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PRODUCTIVITY ASSESSMENT MODEL USING FUZZY LOGIC APPROACH

[1]Sanika Sumesh, [2]Anuragi P,

[1] M.Tech Student, Civil Engineering Department, Vimal Jyothi Engineering College, Kannur

, [2] Assistant Professor, Civil Engineering Department , Vimal Jyothi Engineering College, Kannur

Abstract: Productivity, more often defined as a ratio between an output value and an input value used to produce the output. Cement is one of the key essential materials in the construction industry. For the Indian cement industry, many challenges lie ahead. Increase in productivity is imperative in order to raise the standards of living and also to make the Indian exports globally competitive. Enhancement in productivity cannot be achieved without identifying and analyzing factors that adversely affect productivity. Measuring and quantifying the impact of factors influencing productivity of cement industries is a complex problem. Productivity barriers in cement industries are hampering its growth. Productivity problems can be minimized or avoided when their causes are clearly identified. Hence, exploring productivity determinants and their relationship with productivity of cement industries are important. A set of 49 productivity factors were extracted based on the related literature. The frequency of questionnaire data was obtained from SPSS software & then RII is calculated. Then Structural Equation Modeling is used to show the relationship between the most and least contributing factors. Finally productivity assessment models were then developed using fuzzy logic toolbox. So the study concludes that the power of fuzzy logic techniques can be very useful in the productivity problem environment and has future application

KEYWORDS: Productivity, Productivity determinants, Cement industry, Influencing factor, Modeling

I.INTRODUCTION

Cement is one of the key essential materials in the construction industry. It is classified into various categories based on its composition and specific end uses. Cement is classified as either Portland, blended, or specialty cement. Portland cements are mostly used around the whole world. The key constituents used to manufacture cement include limestone, shells, and chalk or marl combined with shale, clay, slate, blast furnace slag, silica sand, and iron ore. To manufacture cement, limestone, sand, and other additives are combined in rotating kilns at temperatures of up to 1450°C. This process yields a granular intermediate known as clinker, which is then ground in mills to produce cement powder. The final cement mix will include around 5% gypsum and may also include other non-clinker mineral by-product like limestone, slag, and ash from coal-fired power plants. The cement industry presents one of the most energy-intensive sectors within the Indian economy and is therefore of exacting interest in the context of both local and global environmental discussions. Increases in productivity through the adoption of more efficient and cleaner technologies in the manufacturing sector will be effective in merging economic, environmental, and social development objectives. A historical examination of productivity growth in India's industries embedded into a broader analysis of structural composition and policy changes will help identify potential future development strategies that lead towards a more sustainable development path. Production in the cement sector has been increasing over the last years. Despite its fluctuating pattern it shows a relatively stable trend over time. There are many reasons for this excepted increase in coming years in cement production. Among them one is economic growth in developing countries. This inevitably leads to increased demand for building materials, including cement. Though many of the largest and fastest growing cement industries are now in the developing world, still for many developing countries, self-reliance in cement production is a major industrial target as it reduces the dependence on imports and reduces the cost of construction. It also enables further development of the economy through improved infrastructure. These studies identifies the factors affecting productivity of Indian cement production industries and determine the weightage of each productivity factors using Relative Importance Index (RII) technique. It also aims to figure out the relationship between most contributing factor and least contributing factor that affect the productivity and thereby develop the productivity assessment model using Fuzzy Logic approach as well as a model combination of factors that improve the productivity.

II. LITERATURE REVIEW

Agrawal, Aman, and Srijeet Halder. "Identifying factors affecting construction labour productivity in India and measures to improve productivity." Asian Journal of Civil Engineering 21.4 (2020): 569-579, attempts to identify top factors that influence labour productivity. The individuality of this research is that it is one of the very few attempts in capturing the perception of construction workmen directly, instead of managers or supervisors. The results were useful for construction project managers in improving labour productivity at their sites. A survey of construction workmen has been conducted to measure their perception of what influences their efficiency at work. The factors identified were ranked using the Relative Importance Index (RII) method from the level of importance assigned by the respondents on a 0 to 3 scale. Furthermore, a survey of managing engineers, who are involved directly with construction labour in producing construction works, has been used to identify the measures to improve labour productivity at the construction site. These factors were also ranked based on their effectiveness rated by the participants of the survey using RII. These measures identified in the second phase of the study were mapped with the factors they mitigate. The measures were used in the study proactively to keep productivity at optimum levels and also identify the early signs of deteriorating productivity.
Dixit, Saurav, et al. "Study of Significant Factors Affecting Construction Productivity Using Relative Importance Index in Indian Construction Industry." E3S Web of Conferences. Vol. 140. EDP Sciences, 2019, identified and analyzed the significant factors affecting construction productivity using relative importance index method with a special focus on the Indian construction industry. A structured questionnaire survey method is used to collect the data from the primary stakeholders of the Indian construction industry. A total of 201 valid responses were received with a response rate of 32%. The value of reliability analysis obtained is above 0.95, which is considered highly reliable for data-based studies. The findings of the study provide a ranking of factors affecting construction productivity. Most significant factors affecting construction productivity are availability of resources, contractual disputes, scope, clarity of the project, design capability, and frequent design changes having the value on relative importance index scale 0.801, 0.799, 0.790, 0.785, and 0.776 respectively. They concluded that the productivity can be achieved by changing the work culture and reviewing the management process for execution.
Nelsia Priya Dharsini, K., and M. C. Sashikkumar. "Probabilistic model development for estimating construction labor productivity optimization integrating with fuzzy logic approach systems." Iranian Journal of Fuzzy Systems 17.6 (2020): 193-201, studied the association between identified factors affecting the construction labour productivity and individual productive rates through a systematic engineering model. This process comprise with calculation of productivity, collection of productivity information and using that information for designing construction model. Also, it intends to build an optimized probabilistic model for construction industry. Initially, the raw data for instance labour cost, capital cost, and energy consumption has been considered as input so as to compute objective function and total productive factor. The membership function is developed and employed in fuzzy optimization algorithm to optimize the productivity rate in construction. The results through predictable model prove to be more effective model with reasonable generalization capabilities compared to existing traditional work. Furthermore, this paper provides an insight of probabilistic model comprising internal in addition to external variable factors such as supervision, work rules, government rules and public labour unions.
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III. METHODOLOGY

