Report on Environmental Impact Assessment for Cement manufactured in countries around the world

June 2019

Taiheiyo Cement Corporation

1. General

1.1 Assessment implementors

Affiliated institution: Taiheiyo Cement Corporation, Central Research Laboratory
Name: Yusuke Kirino, Seiichi Hoshino
Contact: yusuke_kirino@taiheiyo-cement.co.jp

1.2 Report creation date

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2. Goal of the study

2.1 Reasons for carrying out the study

Use LCA to assess the environmental impact of processes, from raw material procurement to manufacturing, for cement manufactured around the world and ascertain critical impact categories.

2.2 Intended applications

To ascertain critical impact categories related to processes, from raw material procurement to manufacturing, for cement manufactured around the world and provide the information for design improvement.

3. Scope of the study

3.1 Study subjects and specifications

The study assessed 1ton of average cement manufactured in countries around the world. Furthermore, the scope of this survey includes both "pure" Portland cement and blended cements containing by-products or natural raw materials, and is based on the weighted average for each country.

3.2 Functions and functional units

Cement is a binder that functions by hardening when reacting to water. Cement is mainly used as a raw material for concrete that is used in construction projects. The compressive strength of commercially available cement at 28-day (based on ISO 679:2009) is approximately 35-60N/mm^2.

We used cement 1ton as the function unit for this assessment, which is in line with customary practice.

3.3 System boundaries

Excavating natural raw materials, cement manufacturing, and contribution to reductions by the use of wastes in manufacturing processes. (Fig. 3.3-1)

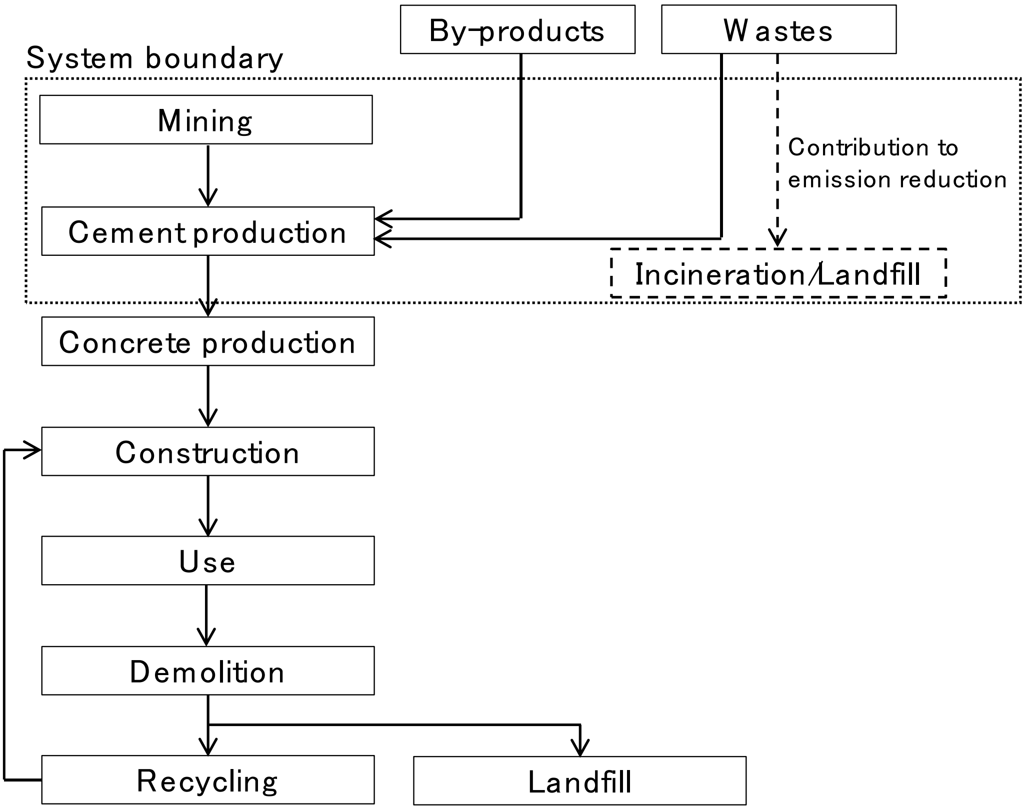

Fig. 3.3-1 Major cement product systems and system boundaries

3.4 Special notes (excluded processes, matters, etc.)

As for the definition of wastes and by-products, of those products not classified as the main product, objects applicable to the Act on Waste Management and Public Cleansing are defined as wastes and objects not applicable are defined as by-products. Specific applicable items are indicated in Chapter 4.1.

