An Analytical Study of the Cement Sector and Selected Cement Companies in India by using Multi Criteria Decision Making (MCDM) Technique of Analytic Hierarchy Process (AHP) and VIKOR

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Abstract: *Cement sector has suffered due to over capacity build up in the last few years. The ratio of actual production to productive capacity has declined from 93.3 percent in 2009-10 to 63.6 percent in 2015-16. The number of factors are responsible for this decline, apart from recession in housing demand, imposition of GST on housing, and demonetisation of currency. In this study attempt is made to evaluate the performance of Cement companies by using Multi-criteria decision technique. The technique of Analytic Hierarchy Process (AHP) is used in the study to identify the weights of the criteria and VIKOR techniques for deriving the ranking of the of the cement companies assessed on the criteria's or ratios pertaining to Shareholders Fund, Investment Valuation Ratios, Profitability Ratios, Liquidity and Solvency ratios, Debt Coverage Ratios, Management efficiency Ratios and Cash-flow indicators. Based on the methodology used and given the data the three best cement firm are Ambuja Cement, Ultra Tech Cement and Orient Cement.*

Keywords: *Cement Companies, MCDM, AHP, VIKOR, Ratio Analysis.*

I. INTRODUCTION

Cement industry was started in the year 1914, when a cement plant with a production capacity of 1000 tons was set at Porbandar in Gujarat. This was a starting point of emergence of cement sector in India. In a next few years many companies tried their luck in cement manufacturing, few of them failed and few introduced a new way of cement production. Two plants that came into existence during this period were one, at Lakheri in Rajasthan and second at Katni from Madhya Pradesh. In 1918, total cement production capacity in India was about 85000 tonnes per annum. Between 1919 and 1924, six new plants came into existence and the capacity of the earlier plants was raised which resulted in an increase in capacity of cement production of India to 0.56 million tons per annum. After independence, the government made a significant public sector investment in setting up of cement plants under Cement Corporation of India. However, considering a huge demand of the growing economy the actual production was far lower than the demand and as a result the supply gap existed in the 1960s and 1970s and as a result cements had to be imported and commodity was subjected rationing. The cement production capacity in India stood at 17.6 MTPA by the end of 1970s increased further to about 24.3 million tonnes per annum by 1979-80. However, cement industry received a boost with the liberalization of the economy in 1991, with the liberalization of sector, many of the existing companies embarked on a capacity expansion and many other new firms both domestic as well as foreign, entered into this sector. As a result, there was a massive increase in installed capacity from 66.56 mt. p.a in 1991-92 to 431 mt. p.a in 2015-16 that made the country the second largest producer of cement in the world after China. India is having more than 85 large and small cement companies with a total 575 plants, of which 210 are large plants that contribute more than 97 percent of total installed capacity and remaining 365 are mini plants account for the rest. The cement capacity or the cement plants are mostly located near the source of raw material –limestone and Coal.

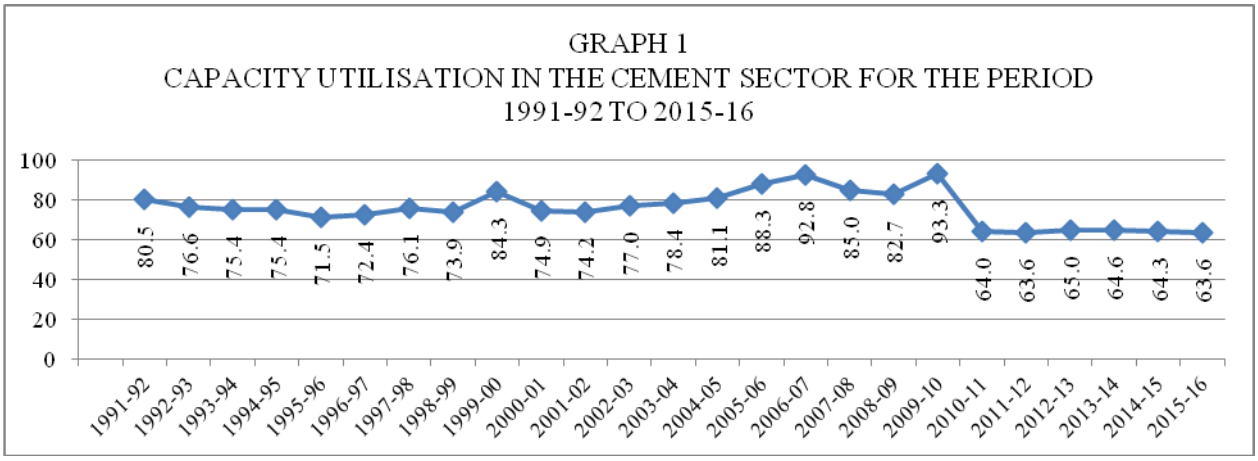
Table1: Growth of Cement Capacity & Production in India

year	INSTALLED CAPACITY (m.t.)	GROWTH RATE (in %)	PRODUCTION (m.t.)	GROWTH RATE (in %)
1991-92	66.56		53.61	
1992-93	70.09	5.30	53.72	0.21
1993-94	76.88	9.69	57.96	7.89
1994-95	82.69	7.56	62.35	7.57