Productivity is often defined as the ratio between an output value and an input value used to produce the output. In India, poor productivity has been identified as one of the most daunting challenges faced by the production industries. For any improvement, it becomes highly necessary and mandatory to identify and quantify the factors that adversely affect productivity, and work out the critical ones out of the available factors. Productivity barriers in cement industries are hampering its growth. Hence, to improve the productivity, proper identification of the factors affecting the productivity of cement industries in India is of great importance.

The basic idea behind the questionnaire design was to design a simple questionnaire that could be easily understandable and accurately interpreted by the respondents. asked on the critical factors reported in the relevant literatures, a structured questionnaire was prepared for gathering information. The questionnaire consisted of two sections. First part includes demographic variables like age, job category, and length of service (in years) of the respondents. The second part includes the factors affecting productivity of the cement industry in India.The target group includes respondent's from following job category: Administrative, Engineering, Finance, Human Resource, Marketing and Production. The questionnaire was sent through google forms for the easiness of data collection. The responses obtained from the respondents would be kept confidential. The productivity rating is done using 5-ponit Likert scale. A Likert scale is a type of psychometric response scale in which responders specify their level of agreement to a statement typically in five points. A Likert scale assumes that the strength or intensity of an attitude is linear, i.e. on a continuum from strongly agree to strongly disagree, and makes the statement that attitudes can be measured.

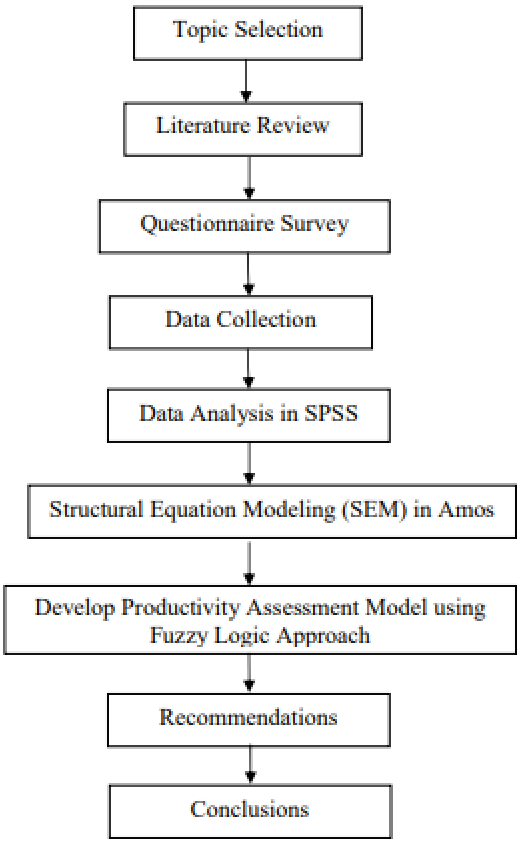


Fig.3.1 Schematic diagram of methodology

Table3.1 Likert Scale Index

LIKERT SCALE INDEX	LEVEL OF RATING
1	Strongly Disagree
2	Disagree
3	Neutral
4	Agree
5	Strongly Agree

The data obtained from questionnaire survey was analyzed using Statistical Package for Social Sciences (SPSS) software to acquire the descriptive statistics. The frequency of questionnaire data was obtained from SPSS software. Quantitative research methodology was adopted to analyse the collected data and the following tools and techniques were applied to the data: reliability analysis to check the consistency of data collected for this study and Relative Importance Index (RII). The rank of various factors affecting productivity was then obtained RII method. Cronbach's alpha method was used for reliability analysis. It is carried out to assess the internal consistency of the survey. It is one of the most common measures of reliability. It indicates the extent to which the items in a questionnaire are related to each other. It is most commonly used when you have multiple Likert questions in a questionnaire survey that form a scale and you wish to determine if the scale is reliable. It is expressed as number between 0 to 1. The higher the reliability value, the more reliable is the scale. A score of 0.7 or greater is generally considered to be acceptable.

Table3.2 Reliability Level

CRONBACH'S ALPHA (Cα)	INTERNAL CONSISTENCY
0.90 and above	Excellent
0.80 - 0.89	Very Good
0.70 - 0.79	Good
0.60 - 0.69	Acceptable
0.50 - 0.59	Poor
Below 0.50	Unacceptable

RII was computed for each sub factors of productivity, using the following equation:

$$\mathbf{RII} = \frac{\mathbf{5n_5 + 4n_4 + 3n_3 + 2n_2 + 1n_1}}{\mathbf{A * N}}$$

Where, n_5 = Number of Responses for Strongly Agree n_4 = Number of Responses for Agree n_3 = Number of Responses for Neutral n_2 = Number of Responses for Disagree n_1 = Number of Responses for Strongly Disagree A (Highest Weight) = 5 N (Total Number of Respondents) = 216

Structural equation modeling (SEM) is a statistical methodology that takes a confirmatory (i.e., hypothesis-testing) approach to the analysis of a structural theory bearing on some phenomenon. IBM® SPSS® Amos is a powerful structural equation modeling (SEM) software helping support your research and theories by extending standard multivariate analysis methods, including regression, factor analysis, correlation and analysis of variance. It is a confirmatory data analysis technique. The model is used to show the relationship between the most and least contributing factor. The productivity assessment model was developed by utilizing Fuzzy Logic Approach. Fuzzy logic is an approach that allows for multiple possible truth values to be processed through the same variable.

