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Analysis of Worker Category Social Impacts in Different Types of Concrete Plant Operations: A Case Study in South Korea

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Abstract: As sustainable development has emerged as a priority on the international agenda, increasing emphasis has been placed on "Life Cycle Sustainability Assessment (LCSA)," wherein environmental, economic, and social performance are comprehensively integrated. This study, as part of an LCSA approach, uses Social Life Cycle Assessment (S-LCA) to analyze the worker category social impact for concrete plants in South Korea. For the analysis, three types of concrete plant with different operating systems were selected and evaluated: Direct operation, operated by dedicated concrete manufacturers, and operated by cement suppliers. Eleven major social topics, which were mentioned in the international standards and international institutes, were selected as the subjects of evaluation; the social impacts were evaluated by applying the evaluative criteria for social topics presented in the Handbook for Product Social Life Cycle Assessment of PRé Sustainability. We determined that the highest social impact was found in concrete plants operated by cement suppliers (0.77), followed by plants operated by dedicated concrete manufacturers (0.50), and finally by plants with direct operations (0.09). These results can be applied by concrete plants to improve worker category areas in which they are lacking and by future researchers to evaluate the sustainable development of a variety of industries.

Keywords: Social impact; concrete plant; worker category; social life cycle assessment

1. Introduction

The practice of sustainable development is being emphasized in nearly every industry [1,2]. Sustainable development is a concept that was introduced to resolve global environmental problems and to secure the balanced social advancement of humanity; its core tenets consist of environmental, economic, and social domains, which are driving the implementation of sustainable development worldwide [3,4].

The concrete industry, which is responsible for approximately 7% of the global carbon emissions annually [5], is currently concentrating its sustainable development efforts on the development of carbon-reduced concrete production technology, which is expected to reduce the amount of carbon emissions from its product stage significantly by exploiting industrial byproducts as "Supplementary Cementitious Materials (SCMs)" [6–8]. The industry also employs the technique of "Environmental Life Cycle Assessment (ELCA)" to develop technologies enabling the quantitative evaluation of the environmental performance of carbon-reduced concrete [5,9–17]. Celik et al. [5] have quantitatively

evaluated the environmental performance of self-consolidating concrete, in terms of carbon emissions, by using the ELCA technique; Yang et al. [9] have evaluated the performance of the carbon emissions reduction of alkali-activated concrete. Additionally, Kim et al. [10] and Gursel [11] have developed a system capable of evaluating the amount of carbon emissions from concrete by applying the ELCA technique.

For many decades, concrete has been considered the most economic material available for construction purposes, and it has been applied in various types of construction. The economic performance of concrete based on life cycle assessment costs is being widely evaluated [18–20]. Further, the concrete production industry has been promoting a variety of studies to lower manufacturing costs and to secure the economic performance of concrete with the use of SCMs and similar materials [21,22].

Studies on the social performance aspects of concrete, however, are still limited to basic information compared to those considering the environmental or economic performance of the material. The social performance of concrete involves complex and diverse concepts for evaluation, making an objective analysis of social performance difficult [23–25]. These studies have focused on developing techniques and diverse approaches to evaluating the evolving concept of sustainable development as part of an analysis of the social performance of concrete products; such evaluative schemes are being standardized in the system that is referred to as Life Cycle Sustainability Assessment (LCSA) [26]. LCSA employs ELCA, Environmental Life Cycle Costing (ELCC), and Social Life Cycle Assessment (S-LCA) to quantify and integrate the environmental, economic, and social impacts and benefits of products throughout their entire life cycle, thereby evaluating the sustainability of their entire life cycle. In particular, S-LCA, which was designed to evaluate the social performance of products and their suppliers from the perspective of diverse stakeholders comprising workers in plants, consumers, and local communities, has recently been spotlighted as a means to evaluate "Corporate Social Responsibility (CSR)" [27]. CSR is a method of analyzing the administrative policies and manufacturing environment of a company supplying products of similar price and quality in terms of social and ethical aspects to determine whether they are socially responsible. The results of such a social impact appraisal can be employed by consumers as referential criteria in selecting sustainable products. Thus, concrete needs to be evaluated in terms of the social performance of the concrete plant in which concrete products are made, and in terms of its environmental and economic performance. Ultimately, LCSA, which integrates the performance evaluations of all three domains, is necessary.

