Approach to innovative supply chain strategies in cement industry; Analysis and Model simulation

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Abstract

Fierce competition in today’s global markets, the introduction of products with shorter life cycles, and the heightened expectations of customers have forced business enterprises to focus attention on their supply chains. Supply chain management is a vast area. It has tremendous potential to add value as a strategic function for companies in industries. This paper will discuss supply chain optimization on its role in reducing cost in cement industry.

Since 2000, supply chain management has played an operational role within cement and mineral extraction commodity companies. Recently, cost reduction projects have brought supply chain management into the limelight. The level of advancement in cement Supply Chain Management (SCM) can facilitate or constrain world economic development. To analyze the cement supply chain we need to understanding well the nature of cement industry, identifying the most important Inputs and Outputs (starting from Quarry until the End-customer) and utilizing Nowadays-Benchmark tools such as Supply Chain Council’s SCOR model processes, Absolute triangle, ABC analysis and Model simulation.

Keywords: SCM, Cement industry, Integration, Model simulation.

1. Introduction

Cement is the second most consumed substance in the world after water. It is irreplaceable ingredient in a vast majority of the applications needed in our daily life. For instance, civil infrastructure projects, houses, power generation plants and many more cannot be built without it. In general, cement is a mixture of limestone, sand, shell, clay and iron. Famous example is the Normal Portland cement which is the most common type used World-wide.

In the new century global demands on construction and infrastructure improvements; growing awareness of the sustainable development and socially and ecologically motivated regulations, limitation of resources, and growth in some cement markets and declines in others forced the cement producers to scope on the supply and logistics chains. Developing and implementing the right supply chain management strategies will lead to increase in productivity,
maximizing efficiency and minimizing costs and ecological impacts. Customers demand in areas of quality and time are ever increasing and to win the competition, companies need to cooperate more than before. All of these elements bring supply chain management to the forefront of company managers.

It is true that Globalization brings opportunities and challenges to the cement industry. It simply provides the opportunity for the international cement leaders to increase their investments by increasing their production to meet local growing demand and also the opportunity to expand their businesses in newly growing international markets. On the other hand, cement industry faces new challenges, for example, higher competition from newly developed materials and the introduction for more restrictive regulations especially environmental regulations. This is why most cement producers are organizing themselves in national and international cement associations, examples of them are VDZ & BDZ in Germany and Cembureau around Europe.

In the following industry analysis, a research background, a literature survey about SCM, nature of cement industry, Cement SC processes and integration are summarized. Data used is taken from German cement market in (2008-2010). The main objective of this research is to identify the suitable SC-strategy in cement industry. The article written by Isabel Agudelo (2009) “Supply Chain Management in Cement industry” is the starting point of this effort.

To gain better understanding about the nature of SCM in cement industry and its behavior many tools can be used, for instance, SCOR-Model, ABC Analysis and Operational Performance Triangles. In this paper Simple-simulation model was created by Arena-software (Educational version 10). The objective of the model is to measure different parameters such as inventory level, Costs, Assets utilization and customer’s loss. This Model simulates three different scenarios. The first to simulate a day in winter, the second is to simulate a normal-operation day and the third is to simulate a day with the highest-demand in summer.

The following chart identifies the research procedure:

![Research Procedure Chart]

Figure 1. Research procedure (Structure)

2. Research background

In today’s business environment with globalization, specialization, innovation, and outsourcing, it is crucial for entities to cooperate and work in networks. However, such networking may come with its own problems. For instance, one small problem in any part of the supply chain might cause severe problems for the whole network. Thus, supply chain management is needed. Although supply chain management is a hot topic science Nineties; still there are not many articles on supply chain in cement industry. After researching on this topic, the result shows that people concentrate more on cement manufacture. Isabel Agudelo from Massachusetts Institute of Technology might be the first to study the cement industry as a whole supply chain.

In the following literature review three questions will be answered. The first is what are Supply Chain and Supply Chain Management? , the second is what supply chain integration is, and why it is important to the cement industry? , and the third question is which Benchmark and decision tools could assist managers in the cement industry to develop an effective Supply Chain strategy?

