water booster, generator, fuel tank, operating room, electrical panels, lightning rod, grounding, and transformer AC panel were investigated within the scope of auxiliary facilities. In addition to the production process also truck mixers, pumps, and loader conformity were evaluated as mobile equipment. Finally, the laboratory was considered. After the process was divided into sections and subsections, a total of 287 safety risks covering the whole process were identified and listed. (Table 1).

Identified safety risk was divided into three groups as negligible, moderate, and critical and their numeric values (NV) were specified 1, 3, and 9 respectively. The purpose of this digitization is enabling the companies to compare their plants numerically and making it easier for them to decide where to start improving. The negligible group includes damages probably less than accident or incident levels, moderate groups covers incident to minor accident damage and critical groups include loss of life, accident level injury of equipment.
loss or damage. Since RMC production is very dangerous, moderate, and critical groups are the majority.

Table 1 - Sections of control list.

| No | Section                        | Subsection                                                                 | List No |
|----|--------------------------------|----------------------------------------------------------------------------|---------|
| 1  | General                        | Managerial OHS precautions                                                 | 1-22    |
| 2  | Plant                          | Plant entrance, plant entrance OHS warning sign, on-site traffic plan, plant lighting | 23-50   |
| 3  | Material storage and production | Stockyard conformity, bunker conformity, horizontal conveyors, vertical conveyors, horizontal-vertical conveyor joints, mixing process, truck mixer loading, cement silo safety, silo automation, cement trailer unloading, admixture tank | 51-153  |
| 4  | Auxiliary facility             | Weighbridge, recycled water reservoir, compressor, water booster, generator, fuel tank, operating room, electrical panels, lightning rod, grounding, transformer AC panel | 154-227 |
| 5  | Mobile equipment               | Truck mixers, pumps, loader conformity                                     | 228-271 |
| 6  | Laboratory                     | Laboratory                                                                 | 272-287 |

Table 2 - Properties of visited plants.

| Plant no | Plant age | Number of workers | Number of trans mixer | Number of pumps |
|----------|-----------|-------------------|-----------------------|-----------------|
| 1        | 6 years   | 39                | 16                    | 4               |
| 2        | 5 years   | 30                | 9                     | 2               |
| 3        | 8 years   | 39                | 13                    | 3               |
| 4        | 9 years   | 50                | 18                    | 4               |
| 5        | 9 years   | 45                | 16                    | 3               |
| 6        | 11 years  | 28                | 15                    | 2               |
| 7        | 4 months  | 10                | -                     | -               |
| 8        | 4 years   | 33                | 12                    | 3               |
| 9        | 3 years   | 37                | 13                    | 2               |
| 10       | 9 years   | 56                | 26                    | 6               |
| 11       | 8 years   | 48                | 22                    | 5               |
| 12       | 4 years   | 83                | 37                    | 7               |
| 13       | 4 years   | 75                | 33                    | 6               |

To demonstrate the applicability and the effectiveness of the created control list, it was applied to thirteen ready mixed concrete plants located in different cities of Turkey which belongs to one RMC company in 2018. The general characteristics of the ready mixed
concrete plants were presented in Table 2. Site visits were conducted with the technical personnel of each plant. The visited plants were evaluated according to their current status.

Detailed control list presented in the Results section were prepared separately for each section to be followed easily. In the first stage, if there is a measure taken against the risk controlled according to the created control list, it is marked as (+), if not (-). Since each safety risk was digitizing in the control list, the maximum risk score of each section was determined. For example, risk value, which is "135" in Table 3, is the score that would be obtained if no measures were taken regarding this section in the visited facility. With this approach, the risk score of each of the 13 visited facilities was determined by collecting OHS negligence. This process was repeated for each section and presented in separate tables. Finally, the sum of the deficiencies of each plant in all sections for an overall assessment was presented. The flow chart of the methodology is presented in Figure 2.

**Figure 2 - Flow chart of the methodology**

3. RESULTS

The plants, analyses performed, were evaluated separately for each section. The first section covers managerial OHS precautions (Table 3). The lack of managerial OHS precautions for almost all visited plants can be listed as OHS policies, reward-penalty systematics, emergency action plan (EAP), first aid instructions, fire extinguishers, OHS policy records, OHS expert, not taking into consideration near-miss reports, and the root cause analysis of previous accidents. Besides these, risk analysis, lockout – tagout system, basic OHS training, a delivery record of personal protective equipment (PPE), and accident and damage reports were mostly missing in plants.