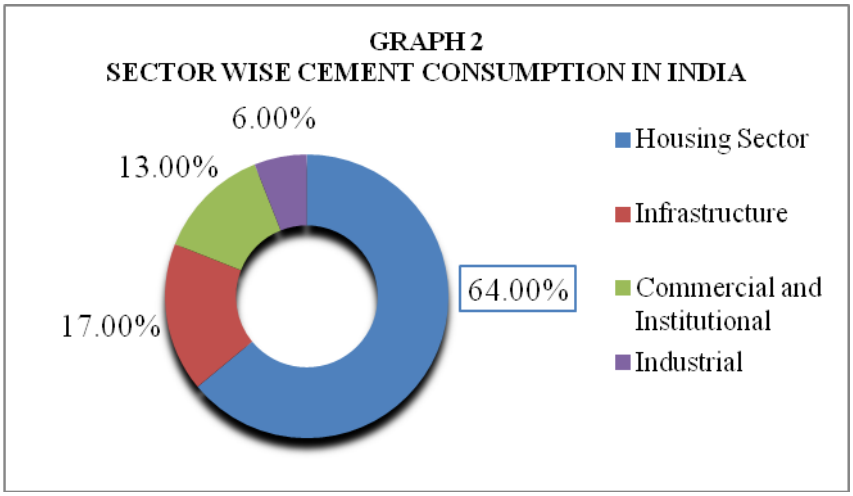
1995-96	97.25	17.61	69.57	11.58
1996-97	105.25	8.23	76.22	9.56
1997-98	109.3	3.85	83.16	9.11
1998-99	118.97	8.85	87.91	5.71
1999-00	119.1	0.11	100.45	14.26
2000-01	130.4	9.49	97.61	-2.83
2001-02	146.13	12.06	108.4	11.05
2002-03	151.17	3.45	116.35	7.33
2003-04	157.48	4.17	123.5	6.15
2004-05	164.69	4.58	133.57	8.15
2005-06	160.24	-2.70	141.51	5.94
2006-07	167.79	4.71	155.64	9.99
2007-08	198.1	18.06	168.31	8.14
2008-09	219.51	10.81	181.61	7.90
2009-10	215.78	-1.70	201.37	10.88
2010-11	328	52.01	210	4.29
2011-12	352	7.32	224	6.67
2012-13	371	5.40	241	7.59
2013-14	387	4.31	250	3.73
2014-15	406	4.91	261	4.40
2015-16	431	6.16	274	4.98
1991-92 to 2000-01		**7.85**		**7.01**
2001-02 to 2010-11		**10.55**		**7.98**
2011-12 to 2015-16		**5.62**		**5.47**
1991-92 to 2015-16		**8.51**		**7.09**

Source: Compiled from various sources
Burange & Yamini (2008)
Report of WG on Cement Industry for XIIth FY Plan (2012-17)
Care Rating (2017) and other magazines etc.

The trend in growth of production and installed capacity is depicted in table 1 above. The table indicates that the installed capacity, which was 66.56 M.T in 1991-92 increased to 130 MT in 2000-01 or in the first decade of the post reform period at an annual average rate of growth of 7.85 percent, whereas, during the same period actual production of cement in the country rose from 53.61 MT in 1991-92 to 97.61 MT in 2000-01 at an average annual growth rate of 7.01 percent. Thus, in the first decade of the post reform period rate of growth of productive capacity was marginally higher than the growth rate of actual production. In the second decade of the post reform period, i.e. for the period 2001-02 to 2010-11 the cement capacity further rose to 328 MT in 2010-11 at an average annual growth rate of 10.55 percent. On the other hand, actual production increased to 210 MT in 2010-11 at an average annual growth rate of 7.98 percent. It can be observed that there is significant difference exists between the rate of growth of Cement Capacity and actual production, indicating over capacity built up in this sector. The post 2010-11 period, saw a further increase in production capacity to 431 MT in 2015-16 with an average rate of growth of 5.62 percent per annum, whereas actual production of cement increased to 274 million tons with an average rate of growth of 5.47 percent. Thus, in the post 2010-11 period the growth of capacity build up as well as actual production slowed down, the major factor that contributed to this slow down was the slowdown in the rate of growth in Indian economy and slowdown in the housing sector due to demand compression. Even if we considered the entire post reform period from 1991-92 to 2015-16 the install capacity increased at an average annual growth rate of 8.51 percent, whereas the actual production rose at an average annual growth rate of 7.09 percent per annum. Thus, for the entire period of the study cement sector is grappled by over expansion of capacity. The capacity utilization in cement sector is shown in the graph 1 below. The capacity utilization in the two decades of the post reform period has fluctuated between a low of 71.5 percent and a high of 93.3 percent achieved in 2009-10. In the post 2009-10 period the capacity utilization has fallen significantly and in 2015-16 it stood at 63.6 percent.



Source: Researchers calculation



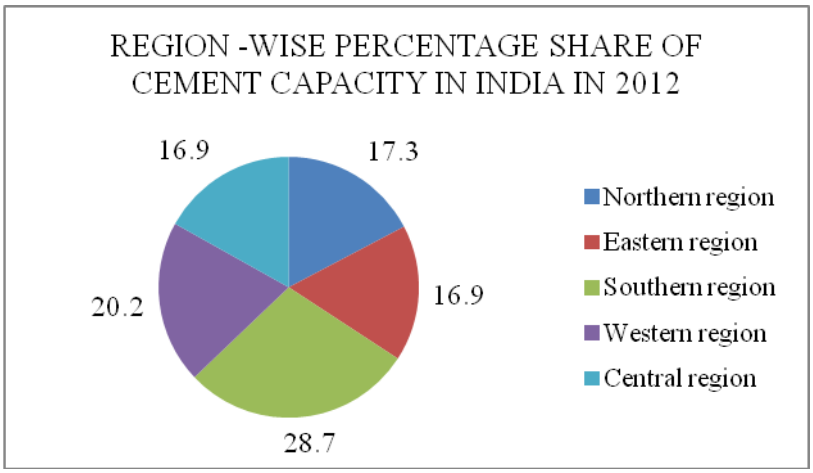
Source: CARE Rating, **January 25, 2017**