Scope2 CO_2 emissions and transport processes were not assessed due to insufficient data. With cement manufacturing, generally Scope1 CO_2 emissions are larger[1)]. Furthermore, due to the low unit price per product weight, long-distance transport is often not conducted.

Concrete manufacturing and structure construction, use, and demolition processes were also eliminated from the scope of this survey. The environmental impact of concrete manufacturing and structure construction and use are not significant[2)]. Conversely, in Japan, 99.3% of waste concrete generated during the structure demolition process is recycled[3)]. However, overseas, this is not sufficiently recycled and it is possible this has a significant environmental impact.

4. Inventory analysis

4.1 Inventory data

For cement foreground data, we used "Getting the Numbers Right (GNR)[4] published by the World Business Council for Sustainable Development (WBCSD) Cement Sustainability Initiative (CSI) and Japan Cement Association data from 2016[5]. For cement produced in countries other than Japan, we conducted the following calculations using additive and mineral admixture data after calculating data for clinker, an intermediate product. We assumed the volume of natural raw material used to be 1500kg/t. It is noted that the volume of wastes used in countries other than Japan is minor[6]. However, there is no published data, we used the rate of alternative raw materials (3.6%) indicated in the Heidelberg Cement Sustainability report as a flat rate for countries other than Japan. We assumed there was no fossil fuel source other than coal and calculated the volume of coal used by dividing the product of the specific heat consumption and conventional fossil fuel rate by the low calorific value of bituminous coal[7]. For NO_X, SO_X, and dust emissions volumes for countries other than Japan, we used the average value published in the CSR Report by the WBCSD CSI core members as a flat rate. The impact on results by using the same value is estimated to be insignificant, because the variation coefficient for NO_X, the substance with the most significant environmental impact, was relatively small at 0.25. Cement data is calculated based on clinker data and the volume of gypsum and mineral admixture used. Only blast furnace slag and fly ash were treated as by-products, and other mineral admixture and gypsum were assumed to be natural resources. Background data on mining of natural raw materials was excluded from the scope of evaluation because sufficient data could not be collected.

4.2 Items in the inventory analysis and the results

Table 4.2-1 shows analyzed items and results of inventory analysis for cement manufactured overseas.

2.1
Environmental impact assessment for cement manufactured in countries around the world.

Table 4.2-1. LCI analysis result of cement (unit (kg/t))

		Japan	India	Philippines	Thailand	USA	Brazil	Germany	Egypt	Ref. No.
Resource comsumption	Natural raw materials	1123	1183	1258	1422	1454	1359	1421	1445	4, 5, E
	Coal	80	87	90	98	116	87	43	125	4, 5, E
Emission	CO_2	651	616	609	707	766	671	578	773	4, 5
	NOx	1.240	1.089	1.029	1.222	1.315	1.171	1.237	1.288	4, 5, E
	SOx	0.065	0.229	0.216	0.257	0.276	0.246	0.260	0.271	
	PM	0.026	0.047	0.045	0.053	0.057	0.051	0.054	0.056	
Avoided emission	Waste use	229	42	40	47	51	45	48	50	4, 5, E

E: Inventory data is estimated by the method described in the text.

5. Impact assessment

5.1 Assessment steps and impact categories

For the impact assessment, we used the LIME3, Life-cycle Impact Assessment Method based on Endpoint modeling, to conduct a damage assessment and an integrated assessment. Impact categories applicable to each assessment are shown in Table 5.1-1. Furthermore, for the LIME3 assessment, we used the rebate rate of 3% to calculate the damage coefficient for social assets.