There is no strict definition of supply chain and supply chain management. As these topics are developing people gave them different definitions. According to (Cooper and Ellram 1993) "supply chain" seems to be more common across authors than the definition of "supply chain management"

La Londe and Masters proposed that a supply chain is a set of firms that pass materials forward. And because it is common that several independent firms are together involved in delivering products, from manufacturing the product to placing it in the hands of the end user, all of them according to (La Londe and Masters 1994) are members of a supply chain. Christopher (2005) defines Supply Chain as a network of organizations that are involved, through upstream and downstream linkages, in the different processes and activities that produce value in the form of products and services in the hands of the ultimate consumer. In general, a supply chain network is designed and developed to create the maximum value for the supply chain members, from the original suppliers to the final customers. These
entities are linked by Materials flow, information and financial flows. Figure 2 shows a summary of comparison between a Cement- Supply Chain Network and a traditional Supply Chain Network.

The Council of Supply Chain Management Professionals (CSCMP) defines Supply Chain Management as follows: “Supply Chain Management encompasses the planning and management of all activities involved in sourcing and procurement, conversion, and all logistics management activities. Importantly, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third-party service providers, and customers”. In essence, supply chain management integrates supply and demand management within and across companies. Ever since the CSCMP adopted the definition of Supply Chain Management, the integration of activities of procurement, manufacture, transport and distribution management, inventory control and customer service has become a major thrust in many companies.

(Stadtler und Kilger 2007) have chain and coordinating material, information and financial flows in order to fulfil (ultimate) customer demands with the aim of improving competitiveness of a supply chain as a whole.

Horizontal integration is the process of merging similar industries, entering new markets and establishing new Plants, creating joint venture with the national companies or another domestic producers; who produce similar products and service. Vertical integration, on the other hand, is the process of buying out suppliers of that particular industries or creating a joint venture with them. For example Cement company would have an advantage over competitors by vertical integration if that company bought out suppliers like aggregates quarries, establishing concrete batching plants. One advantage of this would be maintaining higher control on raw materials and optimize transportation systems. Although supply chain management in the area of cement industry has been the major topic in the last decades, especially in the north of America, there is still there is a big lack of research in many countries and nations such as in Latin America and India; nowadays. Based on Isabel Agudejo’s research, the most discussed topics about cement manufacturing and material management. Sustainability has also become a hot topic in cement industry. In her report she concluded that, there was no conceptualisation about the role of SCM or the right structure of the cement supply chain in the cement industry from a broad perspective, without focusing on a particular company. Furthermore she presented an insight into the role and structure of SCM in cement industry. Concerning strategies; in his article “The essence of excellence” Larry Lapide (2006) presented a framework for supply chain strategy. According to him “An excellent supply chain is a competitively principled supply chain where there is an alignment between supply chain strategies, operating models and metrics within the strategic framework of the company”.

Figure 2: Consistent of a traditional Supply Chain Network and Consistent of cement Supply Chain Network.
Furthermore, Agudelo (2009) emphasized that managers have to understand the corporate strategy and develop and execute the right supply chain strategy which aligns with the corporate strategy.

Following are some decision tools which assist managers to locate the suitable strategies for their supply chains:

- **Operational performance triangles (Absolute and Relative)**
  Performance triangles could identify the actual position of Company within their Competitors in the target market. Supply chain strategy execution needs to balance the operational performance objectives which are classified in three groups: (Customer Response; Efficiency; Asset Utilization). In Figure 4a; Lapide expanded the performance triangle with the conception of absolute and relative triangles. Agudelo also confirmed this tool and benchmarked some cement leaders at her relative Triangle in (Figure 4.b).

![Figure 4. (a) Performance triangle (Lapide 2008); (b) Absolute triangle and Relative triangle; source Agudelo (2009)](image)

- **ABC-Analysis**: This tool is used to help supply chain integration and Push-Pull boundary decision according to seasonal demand and Reorder Points ROP. ABC-Analysis is a range of items which have different levels of significance and should be handled or controlled differently. It gives managers quick and simple review of assortments of products in retail, wholesale or business to businesses. Figure 5 classifies product types into 4 categories: Class ‘A’ is given to clinker as a primary product. Class ‘B’ for bulk cement as the highest sold product. Cement in bags is classified as class ‘C’ and class ‘D’ was given to masonry cement for several Applications. Bulk cement is known as a Mature-market’s product, the major customers are big and middle constructors, concrete producers and manufacturers of building materials. Cement in bags is known as an Emerging-market’s product, the major customers are middle and small constructors, DIY (Do It by Yourself) customers and for exports. Types of masonry cement mostly sold in bags, the major customers are small constructors and DIY customers.