The above chart shows the cement consumption by various sectors in India. The data indicates that the housing sector accounts for the highest consumption of cement in India, accounting for nearly 64% of total consumption during the period 2008-2013. This is followed by infrastructure sector with a share of 17%, commercial and institutional sector at 13% and industrial construction at 6%. The slowdown in the housing sector is the major factor responsible for a glut in the cement production and underutilization of capacity. As a result of the slowdown in cement demand, the sector is witnessing upheavals with many small players exiting the sector and large players consolidating their capacity and expanding through acquisition and merger route termed as inorganic growth. Many of the cash rich new players that operated in soaps, cosmetics and other sectors have made their entry into the cement sector. For instance, Emami Ltd, a fast-moving consumer goods (FMCG) company which presently has a capacity of 2.4 MT and plans to scale it up to 15-20 MT in the next three to five years. Also, Nirma group, with a presence in detergent, soap and chemicals sector, has bought Lafarge India's cement business, consisting of 11 MT production capacity. JP Associates have sold their cement plants to UltraTech Cement to quell its debt. Thus, there is a lot of reorganisation of the industry is taking place not only in India but internationally also. For instance, Lafarge and Holcim have gone for the global merger of their business.

The growth of the cement industry is driven by many factors and by many sectors such as infrastructure, housing, overall growth in the economy, the expectation of the people, government rural development programmes, government policy towards housing, etc. The growth of GDP in India positively affects housing and infrastructure development and this, in turn, leads to a higher realization of cement prices.
Since 2009-10 the Indian cement industry has gone through a severe demand recession, which has forced many cement companies to shut down their cement plant. However, in recent years government has drawn up an ambitious plan for expanding investment in infrastructure projects, building of cement roads, promotion of affordable housing by extending concessional loans and interest subvention scheme, smart city projects, etc., that are expected to enhance the demand for cement significantly in future.

The cement is the bulky item and hence transport cost accounts as significant costs in total cost of production and marketing of cement. Hence, though cement industry in India is highly concentrated yet

regionally dispersed with small plants and small firm successfully facing the onslaught of the bigger firms purely on their location advantage. The data on the relative share of different regions in total cement capacity indicates that southern and western region dominates cement production with 28.7 percent and 20.2 percent share respectively.



The cement Industry in India today is grappled with number of problems due to the cyclical nature of the industry. The slowdown in the housing sector after 2011-12 is further accentuated by the GST on the housing sector and demonetisation that followed in 2017. Today, clearly the industry is faced with over supply and excess capacity. The small manufacturers with small production capacity are finding it difficult to survive and hence are happy to exit from the scene whereas big producers and others with deep pockets are on the spree of acquiring any capacity that is put on the sale. In this UltraTech, Holcim-Lafarge, JK laxmi Cement, Vcat-Bharti, JSW are few of the existing cement manufacturing companies that are the notable names in this regard. Apart from the above, the non-cement producers with a sizeable cash fund like Emami, Nirma have also entered and acquired huge capacity from willing sellers. Thus, Cement sector is consolidating among few large producers. It is, therefore, a time to take stock of the Cement sector by evaluating performance of some selected large market capitalisation companies so as to identify the best cement companies for stock investment by using the MCDM method of VIKOR (Vise Kriterijumska Optimizacija Kompromisno Resenje in Syberian) which means Multi-criteria Optimisation and Compromise Solution.

II. REVIEW OF LITERATURE

There are large numbers of studies that uses VIKOR logarithm with its various variants as well as combining it with other MCDM techniques. Mardani, A (2016) briefly evaluates various studies that use VIKOR with its various variants and its combination with other techniques. According to the study, the VIKOR is used in 176 papers of which largest number is in manufacturing field (18) followed by Material selection (17), Marketing (15), Construction Management (14), Performance Evaluation (14), Risk and Financial Management (14), Sustainable and Renewable Energy (13), Supply Chain (12), Human Resource Management (11), Operational Management (10), Service quality (5), Health Care field (5), Tourism Management (4), Water Resource Planning (3) and Others (21). There are very few studies that adopt the methodology followed in this paper that is use of financial ratios as criteria for financial performance assessment of manufacturing companies. One such study is by the Hajihassani (2015 a) to evaluate the performance of 28 cement companies listed on the Tehran Stock Exchange. The study uses following criteria's viz. A) Growth: measured by i) Sales Growth, ii) Operating Profit Growth, iii) Share holder Equity Growth, iv) Asset Growth; B) Liquidity: measured by i) Current Ratio, ii) Quick Ratio, and iii) Cash Ratio; C) Profitability: measured by i) Net Profit Margin Ratio, and ii) Return on Asset Ratio; D) Activity Ratio: i) Total Assets Turnover Ratio, ii) Leverage Financial Ratios, iii) Long term Debt to Shareholder's Equity ratio, iv) Fixed Assets to Share holder's Equity Ratio. The study concluded that on an average, there is an agreement that the Cement Companies such as Shomal, Ardabil and lime Azar shahr, Khush, Esfahan, Chordestan, Mazandaran and Shargh Cement as the best cement companies. Another similar type of study is done by Dedania *et.al.* (2015) uses numbers of MCDM methods one among which is VIKOR in modified form called p-VIKOR for portfolio ranking. The study uses the data of 13 Indian IT companies for 5 year time period and various financial parameters as criteria's to identify and rank alternatives for portfolio investments. The study uses various financial attributes like Total Income, Net Profit, Net Worth, Return on Net worth, Stock Price, Promoters Holding, FII and DII Holding, Operating Profit Margin, Net Profit Margin, Dividend Pay out Ratio. The study concludes that even if p values are changed in VIKOR method within the certain range the ranking remains the same. Though there are limited numbers of studies using financial ratios as criteria for financial evaluation by using VIKOR logarithm, but there are a number of studies using other MCDM techniques. For instance, a study by Moradi and Janatifar (2014) evaluate