We treated wastes and by-products as follows in the evaluations. Wastes that are alternatives to raw materials are treated as having contributed to reductions since environmental load that would have resulted from the landfill disposal of substances is avoided thanks to their use in cement. Wastes that are alternative energy source are treated as having avoided the CO_2 emissions that would have resulted from incineration outside the cement plant thanks to their use by the cement plant. Using published calculation methods[4)], that portion of CO_2 emissions is subtracted from the CO_2 emissions produced at the time of cement production (in other words, we used the net CO_2 emission intensity). Since it is assumed that by-products are not intended to be disposed but instead will be distributed to the market as products of value, we did not consider the contribution to reductions resulting from landfill avoidance. The method of allocating the environmental load of a main product to by-products is defined in ISO14044. However, due to insufficient data provision from suppliers, here we assume there is no environmental load from by-products and indirectly reflect only the reduction in environmental load attributable to reductions in natural resource consumption.

Table 5.1-1. Applicable environmental impact categories and assessment steps

	Damage assessment
Climate change	✓
Air pollution	✓
Photochemical oxidants	✓
Water resource consumption	
Land use	
Resource consumption (fossil fuels and mineral resources)	✓
Forest resource consumption	
Wastes	✓

	Weighting
IF1	
IF2	✓

5.2 Impact assessment results

5.2.1 Damage assessment

The results of impact assessments for the four areas subject to protection (Breakdown by substance) are shown in Figure 5.2-1 to 5.2-4. With human health and biodiversity, the impact of CO_2 emissions was largest in all countries. In India and Thailand, the impact of NOx on human health was also significant. In the case of the impact on social assets, coal consumption was significant in the Philippines and Egypt while in Japan, USA, and Germany, the impact of reduction contributions due to the use of wastes was significant. In the case of the impact on primary production, limestone and coal consumption was significant and in Japan the impact of reduction contributions due to the use of wastes was also significant. As for the impact on human health and social assets, there was significant divergence between each country, which was attributable to NOx and coal consumption, and waste use.

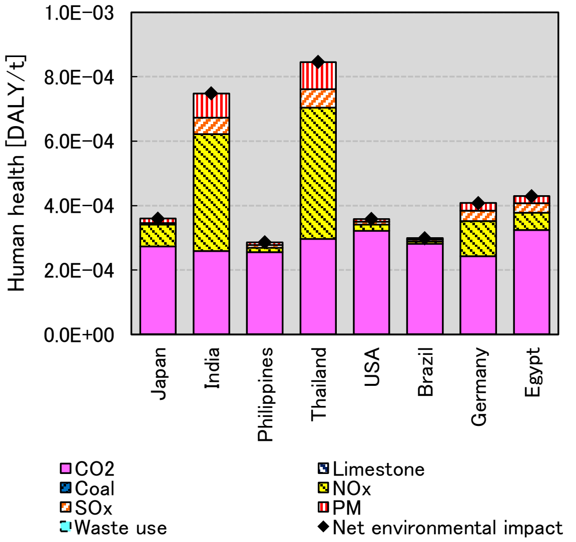

Fig. 5.2-1 Damage assessment results (human health)

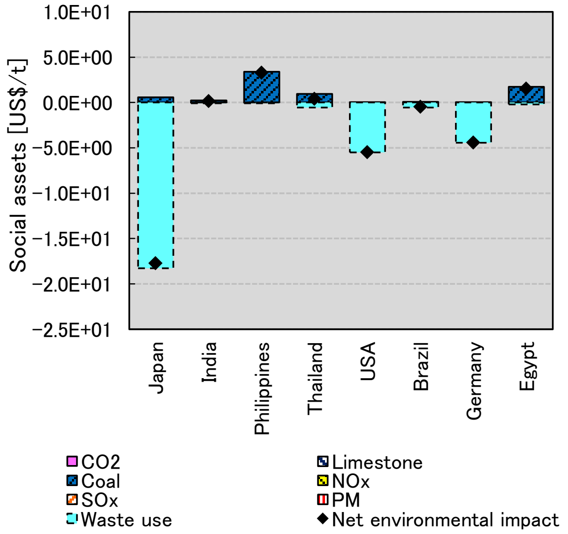

Fig. 5.2-2 Damage assessment results (social assets)