- **Supply-Chain Operations Reference (SCOR) Model** is another tool. It is used as benchmark tool to analyse the cement supply chain processes. In general, SCOR Model is a cross-functional framework for evaluating and comparing supply chain activities. It was developed as an independent global consortium of more than one thousand corporate members. Based on (SCOR Model 2009) Agudelo summarized the cement supply chain characteristics in (Figure 6).

![Figure 5. Classified Products per Production/Sells(%).](image) ![Figure 6. Summary of the cement supply chain Characteristics;(Agudelo)](image)
3. Industry Analysis

From research findings, the literature analysis was divided into following four specific areas: (1) Commutative analysis; (2) Cement industry analysis; (3) Supply Chains analysis; (4) Product analysis; as following:

3.1. Comparative analysis

Consumption of cement is closely linked to both the state of economic development in any given country or region and to the economic cycle. In mature markets, cement sales are dependent on growth and habits in the construction sector, a sector that is itself following very closely -usually after a brief delay- the economic situation prevailing.

Worldwide cement production increased from 1992 million tons in 2003 to 2185 million tons in 2004. Furthermore; the market received about 2840 tons in 2008. It means that; Cement consumption increases of about 700 Million every 5 years; globally. See figure 7.

The largest producer of cement is China which accounts for 48.9% of global production, followed by India and the United States. Both China and India are transition markets which together account for 55.1% of the world total production.

Concerning market competition; the ranking of the top cement producers changes enormously each year. Figure 8 shows the market share of the biggest cement producers worldwide. They produce about 26% of the total world production.

3.2. Cement industry analysis: Cement industry is:

- A capital intensive industry. The investment cost of cement plant with a capacity of one million ton annually is about €120 Million Euro, with correspondingly high costs for modifications. The pay-back of investment of a cement plant is about 8 years, which ranks the cement industry among the most capital intensive industries.
- An energy intensive industry. Each ton of cement produced requires 60 to 130 kilogram of heavy fuel or its equivalent, depending on the cement variety and the process used, and about 105 KWh of electricity.
- An industry with low labour intensity. With the development of modern automated production lines and continuous material handling systems, the cement industry has become a process industry using a limited amount of skilled labours. A modern plant is usually manned by less than 150 employees.
- An industry with a homogeneous product. Although produced from natural raw materials which vary from plant to plant, cement can be considered a standard product. There are only a few classes of cement and in each class products from different producers can generally be interchanged. Therefore, price is the most important sales parameter next to customer service. Quality premiums exist but are rather limited.
3.3. Supply chains analysis:

The Approach of this analysis is based on the main SCORE processes (Plan, source, make, deliver and return).

- **Plan** includes the management processes to coordinate aggregated supply and demand. Plan generates a course of action to satisfy source, make, deliver and return requirements. SCM practices were independent in the last decades until recently the SC processes are integrated and centralized in large cement corporates. Costs can be reduced and cement supply chain processes can be optimized by SC integration. This can be done through alternative raw materials utilization, Cement-Concrete chains integration, vertical transport integration and information integration. Furthermore some of cement producers used IT solutions such as i2 in America and SAP in West-Europe.

- **Source** is an umbrella for the processes that produce goods to satisfy customer requirements, from strategic roles such as identifying and selecting supply sources, to the execution of operational and tactical activities. Source also includes risk management, contracts and negotiation. There is no clear evidence about limitations in the availability of limestone but some countries have more potential than others. Cement companies normally own the quarries or get license agreements with the government to exploit them. In a majority of the countries, governments control cement and mining industries with environmental regulations related either to the exploitation of raw materials or to the environmental impact of the process.

- **Make** covers the processes of transforming a product from raw material to finished good. Make includes processes such as work scheduling, work in process inventory control, testing and packaging. Quarries of a cement plant have to be large enough to support a cement plant that is designed to last about 100 years on average. Cement manufacturing process is capital and energy intensive and highly automated continuous production. Stoppages and fluctuating in production are very costly. Companies have to minimize logistics costs while avoiding stops. Traditional cement production process is make-to-stock (MTS). This means that production is made to satisfy a sales plan so final products can be kept in warehouses and wait for demand to be delivered.