the performance of automobile companies listed on the Tehran Stock Exchange by using Fuzzy Multi-criteria Decision Making Approach (FMCDM). The study generates the weights of the criteria by using the method of the Logarithmic Fuzzy Preference Programming (LFPP) and TOPSIS method is used to aggregate the convert multi criteria's to a single measure of performance. The study evaluates automobile firms by using various ratios like: A) Liquidity- measured by the following ratios: i) Current Ratio, ii) Quick Ratio and iii) Cash Ratio; B) Financial Leverage- measured by the ratio of i) Debt Ratio, ii) Long Term Debt to Equity Ratio; C) Activity Ratios- two ratios, namely, i) Account Receivable Turnover Ratio and ii) Total Asset Turnover Ratio is used to measure the level of activity of the firm; D) Profitability is measured by two ratios viz. i) Net Profit Margin ratio and ii) Return on Asset Ratio. The weights of the criteria generated by using LFPP method are then used in the TOPSIS to derive a single score on the basis of which all the alternatives are ranked. This study identifies that the Zamyad Company is the best alternative among all the alternatives.

Islamoglu, M., Apan, M., and Oztel, A (2015) evaluates the financial performance of real estate and infrastructure firms listed on the Istanbul stock exchange with entropy based TOPSIS method. It considers following criteria and sub-criteria's: A) Liquidity –measured by i) Current Ratio, ii) Acid Test Ratio, iii) Cash Ratio; B) Leverage measured by i)Financial Leverage Ratio, ii) Investment ratio, iii) Debt Equity Ratio; C)Assets and Capital Structure- measured by i) Current Assets to Total Assets, ii) Fixed Assets to Total Assets Ratio, iii) Short Term Liabilities to Total Assets ratio, iv) Long Term Liabilities to Total Assets Ratio, v) Equity to Total Assets Ratio; D)Turnover Ratios- i) Asset Turnover Ratio, ii) Equity Turnover Ratio, iii) Working Capital Turnover Ratio; E) Profitability is assessed by two ratios viz., i) Return on Assets and ii) Return on Equity. The study derives weights of the criteria by the Shannon's Entropy Method and multiple criteria values are reduced to the single measure by using TOPSIS Method. Based on the TOPSIS the study identifies the five best performing firms at Istanabul Stock Exchange.

Farrokh, M., Heydari, H., and Junani, H., (2016) uses two MCDM approaches, namely, VIKOR and TOPSIS for evaluating the financial performance of Basic Metal Companies operating in Iran. It uses the following ratios as criteria's on which firms financial performance is aggregated by using two MCDM techniques. These ratios used are 1. Liquidity ratio is studied by i) Current Ratio and ii) Quick Ratio; 2. Financial Leverage Ratio by i) Debt Ratio, ii) Share Holder Equity to Total Assets Ratio, iii) Fixed Assets to Share Holders Equity Ratio, iv) Fixed Assets to Long term Debt Ratio; 3. Profitability Ratio by i) Net Profit Margin Ratio and ii) Return on equity ratio; 4. Growth Ratio by i) the Sales Growth, ii) Operating Profit Growth, iii) the Share Holders Equity Growth, iv) the Assets Growth. The weights or relative priorities of criteria's are generated by using Fuzzy Analytic Hierarchy Process (FAHP). The study finds that both the MCDM methods identified Zanjan Industries as the best among the eight Iranian Basic Metal companies studies by the researcher.

Kazan, H., and Ozdemir, O (2014) uses TOPSIS method to evaluate the financial performance of the fourteen large scale conglomerates listed on the Istanbul Stock Exchange. The criteria used in the evaluation are the various ratios measuring Liquidity, Financial Structure, Activity ratios, and Profitability ratios. In all, 19 criteria's or ratio are considered by the study, the relative weights or priority values of these criteria's are calculated by the CRITIC Method. The critic method is like entropy method is an objective method of weight determination. The study concludes that in 2009 the best conglomerate operating at Istanbul stock exchange was Global Investment Holding followed by Itifak Holding, and Tav Airport holding at 2nd and 3rd position respectively.

Hajihassani (2015 (b)) uses the multi-criteria decision making method of COPELAND to evaluate the performance of 28 cement companies listed on the Tehran Stock Exchange. Using ratio as a criteria's the study identifies that the Azar Shahr and Ardabil lime Cement industry as the best cement industry listed on the Tehran stock exchange.

III. DATA AND METHODOLOGY

The data used in this study is the secondary data compiled from the stock market website mainly moneycontrol.com. The data so collected is not verified with the actual balance sheets available online on company websites or other business website and hence reliability of the data can be questioned. However, casual comparison by the author of the few selected companies balance sheet data figures with that of the data of the business website are found to be correct.