IV. PRODUCTIVITY DETERMINANTS

Productivity is more often defined as the ratio between an output value and an input value used to produce the output. Productivity is a crucial component in the production performance of firms and often depends upon various factors. It also reflects the scenario of an industry or organization how efficiently and effectively it transforms its inputs to outputs.

Factor influencing growth of global cement sector includes:-

Economic Growth: Segments of growth in the economy of any country are definitely linked to cement company growth. Further growth in Gross Domestic Product (GDP) per capita, a measurement of the average national standard of living is always a contributing factor to cement demand. Increased industrialization caused by economic development has a tendency to drive parallel increases in cement consumption.

Cost Structure and Competitiveness: There isn't much that cement companies can do regarding cost structure because the margins are less to begin with. Cost advantages are usually due to companies having access to a cheaper power source, a quality limestone reserve, or being close to bigger markets.

Legal, Regulatory, and Environmental Scenario: The cement industry is affected by regulatory norms. This is happening prominent in developed countries where environmental issues are more stringent. This adds to the companies costs.

Technological Advancement: Advancement in cement manufacturing technologies also benefit cement industry in many ways. A disruptive innovation can give the modernizing company an advantage. For example, when companies moved from the wet manufacturing process to the dry manufacturing process, there was not only reduction in energy and C02 but a cost savings of 5%—10% of the overall cost structure. **Geographic Advantages** :Cement industry are capital-intensive and it needs to secure valuable deposits over the long term. Close geographical links between cement production and mining sites is also extremely important to reduce the cost and transportation time for carrying the raw material. Not only that short routes for supply of raw materials take burden off of traffic volumes and reduce transport-related emission of pollutants.

Raw Material: Procurement of natural raw materials will continue to form the basis for cement manufacture in future. Use of alternative raw materials can be further increased to a certain magnitude. However, potential for substitution has already been largely exhausted and very much depends on the availability of industrial by-products such as fly ash and the high quality requirements placed on cement in the future.

The factors that affect productivity of cement industries in India are as follows:

Process Performance: Factor Process performance is a measure of how efficient or effective a process is the process performance index is an estimate of the process capability of a process during its initial set-up, before it has been brought into a state of statistical control. The sub-factors include: Change in cycle time, Effective use of raw materials, Machine stoppage, Product quality, Proper utilization of capital, Rework and Unnecessary activities (movement, recheck etc.).

Human Factor: Human factors refer to environmental, organizational and job factors, and human and individual characteristics, which influence behaviour at work in a way which can affect health and safety. The sub-factors include: Change in employee cost, Employment generation, Motivation, Shortage of skilled labor and Skill enhancing training.

Technological Factor: The main potential in reducing energy consumption and CO_2 emissions from cement/concrete production is in improvement of cement pyroprocessing. An important benefit of enhancing energy efficiency in the cement industry would be the reduction in energy costs. The sub-factors include: Automation, New product delivery mode, New technology, On-site recycling and reuse, Product innovation, R&D implementation and Sustainable development.

Financial Factor: The sub-factors in financial activities include: Inflation, Profits reinvestment, Rate of interest and Value addition through R&D.

Corporate Social Relation Factor: Corporate Social Responsibility is a management concept whereby companies integrate social and environmental concerns in their business operations and interactions with their stakeholders. CSR is generally understood as being the way through which a company achieves a balance of economic, environmental and social imperatives. The sub-factors include: Community attitude, Regional development and Social responsibilities.

Marketing Factor: Marketing Cement is not about pretty, colourful bags, shiny brochures, nifty give-aways and customer events. It is about making bold, strategic moves which grow businesses and taking tactical steps to contain potential damage in challenging market situations. The sub-factors include: Competition in the market, Expenses on marketing, Market condition (product), Marketing policy of the country and Product branding and promotion.

Environmental & Safety Factor: Cement manufacturing is an energy and resource intensive process with both local and global environmental, health and safety impacts. Because of these impacts, ensuring healthy and safe working conditions for employees is one of the most significant issues for the cement industry. The sub-factors include: Availability of personal protection equipment, Managerial policy for safety (insurance, medical allowance), Training on safety, Safety in the workplace, Worker attitude to safety and Workstation environment.

Government & Political Factor: The sub-factors included are: Change in government rules, Overall GDP of the country, Political stability and Taxation.

Management Factor: The sub-factors included are: Culture of promoting knowledge sharing to the subordinates, Flexible and adaptable rules, Instantaneous and independent decision making, Managerial skill and Strategic alliance (share resources to undertake a specific, mutually beneficial project).

Supply Chain Factor: The major factors identified as supply chain structure, inventory control policy, information sharing, customer demand, forecasting method, lead time and review period length. The optimum selection of parameters of these factors improves the supply chain performance. The sub-factors included are: Application of lean tool, Efficient plant operation, Energy availability, Energy price Maintenance delay, Material availability, Pricing of raw materials, Supply chain management, Transportation cost and Variation of product.