Plant entrance, plant entrance OHS warning sign, on-site traffic plan, and plant lighting were investigated in section two (Table 4). The most striking point in this section is that no facility had a plant entrance OHS warning sign. In addition, only 2 plants had an "on-site traffic plan". Although there were deficiencies in the entrance and lighting parts of the plant, certain precautions had been taken.
Table 3 - General evaluation.

| List No | MANAGERIAL OHS PRECAUTIONS | PILOTED-TEST |
|---------|---------------------------|--------------|
|         |                           | NV*  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| 1       | Is a risk analysis available in terms of OHS? | 9    | − | − | + | − | + | + | + | + | + | − | − | − | − |
| 2       | Does the company possess an approved OHS policy? | 3    | − | − | − | − | − | − | − | − | + | − | − | − | − |
| 3       | Is a reward & penalty audit systematic available? | 3    | − | − | − | − | − | − | − | − | − | − | − | − | − |
| 4       | Is a lockout tagout system available? | 9    | − | + | + | + | + | + | + | + | + | + | − | − | − |
| 5       | Are the general cleaning and maintenance rules followed? | 3    | − | + | + | + | + | + | + | + | + | + | + | + | + |
| 6       | Is an emergency action plan (EAP) available at the plant? | 9    | − | − | − | − | − | − | − | − | − | − | − | − | − |
| 7       | Is the list of fire extinguishers and their places hanged visibly? | 9    | − | − | − | − | − | − | − | − | − | − | − | − | − |
| 8       | Is the EAP visibly hanged? | 3    | − | − | − | − | − | − | − | − | − | − | − | − | − |
| 9       | Are fire, earthquake, flood - with a script drills performed? | 9    | − | − | − | − | − | − | − | − | − | − | − | − | − |
| 10      | Are first aid instructions prepared? (teams - gathering points) | 9    | − | − | − | − | − | − | − | − | − | − | − | − | − |
| 11      | Do all employees (incl. Subcontractors) have basic OHS training? | 3    | − | + | − | − | − | − | − | − | − | − | − | − | + |
| 12      | Do all employees (incl. Subcontractors) have PPE? | 9    | + | + | + | + | + | + | + | + | + | + | − | − | − |
| 13      | Do all employees (incl. Subcontractors) have delivery record of PPE? | 3    | + | − | − | + | − | + | + | + | − | − | − | − | − |
| 14      | Do all employees (incl. Subcontractors) possess certificate of no objection from heavy and hazardous works? | 9    | + | + | + | + | + | + | + | + | + | + | − | − | − |
| 15      | Are periodical health examinations of all employees (incl. Subcontractors) carried out? (ears & lungs) | 9    | + | − | + | + | + | + | + | + | + | + | + | + | − |
| 16      | Is the OHS policy written issued to employees? Are records available? | 3    | − | − | − | − | − | − | − | − | − | − | − | − | − | − |
| 17      | Is a person available, who is responsible for OHS? | 3    | + | − | − | − | − | − | − | − | − | − | − | − | − | − |
| 18      | Do employees use their PPE for their own good and safety at the plant and working sites? | 9    | − | + | + | + | − | + | + | + | − | − | − | − | − | − |
| 19      | Are the accident and damage reports available? | 3    | − | + | − | − | − | + | + | + | + | − | − | − | − | − |
| 20      | Are near miss reports available? | 3    | − | − | − | − | − | − | − | − | − | − | − | − | − | − |
| 21      | Is an adequate organization available for delivering near-miss reports? | 9    | − | − | − | − | − | − | − | − | − | − | − | − | − | − |
| 22      | Is a root cause analyze system available and implemented? | 9    | − | − | − | − | − | − | − | − | − | − | − | − | − | − |

**RISK VALUE:** 105

*NV = Numeric Value*
The material storage and production section were presented in Table 5. Common lack of stockyards was warning signs and indoor stock area. Frame and cover of a manhole, bump concrete in front of the bunker and warning signs of bunker were missing. In general, the
lack of horizontal conveyors was warning signs, secured surrounding, fire extinguishers, and appropriate walking platforms and their railings. It is quite remarkable that almost in all plants vertical conveyors were not secured and there were no emergency stops. Besides, there were no warning signs. The interlock system of the mixer was not secured against dust and there were no cleaning and maintenance instructions. Common lack of truck mixer loading can be listed as: no loading indicator, no docking stop mechanism, no safe area for the operator. Common lack of cement silo safety was rubber protection under the electric panel, warning signs around the electric panel, rope grab & d-clip, bottom cap of stairs to the silo, guard chains on silo venting filters, and safety belts and appropriate working platform. The pressure gauge was missing in the silo automation of all plants. There were no warning signs around the cement trailer unloading part and no fixing support (bed) for hose clamps. Commonly, there was no instruction to follow for drivers. In general, like other parts, there were no warning signs around the electric panel of the admixture tank. Commonly, there were no rubber protection under the electric panel, an emergency instruction, and emergency instruction.