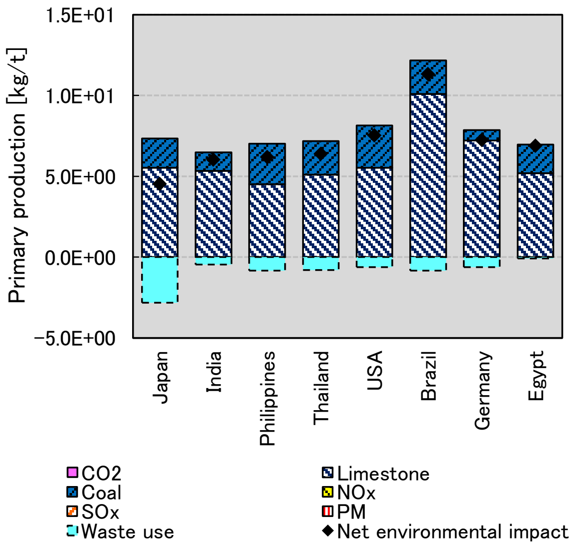

Fig. 5.2-3 Damage assessment results (primary production)

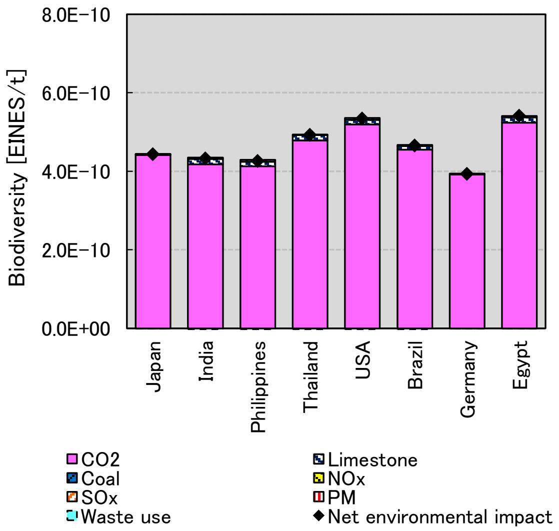

Fig. 5.2-4 Damage assessment results (biodiversity)

5.2.3 Weighting

Fig. 5.2-5 shows weighting results for cement manufactured in each country (by substance). The environmental impact of CO_2 emissions was significant in all countries. On the other hand, the environmental impact of coal consumption assessed as high in the Philippines. This is because sustainability (Reserves to production ratio) was assessed as low due to the use of coal from countries with low reserves. The environmental impact of NOx was assessed as significantly high in India and Thailand. This is because of large populations in dispersed areas, resulting in significant total health damage. In terms of total environmental impact, results for India, the Philippines, and Thailand were very high compared to other countries. As mentioned above, this is because the environmental impact of coal consumption or NOx was higher compared to other countries.

When assessing reduction contributions attributable to avoiding the landfilling of wastes, it was found that the impact was greater in Japan, the United States, and Germany. With Japan in particular, avoiding landfills makes a significant contribution to reduction because cement clinker is manufactured using large volumes of waste, and user costs for waste disposal are significant. Furthermore, the results for Japan showed similar trends to the assessment conducted using LIME2.[8)] In the United States and Germany, user costs for waste disposal are significant, resulting that reduction contributions due to waste utilization were assessed to be high. However, the accuracy of these results is considered to be lower than other results because waste utilization volume in countries other than Japan is an estimated value and the accuracy of the damage coefficient estimate for foreign waste in LIME3 was low.

Fig. 5.2-6 shows weighting results for cement manufactured by impact domain. Global warming had a significant impact in all countries. On the other hand, the impact of resource consumption, air pollution and the reduction contributions due to the use of waste utilization varied greatly depending on the manufacturing methods and environmental conditions in the target countries.