V. RESULTS AND DISCUSSIONS

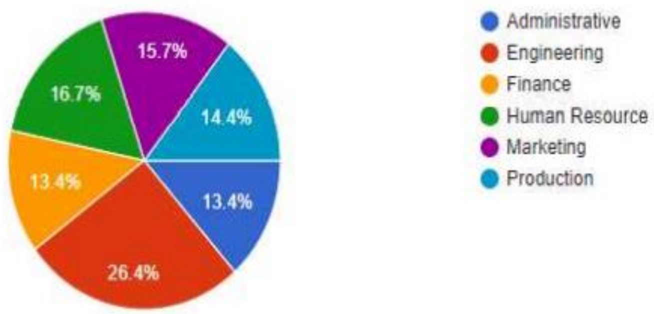
A questionnaire survey was designed to gather all necessary information in an effective way. A set of 49 productivity factors were extracted based on the related literature. The factors rating is done on a five point Likert scale. The frequency of questionnaire data was obtained from SPSS software. The collected survey data were initially analyzed using Relative Importance Index (RII) technique, thereby determining the weightage of each productivity factors. Then Structural Equation Modeling (SEM) is used to show the relationship between the most and least contributing factors. Productivity assessment models were then developed using fuzzy logic toolbox. A set of 49 factors was identified from the literatures which were categorized under ten broad categories.

DEMOGRAPHIC CHARACTERISTICS

A total of 265 survey questionnaires were distributed to the target group. Out of the 265 questionnaires distributed, 216 responses were obtained. The rate of response was approximately 81.5%. The target group includes respondents from following job category: Administrative, Engineering, Finance, Human Resource, Marketing and Production.

The percentage of respondents belonging to different job category is show in Fig 5.1. From the pie chart it is clear that majority of the respondent were belonging to Engineering with 26.4% of the total respondents. Remaining categories represented as, about 16.7% were under Human Resource, 15.7% were under Marketing and 14.4% were under Production s percentage. The least percentage of 13.4% each was shared under the Finance and Administrative category.

The respondents were having different level of experience. Experience is related to the accuracy of their response to be correct. The length of service in number of years spent working is represented as percentage is shown in Fig.5.2. The least percentage were having length service more than 15 years and the most percentage of respondents were having length of service between 1- 4 years. About 15.7% of the respondent's having less than having 11- 14 years' service and 25.5% having 5-10 years.



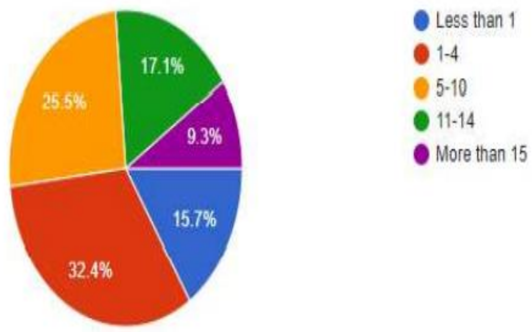


Fig.5.1 Respondents Job Category Fig.5.2 Respondent length of service in years

The age groups of respondents were also collected and is represented in fig 5.3. It is obtained that 19% of respondents have age less than 25, 18.5% having age 25-30, 21.3% having age 31-35, 19.9% having age 36- 40, 13.4% having age 41- 50 and 7.9% having age morethan 50 years. The responses may vary among different age groups.

The questionnaire focused on understanding the mentality of respondents in contributing to improvement. The pie chart in Fig 5.4 shows the percentage of employees who are willing to give suggestions and ideas regarding improvement in the industry. A scale consisting of three rating namely Very often, Sometimes and Never is used. From the pie chart it is clear that out of 216 respondents only 31.9% of employees were actively participating in contribution to productivity improvement in cement industries. About 42.6% of employees were giving contribution sometimes only. Remaining 25.5% of respondents were not giving any suggestions. They were those categories who would remain idle in giving any idea regarding improvement.

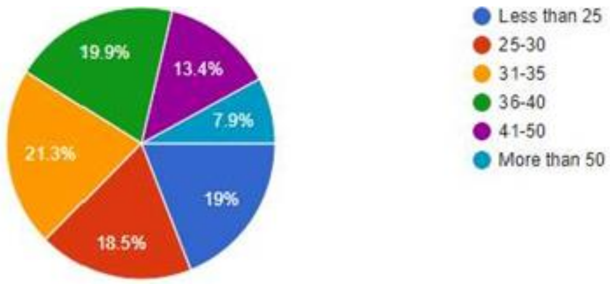


Fig.5.3 Respondents Age

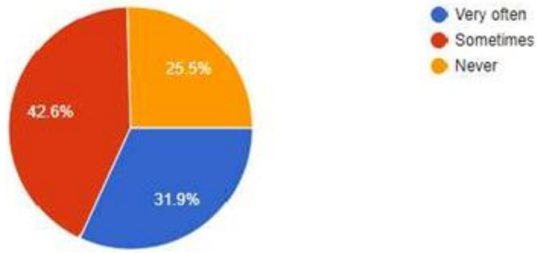
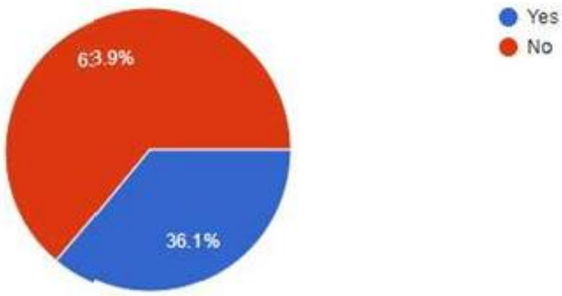


Fig.5.4 Respondents Contributing to Improvement

The pie chart in Fig5.5 shows respondents level of satisfaction regarding the present performance of the cement industry. A Yes or No styled question was used in order to arrive at the conclusion quickly and efficiently. From the chart it is clear that majority of the respondents answered no to the question which suggests that about 63.9% were not satisfied with the present level of performance. Only a small percentage of workers about 36.1% were satisfied with the performance level. So it is clear that performance improvement is important and necessary in the cement industry. Performance improvement is possible by improving productivity. So productivityimprovement is necessary.