Table 5 - Material storage and production evaluation.

| No  | STOCKYARD CONFORMITY                                                                 | PILOTED TEST |
|-----|--------------------------------------------------------------------------------------|--------------|
| 51  | Are aggregate labelling signs appropriate?                                           | 9            |
| 52  | Are closing metal sheet of stockyard appropriate?                                    | 9            |
| 53  | Is the stockyard efficiently lighted?                                                | 9            |
| 54  | Is the slope of the stockyard acceptable?                                            | 9            |
| 55  | Are the guards on the way from the stockyard to the bunker suitable?                | 9            |
| 56  | Is there any warning sing available? (exp. no trespassing)                          | 3            |
| 57  | Is the maneuvering area appropriate for the loader?                                  | 9            |
| 58  | Is the working slope of the stockyard appropriate for loaders and trucks?            | 9            |
| 59  | Is the dust emission levels at acceptable levels in the stockyard?                   | 3            |
| 60  | Is there indoor stock area?                                                          | 3            |
|     | BUNKER CONFORMITY                                                                    |              |
| 61  | Are there railings around the bunker?                                                | 3            |
| 62  | Is there frame and cover of manhole of bunker?                                       | 3            |
| 63  | Are the grate openings of the bunker appropriate?                                    | 9            |
| 64  | Is an upside closing possible?                                                       | 3            |
| 65  | Is there bump concrete in front of the bunker?                                       | 9            |
| 66  | Are aggregate labelling signs of bunker divisions?                                   | 3            |
| 67  | Is there any warning sing available?                                                 | 9            |
| 68  | Are the bunker efficiently lighted?                                                  | 9            |
| **HORIZONTAL CONVEYORS** |  |
|--------------------------|--|
| Are power outlets protected? | 9 + + + + + + + + + + + |
| Are walking platforms and their railings appropriate? | 9 + + + + + + + + + + + |
| Is the lighting sufficient? | 9 + + + + + + + + + + + |
| Are the warning signs available? | 3 + + + + + + + + + + + |
| Is there cord switch? | 9 + + + + + + + + + + + |
| Is there emergency stop? | 9 + + + + + + + + + + + |
| Is there any platform with railings? | 9 + + + + + + + + + + + |
| Is the surrounding secured? | 3 + + + + + + + + + + + |
| Is the lighting cleaned? | 3 + + + + + + + + + + + |
| Are there sufficient appropriately located fire extinguishers? | 9 + + + + + + + + + + + |
| Is the periodic check and filling of the fire extinguishers done? | 9 + + + + + + + + + + + |
| Are there top, side and bottom protections for weighing belts available? | 9 + + + + + + + + + + + |

| **VERTICAL CONVEYORS** |  |
|-------------------------|--|
| Is the walkway available? | 9 + + + + + + + + + + + |
| Is the railing appropriate? | 9 + + + + + + + + + + + |
| Is the protecting upper cover? | 3 + + + + + + + + + + + |
| Is there protection under the conveyor? | 3 + + + + + + + + + + + |
| Are vertical conveyors secured? (chain) | 3 + + + + + + + + + + + |
| Is there motor protecting casing available? | 9 + + + + + + + + + + + |
| Does cord switch work in order? | 9 + + + + + + + + + + + |
| Does emergency stop work in order? | 9 + + + + + + + + + + + |
| Is the lighting sufficient? | 9 + + + + + + + + + + + |
| Are the warning signs? | 3 + + + + + + + + + + + |
| Are walking platform stairs appropriate? | 9 + + + + + + + + + + + |

| **HORIZONTAL-VERTICAL CONVEYOR JOINTS** |  |
|------------------------------------------|--|
| Is there protecting upper cover available? | 9 + + + + + + + + + + + |
| Is the surrounding secured? | 9 + + + + + + + + + + + |
| Does cord switch work in order? | 9 + + + + + + + + + + + |
| Does emergency stop work in order? | 9 + + + + + + + + + + + |
| Are there warning signs available? | 3 + + + + + + + + + + + |
| Is it well-organized? | 3 + + + + + + + + + + + |