This study utilizes the S-LCA approach to analyze the social impacts of workers in different types of South Korean concrete plant operations as part of LCSA.

2. Background

2.1. Life Cycle Sustainability Assessment (LCSA)

LCSA was established in 2011 by the United Nations Environment Programme (UNEP) [26]. This method of evaluating sustainability quantifies the environmental, economic, and social impacts and benefits of a product system throughout its life cycle and comprehensively evaluates all aspects of the system. It consists of ELCA, ELCC, and S-LCA, as shown in Equation (1):

$$\text{LCSA} = \text{ELCA} + \text{ELCC} + \text{S-LCA}. \quad (1)$$

The concept of LCSA was first introduced in 2003 by Klöpffer and was transformed into a conceptual equation in 2008 by the same author to integrate the evaluation results of ELCA, ELCC, and S-LCA [28,29]. The LCSA was introduced worldwide through the UNEP "Towards a Life Cycle Sustainability Assessment" report published in 2011 [26]. Figure 1 shows the system boundaries of LCSA.

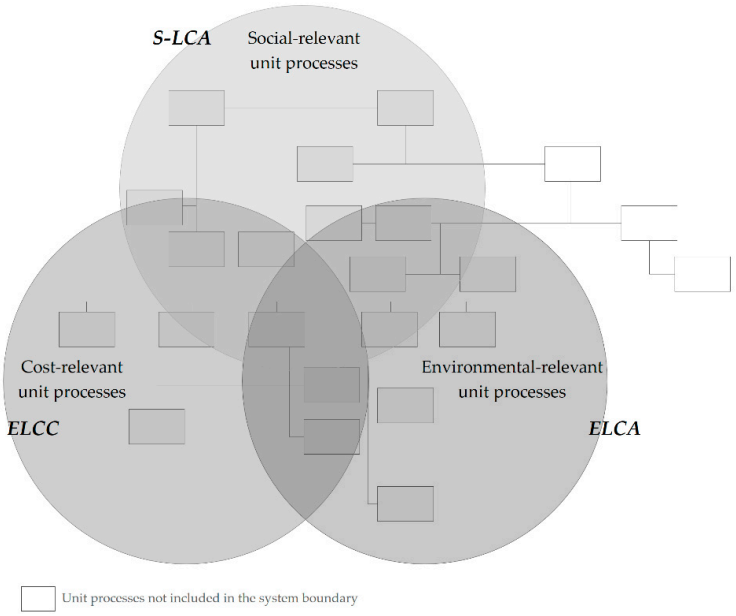

Figure 1. System boundaries of Life Cycle Sustainability Assessment (LCSA).

2.2. Social Life Cycle Assessment (S-LCA)

S-LCA is a comprehensive evaluation technique that assesses positive or negative social impacts of a product system throughout its life cycle; the subjects of evaluation can be companies, organizations, industries, and societies that produce and manufacture product systems [30].

The detailed S-LCA evaluation method and system were introduced in 2006 in studies by Norris [31], Dreyer et al. [23], and Hunkeler [32], and became widely known through the "Guidelines for Social Life Cycle Assessment of Products" published in 2009 by UNEP [30]. As S-LCA is a fairly new evaluation technique, few studies have utilized it so far. There are case studies targeting particular industries and products such as salmon production [33], Cameroon's banana industry [34], and waste product recycling in low-income countries [35]. Therefore, many studies are actively being conducted with respect to the development of S-LCA methods and systems by targeting a wide range of product systems, analyzing various social topics, and establishing a database.