5.5 Respondents Satisfied with the Level of Performance

ANALYSIS OF FACTORS IN SPSS

The data obtained from questionnaire survey was analyzed using Statistical Package for Social Sciences (SPSS) software to acquire the descriptive statistics. The frequency of questionnaire data was obtained from SPSS software. The responses from google form were converted to excel file before importing into SPSS software. SPSS software is employed to find the Relative Importance Index (RII) and reliability (Cronbach’s Alpha) for each factor individually according to the respondents reply to the questionnaire, and to find the frequencies that are used in the calculation of RII. For the calculation of RII excel program is further used for the application of the formula.

Reliability Statistics

In order to determine precisely whether the respondents have similar opinions and the internal consistency or reliability of the scale, Cronbach’s Alpha was used by using SPSS software. Cronbach’s Alpha value ranges from 0 to 1 with a higher value indicating greater consistency. All of the Cronbach’s Alpha values are greater than 0.6 which indicate that all are acceptable. The ronbach’s Alpha value ofHuman, Technological, Environmental & safety, Management and Supply chain factors are greater than 0.8 which indicate a very good level of internal consistency. Remaining factors are having Cronbach’s Alpha value less than 0.8 but greater than 0.6. Hence, allare acceptable. The overall consistency is obtained as 0.781.

Table5.1 Reliability Statistics

FACTOR GROUP	NO. OF FACTORS	RELIABILITY (CRONBACH'S ALPHA)
Process Performance Factor	5	0.692
Human Factor	6	0.820
Technological Factor	4	0.844
Financial Factor	4	0.739
Corporate Social Relation Factor	3	0.681
Marketing Factor	4	0.775
Environmental & Safety Factor	7	0.865
Government & Political Factor	3	0.688
Management Factor	6	0.862
Supply Chain Factor	7	0.843
Total Factor Group Affect	49	0.781

RII AND RANKING OF PRODUCTIVITY FACTORS

The Relative Importance Index (RII) method was adopted to determine the relative importance of various factors affecting the productivity of cement industries. The higher the RII value greater is the impact or frequency of occurrence of the variables.

Process Performance Factor

The Relative Importance Index (RII) and ranks of the five factors are classified under the Process Performance group as shown in Table 7.2. The problem statement includes five factors. The problem statements included in this factor group are: Lack of proper utilization of capital, Product quality not maintained, Stoppage of machines, Ineffective use of raw materials and Unnecessary activities are involved.

Table5.2 Ranking Process Performance Factor

PROCESS PERFORMANCE FACTOR	CODE	RII	RANK	AVERAGE OF RII
Lack of proper utilisation of capital	A	0.465	5	0.498
Product quality not maintained	B	0.484	4	
Stoppage of machines	C	0.509	2	
Ineffective use of raw materials	D	0.541	1	
Unnecessary activities are involved	E	0.490	3	

Table 5.2 illustrates that the surveyed participants ranked Ineffective use of raw materials as the most important factor that influence productivity in this group, with RII of 0.541. The factor Lackof proper utilization of capital is the least important factor that influences productivity in this group, with RII of 0.465. This group scored the ninth rank.

Human Factor

The Relative Importance Index (RII) and ranks of the five factors are classified under the Human group as shown in Table 5.3. The problem statements included in this factor group are: Trainings not promoted, Shortage of skilled labour, Not arranging motivational programs, Frequent changes in employee cost, Lack of labour experience and Lack of labour attitude & morale. Table 5.3 illustrates that the surveyed participants ranked Trainings not promoted & Frequent changes in employee cost as the most important factor that influence productivity in this group, with RII of 0.805. The factor Lack of labour experience is the least important factor that influences productivity in this group, with RII of 0.764. This group scored the first rank.

Table5.3 Ranking Human Factor

HUMAN FACTOR	CODE	RII	RANK	AVERAGE OF RII
Trainings not promoted	A	0.805	1	0.789
Shortage of skilled labour	B	0.794	4	
Not arranging motivational programs	C	0.796	3	
Frequent changes in employee cost	D	0.805	1	
Lack of labour experience	E	0.764	6	
Lack of labour attitude & morale	F	0.767	5	

Technological Factor

The Relative Importance Index (RII) and ranks of the five factors are classified under the Technological group as shown in Table 5.4. The problem statements included in this factor group are: Lack of bringing new technology, Lack of recycling & reuse, No innovations to the product and Lackof focus on sustainable development. Table 5.4 illustrates that the surveyed participants ranked No innovations to the product as the most important factor that influence productivity in this group, with RII of 0.567. The factor

Lack of bringing new technology is the least important factor that influences productivity in this group, with RII of 0.516. This group scored the second rank.

Table5.4 Ranking Technological Factor

TECHNOLOGICAL FACTOR	CODE	RII	RANK	AVERAGE OF RII
Lack of bringing new technology	A	0.516	4	0.539
Lack of recycling & reuse	B	0.524	3	
No innovations to the product	C	0.567	1	
Lack of focus on sustainable development	D	0.550	2	

Financial Factor

The Relative Importance Index (RII) and ranks of the five factors are classified under the Financial group as shown in Table 5.5. The problem statements included in this factor group are: Changes in rate of interest, Inflations occur, Reinvestment of profits and Value additions done. Table 5.5 illustrates that the surveyed participants ranked Changes in rate of interest as the most important factor that influence productivity in this group, with RII of 0.537. The factor Inflations occur is the least important factor that influences productivity in this group, with RII of 0.508. This group scored the fourth rank.

Table5.5 Ranking Financial Factor

FINANCIAL FACTOR	CODE	RII	RANK	AVERAGE OF RII
Changes in rate of interest	A	0.537	1	0.524
Inflations occur	B	0.508	4	
Reinvestment of profits	C	0.530	2	
Value additions done	D	0.520	3	

Corporate Social Relation Factor

The Relative Importance Index (RII) and ranks of the five factors are classified under the Corporate Social Relation group as shown in Table 5.6. The problem statements included in this factor group are: Focus on social responsibility, Development on regional basis and Changes in communityattitudes.