| **MIXING PROCESS** |  |
|---------------------|--|
| Are power outlets protected? | 9 + + + + + + + + + + + |
| Question                                                                 | Rating |
|------------------------------------------------------------------------|--------|
| Does emergency stop of the mixer work in order?                        | 100    |
| Are the railing and baseboards of the discharge platform appropriate?  | 101    |
| Is the interlock system of the mixer appropriate?                      | 102    |
| Is the interlock system of mixer secured against dust?                 | 103    |
| Are mixer chain, locked protecting covers of chain gear, switch available? | 104    |
| Are cleaning and maintenance instructions of the mixer?                | 105    |
| Are belt and pulley protections appropriate?                            | 106    |
| Is the loading indicator?                                              | 107    |
| Are there docking stop mechanism?                                      | 108    |
| Are there safe area for operator?                                      | 109    |
| Are the discharging chute rubbers appropriate?                         | 110    |
| Is the discharging unit sufficiently lighted?                           | 111    |
| Are railings on the stairway to the loading platform?                   | 112    |
| Are covering sheets of loading unit appropriate?                       | 113    |
| Are belt and pulley protections appropriate?                            | 114    |
| Is there cleaning and maintenance instructions of the mixer?           | 115    |
| Are the mixer caps leak cement grout?                                  | 116    |
| Is the loading area ground appropriate?                                 | 117    |
| Are there electric panel doors available, working in order?            | 118    |
| Are silo filters working in order?                                      | 119    |
| Is the maintenance of silo venting filter periodically performed?       | 120    |
| Are railings & baseboard on the upper platform of the silo?             | 121    |
| Are there warning signs around the electric panel?                      | 122    |
| Is silo filters working in order?                                       | 123    |
| Are there guard chains on silo venting filters?                         | 124    |
| Is there any false loading preventive system?                           | 125    |
| Are silos sufficiently lighted?                                         | 126    |
| Is there overloading safety valve?                                      | 127    |
| Are silos sufficiently lighted?                                         | 128    |
| Are railings and baseboards of the discharge platform appropriate?     | 129    |
### SILO AUTOMATION

| Question                                                                 | Score |
|--------------------------------------------------------------------------|-------|
| Are there pressure gauges?                                               | 3     |
| Does maximum level indicator work in order?                             | 3     |
| Does electrical system work in order?                                    | 3     |
| Is there overflow emergency siren?                                      | 3     |

### CEMENT TRAILER UNLOADING

| Question                                                                 | Score |
|--------------------------------------------------------------------------|-------|
| Are there warning signs?                                                 | 3     |
| Is fixing support (bed) for hose clamps provided?                        | 3     |
| Does electrical system work in order?                                    | 3     |
| Is there overflow emergency siren?                                      | 3     |

### ADMIXTURE TANK

| Question                                                                 | Score |
|--------------------------------------------------------------------------|-------|
| Are electric panel doors available, working in order?                   | 9     |
| Are rubber protection under electric panel available?                    | 9     |
| Are there warning signs around the electric panel?                       | 3     |
| Are there railings on admixture tank stairs and upper platforms?         | 9     |
| Are there admixture labelling signs on the tanks?                        | 1     |
| Are the admixture tanks sufficiently lighted?                            | 9     |
| Are empty tanks, barrels etc. kept under control in a suitable place?    | 3     |
| Are there any leak?                                                      | 9     |
| Does the level indicator work?                                           | 1     |
| Are there an overflow measure?                                           | 9     |
| Is the engine under protection?                                          | 9     |
| Is there an emergency instruction?                                       | 3     |
| Is the MSDS (material safety data sheet) hanged?                         | 3     |

| RISK VALUE:                                                               |       |
|--------------------------------------------------------------------------|-------|
| 673                                                                      | 252   |
| 286                                                                      | 259   |
| 255                                                                      | 277   |
| 377                                                                      | 305   |
| 247                                                                      | 253   |
| 238                                                                      | 269   |
| 231                                                                      | 246   |
| 236                                                                      | 275   |
| 253                                                                      | 308   |
| 312                                                                      | 314   |
| 305                                                                      |       |

Weighbridge, recycled water reservoir, compressor, water booster, generator, fuel tank, operating room, electrical panels, lighting rod, grounding, and transformer AC panel were investigated in section four (Table 6). In general, there were no protection sets on the weighbridge ramp and the weighbridge itself. Cleaning records and instructions of the recycled water reservoir were missing. Shield grid over the reservoir and lighting was missing and chain hoists of the submersible pumps were inappropriate mostly. In general, maintenance and operation instruction of compressors and warning signs were not hanged.
There was no rubber protection under the electrical panel and the compressor room was not sufficiently lighted. In general, the lack of water booster can be listed as, warning signs around the electrical panel, signs of booster tank room, operation and maintenance instruction and rubber protection under the electrical panel. General physical precautions of the generator were not taken in most of the plants. In addition, operation instruction of the generator was not hanged, generator maintenance reports were missing, and lighting was poor. The antistatic precaution was not available in none of the plants. Although there are deficiencies in the operating room and electrical panels, rubber protections and warning signs were missing.