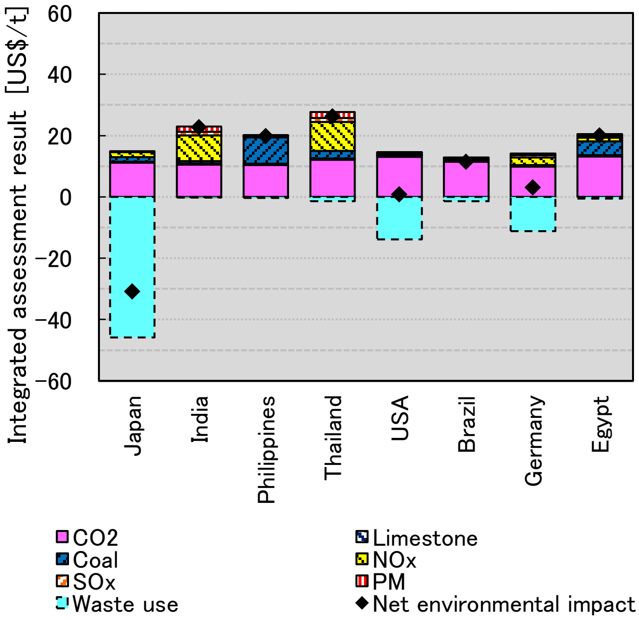

Fig. 5.2-5 Integration results (by substance)

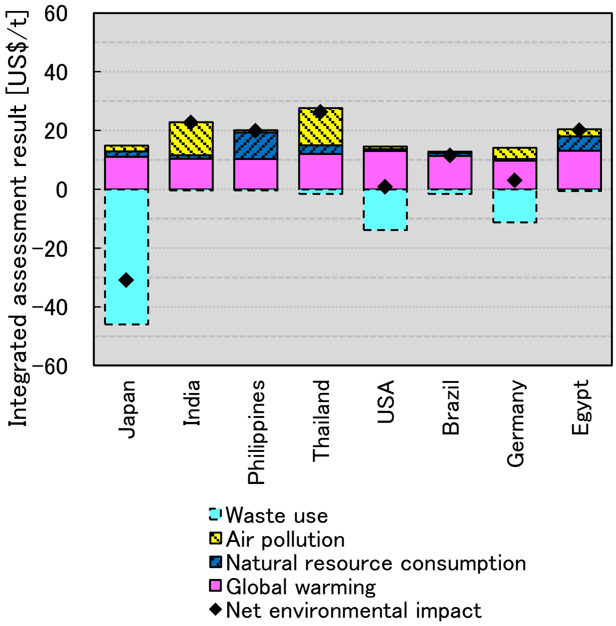

Fig. 5.2-6 Integration results (by impact domain)

6. Conclusion

6.1 Summary of the results

We assessed the environmental impact of processes, from raw material procurement to manufacturing, per 1ton of cement manufactured around the world. Results showed that the environmental impact of CO_2 was large in all countries. On the other hand, the environmental impact of coal consumption was assessed to be large in the Philippines, and the environmental impact of NOx was assessed to be significant in India and Thailand. In terms of total environmental impact, significant results were obtained in the above three countries (Philippines, India, and Thailand). The assessment of landfill avoidance through the use of wastes suggests that Japan, the United States, and Germany can achieve a significant reduction contribution effect.

6.2 Limits and future issues

Since inventory data other than that related to CO_2 emissions have not been sufficiently disclosed by the WBCSD-CSI, many numerous assessments were made using estimated values. Since we used indirect data, including CSR reports from major manufacturers, not released by country, the evaluation results are not expected to change significantly but further verification is required. Also, based on the results of this impact assessment, it is necessary to inform relevant parties that the disclosure of data other than CO_2 emissions is also important.

Since only the cement manufacturing process was evaluated, we could not conduct an assessment throughout the life cycle. In particular, the demolition process (waste concrete) of structures overseas is thought to have a significant impact.

WBCSD-CSI[4)] did not have sufficient data, so no assessment of China was conducted. Since China is the world's largest producer of cement, it is necessary to utilize other databases and conduct an assessment in the future.

Reference literature

1) Sakai and Daimon (eds.) (2009) Gijutsu Shoin
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