- **Delivery** is an umbrella for the processes that provide finished goods to meet planned or actual demand. Delivery typically includes order management, transportation management, and distribution management. Cement is a heavy load with low value-to-weight ratio. In many times the transportation of the product by trucks over distances longer than 300 kilometres may not be feasible (Cembeureau 2008). Mostly, river and railroad transportation enables the expansion of plants coverage by reducing the transportation cost per ton. However, this may require high investment in an adequate infrastructure like terminals and railroads. Cement hardens with water which also creates a challenge in transportation. Cement is distributed in bulk or bags. Bulk distribution requires a dedicated and expensive fleets and specialized equipment for unloading. Bags are more flexible because they can be moved in normal trucks. In emerging markets, distributors such as retailers and wholesalers are the distribution channel for cement in bags, but bags are also hard to load and to unload. Vertical integration with logistics providers and infrastructure is common in the cement industry. This decision depends on the company strategy, the political situation of the country, the competitor’s strategy and the size of the market.

- **Return** covers two types of processes, the return of raw materials to the supplier; the return of finished goods from the customer; and disposing defective, excess or hazardous products to the appropriate destination and ensuring adequate final disposal. Cement returns are uncommon. Returns can be generated by problems with the quality of the product (e.g. wet product) and they are normally resolved by replacing it.

3.4. Product analysis: Cement is

- **A sensitive product.** The conditions during reaction step must be carefully controlled; otherwise, the quality of cement will be influenced. Cement is also sensitive to moisture which makes the storage and transportation have more requirements and causes more costs.

- **A heavy product.** Land transportation costs are significant and cement could not be economically hauled beyond 200 or at most 300 km. Bulk shipping has changed that and it is now cheaper to cross the Atlantic Ocean with 35,000 tons of cargo than to truck it 300 km. However, in large countries transportation costs normally cluster the markets into regional areas, with the exception of a few long-distance transfers where, for example, sea terminal facilities exist.
4. Cement supply chain modelling:

To understand well the structure and behavior of a cement-supply chain, Figure 8 describes the whole production line, including traditional manufacturing steps, distribution networks, common cement transportation modes and Inventory points (Storage). Most of traditional Cement Supply Chains are divided into five major Sections: (1) Quarry works and Crushers, (2) Clinker production, (3) Cement grinding, (4) Delivery processes, through (Bulk / Bags distribution networks).

Figure 8: Cement Supply Chain Model (innovative case)

Materials flow and Resources planning are functionally required to be managed. Assets utilization, costs, Inventory and customers losses will be measured by the target simulation model.

Inventory points represent the stock level of the store units: (1) Raw materials yard, (2) Clinker yard and (3) Cement silos. Inventory during distribution processes is excluded in this paper. In this study the cement plant assumed with a designed capacity of one Million tpa Clinker. It is Assumed that 4% Market share satisfies actual production of 800,000 tpa-cement. Annual operation days between (300-310) days/year. And about 45 days of planned shutdowns for Maintenance and other emerging Shutdowns between (10-20) days/year.

Market demand are taken from the German Market (Annual/Monthly Cement production in Germany, Table 6).

From (Table 6) it is clear that the lowest demand is about 38 (t/hr) in January and the highest demand is in September which is about 139 (t/hr). This means that the plant will lost some customers in the summer. These are taken as Scenario 2 and Scenario 3 whereas Scenario 1 is a normal production day. Data taken from Annual statistics of (BDZ 2009).

Table 6: One Hour cement demand in every Month

| Year | Demand in Germany | Percent. | Plant t/month | Plant t/d | Plant t/hr |
|------|-------------------|----------|---------------|-----------|------------|
| 2009 |                   |          |               |           |            |
| Jan  | 698,298           | 3.0%     | 23,683        | 917       | 38         |
| Feb  | 1,158,810         | 4.9%     | 39,301        | 1522      | 63         |
| Mar  | 1,997,258         | 8.5%     | 67,737        | 2622      | 109        |
| Apr  | 2,218,754         | 9.4%     | 75,250        | 2913      | 121        |
| May  | 2,149,788         | 9.1%     | 72,911        | 2823      | 118        |
| Jun  | 2,386,513         | 10.1%    | 80,939        | 3134      | 131        |
| Jul  | 2,527,485         | 10.7%    | 85,720        | 3319      | 138        |
| Aug  | 2,199,494         | 9.3%     | 74,596        | 2888      | 120        |
| Sep  | 2,536,074         | 10.8%    | 86,012        | 3330      | 139        |
| Oct  | 2,395,443         | 10.2%    | 81,242        | 3145      | 131        |
| Nov  | 2,067,536         | 8.8%     | 70,121        | 2713      | 113        |
| Dec  | 1,252,760         | 5.3%     | 42,488        | 1645      | 69         |
| Sum  | 23,588,213        | 100.0%   | 800,000       | 30972     | 1290       |