**Table 6 - Auxiliary facility evaluation.**

| No  | WEIGHBRIDGE                                                                 | PILOTED TEST               |
|-----|-------------------------------------------------------------------------------|----------------------------|
|     |                                                                              | NV 1 2 3 4 5 6 7 8 9 10 11 12 13 |
| 154 | Are there protection sets on weighbridge ramp?                               | 9 − − − − − − − − − − − − − − |
| 155 | Are there protection sets on weighbridge?                                     | 9 − − − − − − − − − − − − − − |
| 156 | Are weighbridge bolts controlled periodically?                                | 3 + + + + − − + + + + + + + + |
| 157 | Is weighbridge lighted sufficiently?                                          | 9 + + + + + + + + + + + + + + |

**RECYCLED WATER RESERVOIR**

| 158 | Is there railing?                                                            | 9 − + + + − − + + + + + + + + |
| 159 | Is there shield grid over the reservoir?                                     | 9 + − + − − − + + + − − − − |
| 160 | Is it lighted?                                                                | 9 + − − − − − − − − − − − − − |
| 161 | Is motor secured?                                                             | 9 + + + + + + + + + + + + + + |
| 162 | Are there warning signs? (reservoir depths - no walk around, etc.)            | 3 − − − − − − − − − − − − − − |
| 163 | Are electric panel doors available, working in order?                         | 9 − + + + + + + + + + + + + + |
| 164 | Is rubber protection under electric panel available?                          | 9 − − − − − − − − − − − − − − |
| 165 | Is the capacity of the reservoir sufficient?                                  | 1 + + + + + + + + + + + + + + |
| 166 | Is there cleaning instruction of the reservoir?                               | 1 − − − − − − − − − − − − − − |
| 167 | Are there cleaning records of reservoirs?                                     | 1 − − − − − − − − − − − − − − |
| 168 | Are the chain hoists of the submersible pumps appropriate?                    | 3 − − − − − − − − + + + + + + |

**COMPRESSOR**

| 169 | Are general physical precautions taken? (securing the surrounding of closed area - materials storage) | 3 + − + + + − − − + − − + + + |
| 170 | Are compressor belt protection, air tank safety valve, manometer appropriate? | 9 + + + + + + + + + + + + + + |
| 171 | Is the hydrostatic test report up to date?                                    | 9 − + − − − − − − + + + + + + |
| 172 | Is the maintenance and operation instruction hanged?                          | 3 − − − − − − − − − − − − − − |
| 173 | Are the warning signs hanged? (ear protection, only authorized person)        | 3 − − − − − − − − − − − − − − |
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| Item                                                                 | Rating |
|----------------------------------------------------------------------|--------|
| 174 Is there electrical panel covers, does it work in order?         | 9      |
| 175 Is there rubber protection under the electrical panel?            | 9      |
| 176 Is the compressor room sufficiently lighted?                      | 9      |
| **WATER BOOSTER**                                                    |        |
| 177 Is there electrical panel covers, does it work in order?         | 9      |
| 178 Is there rubber protection under the electrical panel?            | 9      |
| 179 Is the booster tank room sufficiently lighted?                    | 9      |
| 180 Are there warning signs around electrical panel?                  | 3      |
| 181 Are the signs of booster tank room sufficient?                    | 3      |
| 182 Is the operation and maintenance instruction of booster tank available? | 3      |
| 183 Are the water booster and pressured tanks in a closed room?       | 9      |
| 184 Are the physical conditions of the booster and pressured tanks room appropriate? | 3      |
| 185 Are there warning signs around electrical panel?                  | 3      |
| **GENERATOR**                                                        |        |
| 186 Are general physical precautions taken? (securing the surrounding of closed area) | 3      |
| 187 Is the operation instruction of the generator hanged?             | 3      |
| 188 Is there a leak or overflow in the generator fuel tank?           | 9      |
| 189 Is the periodic maintenance of fire extinguishers appropriate?    | 9      |
| 190 Are warning signs hanged? (danger; do not touch the generator; only authorized person, etc.) | 3      |
| 191 Are there generator maintenance reports?                          | 3      |
| 192 Is the generator sufficiently lighted?                            | 9      |
| **FUEL TANK**                                                        |        |
| 193 Is there a set to prevent vehicles from crushing into fuel tank?  | 9      |
| 194 Are warning signs available?                                      | 3      |
| 195 Are operating instructions available?                             | 3      |
| 196 Is a fire extinguisher available?                                 | 9      |
| 197 Is there antistatic precaution?                                   | 9      |
| 198 Is there fuel tank ventilation does it work in order?             | 3      |
| 199 Is the tank sufficiently lighted?                                 | 9      |
| 200 Is there a locking mechanism for the fuel tank and the pump, does it work in order? | 9      |
| OPERATING ROOM                                                                 |   |
|--------------------------------------------------------------------------------|---|
| 201 Is there emergency stop switch-marking (on-off) system?                     | 9 + + + + + + + + + + + + + |
| 202 Is there fire extinguisher (30 cm high; fixed; not expired)                | 9 − − + + + + + + + + + − − |
| 203 Is there air conditioner?                                                  | 1 + + + + + + + + + + + + + |
| 204 Is everything well organized?                                             | 3 + + + + + + + + + + + + + |
| 205 Is there electrical panel covers, does it work in order?                  | 9 + + + + + + + + + + + + + |
| 206 Is there rubber protection under the electrical panel?                     | 9 − − − − − − − − − − − − − |
| 207 Are there warning signs around the electrical panel?                        | 3 − − + − − − − − − − − − − |
| 208 Are electrical panel keys available?                                       | 9 + + + + + + + + + + + + − + |
| 209 Is the operating room sufficiently lighted?                                | 9 + + + + + + + + + + + + + |

