Proceedings of the
International Conference on Mechanical Engineering and Renewable Energy 2015
(ICMERE2015) 26 – 29 November, 2015, Chittagong, Bangladesh

ICMERE2015-PI-100

ECONOMY-WIDE MATERIAL FLOW ANALYSIS OF CEMENT INDUSTRY IN BANGLADESH

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Abstract- *Cement consumption in Bangladesh is increasing. However, little information is publicly available on the flow of materials in this sector which we addressed through the material flow analysis (MFA) of cement for the first time in Bangladesh. MFA elucidates inflows, hidden flows, outflows, emissions, stocks etc. We have utilized trade data from domestic and international, online and offline, free and proprietary sources. Demand and supply scenario of cement was analyzed and projections for future scenario have been done. The export potential may not increase that much (only 8.5% growth) which means a substantial percent of the installed cement production capacity will remain useless which indicates poor resource efficiency. MFA indicated that in 2011 for every 1% GDP growth the cement consumption was 1.695976 million MT and 1.995084 million MT under two scenarios which we have considered. Total material requirement (TMR) for cement in Bangladesh was 14.89445 and 15.04116 million MT under two scenarios. Due to absence of recycling, we could not calculate recycling efficiency. If recycling is done pressure on virgin raw material will be reduced and environmental footprint of this industrial sector will be minimized.*

Keywords: Cement industry, Industrial ecology, MFA, Economy-wide material flow analysis, Sustainability.

1. INTRODUCTION

The natural resources are indiscriminately used all over the world without any control. This is causing serious problem like energy crisis, environmental pollution and degradation of ecosystem functions. The essence of realizing the sustainable development of the economy lies in coordinating economic growth with sustainable resource consumption and environment protection [1].

Cement consumption is increasing rapidly as the economic growth and infrastructure development is showing simultaneous increment. It serves as the most vital building material in most of the modern societies. Cement concrete is the second most widely consumed material of the world after water [2]. Cement production process is complex, involving quite a number of materials with various properties and pyro-processing techniques. The process involves consumption of handsome amount of limestone and clay as the main raw materials and of coal and electricity as energy [3], [4]. Cement industry uses different types of fuels [5] and it results in emission of CO_2, dusts and other harmful substances during production [6]. The production brings both economic output as well as huge ecological stress [7], [8]. In Bangladesh, the real estate industry is expanding rapidly, and the infrastructure construction is constantly improving [9]. Consequently, the demand for cement is increasing. Besides, many entrepreneurs are willing to use the favorable condition to manufacture cement for export. As a result, cement industry is a vibrant one in Bangladesh.

Cement industry is completely dependent on the import for raw materials and the sources of these materials are virgin resources. The supply of these materials is affected by natural stock, geopolitics, inter-governmental relationship and the economic condition of the country. The cement industry is responsible for approximately 5% of global anthropogenic CO_2 emissions [8]. The cement industry emits around 0.9 tons of CO_2 for every ton of Portland cement produced. This emission comes from both energy use and the calcination process, which is a chemical reaction in the kiln [6]. These altogether demands a dire necessity of a comprehensive material flow analysis (MFA) from the perspective of cement industry as a whole and of policy makers to ensure sustainability in this sector. This paper presents the framework, assumptions and results of an Economy-wide MFA (EW-MFA), which portrays the material basis of a country or region, for cement industry in Bangladesh and it is the first time that such an analysis has been performed for the case of Bangladesh. It provides an insight into the consumption of cement, raw materials acquisition for production, production process and types of cement, and some indicators of MFA study.

In a broader scale, this study is a move to address the opportunities for more effective material management of cement industry in general. This study is an attempt to clearly define the lifecycle of cement from import of raw materials to cement consumption, to perform an input-output based study of the cement industry in Bangladesh, to make projections for the cement industry and to derive and compare MFA indicators for the industry. The article starts with a view of the history of cement and cement industry in Bangladesh. Later the MFA methodology and indicators are discussed. The cement consumption pattern over time, cement production and production capacity of the industry are illustrated. The study also addresses some future projection for the industry.

1. MATERIALS AND METHODS

Five basic steps were taken to conduct this MFA viz. determination of system boundaries, data collection, and assimilation of useful forms, accounting and presentation of results which are addressed in the upcoming texts.

2.1 Data Collection

To account the inflows and outflows, a comprehensive database is established.