The Multi-criteria Decision Making (MCDM) Techniques or methods starts with data matrix consisting of n-set of alternatives which are evaluated on the basis of m-set of criteria's. Here, the term alternatives imply cement producing companies and criteria's refers to the ratios or indicators on which their performance is judged. The first step in most of the MCDM methods is normalisation of decision matrix in order to eliminate the scale effect. There are large numbers of normalisation techniques that are followed by the researchers in MCDM literature. The Normalisation is generally followed by the weighting of the matrix by the weight vector. The weighting of the matrix is important because a weight implies relative priorities given by the researcher to different criteria's. In fact, the result of the computation will be significantly determined by the weights given to

the criteria's. Here, the researcher can use two methods of weight determination, namely subjective and objective. In subjective method weights are arbitrarily determined by the researcher based on his preference or using the advice or preferences of the experts. There are large number of the methods used by the researcher over the years the documentation of these beyond the scope of this papers. However, the paper uses Analytic Hierarchy Process (AHP) method to derive weights subjectively. The detailed methodology of AHP will be discussed in the later sections of this paper. The accuracy in subjective weights determination largely depends on the experience of the decision maker. In objective weight determination data in the matrix is used to generate weights. In this category, there are methods like Entropy Method [Hwang & Yoon, 1981], CRITIC Method [Diakoulaki *et. al.* 1995], Standard Deviation Method[Diakoulaki *et. al.* 1995], Maximising Deviation Method [Wu & Chen 2007]. Once, the weights of the criteria are determined then weighting of the normalised data matrix is done by multiplying normalised data matrix with the weight vector. The aggregation of the data matrix is then done depending upon the MCDM method that is used in aggregation. In MCDM literature there are large number of methods that are available some of the which are Simple Additive Weighting (SAW) Method, Weighted Product Method (WPM), Analytical Hierarchy Process (AHP) Method, Technique for Ordering Preference by Similarity to Ideal Solution (TOPSIS) Method, (1981), Preference Ranking Organisation Method for Enrichment Evaluation (PROMETHE) Method, Grey Relational Analysis (GRA). Elimination and Choice Expressing Reality (ELECTRE) Method, Complex Proportional Assessment (COPRAS) Method, (Multi-criteria Optimisation and Compromise Solution) VIKOR Method, Additive Ratio Assessment (ARAS) Method, Multi Objective Optimisation on the basis of Ratio Analysis (MOORA) method, etc. The field and scope of the techniques is expanding rapidly with fuzzy or gray variants of this methods or by use two or more methods in combinations in the analysis. In this study we use two method of MCDM namely VIKOR for identifying best performing cement companies from set of top 15 market capitalisation companies operating on Indian stock Exchange and AHP for determination of weights of the criteria.

The criteria's or ratios used in the evaluation of the alternative or cement firms are given in the table 2 below.

Table 2: Brief Outline of Criteria's Used in Performance Evaluation along with the Weights

Sr.No	Criteria or Ratio	Formula of Calculation	Criteria Code	Type of Criteria	Entropy determined weights
1	**SHAREHOLDERS FUND**		**C1**		**0.025**
1.1	EARNING PER SHARE	$=\frac{Earning\ After\ Tax - Prefered\ Dividends}{Equity\ Share\ Outstanding}$	C1.1	Benefit Criteria	0.0125
1.2	BOOK VALUE OF THE SHARE	$=\frac{Total\ Common\ Stockholders\ Equity}{Number\ of\ Common\ Shares}$	C1.2	Benefit Criteria	0.0125
2.	**INVESTMENT VALUATION RATIOS**		**C2**		**0.025**
2.1	OPERATING PROFIT PER SHARE	$=\frac{Operating\ Expenses}{Net\ Sales}\times 100$	C2.1	Benefit Criteria	0.0125
2.2	NET OPERATING PROFIT PER SHARE	$=Operating\ Income\times(1-Tax\ Rate)$	C2.2	Benefit Criteria	0.0125
3	**PROFITABILITY RATIOS**		**C3**		**0.313**
3.1	NET PROFIT MARGIN	$=\frac{Earning\ After\ Tax}{Net\ SALES}\times 100$	C3.1	Benefit Criteria	0.1040
3.2	RETURN ON CAPITAL EMPLOYED	$=\frac{Earning\ Before\ Inerest}{Capital\ Employed}$	C3.2	Benefit Criteria	0.1040
3.3	RETURN ON LONG TERM FUNDS	$=\frac{Operating\ Profit}{Long\ Term\ Funds}\times 100$	C3.3	Benefit Criteria	0.1040
4.	**LIQUIDITY AND SOLVENCY RATIOS**		**C4**		**0.160**
4.1	CURRENT RATIO	$=\frac{Current\ Assets}{Current\ Liabilities}$	C4.1	Benefit Criteria	0.0533

4.2	QUICK RATIO	$= \frac{Quick\ Assets}{Current\ Liabilities}$	C4.2	Benefit Criteria	0.0533
4.3	DEBT EQUITY RATIO	$= \frac{Outsider\ Fund\ (Total\ Debts)}{Shareholders\ Funds}$	C4.3	Costs Criteria	0.0533
5.	**DEBT COVERAGE RATIOS**		**C5**		**0.082**
5.1	INTEREST COVER	$= \frac{Earning\ Before\ Interest\ \&\ Tax}{Interest\ Charges}$	C5.1	Costs Criteria	0.0820
6	**MANAGEMENT EFFICIENCY RATIOS**		**C6**		**0.325**
6 (a)	INVENTORY TURNOVER RATIO	$= \frac{Cost\ of\ Goods\ Sold}{Average\ Inventory}$	C6.1	Benefit Criteria	0.1040
6 (b)	DEBTORS TURNOVER RATIO	$= \frac{Net\ Credit\ Sales}{Average\ Trade\ Debtors}$ or $= \frac{Total\ Sales}{Trade\ Debtors}$	C6.2	Benefit Criteria	0.1040
6 (c)	INVESTMENTS TURNOVER RATIO	$= \frac{Net\ Sales}{Shareholders\ Equity + Debtors\ Outstandig}$	C6.3	Benefit Criteria	0.1040
7.	**CASH FLOW INDICATOR RATIOS**		**C7**		**0.0820**
7 (a)	EARNING RETENTION RATIO	$= \frac{Plowed\ Back\ Gross\ Profits}{Total\ Gross\ Profit}$ OR $= \frac{Total\ Gross\ Profits}{Payout\ Ratio}$	C7.1	Benefit Criteria	0.0820