| ELECTRICAL PANELS                                                             |   |
|--------------------------------------------------------------------------------|---|
| 210 Is grounding available?                                                    | 9 + + + + + + + + + + + + + |
| 211 Are the panel doors closed?                                                | 9 + + + + + + + + + + + + + |
| 212 Are they locked and do only authorized personnel have the keys?            | 9 − + + + + + + + + + + + + |
| 213 Is there rubber band?                                                      | 9 − − − − − − − − − − − − − |
| 214 Are warning signs hanged? (50v, danger, only electrician, etc.)            | 3 − − − − − − − − − − − − − |
| 215 Are the physical conditions (height, appearance, etc.) appropriate?       | 9 + + − − + − + + + + + + + |

| LIGHTNING ROD, GROUNDING, TRANSFORMER AC PANEL                                 |   |
|--------------------------------------------------------------------------------|---|
| 216 Are lightning rod annual maintenance reports available?                    | 9 + + + + − − + − + + + + + |
| 217 Is there facility grounding?                                              | 9 + + + + + + + + + + + + + |
| 218 Is the facility transformer mast safety lock available?                    | 9 − + + − − + + + + + + + + |
| 219 Is the transformer maintained (oil change)?                                | 9 + + + + + + + + + − − + + |
| 220 Are tips available? Does it work in order? Is capacity sufficient?        | 9 + + + + + + + + + + + + + |
| 221 Are the doors of transformer and ac panel locked?                          | 9 − + + − − + + + − − + + + |
| 222 Is the transformer and ac panel suitable for internal, external lighting?  | 9 + + − + + + − − + − − + + |
| 223 Is the transformer and ac panel high enough from the ground?               | 9 + + + + + + + + + + + + + |
| 224 Is there any deformation in the transformer and ac panel?                  | 9 + + + + + + + + + + + + + |
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225 Is there a rubber band in front of the transformer and ac panel? 9 − + − − − − − + + + + +
226 Are the warning signs in the transformer and ac panel sufficient? 3 − + − − − − − − + + − −
227 Is there enough fire extinguisher in transformer? Are they appropriately located? 9 − − − − − − + − − − + +

RISK VALUE: 582 212 218 150 266 257 262 209 188 230 210 225 203 203

Precautions taken regarding mobile equipment were more extensive than those of other sections (Table 7). The common missing in all plants was the lack of fire extinguisher. Except for this, the truck mixers, pumps, and loaders can be said to be generally safe.

Table 7 - Mobil equipment evaluation.

| No. | TRUCK MIXERS | PILOTED TEST |
|-----|--------------|--------------|
|     |              |  NVT  2 3 4 5 6 7 8 9 10 11 12 13 | |
| 228 | Is there vehicle tracking system on truck mixers? | 3 + + + + + + + + + | |
| 229 | Does audible reversing device work properly? | 9 + + + + + − + − + + + + | |
| 230 | Is there protection on upper platform of the ladder? | 9 + + + + + + + + + + + | |
| 231 | Do the backlights of the truck mixers work in order? | 9 + + + + + + + + + + + | |
| 232 | Is the ladder to driving cabin appropriate? | 9 + + + + + + + + + + + | |
| 233 | Is there side protection of discharge gutters? | 9 + + + + + + + + + + + | |
| 234 | Is there any mechanism on truck mixers to prevent overflow of concrete? | 3 − − + + + + + + + + + | |
| 235 | Are the headlights and taillights working in order? | 9 + + + + + + + + + + + | |
| 236 | Are the fire extinguishers available? | 9 − − + + + − + + − + + + + | |
| 237 | Is the rest of components of drive cab fixed inside? | 3 − − + + + − + + + + + | |
| 238 | Are the periodically serviced? | 9 − − + + + − + + + + + | |
| 239 | Are there first aid kits in every truck mixer? | 9 + + + + + − + + + + + | |
| 240 | Do tachometers work in order? | 3 + + + + + + + + + + + | |
| 241 | Do truck mixer drivers have operating license? | 3 + − + + + + + + + + − | |
| 242 | Do truck mixer drivers have psychotechnical report? | 9 + + + + + + + + + + + | |
| 243 | Did truck mixer drivers have orientation training? | 3 − − + + + − + + + + | |
| 244 | Are the headlights of working truck mixers on?? | 9 + − + − − − + − − − + | |
|     |              |              | |
|     | PUMPS |              |              |
| 245 | Is there vehicle tracking system on pumps? | 3 + + + + + + + + + + − + | |
| 246 | Is there any automatic system on pumps against rollover? | 9 + + + + + + + + + + + | |
| 247 | Does audible reversing device work properly? | 9 − + + + + n/a + − + − − | |
| 248 | Are the backlights of the pumps work properly? | 9 − + + + + − + + − − + + | |
| 249 | Are pumps periodically maintained? | 9 − + + + + + + + + + + + | |
| 250 | Are pumps periodically maintained? | 9 − + + + + + + + + + + + | |
According to laboratory evaluation (Table 8) common missing precautions were precaution against electric shock in the cure pools, precaution against the slippery ground, precaution against free fall of concrete specimens, warning signs, instructions, and labeling, specimen tong.