2.1.1 Data sources

Though taking data from each individual relevant contributor/stakeholder in this industry is preferred; the large scope of this study falls short of doing so. The main data sources utilized for this study are: interview in the cement industry; Chittagong customs house (CCH) database; export promotion bureau of Bangladesh; United Nations Commodity Trade (UNComtrade) Statistics database; publicly available data from the World bank; reports, prospectus, documents on cement industry of Bangladesh and newspaper articles.

2.1.2 Dealing with data uncertainties

Data uncertainties arise from various aspects as methods of data collection are different and statistical integrity of data collection is not homogenous in all the cases. Another uncertainty rises from unclear definition of system boundary. Considering the unavailability and unreliability of databases in a certain system boundary, MFA studies sometimes warrant estimation/assumption which may further cause data uncertainty. To deal with above mentioned uncertainties in this study we have tried to follow some consistent data sources and made some criteria prior to the selection of data.

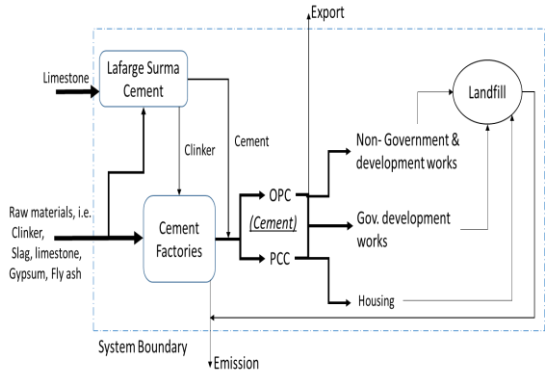

Fig.1: Delineation of the system boundary for this study.

We used CCH database for the period of 2006 to 2012 to know the imported raw materials. But, there is a possibility of importing raw materials through other entry points other than Chittagong e.g., Mongla port and other land ports of Bangladesh and the data through these entries were not possible to account. To overcome this discrepancy, we utilized UNComtrade database as main data source. Again in case of UNComtrade we have data available for 2000 to 2007 and for 2011. But there is no data available for the year 2008 to 2010. In that case we have used the data from CCH. Two different scenarios have been assumed based on the different data sources and information which have been addressed in the upcoming texts.

2.2 Tools and Software Used for Analysis

Analysis and graphs are prepared using Microsoft Excel. Maps are prepared with ArcMap, a GIS based mapping software.

2. RESULTS AND DISCUSSIONS

The cement producers have increased their production capacity day by day as the demand of cement is increasing over time (shown in figure 2).

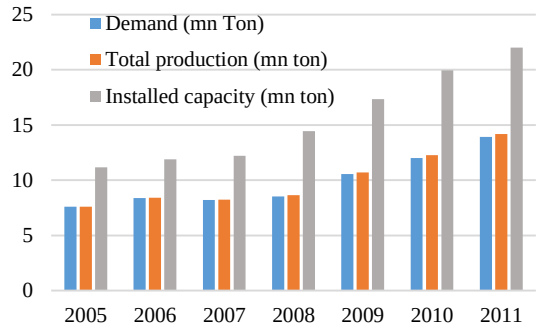

Fig.2: Overall market condition for the Cement industry in Bangladesh.

Although the actual production is a bit higher than demand, a huge gap exists between installed production capacity and the actual production of cement. Figure 3, shows the demand and demand growth rate of cement over time. Kabir [10] suggested that the demand of cement is influenced by several indicators like political unrest, government initiated large infrastructural projects etc.

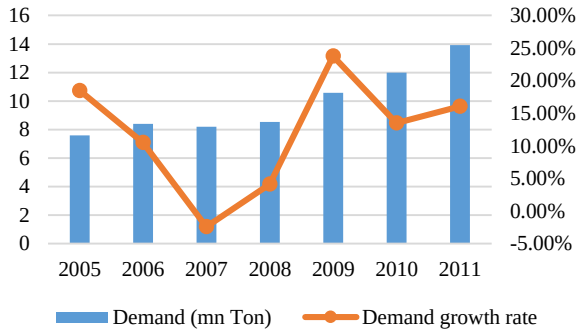

Fig.3: Demand growth rate of cement in Bangladesh.