Figure 9: Cement Demand (tph); monthly.
5. Model simulation

In general, Model simulation shows how the values are added step by step in the chain and which process might cause the most cost. Optimizing a supply chain network can be carried out by different scenarios with the help of Input, Process and Output Analyzer. Therefore, it gives the decision makers a chance to know how to reduce the cost and improve facility utilization.

There is a lot of simulation software that can be used for industry supply chains. A comparison was made by Kim et al between Arena with other software such as Weight, Extend, Pro-Model, Quest and Witness. According to the study Arena won the highest Score. For those reasons Arena was selected. (Chang-Seop Kim et al. 2004. pg.44)

5.1. Main Simulation model

The simulation model covers the industrial process from the Quarry and Crushers to different customers Records and Discrete modules. This simple model is oriented in customers’ sectors, for instance, Clinker customers, Concrete producers or Constructors, Retailers or Distribution centres (DC) and bags customers and further emerging customers.

Main Model (Figure 10) is divided into 3 Sub-models: (1) Raw materials crushing sub-model, (2) Clinker production Sub-model (Clinking), and (3) Cement grinding Sub-model. See attached Appendix.

According to inventory control, the production process either continues or shut down. When the raw material or clinker inventory reaches its full capacity, the production will be stopped, otherwise it will continue. In General, the production will be stopped when the stock is full. At the same time, if the inventory is smaller than the customer demand the cement plant will lost customer/s.

Elements of cement simulation Model are:
Entity: 1 tph Clinker/Cement
Resources: Crusher, Kiln, Mill and Silo;
Processes: Crushing, Clinking & Grinding

Figure 10: Main simulation model

5.2. Input Data

Based on the 800,000 ton production per year and 305 work days (average), the quantity of entities in 1 hour is 109 Metric ton, if there is no production schedule. The entity enters the system with 11€ initial cost which is the cost of raw material (quarrying and outsource) per ton. Simulation length is 24 hr.

Table 4: Input Data for Entities

| Entity         | 1 ton cement | unit |
|----------------|-------------|------|
| Number of entities | 109         | tph  |
| Initial Value of entity | 11          | €/t  |
| Holding costs    | 10          | €/hr |
| Interarrival time | 0.55        | min  |
|                 |             | EXP  |

Table 5: Input Data for Resources

| Resources       | Capacity | Cost | Quantity | Operat. |
|-----------------|----------|------|----------|---------|
| Quarry & Crusher| 530      | 9    | 11       | 1       |
| Kiln            | 125      | 2    | 19       | 1       |
| Cement Mill     | 220      | 4    | 11       | 1       |
| Silo            | 42000    | 700  | 5        | 1       |
|                 |          |      |          | 24      |
5.3. Output Analysis:

After running the program several times, we got the results in three scenarios as shown in Table 8.

Table 8: Inputs and Outputs analysis in three scenarios

| Items                            | Scenario 1 Normal demand-day | Scenario 2 Lowest demand-day | Scenario 3 Highest demand-day |
|----------------------------------|------------------------------|------------------------------|------------------------------|
| Inputs                           | EXPO(0.55)                   | EXPO(1.8)                    | EXPO(0.55)                   |
| Entity Interarrival              | 67,000                       | 23,683                       | 86,012                       |
| Customer Demand t/month          | UNIF(2.6)                    | UNIF(4.8)                    | UNIF(1.3)                    |
| crusher                           | 5%                           | 1%                           | 5%                           |
| facility utilization              | 88%                          | 27%                          | 87%                          |
| Raw Material Inventory           | 3,563                        | 347                          | 3,984                        |
| Clinker Inventory                | 967                          | 26                           | 577                          |
| Cement Inventory                 | 22,264                       | 5,249                        | 918                          |
| Customer Lost (Account)          | 0                            | 0                            | 11                           |
| Account Lost (t)                 | 0                            | 0                            | 15,200                       |
| Response                         | 49.96                        | 49.53                        | 49.91                        |

In first Scenario, if there is no consideration of customer demand; just to fulfill the 80% of production capacity (target). The utilization of kiln and mill is high enough, but the cement product inventory is the highest (22,264 t).