Table5.6 Ranking Corporate Social Relation Factor

E SOCIAL RELATIONFACTOR	CODE	RII	RANK	AVERAGE OF RII
Focus on social responsibility	A	0.476	3	0.500
Development on regional basis	B	0.505	2	
Changes in community attitudes	C	0.520	1	

Table 5.6 illustrates that the surveyed participants ranked Changes in community attitudes as the most important factor that influence productivity in this group, with RII of 0.520. The factor Focuson social responsibility is the least important factor that influences productivity in this group, withRII of 0.476. This group scored the eighth rank.

Marketing Factor

Table 5.7 illustrates that the surveyed participants ranked Availability of marketing expenses as the most important factor that influence productivity in this group, with RII of 0.502. The factor Gives priority to promotion & branding is the least important factor that influences productivity in this group, with RII of 0.382. This group scored the tenth rank.

Table5.7 Ranking Marketing Factor

MARKETING FACTOR	CODE	RII	RANK	AVERAGE OF RII
Market competitions exists	A	0.403	3	
Gives priority to promotion & branding	B	0.382	4	
Availability of marketing expenses	C	0.502	1	
Changes in market conditions	D	0.422	2	0.427

Environmental & Safety Factor

Table 5.8 illustrates that the surveyed participants ranked Workplace safety as the most important factor that influence productivity in this group, with RII of 0.543. The factor Unsafe working condition is the least important factor that influences productivity in this group, with RII of 0.493.

Table5.8 Ranking Environmental & Safety Factor

ENVIRONMENTAL & SAFETY FACTOR	CODE	RII	RANK	AVERAGE OF RII
Lack of use of PPE	A	0.530	4	
Medical allowances not provided	B	0.532	3	
Safety trainings not carried out	C	0.541	2	
Workplace safety is not ensured	D	0.543	1	
Awareness classes kept regularly	E	0.503	6	
Workers are willing to ensure safety	F	0.513	5	
Unsafe working condition	G	0.493	7	0.522

Government & Political Factor

Table 5 .9 illustrates that the surveyed participants ranked Proper taxation as the most important factor that influence productivity in this group, with RII of 0.515. The factor Political stability ensured is the least important factor that influences productivity in this group, with RII of 0.506.This group scored the sixth rank.

Table5.9 Ranking Government & Political Factor

GOVERNMENT & POLITICAL FACTOR	CODE	RII	RANK	AVERAGE OF RII
Regulatory changes by government	A	0.508	2	
Political stability ensured	B	0.506	3	
Proper taxation	C	0.515	1	0.510

Management Factor

Table 5.10 illustrates that the surveyed participants ranked Lack of resource sharing among mutually beneficial projects as the most important factor that influence productivity in this group, with RII of 0.528. The factor Share knowledge among subordinates is the least important factor that influences productivity in this group, with RII of 0.494. This group scored the fifth rank.

Supply Chain Factor

Table 5.11 illustrates that the surveyed participants ranked Unavailability of materials as the most important factor that influence productivity in this group, with RII of 0.525. This group scored the seventh rank

Table7.10 Ranking Management Factor

MANAGEMENT FACTOR	CODE	RII	RANK	AVERAGE OF RII
Share knowledge among subordinates	A	0.494	6	
Adaptable and flexible rules	B	0.503	5	
Lack of resource sharing	C	0.528	1	
Skilled managers not available	D	0.525	2	
Lag in decision making	E	0.519	3	
Lack of periodic meetings	F	0.505	4	0.512

Table7.11 Ranking Supply Chain Factor

SUPPLY CHAIN FACTOR	CODE	RII	RANK	AVERAGE OF RII
Delay in maintenance	A	0.488	7	
Variation of product exists	B	0.496	5	
Inefficiency of operation plant	C	0.511	3	
Lack of energy available	D	0.512	2	
More cost for energy	E	0.493	6	
Unavailability of materials	F	0.525	1	0.505
High raw material cost	G	0.508	4	

SEM IN AMOS

Structural Equation Model (SEM) is used to obtain casual relationships among variables when using observational data. Here SEM is utilized to obtain the relationship between the most and least contributing factor of productivity after the RII analysis. The path diagram representing the model is drawn using the drawing tools. Then the SPSS data file is added which is to be analyzed. Next step is to name the variables. Observed variables can be directly taken from your data set easily without naming them. Unobserved variables are named from the plugins. Error is an unobserved variable and therefore, used an ellipse to draw the variable. Double headed arrow shows the correlation between the most contributing (Human) and least contributing (Marketing) factor.

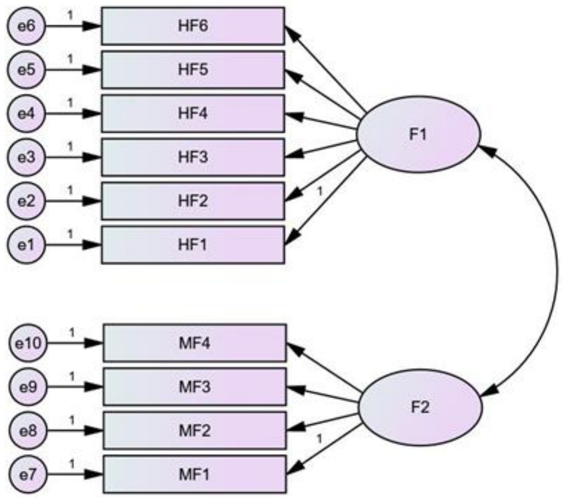


Fig.5.6 Model Drawn for Analysis

Analysing AMOS Output

The analysis is carried out to obtain the relationship between the variables. Different types of outputs can be obtained from Amos after calculating estimate. The outputs are easy to understand.