The framework of S-LCA consists of four stages: Goal and scope definition, life cycle inventory analysis (LCI), life cycle impact assessment (LCIA), and life cycle interpretation. To be more specific, in the goal and scope definition stage, the goal and scope of a given system are defined and details, such as the reason for execution of the research, intended application fields, function of a product system to be evaluated, system boundaries, and functional unit, are determined. The functional unit can be quantified, but it is usually expressed qualitatively since social impact is portrayed as a criterion-based relative indicator. In addition, given that S-LCA is composed of numerous social topics targeting various stakeholders, it is important to select factors that have direct impact on the subjects of evaluation based on the exclusion criteria for the system boundaries [31]. In the LCI stage, data about the scope and social topics of stakeholders who belong to the system boundary are collected. Herein, the data can be divided into general data, which is obtained from international and national statistics, and field data, which is collected in an actual survey. The data must be carefully selected to conform to the purpose and scope of a study. In the LCIA stage, the potential social impact of a product system is evaluated based on data collected in the LCI stage by social topics. The evaluation results of each social topic are converted into stakeholder categories, and the relative advantages of the different stakeholder categories are determined and weighted. In the life cycle interpretation stage, the evaluation results of S-LCA are put together, the key factors of S-LCA are identified, and the final conclusions are drawn. In addition, a reliability test of the study results can be carried out. Figure 2 shows the evaluation structure of S-LCA.

The social impact can be specified through social topics, which are classified into detailed items that affect the category involved in a product system, including the worker, consumer, local community, society, and value chain [30]. When it comes to social topics, it is crucial to first select major social topics that meet the subjects and objectives of an assessment to carry out S-LCA because there are a lot of issues across various categories. Major social topics, suggested by international organizations, including UNEP [30], the International Standard ISO 26000 [36], World Business Council for Sustainable Development (WBCSD) [37], Global Reporting Initiative (GRI) [38], PRé Sustainability [27], and Global Social Compliance Programme (GSCP) [39], are summarized in Table 1. UNEP proposed a total of 31 social topics for categories, including workers, consumers, local community, society, and value chains, and ISO 26000, WBCSD, and GRI suggested 41, 15, and 23 social topics, respectively. PRé Sustainability introduced 19 social topics mainly focusing on the worker category, and GSCP presented seven social topics with respect to the worker category.

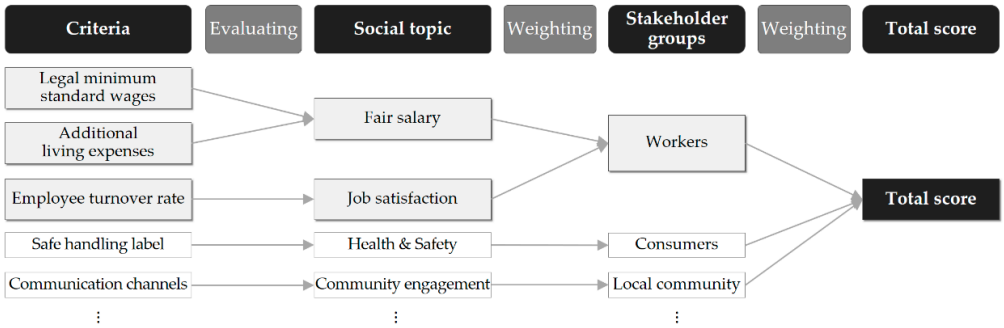

Figure 2. Evaluation structure of S-LCA [30].

Table 1. Social categories and social topics.

Category	Social Topics	UNEP [30]	ISO 26000 [36]	WBC SD [37]	GRI [38]	PRé [27]	GSCP [39]
Worker	Freedom of association & collective bargaining	●	●		●	●	●
	Child labor	●	●	●	●	●	●
	Fair salary	●	●	●		●	●
	Working hours	●	●			●	●
	Forced labor	●	●	●	●	●	●
	Equal opportunities & discrimination	●	●	●	●	●	●
	Health & safety	●	●	●	●	●	●
	Social benefits	●	●	●	●	●	
	Training & education		●	●	●	●	
	Employment relationships		●			●	
	Job satisfaction					●	
Consumer	Health & safety	●	●	●	●	●	
	Consumer privacy	●	●	●	●	-	
	Transparency	●	●		●	-	
Local community	Safe & healthy living conditions	●	●				
	Community engagement	●	●	●	●	●	
	Local employment	●	●		●	-	
Society	Public commitment to sustainability issues	●					
	Contribution to economic development	●					
	Technology development	●	●				
Value chain	Fair competition	●	●		●		
	Respect of intellectual property rights	●	●				

The symbol (●) indicates the social impact category is included; UNEP is the United Nations Environment Programme; ISO 26000 is the Guidance on social responsibility; WBCSD is the World Business Council for Sustainable Development; GRI is the Global Reporting Initiative; PRé is PRé Sustainability; GSCP is the Global Social Compliance Programme.