Table 8 - Laboratory evaluation.

| No  | LABORATORY | PILOTED TEST |
|-----|------------|--------------|
| 272 | Is there any precaution against electric shock in cure pools? | 9  | 2  | 3  | 4  | 5  | 6  | 7  | 8  | 9  | 10 | 11 | 12 | 13  |
| 273 | Is there a system to cover the curing pool? | 3  |  +  | +  | +  |  +  |  +  |  +  |  +  |  +  |  +  |  +  |  +  |  +  |
| 274 | Is there any precaution against slippery ground? | 9  |  +  |  +  |  +  |  +  |  +  |  +  |  +  |  +  |  +  |  +  |  +  |  +  |
275 Is there any precaution against free fall of concrete specimens?  

276 Are there warning signs, instructions, and labeling?  

277 Is there any tool to carry specimens from the curing pool to test machine?  

278 Is there protective cap-door-cover in front of the test machine?  

279 Is there warning sign on the test machine as “only authorized person”?  

280 Is pneumatic specimen demolding system secured?  

281 Are there appropriate PPE in the laboratory? (glove, glasses, mask, etc.)  

282 Are there specimen tong in the laboratory?  

283 Is the drying oven instruction appropriate?  

284 Is there protective glove for drying oven?  

285 Is there a kit/tool at the end of pneumatic specimen demolding hose?  

286 Are there enough fire extinguishers? Are they appropriately located?  

287 Is periodic maintenance of fire extinguishers properly performed?  

RISK VALUE:

Table 9 - Risk values of visited plants.

| List No. | Section                        | Total RV of Sections | Risk Values of Visited Plants |
|----------|--------------------------------|----------------------|-------------------------------|
| 1-22     | General                        | 135                  | 111 105 84 87 87 99 114 90 84 99 90 111 111 |
| 23-50    | Plant                          | 168                  | 84 111 102 120 120 132 111 99 102 99 99 66 66 |
| 51-153   | Mat. storage and pro.          | 673                  | 232 236 246 259 289 377 247 275 253 312 314 308 305 |
| 154-227  | Auxiliary facility             | 508                  | 212 218 150 266 257 242 209 188 230 210 225 203 203 |
| 228-271  | Mobil equipment                | 330                  | 150 93 30 45 45 108 24 63 96 96 60 60 |
| 272-287  | Laboratory                     | 120                  | 57 30 57 84 84 84 84 99 72 48 48 39 39 |
| Total    |                                | 1934                 | 846 793 669 861 882 1042 765 775 804 864 872 787 784 |
| %        |                                | 43.74 41.00 34.59 44.52 45.60 53.88 47.69 40.07 41.57 44.67 45.09 40.69 40.54 |
The sum of the deficiencies of each plant in all sections for an overall assessment is presented in Table 9. According to the risk values for 13 plants, belong to one company, the deficiencies change between 53.88% to 34.59. This is a good example of the fact that even the same company cannot ensure stability in terms of OHS between its plants.

4. DISCUSSION AND CONCLUSION

Ready mixed concrete industry, commonly used not only in Turkey but also in other countries, needs to be investigated in terms of occupational health and safety because academic studies on this subject are not abundant. This study aimed to develop a control list to be used within the scope of an internal safety evaluation program that can be used by all producers to understand and improve OHS performance in the production process. For this reason, it was investigated what should be considered for detailed ISEP of the production area of a ready mixed concrete plant and the 287-item control list was created. Since each safety risk was digitizing in the control list, the maximum risk score of each section was determined. Afterward, the created control list was applied in 13 ready mixed concrete plants of one company. RMC companies need to benefit from a guideline when conducting their own internal evaluations to improve their occupational safety efforts and to make all their plants equally safe. In this respect, the study is a reliable guide for RMC manufacturers. Also, it is important to note the common deficiencies of the plants visited listed follows.

- Risk analysis was missing in most of the visited plants. Besides, none of the plants had an approved OHS policy. The ready mixed concrete industry is one of the subsectors of construction which has a lot of risks which are described above. That’s why risk assessment is very important for any ready mixed concrete plant. Carrying out these assessments is the only way of ensuring that the chances of incidents occurring are reduced as much as possible, and everyone is kept safe.