The details of variable counts of the model are represented in Table 5.14

Table 5.14 Model Variable Count

DESCRIPTION	NO.
Number of variables in the model	22
Number of observed variables	10
Number of unobserved variables	12
Number of exogenous variables	12
Number of endogenous variables	10

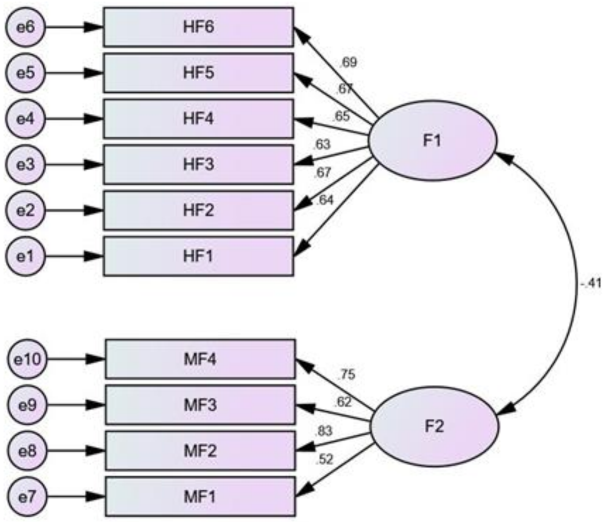


Fig.5.7 Graphical Output of AMOS

Notes for Model (Default model)

Computation of degrees of freedom (Default model)

Number of distinct sample moments: 65
Number of distinct parameters to be estimated: 31
Degrees of freedom (65 - 31): 34

Result (Default model)

Minimum was achieved
Chi-square = 86.908
Degrees of freedom = 34
Probability level = .000

Fig.5.8 Notes for Model

The correlation between F1 and F2 is obtained as -0.409. The direction of correlation coefficient is indicated by the sign of the correlation coefficient. A positive coefficient indicates that as one variable increases, so does the other. A negative indicates that as one variable increases, the other variable decreases. Here a negative coefficient is obtained indicating an opposite or reversal relation between F1 and F2. In the correlation variables are not identified as i because we would be measuring the one relationship that is mutually variables. AMOS will display most errors and warnings in this section of the output. In the output shown in Fig.5.8 AMOS reports that the minimum was achieved with no errors or warnings. If errors or warnings are not reported in this section of the output means that it is safe for you to proceed to the next output section of interest. The Chi-square test of overall model fit value of the model is 86.908 with 34 degrees of freedom. CMIN stands for the Chi-square value and is used to compare if the observed variables and expected results are statistically significant. The CMIN/DF value of the default model is 2.556. If the CMIN/DF value is ≤ 3 it indicates an acceptable fit**.** Hence the value is within the range of acceptable fit. Baseline Comparisons refers to the models automatically fitted by Amos for every analysis, respectively the default, saturated, and independence model. Normed Fit Index also referred to as Delta 1 consists of values scaling between (terribly fitting) independence model and (perfectly fitting) saturated model. A value of 1 shows a perfect fit while models valued < 0.9 can be usually improved substantially. The NFI of default model is obtained as 0.877 which is close to 1. RFI: Relative Fit Index and derived from NFI where values closed to 1 indicate a very good fit while 1 indicates a perfect fit. The RFI of default model is obtained as 0.802 which is close to 1.IFI: Incremental Fit Index where values closed to 1 indicates a very good fit while 1 indicates a perfect fit. The IFI of default model is obtained as 0.922 which is close to 1.TLI: Tucker-Lewis coefficient also known as Bentler-Bonett non-normed fit index (NNFI) ranges from (but not limited to) 0 to 1 where a value closer to 1 represents a very good fit while 1 represents a perfect fit**.** The TFI of default model is obtained as 0.869 which is close to 1.CFI: Comparative Fit Index has value truncated between 0 and 1 where values closed to 1 show a very good fit while 1 represents the perfect fit. The CFI of default model is obtained as 0.919 whichis close to 1.

RMSEA stands for Root Mean Square Error of Approximation and measures the difference between the observed covariance matrix per degree of freedom and the predicted covariance matrix. Root Mean Square Error of Approximation where values higher than 0.1 are considered poor, values between 0.08 and 0.1 are considered borderline, values ranging from 0.05 to 0.08 are considered acceptable, and values ≤ 0.05 are considered excellent. The RMSEA of default model is obtained as 0.085 which is lying in the borderline but is not poor.

PRODUCTIVITY ASSESSMENT MODEL- Modeling in Fuzzy Inference System

Fuzzy logic is a powerful modeling technique that is specifically designed to handle natural language and approximate reasoning, similar to human reasoning process. The identified most influencing and least influencing productivity factors were considered as the main input. To perform the fuzzy inference, the rules that connect the input variables to the output variables in If-Then forms

(Mamdani – style fuzzy rules) were used to describe the desired model in terms of linguistic variables (words) rather than mathematical formulas. The importance values were assigned as weights to the fuzzy rules framed in the software. The weightage of each fuzzy rule differed as the RII of each factors influencing productivity had a distinct value. Thus, ensuring the relative importance of each if-then fuzzy rules constructed. Fuzzy Inference System is the key unit of a fuzzy logic system which has decision making as its primary work. The Mamdani Fuzzy Inference System was proposed in 1975 by Ebhasim Mamdani. The output from FIS is always a fuzzy set irrespective of its input which can be fuzzy or crisp. Running the program a productivity assessment model will be generated. This assessment models can be utilized inorder to assess the productivity of cement industry as and when required. Running the model a link is generated that can be accessed by any employee with the industry. This model benefits to give the best result from the input provided. The employees can enter the site through the link and give the answers. The employees will be provided with a proper login id and password. Using this they can enter the site without any other extra process.