3. Materials and Methods

3.1. Analysis Targets

The target of this study is the concrete plant in South Korea. Therefore, the concrete plants in South Korea were classified into three categories: Direct operation, plants operated by dedicated concrete manufacturers, and plants operated by cement suppliers, depending on the respective types of operation. Based on the data from a previous study by Jeong [40], the concrete plants were selected by their respective categories for the analyses to be conducted in this study. Here, the direct operation plants signify small- and medium-sized corporations of concrete plants founded by individuals, whereas the concrete plants operated by dedicated concrete manufacturers are directly under the control of medium-sized or large enterprises that were established to secure competitiveness in the market. The concrete plants operated by cement suppliers (mainly of large enterprises) were established to consume cements produced spontaneously. Table 2 shows an overview of the concrete plants selected for this study.

Concrete plant A is in the direct operation category and is located in Yongin, Gyeonggi-do Province, wherein 21 workers of regular employment are working. The production capacity of the plant is 420 m^3/h, for which a cement silo (1000 tons) and 55 transit mixer trucks are provided. Concrete plant B is in the operated by dedicated concrete manufacturers category and is located in Goyang, Gyeonggi-do Province with 34 workers. The production capacity of the plant is 720 m^3/h, for which a cement silo (2000 tons) and 87 transit mixer trucks are provided. Concrete plant C is in the operated by cement suppliers category and is located in Bucheon, Gyeonggi-do Province; it has a total of 41 workers. The production capacity of the plant is 620 m^3/h, for which a cement silo (3500 tons) and 101 transit mixer trucks are provided.

Table 2. Overview of concrete plants selected in this study.

Classification	Concrete Plant A	Concrete Plant B	Concrete Plant C
Operation type	Plant of direct operated	Plant operated by dedicated concrete manufacturer	Plant operated by cement supplier
Location	Yongin, Gyeonggi-do Province	Goyang, Gyeonggi-do Province	Bucheon, Gyeonggi-do Province
Number of employees	21	34	41
Production capacity (m^3/h)	420	720	620
Cement Silo (ton)	1000	2000	3500
Transit mixer truck	55	87	101
Annual shipments (m^3)	300,000	691,000	638,000
Rate of operation (%)	35	47	50

3.2. Analysis Methdod

Eleven worker category social topics were selected from major international standards' and institutes' social topics [27,30,36–39] and analyzed. Social topics included: (1) Freedom of association and collective bargaining; (2) child labor; (3) fair salary; (4) working hours; (5) forced labor; (6) equal opportunities and discrimination; (7) health and safety; (8) social benefits; (9) training and education; (10) employment relationship; and (11) job satisfaction.

The criteria for social topics have mostly been described qualitatively. In this study, interval scale-based analysis was applied to quantitatively evaluate the social impact of concrete plants. Interval scale-based analysis measures the degree of flow of a variety of situations and contexts for any reference point. Using this method, the scores of the subjects of evaluation are not necessarily proportional to their performance, which is a disadvantage. However, good or poor performance can be identified according to certain criteria, allowing the level of performance to be compared among various subjects.

The criteria for the worker category social topics are based on the "Handbook for Product Social Life Cycle Assessment [27]" presented in PRé Sustainability (refer to Table 3).

Table 3. Evaluation criteria for worker category social topics.