Figure 3 suggests that the demand of cement seems to decline in 2006 and 2007. One of the possible reasons behind this declining trend might be the country's political unrest during that time. Caretaker government was in power at that time. Huge amount of cash flows are involved in real estate sector. In line with the constitutional mandate of caretaker government, they initiated to cease the black money which ultimately insisted this moratorium. In figure 4 we can see that the GDP growth rate and population growth rate are consistent over time and the demand of cement is maintaining almost a positive growth rate too, except in the period of care taker government (2007). The GDP (in billion USD) and per capita consumption of cement (in kg) have been increasing over time which is apparent from figure 5. Cement export has been stared since 2003 in Bangladesh and export rate

continuously receiving an increment rate in each year. The highest amount of cement was exported in 2010 (figure 6) and Bangladesh earned more than 21 million USD that year.

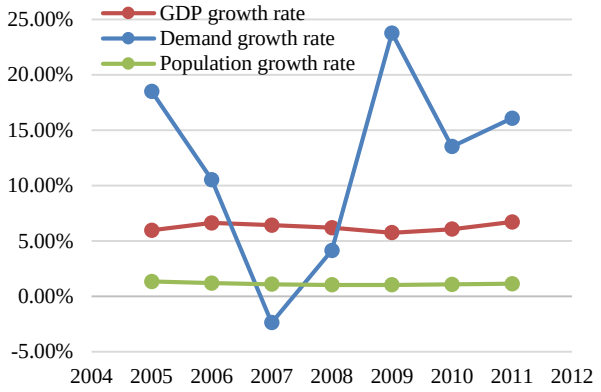

Fig.4: GDP growth rate, cement demand growth rate and population growth rate in Bangladesh.

Depending on the available data, future prediction for country's cement demand, installed production capacity and the export potential of cement has been made for the year of 2015, 2020, 2025 and 2030. The predicted values are given in table 1. Prediction was done using linear regression.

Considering the present growth, the demand of cement in Bangladesh will be 22.1 million tons in 2020 and 32.3 million tons in 2030. Again the installed capacity will rise to 38.672 million tons in 2020 and about 58 million tons in 2030. The export potential will also rise as the production trend of cement in Bangladesh is higher than the demand. From figure 7 it is obvious that with the increase in amount of cement production, the amount of export is also increasing.

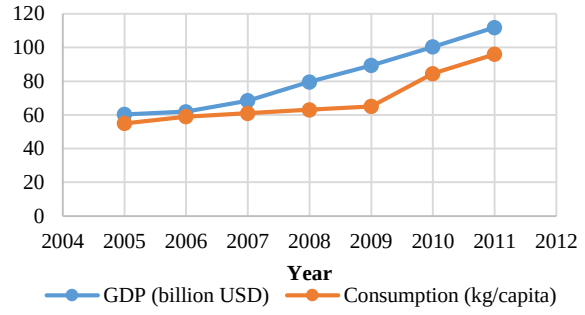

Fig.5: GDP and per capita cement consumption in Bangladesh.

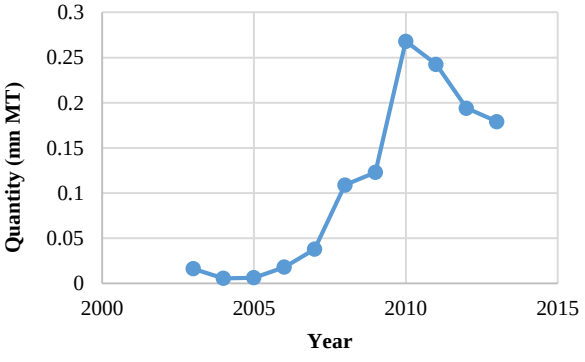

Fig.6: Year wise cement export from Bangladesh.

In Bangladesh amount of cement consumption is dependent on region. More developing regions have higher cement consumption and this has been well reflected in figure 8. As cement is a low cost product, the manufacturers of cement have to minimize their cost by cutting different types of costs from production level to selling. So it is obvious that the cement factories will have a region based market of their product and the factories will be located in such a place that the transport cost will be minimal.

Table 1: Predicted scenario for cement industry of Bangladesh.