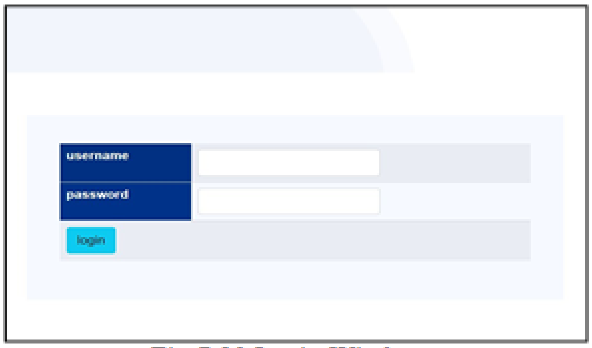


Fig.5.9 Login Window

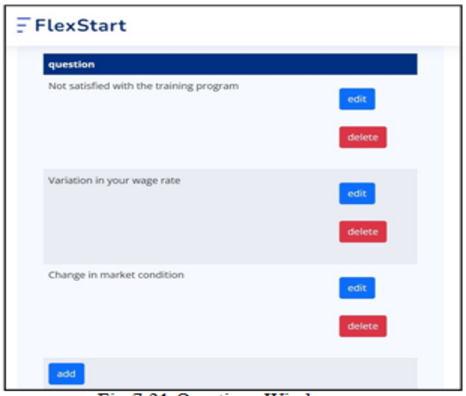


Fig.5.10 Questions Window

The question window can be managed by the managers or supervisors of the industry who is related or are engaged in improving productivity. The admin can only edit the question window. The questions can be added by monitoring the changes initiated. The employees can assign their response by entering the login provided by managers through the link using their unique username and password. The response provided by each employee can be viewed by the managers through their personal computer systems. The response rating used is a scale from 1 to 5 which ranges from poor to outstanding. From just a click the model can the model can create the best result out of it that will be a result obtained by close relation shared by the input factors. The managers can view the output and make changes as and when required in the procedures followed in the industry for improving the productivity.

Fig.5.11 Employee Response

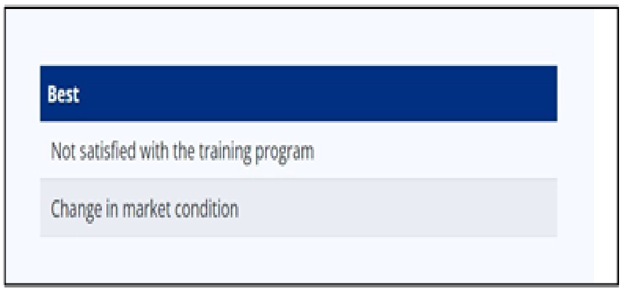


Fig.5.12 Best Result

MEASURES TO IMPROVE PRODUCTIVITY IN CEMENT INDUSTRY

Some of the methods to improve productivity of cement industries include the following:

1) Continuous training and meetings should be arranged to achieve better productivity of cement industry.

2) Everybody related to industry prefer to work in healthy and positive environment. Therefore it is the responsibility of the responsible authority to provide an ambiance to work efficiently without any difficulty.

3) Unskilled labours is also a main issue. Skilled labours play an important role in the enhancement of productivity. Shortage of skilled labours are also an important point to be noted.

4) Improved wages boost up productivity. Appreciation to best employee would help achieving better productivity. Changes in employee cost is also an issue.

5) Labour absenteeism can be reduced by providing them necessary allowances like a paid holiday, or any similar incentives. Sharing duties would help relieve the work load.

6) Following the considerable contribution of raw materials in the cost structure, any movement in the price and availability of clinker and other raw materials eventually affects the profitability as well as productivity of the cement manufacturing industries. Moreover, cement industries need to reduce manufacturing cost and hence, the price of the cement through improving their productivity. It is possible to enhance the productivity through maximizing the raw material utilization.

7) To enhance the productivity through maximizing the raw material utilization is also important.

8) Carrying out safety trainings that will provide a motivation and sense of safe working environment to workers.

VI. CONCLUSION

1. The cement industry occupies an important position in Indian economy. The economic progress can be achieved by increasing the production coupled with increased productivity.

2. Productivity is a crucial component in the production performance of firms and often depends upon various factors. It also reflects the scenario of an industry or organization how efficiently and effectively it transforms its inputs to outputs. Productivity determinants of the cement industry include social, technological, managerial, financial, and cultural issues; and widely differ from region to region.

3. Hence, to improve the productivity, proper identification of the factors affecting the productivity of cement industries is important. Productivity problems can be avoided or minimized when their causes are clearly identified.

4. The factors that adversely affect productivity needed to be quantified and the critical ones should be worked out of the available factor. Relative Importance Index (RII) is calculated to identify the relative importance of factors. The most and lest contributing factor is obtained asHuman & Marketing Factor respectively.

5. Then the relationship or correlation of these independent variables are obtained from the SEM result in AMOS. A negative relation is obtained indicating reversal relation among thefactors.

6. Finally the productivity assessment model is generated using Fuzzy rules. This model can be utilized to assess the productivity of industry whenever necessary.

7. The study concludes that the power of fuzzy logic techniques can be very useful in the productivity problem environment, as its ability to represent the problem in natural language.

8. Since, the model is developed based on the perceptions of the individuals participated in the survey, so as to get a more accurate picture of the perceptions of the whole construction industry, the number of respondents can be increased.

9. Hence the project opens up a realm of possibilities where future researchers can produce more powerful, user friendly software that can analyse all the possible productivity factors thereby producing a fast and reliable results.

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