Social Topics	Criteria	Score				
		+2	+1	0	−1	−2
(1) Freedom of association & collective bargaining	• Where free association is restricted by law, workers are proactively informed about their choice of whether to organize themselves.	Yes	Partial			
	• Workers are not hindered in their attempts to exercise their right to organize themselves	Yes	Yes	Yes		
	• Workers may bargain collectively, and worker representatives do not face disciplinary action.	Yes	Yes	Yes	Partial	
(2) Child labor	• A company operates a management and compliance system to prevent child labor.	Yes	Yes	Yes	Yes	
	• A company archives documents to prove the age of the workers.	Yes	Yes	Yes		
	• Employment or recruitment agencies and suppliers are proactively monitored to prevent child labor.	Yes	Partial			
(3) Fair salary	• A company pays legal minimum standard wages for:	All workers	All workers	All workers	≥75% of workers	<25% of workers
	• A company pays additional living expenses for:	≥25% of workers	<25% of workers			
(4) Working hours	• Workers do not exceed the legal limited working hours in the normal working week.	Yes	Yes	Yes	Peak seasons only	Usually exceeds
	• Overtime is recorded, voluntary, and compensated.	Yes	Yes	Yes		
	• Company pays overtime with a premium rate, and overtime does not exceed 12 h.	Yes	Partial			
(5) Forced labor	• A company is not forcefully attributional to wages or workers' passports or residence permits.	Yes	Yes	Yes	Yes	
	• A company provides employees with reasonable working conditions, including the right of workers to leave the workplace early.	Yes	Yes	Yes		
	• Employment or recruitment agencies and suppliers are monitored to prevent forced labor.	Yes	Partial			
(6) Equal opportunities & discrimination	• A company has a system that allows an employee to file a complaint about discrimination.	Yes	Yes	Yes	Yes	
	• A company pays equally for equal amounts of work.	Yes	Yes	Yes		
	• Goals for staff diversity are:	Achieved	Set			
(7) Health & safety	• A company provides its employees with health and safety training and defines a job responsibility system for health and safety.	Yes	Yes	Yes	Partial	
	• Workers are involved in the design, development, and review of health and safety programs.	Yes	Yes			
	• The level of incidents is measured, and reduction targets are set.	Yes				
(8) Social benefits	• A company grants social benefits outlined in the Labor Standards Act for:	All workers	All workers	All workers	≥75% of workers	<25% of workers
	• A company offers additional social benefits for:	≥25% of workers	<25% of workers			
(9) Training & education	• A company implements training and education for:	All workers	>75% of workers	≥75% & ≤50% of workers	<50% of workers	
(10) Employment relationships	• A company signs a labor contract (documented employment conditions) for:	All workers	All workers	All workers	>75% of workers	≤25% of workers
	• The number of workers who have a permanent employee relationship is:	≥25% of workers	<25% of workers			
(11) Job satisfaction	• Employee turnover rate.	<5%	≥5% & <10%	≥10% & <15%	≥15% & <20%	≥20%

The scores for each social topic were based on zero, which represents an average of the industry or a minimum level of welfare and benefit from the social and ethical perspective. A maximum score of "+2" was given for additional positive influences, and a minimum score of "−2" was given for negative influences. Therefore, if the social score or social impact is zero or higher, a positive social impact is indicated. If either score is below zero, a negative social impact is implied. Table 3 shows the social topics evaluation criteria [27]. Equation (2) demonstrates the social score calculation. The social impact of concrete plants can be calculated by dividing the sum of the scores of 11 social topics by the sum of the scale, as shown Equation (3):

$$SC = \sum_{i=1}^{11} ST_i \quad (2)$$

$$SI = \frac{SC}{22} \quad (3)$$

where SC is the social score, ST_i is the point for a social topic (i), and SI is the social impact of the concrete plant.

3.3. Data Collection

Table 4 shows an overview of the data adapted for this study. Based on Table 4, site-specific data were preferentially applied in accordance with the principles of S-LCA. The features of South Korean concrete plant labor-management relations, determined in a previous study by Jeong [40], were reanalyzed in this work. When site-specific data was difficult to apply, general data, based on South Korean statistics or those of other countries. were considered.

Table 4. Data type adapted for this study.