	Equation	2015	2020	2025	2030
Demand (in mn ton)	Y= 1.02x - 2038.3 (R^2 = 0.8727)	17	22.1	27.2	32.3
Installed capacity (in mn ton)	Y= 1.9186x - 3836.9 (R^2 = 0.9448)	29.079	38.672	48.265	57.858
Export potential (% of production)	Y= 0.3396x - 680.89 (R^2 = 0.8624)	3.404	5.102	6.8	8.498

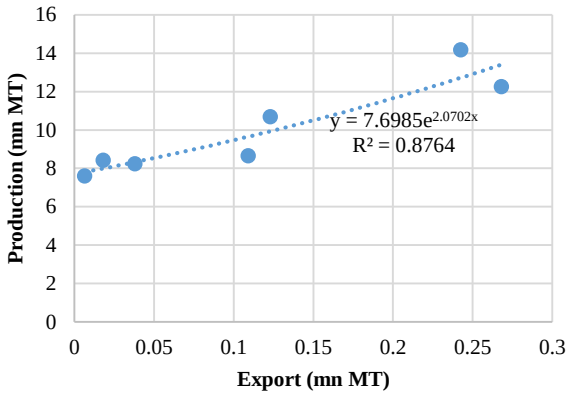

Fig.7: Relationship between production and export of cement in Bangladesh.

In figure 9 cement production capacity as per major regions of Bangladesh is shown. It is to be mentioned that region wise demand and cement production capacity are almost same, which reduces the overall costs for the producers. Among the running 34 cement factories, only 10 producers control over 81% of the total market share. These 10 producers along with their market share is shown in figure 10. Almost all of the cement producers have to import all of their raw materials (clinkers, limestone, gypsum, granulated iron slags, fly ash and other additives) from abroad, except Lafarge Surma Cement Ltd. as it produces clinker from raw materials imported from India. Lafarge produces clinker for its own cement production as well as it sells clinkers to other factories.

Import data has been collected from two different

sources; CCH and UNComtrade. One important thing is to be mentioned here that clinker is the only material among the raw materials which is being used only in cement production; all the other raw materials are being used in many other industrial sectors. So, for this MFA study two different scenarios are considered, where based on the amount of clinkers imported annually the amount of other conjugating raw materials as well as cement production, emissions are calculated.

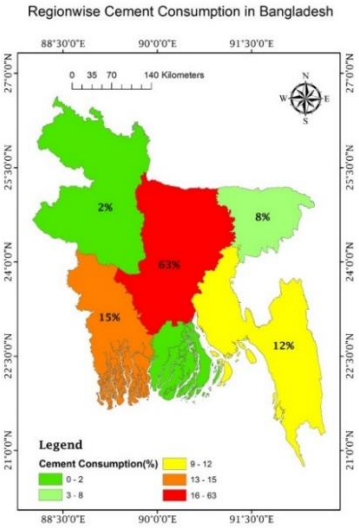

Figure 8: Region wise cement consumption percentage in Bangladesh.

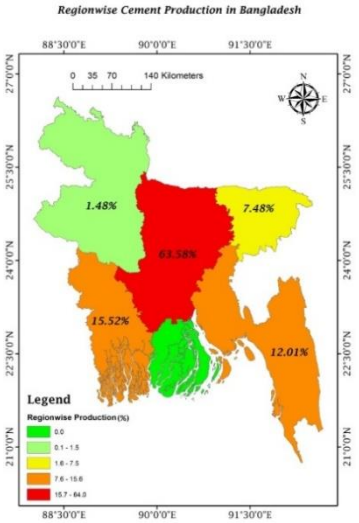

Figure 9: Cement production in different regions of Bangladesh.

Bangladesh mainly produces two types of cement. One is Portland composite cement (PCC), comprising 95% of total production, and another one is ordinary Portland cement (OPC), which is the rest 5%. The raw material composition ratio is different for these two types. Depending on different source of information about the composition ratio of PCC and OPC, MFA calculation for the cement industry has been done.

Scenario 1

In this scenario reference for PCC composition is used from a literature [1]. And OPC composition was confirmed by an interview from a personal of a cement producing company in Bangladesh and from a website [11].

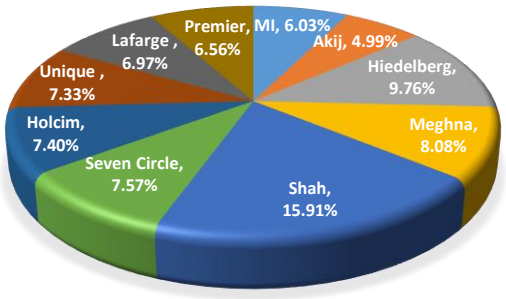

Figure 10: Top ten cement producers of Bangladesh.

Scenario 2

Here the composition of PCC is calculated as found from the interview of the personal from cement industry. And the OPC composition is considered same as scenario 1.