In the second scenario, the plant manufacture according to the demand which is the lowest in the year. Because of the cold weather, a lot of constructions are postponed. On the other hand, holidays in this season are the highest in the whole year, in this scenario the facility utilization is very low, but the cost of one ton cement production stays the same.

The demand in September (Scenario 3) is also the highest in the year, it can not be fulfilled due the Limitation of the operation capacity; (Figure 9).

The entity cost and facility utilization is similar to those in scenario 1, but there are 11 customers are lost and profit from 15,200 ton of cement is also lost. Scenario 3 has the lowest inventory. After analyzing the output results, we can see that, Make to Order does not fit for cement production, but if customer demand is ignoring, this will lead to higher levels of inventory. The sensitive nature of cement product makes the inventory cost very high. The production cost of one ton cement in this simulation is near to the real figure, which was about 50 Euro without packaging and freight costs. Cement price from the factory is about 60 €/ton, of which is nearly 11% results from transportation (approximately 0.6 €/t.km).

5.4. Innovative strategies: (new Trends)

Regarding to nowadays market changes and new trends, the strategies of cement supply chains and production have to be flexible during the year to meet the Seasonal demand-decline and market changes; especially in the case of emerging markets. Based on Seasonal demand-decline (Figure 9); MTS (Make To Stock) is the traditional supply chain strategy in cement industry and it could be applied in a case of high demand-days **from April to October**.

In Winter- and Autumn days; MTO (Make To Order) Supply Chain strategy or CTO (Configure To Order) are both suitable meet the seasonal demand-decline.a

In cement industry, MTOSCS could be divided into: (Grind-clinker To Order GTO) and (Back-cement To Order BTO) to satisfy an effective supply chains. Alternative strategies recommended as future solutions.b

Further solution is (B&S) Back & Store cement for the next season; which feasible in the countries with low storage costs. Cost assignment is required to confirm this alternative.

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a Janat Shah. (2009) recommended CTO as alternative strategy in the emerging markets and high demands of cement bags in India, pp.252.
b Agudelo(2009) proposed further research to confirm the feasibility of these alternatives; published paper, pp.3.
6. Conclusion:

According to the research, it seems that cement industry lacks of supply chain management. The purpose of this paper is to analyse the supply chain management in cement industry and find out the right supply chain taking into account the specific characteristic of the product and the industry. Market competitiveness between cement producers leads to shortages on data, that avilables for research. Since cement is a commodity, after sales service is not required. But the challenges like pricing elimination and distribution barrier make the cement companies have to rethink about their supply chain strategies. This industry is changing from product-oriented to be customer-oriented. Governments have to take more steps to develop an adequate infrastructure for transportation and to give cement producers the opportunity to integrate will their cement supply chains (horizontally and vertically) and leads them use the friendly transportation modes.

In this paper, Simple simulation model was built, just to give it the first Breathing to run. Different inventories in the three scenarios are presented, but the exact inventory costs and Transport costs were not calculated and analyzed. Arean Model is used in this paper as a simple simulation experiment only; without any innovation. IT Solutions, like simulation tools give the managers the ability to meet the chalenge of the change of prices and competitiveness nowadays. Simulating a sustainable Cement Supply Chains is the next step.

The future vision of the suitable strategy is "shifting cement industry from Assets utilization to be more effective and more customer response".