Social Topics	Site Specific Data	Generic Data	Source
(1) Freedom of association & collective bargaining	●		A
(2) Child labor		●	B
(3) Fair salary	●		A
(4) Working hours	●		A
(5) Forced labor		●	C
(6) Equal opportunities & discrimination		●	C
(7) Health & safety		●	D
(8) Social benefits	●		A
(9) Training & education	●		A
(10) Employment relationships	●		A
(11) Job satisfaction	●		A

A: Previous study by Jeong [40]; B: 2013 United Nations International Children's Emergency Fund (UNICEF) report [41]; C: South Korea's labor rights report of the United States Department of Labor (USDOL) [42]; D: South Korea's Occupational Safety and Health Act [43].

4. Results and Discussion

Figure 3 and Table 5 describe the results of the 11 social topics of analysis regarding concrete plant workers in South Korea. According to Table 5, the total score and social impacts of concrete plant A were the lowest while those of concrete plant C were the highest; detailed explanations are as follows:

(1) Freedom of association and collective bargaining: It was reported that concrete plants A and B do not have labor unions that exercise the rights of workers, but concrete plant C do. Concrete plants A and B have not had any organizations that represent the interests of employees and

have never allowed collective bargaining. On the other hand, concrete plant C allowed active collective bargaining through a labor union and had a labor council, which guarantees the regular articulation of the opinions of workers. Therefore, concrete plants A and B were assigned "−2", and concrete plant C was evaluated as "+2".

(2) Child labor: According to the 2013 United Nations International Children's Emergency Fund (UNICEF) report [41] that surveyed the reality of child labor in 104 countries, this study assumed no child labor at any workplace in South Korea. Accordingly, concrete plants A, B, and C were all evaluated as "+2".

(3) Fair salary: It was reported that concrete plant A, which is a typical small- and medium-sized enterprise (SME), pays the legal minimum standard wages but no additional living expenses. Concrete plants B and C, which are large companies or belong to a conglomerate, pay the legal minimum standard wages and a variety of living expenses, such as factory allowances, qualification allowances, communication costs, and tuitions. As a result, concrete plant A was given a zero, and concrete plants B and C were given "+2".

(4) Working hours: Concrete plant A introduced a 40-h work week, but their employees work from dawn to evening during the week and even on most legal holidays and Sundays due to the nature of the industry. Concrete plants B and C also introduced a 40-h workweek, but their employees also work on holidays depending on the operation status of the factory. However, in concrete plants B and C, when an employee works during holidays, he or she can take a compensatory day off. Concrete plant A was given "−2" and concrete plants B and C were given "−1".

(5) Forced labor: We referred to South Korea's labor rights report [42] of the United States Department of Labor (USDOL) surveyed in 2011 and assumed no forced labor in any workplace in South Korea. It was also determined that employers and suppliers directly related to products do their best to prevent forced labor by complying with the Trade Union and Labor Relations Adjustment Act. As a result, concrete plants A, B, and C were all given "+2".

(6) Equal opportunities and discrimination: Based on South Korea's labor rights report [42] of the USDOL surveyed in 2011, we assumed no discrimination in any workplace in South Korea. As a result, concrete plants A, B, and C were all given "+2".

(7) Health and safety: In accordance with South Korea's Occupational Safety and Health Act [43], we determined that the three concrete plants conduct regular safety and health inspections as prescribed by the Ordinance of the Ministry of Employment and Labor. Additionally, they have a safety and health manager, supervisor, and senior safety manager who are responsible for the workers' health and safety. However, it was difficult to have workers participate in the design, development, and review of the training programs for health and safety or to determine whether a concrete plant establishes and manages reduction targets and disaster levels. Therefore, additional scores were not given. Concrete plants A, B, and C were all given scores of zero.

(8) Social benefits: Concrete plant A grants social benefits outlined in the Labor Standards Act but has no employee welfare system. On the other hand, Concrete plants B and C provide factory allowances, office allowances, qualification allowances, tuitions, and social benefits specified by law. Concrete plant A was given zero and concrete plants B and C were given "+2".

(9) Training and education: Concrete plant A has not built its own education system and has only conducted the minimum training specified in the Korean Industrial Standards (KS) regulations. Concrete plants B and C periodically operate online and provide classroom training related to the job. In addition, they provide their employees with training that considers various cultures, languages, and jobs by operating a corporate educational credit system. Accordingly, Concrete plant A was given "−1" and concrete plants B and C were given "+2".