The alternatives or top ten cement companies considered for evaluation on the basis of market capitalisation are 15 cement companies shown in data table 3.

Analytic Hierarchy Process (AHP) was developed by the Thomas L. Satty in 1980 and since then it is widely used in multi-criteria decision making. Its wide use in MCDM decision making can be attributed to its reliability and easy to use formulation. In AHP, objectives are first defined, then the criteria's to be used for evaluation are identified and then the alternatives to be evaluated are selected. Thus, in AHP, top to bottom approach is used. Here, we use AHP only for the determination of weights of the criteria or relative priorities to be attached to the criteria's.

In AHP, the numerical values are given to the variables depending upon its importance relative to other. The variables or attributes considered may be qualitative or quantitative all are reduced to common measure by using Saaty Scale of Measurement as given in the table 3 below.

Table3: The Fundamental Scale of Ahp (Saaty Scale)

Intensity of Importance		
1	Equal Importance	If two elements contribute equally to the objective
3	Moderate Importance	If criteria is slightly favoured over the other
5	Strong Importance	If criteria is strongly favoured over the other
7	Strong Importance	If one criteria is very strongly favoured over the other
9	Absolute Preference	If the preference of the criteria over the other is absolute or is of the highest possible order of affirmation
2,4,6,8	Used for Express Intermediate values	
Decimals	1.1, 1.2, 1.3,....,1.9	For comparison of elements that are very close
Reciprocal	If element i has one of the above non-zero number compared to j, then j has the reciprocal value when compared with i.	If the judgemental value is K in the (i, j)position in the matrix, then the value 1/K is to be entered into the inverse position (j, i)

In short, weight calculation with the AHP involves the following steps:

- **Construct the pair-wise matrix** by one to one comparison of each of the criteria with each other by using Saaty scale given in the table 3. This yields the matrix $[a_{ij}]_{mxm}$ as shown in the table Matrix 1.

Matrix 1
Pair-wise Matrix of the Criteria's

	C1	C2	C3	C4	C5	C6	C7
C1	1	1	1/9	1/7	1/5	1/9	1/5
C2	1	1	1/9	1/7	1/5	1/9	1/5
C3	9	9	1	3	5	1	5
C4	7	7	1/3	1	3	1/3	**3**
C5	5	5	1/5	1/3	1	1/5	1
C6	9	9	1	3	5	1	5
C7	5	5	1/5	1/3	1	1/5	1

Note that the diagonal values of the matrix are 1 as each of the criteria when compared to itself yield the value of 1. The researcher has to fill only upper section of the diagonal of matrix by pair-wise comparison. Lower values of column are the inverse of the upper values of row.

- **Normalise the matrix** by dividing of the component by sum of the component in each matrix column. i.e $[N]_{ij} = {a_{ij}}/{\sum_i^m a_{ij}}$

- By summing up each of the row of normalised matrix derive the priority vector i.e. the resulting relative weights
- Calculate the maximum value of Eigen Vector (λ_{max}) as a product of the pair-wise matrix and priority vector.
- Calculate consistency index as sum of the values in a maximum Eigen Value Vector (λ_{max}) minus the number that represents the size of the comparison matrix and divide the resulting value by the size of the comparison matrix minus 1. i.e. $CI = \frac{\lambda_{max}-n}{n-1}$.
- Calculate consistency ratio as $CR = \frac{CI}{RCI}$ where CI is consistency Index and RCI is a Random Consistency Index Given by the Saaty. The consistency ratio measures the comparative consistency of elements in the matrix. If the value of CR < 0.10 then there is consistency in comparison of various criteria with each other. If CR > 0.10 then the comparisons made by the decision maker (DM) are inconsistent and DM needs to revise its pairwise comparison.
- Saaty's Random Consistency Index table is as follows;

N	1	2	3	4	5	6	7	8	9	10
RCI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

n- represents the number of items compared in the matrix

Calculations based on the above data matrix 1 yield the following results.

	C1	C2	C3	C4	C5	C6	C7	$\sum n_i$	Priority Vector	$Eigen\ Value$	CI=$\frac{\lambda_{max}-n}{n-1}$	CR=$\frac{CI}{RCI}$
C1	0.027	0.027	0.038	0.018	0.013	0.038	0.013	0.173	0.025	0.175		
C2	0.027	0.027	0.038	0.018	0.013	0.038	0.013	0.173	0.025	0.175		
C3	0.243	0.243	0.338	0.377	0.325	0.338	0.325	2.190	0.313	2.376		
C4	0.189	0.189	0.113	0.126	0.195	0.113	0.195	1.119	0.160	1.210		
C5	0.135	0.135	0.068	0.042	0.065	0.068	0.065	0.577	0.082	0.591		
C6	0.243	0.243	0.338	0.377	0.325	0.338	0.325	2.190	0.313	2.376		
C7	0.135	0.135	0.068	0.042	0.065	0.068	0.065	0.577	0.082	0.591		
								7.000	1.000	λ_{max} = 7.492	0.082	0.062<0.10

Since CR=0.062 < 0.10 the weight of the criteria's obtained by pairwise comparison of criteria's has been consistent. The weights so obtained for the criteria are further allocated equally among sub-criteria in such a way that the sum of the weights allocated to sub criteria is equal to priority values obtained by the AHP method for the criteria. The weights of the sub-criteria are shown in the table 1 above.