References

Alsop PA, Post JW. (1995). The Cement Plant Operations Handbook. Dorking, UK: Tradeship. 1st Ed.
Antonio Cimino, Francesco Longo and Giovanni Mirabelli, (2010). A General Simulation Framework for Supply Chain Modeling: State of the Art and Case Study; ICSII International Journal of Computer Science Issues Volume 7, Issue 2, No 3, pp 1-9, ISSN 1694-0784
BDZ; Bundesverband der Deutschen Zementindustrie. (2003). Nachhaltige Transport- und Logistikketten; Ist-Analyse in der deutschen Zementindustrie, (Online) www.initiative-nachhaltigkeit.de
Chang-Seop Kim, James Tannock, Mike Byrne, Richard Farr, Bing Cao, Mahendrawathi Er, (2004). STATE-OF-THE-ART REVIEW; Techniques to Model the Supply Chain in an Extended Enterprise; published by VIVAC Consortium; Task 2.5.1, issue nr. 1
Detwiler, R. J. (1985). Blended cement: Now and for the future, Rock Products Cement Edition 99(7):27–32. Duda, Cement data-book, Vol. 1. 3rd.
Dr. Divina M. Edralin, (Sep. 2004). Are the Cement Industry and its Workers Victims of Globalization? CBE Faculty in the column of Business Focus of Manila Bulletin (online): http://www.dlsu.edu.ph/research/centers/cberd/pdf/bus_focus/cement_industry.PDF
Dr. Raj Kumar. (Sep. 2008). Simulation Modeling in Retail Logistics and Supply Chain, Chapter 28 pp 261; International Research Conference on Retail -Mumbai, ISBN9788174468130.
Handfield and Nicholas Jr. (Sep. 2001). Supply Chain Redesign – Transforming Supply Chains into Integrated Value Systems. FT Press
Hendriks C.A., Worrell E., Price L., Martin N. and Orazua Meida L. (2001). Carbon Dioxide Emissions from the Global Cement Industry. Annu. Rev. Energy Environ. 26:303–29
Hendriks, C.A., E. Worrell, L. Price, and N. Martin, forthcoming, (2003). Greenhouse Gases from Cement Production, Ecofys Energy and Environment, Utrecht, the Netherlands, and Berkeley National Laboratory, Berkeley, California.
Hendrik G. van Oss and Amy C. Padovani. (2003). Cement Manufacture and the Environment Part II: Environmental Challenges and Opportunities. Copyright by the Massachusetts Institute of Technology and Yale University
Hendriks C.A., E Worrell, D. de Jager, K. Blok, and P. Riemer. (2004). Emission Reduction of Greenhouse Gases from the Cement Industry. Greenhouse gas control technologies conference paper - cement, (online) accessed in May 8th, 2010:
Hendrik G. van Oss. (January 2010). U.S. Geological Survey, Mineral Commodity Summaries (Online) accessed in September 2010 http://minerals.usgs.gov/minerals/pubs/commodity/cement/mcs-2010-cemen.pdf
Isabel Agudelo(2009). Supply Chain Management in the Cement Industry. Master thesis in Logistics, published by Massachusetts Institute of Technology, under DOI 496817625
James M Reeve; Mandyam M Srinivasan. (May/Jun 2005). Which Supply Chain Design Is Right for YOU? Supply Chain Management Review; 9, 4; ABI/INFORM Global. pg.50
Janat Shah. (2009). Supply Chain Management; Text and Cases. Dorling Kindersley (India) Pvt. Ltd., ISBN 978-81-317-1517-8. pg.252.
Javed I. Bhatty, Hammer Kosmatka. Innovations in Portland Cement Manufacturing. (2004). Portland Cement Association ; ISBN-10: 0893122343
Portland Cement Association "Cement Industry Overview", (online), accessed in Jun.12th, 2010: http://www.cement.org/econ/industry.asp
Robert B. Handfield. Ernest L. Nichols, Jr. (2002). Supply Chain Redesign: Transforming Supply Chains into Integrated Value Systems. Financial Time Prentice Hall, ISBN 0-13-060312-0
Stadtler H, Kigler C. (2007). Supply Chain Management and Advanced Planning. Springer-Berlin, 4th edition.
The Loreti Group. (Dec. 2008), Greenhouse Gas Emission Reductions from Blended Cement Production; Issues paper, prepared for California Climate Action Registry.
USGS; Cement Statistics and Information/Minerals Information. US-Geological Survey; (online) accessed in April 2010: http://minerals.usgs.gov/minerals/pubs/commodity/cement/
William T. Choate, (Dec. 2003) Energy and Emission Reduction Opportunities for the Cement Industry. prepared for U.S. Department of EERE (Online) accessed in Oct. 22th, 2010: http://www1.eere.energy.gov/manufacturing/industries_technologies/imf/pdfs/eeroci_dec03a.pdf
Appendix: Structures of Sub-models

Sub-model 1.
Crushing and Raw materials-inventory management

Sub-model 2.
Clinkering and Clinker-inventory management

Sub-model 3.
Cement grinding and Cement-inventory management