(10) Employment relationship: The three concrete plants provide all workers with employment contracts in accordance with the Labor Standards Act, and more than 25% of their employees are full-time workers. All concrete plants were given "+2".

(11) Job satisfaction: The annual turnover of concrete plant A ranges from 15% to 20% and that of concrete plant B varies from 8.3% to 15%. On the other hand, the service years of the employees of concrete plant C range from 15 to 20 years, which is quite long, and their turnover rates are very low. Concrete plant A was given "−1", concrete plant B was given zero, and concrete plant C was given "+2".

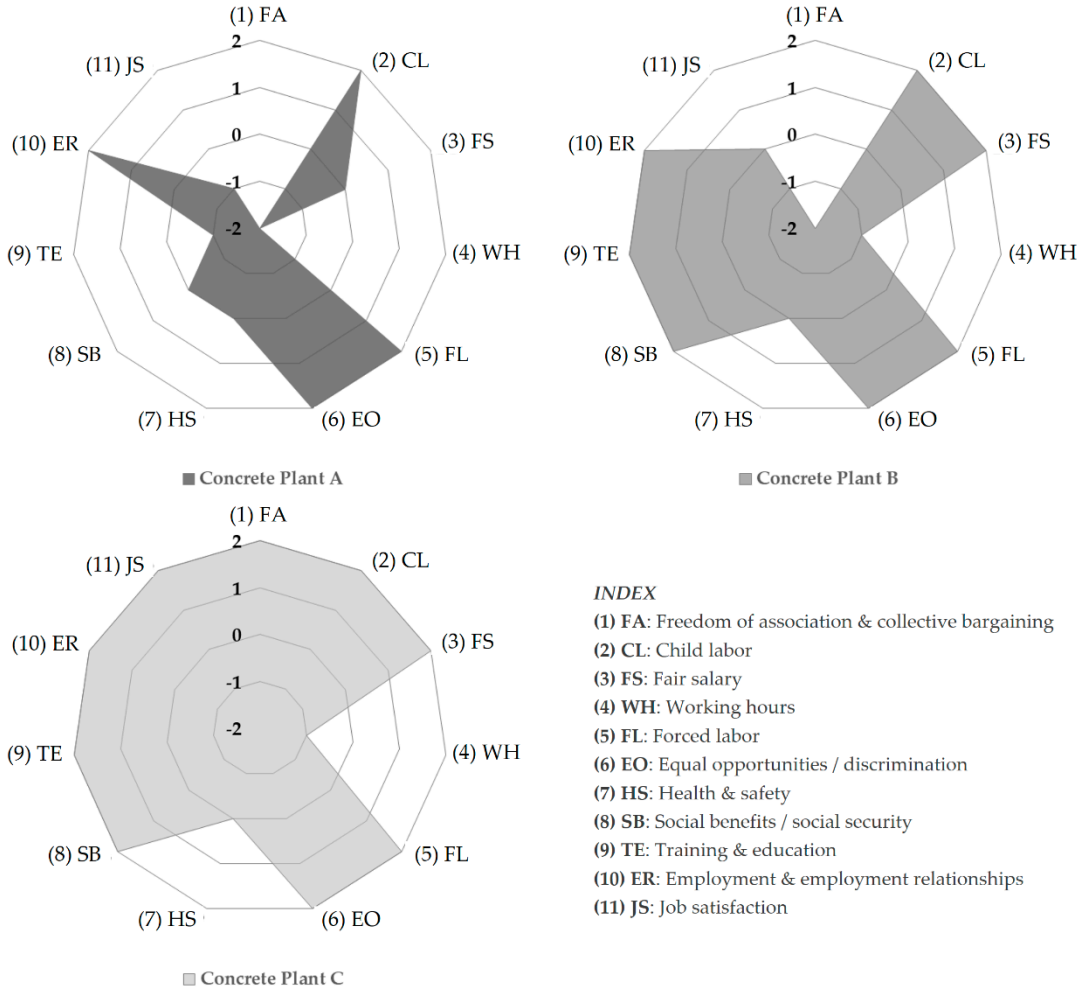

Figure 3. Evaluation results.