- The emergency action plan and was not available in any of the plants. A workplace emergency is any unforeseen situation that threatens employees, customers, or the public; disrupts or shuts down operations; or causes physical or environmental damage [50]. The purpose of an EAP is to facilitate and organize employer and employee actions during workplace emergencies [51]. Therefore, it is crucial to have EAP in plants and visibly hanged.

- OHS training was mostly missing in plants. Sawacha et al. (1999) stated that a lack of safety training is one of the causes of accidents [52]. Researchers also indicated that safety training is the most important safety management practice in terms of safety performance components [53-55]. Adopting safety-training programs increase the awareness of workers on the subject, thereby allowing them to work safely. Therefore, producers should organize and record regular OHS training. Besides, it should be noted that keeping training up to date is just as important as taking it the first time.

- Collecting statistics on safety activities will allow a company to identify common injuries and areas that may be lacking in their safety program. OSHA states that collecting near-miss reports helps to create a culture that seeks to identify and control hazards, which will reduce risks and the potential for harm [56]. In addition,
reporting near miss incidents can significantly improve worker safety and enhance an organization’s safety culture [57]. Near-miss reports were not available in visited plants. Therefore, to better understand the weaknesses in the system that resulted in the circumstances that led to the near miss, root cause analyses could not conduct. Near miss forms to collect relevant incident data during an investigation and to learn lessons, review controls and implement change where required should be used.

- Surprisingly, no facility had a plant entrance OHS warning sign. OHS warning signs should be made at the entrance of the plant. This warning sign should symbolize the summary rules that must be observed when entering the plant (Speed limit, helmet use, etc.). Warning signs also were missing in many parts of the production process such as: stockyard, bunker, horizontal conveyors, vertical conveyors, horizontal-vertical conveyor joints, cement silo, cement trailer unloading, admixture tank, compressor, generator, operating room, electrical panels. Safety signs play a large part in keeping facilities compliant and employees knowledgeable. It is critical for workers to understand the types of hazards in the workplace, the level of risk the hazard presents, and what precautions to take [58].

- Instruction is an outline or manual of technical procedures. Instructions also tell someone how to do something or in which order to do something. First aid instructions, cleaning, and maintenance instructions of the mixer, emergency instruction of admixture tank, cleaning instruction of the reservoir, operation and maintenance instruction of booster tank, operating instruction of fuel tank were missing. These instructions should be prepared by the managers and actively used by workers to prevent them from potential accidents because of the described risks.

- Moving vehicles and equipment on manufacturing sites can be fatal if not used correctly and safely. The layout and traffic flow of a workplace is important in keeping people and plant safe as they move around [59]. Only 2 plants had an "on-site traffic plan" within visited plants. Related plans should be prepared and actively used in all RMC plants.

To sum up, risk may remain within acceptable bound within organization to sustain OHS management applications by using an internal safety evaluation program. Described risks cannot be totally avoided, but the choice can be made so that the risk is minimized. This study is mainly concerned with the assessment of pure risk in ready mixed concrete production, where managers need to know how much risk is involved in the process to decide how to go about it. It is expected that the control list would be an effective tool of preventing and minimizing accidents of RMC industry.

In addition, the control list created within the scope of the internal safety evaluation program includes the legal obligations in the laws and standards in force. According to the risk scores obtained from the control list, it is observed that some of the measures described in the Occupational Safety Law No. 6331 and accompanying standards were not taken at the facilities visited. For this reason, ready-mixed concrete producers will also fulfill their legal obligations in the improvement works they will make with reference to this control list.

Besides, the created control list is a guide for ready-mixed concrete companies to make their own preliminary assessments and due diligence to reach internationally accepted standards and regulations. Considering the provisions of the ISO 45001 Occupational Health and Safety
Management System Standard, the created control list will be able to guide companies, especially in Section 6.1 (Methods of identifying risks and opportunities) and Section 6.2 (OHS targets and planning to achieve them).

The employees of the ready mixed concrete industry also experience the risks that may cause occupational diseases such as noise (hearing loss), dust (respiratory system diseases), ergonomics (musculoskeletal system disorders) and so on. However, the control list presented in the study does not cover occupational diseases. In future studies, the subject can also be addressed from this aspect.

Abbreviations
ACPA - American Concrete Pumping Association
EAP - Emergency Action Plan
ISEP - Internal Safety Evaluation Program
NSCSA - National Ready Mixed Concrete Association
NV – Numeric Value
OHS - Occupational Health and Safety
OSHA - Occupational Safety and Health Administration
PPE - Personal Protective Equipment
RMC - Ready Mixed Concrete
RV - Risk Value
SMS - Safety Management System

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