VIKOR (Vise Kriterijumska Optimizacija Kompromisno Resenje in Siberian) which means Multi-criteria Optimisation and Compromise Solution was for the first time used by the Opricovic (1998) and later by Opricovic and Tzeng (2002) is based on the LP matrix concept.

$$L_{pj} = \left\{ \sum_{i=1}^{n} \left[w_i \frac{f_i^* - f_{ij}}{f_i^* - f_i^-} \right]^p \right\}^{1/p}$$

$-1 < p < \infty$

$j = 1,2,3, \ldots \ldots, J$

In VIKOR method L_{1j} Lp metric is used to formulate ranking method. The solution given by the $Min_j S_j$ is the maximum group utility and the $Min_j R_j$ gives the minimum individual regret of opponents. The compromise solution is F^c is most feasible solution that is closest to the ideal F^* and compromise means an agreement arrived at mutual agreement. In figure it implies $\Delta f_1 = f_1^* - f^c$ and $\Delta f_2 = f_2^* - f^c$.

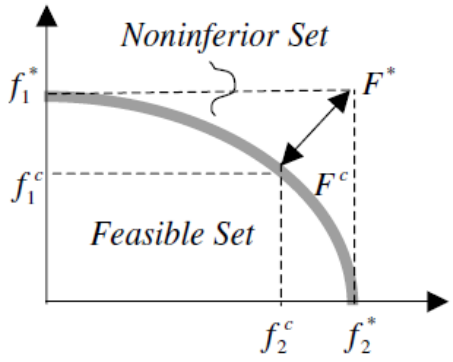


Fig. 1. Ideal and compromise solutions.

Source: Opricovic & Tzeng (2004)

First and foremost data matrix given in the table 4 need to normalised in order to make non-commensurate criteria values commensurate. In VIKOR linear method of normalisation is generally used. In this method:

$n_{ij} = \frac{x_{ij}}{x_j^{max}}$; if benefit criteria;

$n_{ij} = 1 - \frac{x_{ij}}{x_j^{max}}$; if Cost criteria; also

$n_{ij} = \frac{x_j^{min}}{x_{ij}}$; if cost criteria.

The algorithm of VIKOR based on compromise solution is as under:

Step 1: Identify benefit and cost criteria's and determine ideal f_1^* and the nadir f_1^- of all the criteria's such that $f_i^* = \max_i f_{ij}$; $f_i^- = \min_i f_{ij}$; if i^{th} is the Benefit Criteria;

$f_i^* = \min_i f_{ij}$, $f_i^- = \max_i f_{ij}$; if i^{th} is the Cost Criteria.

Step 2: Calculate the S_j and R_j ; j= 1, 2, , ..., J by the relations

$S_j = \sum_{i=1}^{n} w_j \frac{f_i^* - f_{ij}}{f_i^* - f_i^-}$; and $R_j = \max_j \left[w_j \frac{f_i^* - f_{ij}}{f_i^* - f_i^-} \right]$; where w_j are weights of the criteria expressing their relative importance.

Step 3: Compute the values of $Q_j = v \frac{(S_j - S^*)}{(S^- - S^*)} + (1 - v) \frac{(R_j - R^*)}{(R^- - R^*)}$;

Where, $S^* = \min_j S_j$; $S^- = \max_j S_j$; $R^* = \min_j R_j$ and $R^- = \max_j R_j$

The v is the weight of the strategy of 'maximum group utility' and $(1 - v)$ is the individual regret. Generally, $v = 0.5$ is chosen, when$v > 0.5$, the index Q_j will tend to majority agreement and when $v < 0.5$ implies veto.

Step 4: Rank all the alternatives by sorting the values in descending order of S, R and Q and rank the alternatives.

Step 5: From the resultant list of three ranking of alternatives now propose a compromise solution, the alternative (a') which is ranked the best by the measure Q (minimum), the following two conditions are satisfied.

A1 –Acceptable Advantage if

Q (a") –Q (a') ≥ DQ

DQ=$\frac{1}{M-1}$ where M is number of alternatives.

A2 – Acceptable Stability in Decision making

Alternative a' should also be ranked best S as well as R. If one of the above conditions is not satisfied, then set of compromise solution is proposed that consists of:

Alternative a', a", ..., a^m if A1 is not satisfied.

Q^m is determined by the relation

Q (a^m) – Q (a') < DQ for maximum m.

The best alternative ranked by Q is one with minimum value of Q.

IV. DATA ANALYSIS

By performing step1, 2 and 3 the values obtained of S_j, R_j, Q_j are shown in the table 5 below.