Table 5. Evaluation results by social topics.

Social Topics	Concrete Plant A	Concrete Plant B	Concrete Plant C
(1) Freedom of association & collective bargaining	−2	−2	2
(2) Child labor	2	2	2
(3) Fair salary	0	2	2
(4) Working hours	−2	−1	−1
(5) Forced labor	2	2	2
(6) Equal opportunities & discrimination	2	2	2
(7) Health & safety	0	0	0
(8) Social benefits	0	2	2
(9) Training & education	−1	2	2
(10) Employment relationships	2	2	2
(11) Job satisfaction	−1	0	2
Total score	2	11	17
Social impact (= Total score/22)	0.09	0.50	0.77

The results obtained from the analyses conducted in this study revealed the social impact of the concrete plant types in the following order ($-1 \leq$ social impact ≤ 1): Operated by cement suppliers (0.77), operated by dedicated concrete manufacturers (0.50), and direct operation (0.09). A higher social impact (closer to 1) is better in terms of S-LCA than a value close to -1. It was inferred that this order could be attributed to the higher systematic degree of operation in the former two plant types, which would thereby result in more benefits to the workers than in the small-scale direct operation plant.

All the concrete plants in South Korea received low scores in terms of working hours, irrespective of the operation type. We concluded that this could be partially attributed to the variability in concrete production, which is seasonally-dependent and fluctuates with the demand of the construction business; improvements to the operations of the plants could therefore benefit workers. Direct operation and operated by dedicated concrete plants received low scores for freedom of association and collective bargaining, likely due to the relatively conservative culture and working environment in the industry, which should be improved upon for future workers. These results will provide areas of improvement for each plant type and can be used as data that reflects the social performance of concrete products in LCSA.

Nevertheless, the results of this study still have some limitations. First, only one concrete plant of each operation type was evaluated due to limitations in data collection. The labor condition data such as salaries, welfare, and benefits are considered sensitive data related to the management of the company, so almost concrete plants are reluctant to disclose them. However, there are actually over 1000 concrete plants in South Korea. Thus, future studies should expand on the number of concrete plants evaluated to increase the reliability of the results. Second, this study employed general evaluation criteria that were established for ordinary commodities worldwide; the topics of child and forced labor, however, were not particularly applicable for the study region considered. Thus, more accurate evaluation criteria for South Korea specifically would be valuable for future studies. Third, there are diverse social impact categories beyond those of workers, such as those of consumers and local communities. Due to limitations in the data collection and evaluation criteria, we only utilized the worker category social topics. Future studies, however, should consider a more comprehensive evaluation of the social impacts of concrete plants that includes consumer satisfaction and the effects on local communities.

5. Conclusions

This study utilizes the S-LCA approach to analyze the social impacts of workers in different types of South Korean concrete plant operations as part of LCSA. In particular, the 11 major social topics, which were mentioned in the international standards and international institutes among diverse social topics of the category of workers, were evaluated, and for which, the evaluation criteria presented in the Handbook for Product Social Life Cycle Assessment [27] of PRé Sustainability were used. The results of this study are summarized as follows:

1. The worker category social impact by concrete plants in South Korea analyzed in the following order ($-1 \leq$ social impact ≤ 1): operated by cement suppliers (0.77), operated by dedicated concrete manufacturers (0.50), and direct operation (0.09). A higher social impact (closer to one) is better in terms of S-LCA than a value close to -1. It was attributed to the differences of the systematic degree of operation and benefits to the workers depending on the company's scale.
2. All the concrete plants in South Korea received low scores in terms of working hours, irrespective of the operation type. It was partially inferred to the variability in concrete production, which is seasonally dependent and fluctuates with the demands of the construction business.
3. Direct operation and operated by dedicated concrete plants received low scores for freedom of association and collective bargaining, likely due to the relatively conservative culture and working environment in the industry.

The results of this study could be expected to be utilized as basic data for the improvement of social impact and evaluation of social performance of concrete in terms of LCSA. Future studies, however, should consider a more exclusive evaluation of the social impacts of concrete plants to increase the reliability of the results.

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