Another important outcome from MFA study are the indicators derived from calculations. In this study indicators are calculated for both of the scenarios. Those indicators are shown in table 2.

In case of Bangladesh, DMI illustrates only the total amount of raw materials imported since there are no available raw materials found domestically. This suggests that Bangladesh needs to maintain some secure source for those raw materials so that any abnormality in supply for any of them may not lead to an adverse impact on the overall industry. Lafarge Surma Cement Company faced similar situation in 2007-2010 since Indian government banned import of limestone from the mines in Meghalaya from where Lafarge collects its limestone for clinker and cement production [12]. From examining the inflow of cement's raw materials, decisions have to be taken with which countries Bangladesh has to maintain good geo-political relationship for her own sake. DMI for scenario 2 is higher than scenario 1. It's because of the composition ratio where in case of scenario 2 the ratio of clinker is lower than the other scenario.

In the two scenarios, total cement production was calculated based on the amount of clinker and its proportion in producing PCC and OPC differently. Later the outcomes were compared with the production data collected from different reports, newspaper articles. The difference between the calculated value and reported value is termed as hidden flow in this context. The differences might have been occurred due to uncertainty of import data as it has been mentioned already.

Another thing is that, the amount of clinker production in Lafarge Surma Cement Company has been added considering their total clinker production capacity (1.15 million MT) in the calculation as well as the total cement production data for Chatak Cement Company has been added as per their production capacity. So there are possibilities to add some amount to the hidden flow from

Lafarge and Chatak cement's calculation.

Table 2: MFA indicators for the cement in Bangladesh.

Type	Indicator	Definition	Scenario	2008	2009	2010	2011
Input	*Direct Material Input (DMI)*	Domestic raw material + Imports in million MT	1	7.568329	8.13763	10.64838	11.38
			2	8.903108	9.572813	12.52637	13.38702
	Total Material Requirement (TMR)	DMI + relevant HF* in million MT	1	9.092242	11.17776	12.93638	14.89445
			2	9.189815	11.28267	13.07366	15.04116
Output	*Domestic processed output (DPO)*	Emissions + waste in million MT	1	0.553245	0.594861	0.778397	0.831878
			2	0.650817	0.699773	0.915678	0.978591
	Total domestic output (TDO)	DPO + relevant HF in million MT	1	2.077158	3.634993	3.06639	4.346328
			2	0.937524	2.409635	1.462965	2.632736
Efficiency	*Resource consumption efficiency (RCE)*	GDP/DMI	1	10.51149	10.98068	9.424915	9.833534
			2	8.935577	9.334425	8.011906	8.359263
	Resource recycle efficiency (RRE)	Recycling waste/DMI	1	-	-	-	-
			2	-	-	-	-
	Resource efficiency of material extraction	Unused/used= HF/DMI	1	0.201354	0.373589	0.214868	0.308827
			2	0.032203	0.178616	0.043691	0.123563
	DMI/GDP growth rate		1	1.22267	1.417706	1.754264	1.695976
			2	1.438305	1.667737	2.063652	1.995084

**HF= hidden flow; GDP is in billion USD.*

DPO has been calculated as 7.31% of total cement production for both of the scenarios. Resource consumption efficiency displays contribution of the cement production sector to overall GDP of Bangladesh. The outcomes are contradictory with some literatures as they have mentioned that the contribution of construction sector to GDP growth is increasing yearly [13], [14]. But some similarities can also be found as the real estate contribution to GDP growth has a decreasing trend [13].

In this study we have not found any evidence or literature of recycling of cement waste in Bangladesh. Almost all of the cement wastes are used for landfill purpose. In that sense the resource recycle efficiency has not been calculated. On the other hand, the indicator resource efficiency of material extraction which is the ratio of unused extracted resources and used extracted resources shows an increasing trend, meaning the production processes are being much more efficient over time.

3. CONCLUSION

Our study suggests that each and every cement companies in Bangladesh are dependent on different sources for their raw material supply. Since the installed

production capacity is much higher than the actual production and cement demand of the country, an avenue exists for the producers to increase amount of their cement export.

Besides, our study encourages recycling of cement waste since no such evidence was found. Noteworthy is that cement is being recycled at the end of their lifecycle in many other countries [2] which means less amount of virgin raw materials are needed for the production.

While initiating the study we have faced difficulties related to the unavailability of relevant data. There are very less information is available publicly on individual cement producers. For future research and analysis of different situations, construction and maintenance of a database will help us to ensure sustainable growth of the industry.

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