Table 4
Ranking of the DMUs based on the VIKOR Method

	Value of			Ranking Based on Values of		
	Si	Ri	Qi	Sj	Rj	Qj
ULTRA TECH	0.5864	0.0937	0.1557	3	2	2
SHREE	0.5295	0.1040	0.5000	1	15	6
AMBUJA	0.6009	0.0922	0.1161	5	1	1
ACC	0.5407	0.1000	0.3486	2	9	4
DALMIA	0.7023	0.1040	0.7812	8	15	12
RAMCO	0.6593	0.1000	0.5408	7	8	7
RAIN	0.7172	0.1040	0.8054	10	15	13
BIRLA	0.7661	0.0977	0.6175	13	5	9
OCL	0.6577	0.0967	0.3981	6	3	5
JK	0.7139	0.0989	0.5838	9	6	8
PRISMA	0.8368	0.1040	1.0000	15	15	15
INDIA	0.8238	0.1023	0.9074	14	11	14
JK LAKSHMI	0.7298	0.0998	0.6468	12	7	10
ORIENT	0.5975	0.0974	0.3312	4	4	3
HELDELBURG	0.7196	0.1019	0.7194	11	10	11

According to the study best firm on the basis of Q DMU 3 is the best firm as it has least Q value. But, does it fulfils the Acceptable Advantage A1 - $Q(a'') - Q(a') \geq DQ$ *i.e.* 0.1557 - 0.1161= 0.0396 < 0.0714 or ($\frac{1}{m-1}$). Hence, the acceptable advantage A1 condition is not fulfilled hence the alternative Q(a^m) - Q($a^{'}$) < DQ for maximum M. The best alternative ranked by Q there for is one with minimum value of Q.

V. CONCLUSION

The ranking of the alternatives are given as per the value of S, R and Q are given in the table. For the table it can be seen that the three best cement companies on the basis of VIKOR technique are:

1. Ambuja Cement
2. Ultra Tech Cement
3. Orient Cement.

It should be noted here that the weights or relative priority of criteria used in the study determines its final ranking. In this technique weights are determined by the AHP technique based on subjective assessment of decision maker. The effectiveness of the results depends on the experience of decision maker (DM). If DM is novice or inexperience then the better option would be to use objective weights determination of criteria by using methods like entropy, critic, etc or simply use equal weights for all the criteria's when choice is difficult to make.

However, the effort here was to use VIKOR technique to identify the best cement companies for stock investment based on relative judgement on priority of different criteria or ratios used in the decision making.

TABLE 2

DATA MATRIX: AVERAGE OF FINANCIAL INDICATORS OF THE CEMENT COMPANIES FOR THE PERIOD 2013 TO 2017

	SHARE PERFORMANCE		INVESTMENT VALUATION RATIO		PROFITABILITY RATIO			LIQUIDITY & SOLVANCY RATIO			DEBT-COVERAGE RATIO	MANAGEMENT EFFICIENCY RATIO			CASH FLOW INDICATORS RATIO
Name of the Cement Company	Earning Per Share	Book Value Of The Share	Operating Profit Per Share	Net Operating Profit Per Share	Net Profit Margin	Return on Capital Employed	Return on Long Term Funds	Current Ratio	Quick Ratio	Debt Equity Ratio	Interest Cover	Inventory Turnover Ratio	Debtors Turnover Ratio	Investment Turnover Ratio	Earning Retention Ratio
ULTRA TECH	84.70	698.82	162.37	812.03	10.50	15.39	16.17	0.66	0.49	0.27	9.98	10.47	18.99	10.47	89.02
SHREE	230.31	1590.66	458.25	1832.98	12.39	15.39	17.69	0.93	0.93	7.85	8.48	19.55	8.48	16.96	0.10
AMBUJA	7.04	3.55	10.37	57.82	12.08	10.00	14.46	1.76	1.47	0.18	20.07	10.38	39.00	11.26	45.77
ACC	46.05	441.12	80.97	610.67	7.54	9.63	13.43	1.05	0.48	16.42	9.59	25.81	10.77	63.58	0.00
DALMIA	5.76	101.14	118.97	539.56	24.72	5.94	8.39	4.63	5.71	1.75	1.53	9.57	12.30	9.57	106.37
RAMCO	16.75	125.56	37.96	157.16	10.57	14.76	17.06	0.50	0.45	0.69	4.61	7.07	10.78	7.07	87.49
RAIN	0.72	13.99	0.12	1.56	109.89	8.74	8.74	3.81	3.81	0.60	2.22	1.00	35.87	1.00	-48.23
BIRLA	24.58	350.18	41.75	401.25	6.26	8.36	8.75	1.01	0.78	0.46	3.91	6.63	39.69	6.63	75.46
OCL	24.27	249.89	79.12	402.96	8.21	14.94	16.01	0.72	0.56	0.70	3.65	8.05	12.67	7.97	86.51
JK	34.73	249.60	75.61	487.29	4.98	11.74	12.51	0.87	0.75	1.28	2.18	7.33	26.42	7.33	80.71
PRISMA	0.02	20.10	5.13	102.87	-0.43	6.56	7.40	0.83	0.74	1.55	0.76	11.36	9.84	11.36	100.00
INDIA	2.19	132.12	23.71	152.78	1.36	7.87	8.61	1.00	1.19	0.71	1.41	8.75	10.70	8.75	80.74
JK LAKSHMI	7.68	112.30	29.16	203.09	4.05	8.85	8.99	0.56	0.51	1.19	2.39	14.68	36.95	14.68	85.45
ORIENT	4.76	44.56	11.73	76.84	6.56	13.70	14.74	0.68	0.65	0.83	9.47	17.21	20.17	17.21	91.35
HELDELBURG	1.45	38.96	8.99	68.22	1.82	7.59	7.70	0.86	0.68	1.07	2.14	10.49	68.00	10.49	100.00

Source : Calculated from Financial Statement of Cement Companies as available on moneycontrol.com

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