International Journal of Management Research and Development (IJMRD)

ISSN 2248 – 938X (Print), ISSN 2248 – 9398(Online),
Volume 4, Number 1, January - March (2014), pp.30-39
© PRJ Publication,
http://www.prjpublication.com/IJMRD.asp

IJMRD

© PRJ PUBLICATION

AN INTEGRATED APPROACH FOR ENHANCING READY MIXED CONCRETE UTILITY USING ANALYTIC HIERARCHY PROCESS (AHP)

Ashish H. Makwana [1], Prof. Jayeshkumar Pitroda [2]

[1]Student of final year M.E. C. E. & M., B.V.M. Engineering College, Vallabh Vidyanagar
[2]Assistant Professor and Research Scholar, Civil Engineering Department,
B.V.M. Engineering College,Vallabh Vidyanagar– Gujarat – India.

ABSTRACT

This research work has been aimed to rank the Ready Mixed Concrete on the basis of selected multiple criterions. The need of this Research work based upon various utility measures like quality control, cost, delivery, quantity at which Owners or Ready Mixed Concrete (RMC) Plant Managers have to concentrate for enhancing profit as well as maintaining standard by Analytic Hierarchy Process (AHP) Technique which will help the decision maker to understand the problem systematically. This research activity was entirely assessed through questionnaire survey. Various literatures have been reviewed for assessment and evaluation of Criterias that are related to Ready Mixed Concrete. The respondents were selected from various construction occupancy mainly Ready Mixed Concrete Plant Managers, Consultant and contractors. Total 100 Survey Questionnaires were distributed to Respondents in Anand, Nadiad, Vadodara, Ahmedabad, from which 60 Responses were collected as per sample size calculation,in that 21 were from Ready Mixed Concrete (RMC) Plant Managers, 26 were from consultants and 13 were from contractors. According to Analytic Hierarchy Process (AHP) Technique first 10 crucial Criterias in descending order are Large Quantity, Quality of Material, Delivery Lead Time, Sales/Utilization Area, Manager, Location, Equipment Safety, Standard and Certification, Accidents.

KEYWORDS: Ready Mixed Concrete, Analytic Hierarchy Process, Decision maker, Questionnaire Survey, Respondents, Crucial Factors

INTRODUCTION

Ready-Mixed Concrete (IS: 4926-2003) as "Concrete mixed in a stationary mixer in a central batching and mixing plant or in a truck mixer and supplied in the fresh condition to the purchaser either at the site or into the purchaser's vehicles." Ready Mixed Concrete (RMC) is a specialized material in which cement, aggregate, and other ingredients are weigh batched at a plant in a central or truck mixer before delivery to the construction site in a condition ready for placing by the customer. Ready Mixed Concrete (RMC) is manufactured at a place away from the construction site, the two locations being linked by a transport operation.

The short 'life' of fresh concrete, with only 2-3 hours before it must be placed, results in Ready Mixed Concrete being a very much local delivery service, with rarely more than 30-60 minutes journey to the construction site. The need for supply of Ready Mixed Concrete to fit in with the customer's construction program means that Ready Mixed Concrete (RMC) has to be both a product and a delivery service.

NEED OF THE STUDY

Present approach lacks scientific methodology and does not consider multi-criteria in decision making. There is a need of scientific methodology for Ready Mixed Concrete selection approach.

Hence, the need of this Research work based upon various utility measures like quality control, cost, delivery, quantity at which owners or plant managers have to concentrate for enhancing profit as well as maintaining standard by Analytic Hierarchy Process (AHP) Technique which will help the decision maker to understand the problem systematically.

OBJECTIVES OF THE STUDY

1. To Study of Analytic Hierarchy Process (AHP) Technique.
2. To derive the relation between various Criterias for enhancing utility of Ready Mixed Concrete.
3. To achieve optimization by Analytic Hierarchy Process (AHP).

SCOPE OF THE STUDY

The scope of this research work of development of Ready Mixed Concrete selection process is limited to four cities of Central Gujarat Region of India: Ahmedabad, Nadiad, Anand, and Vadodara.

RESEARCH METHODOLOGY

The relevant data for this investigation were collected by a structured, close-ended questionnaire survey. From the study of past research work and with the help of expert opinion, Criterias were identified which affects Ready Mixed Concrete selection process for construction companies of Central Gujarat Region of India.

SAMPLE SIZE CALCULATION

According to the targeted City and Stakeholders, the total no. of available population is 467 which comprises of 50 Ready Mixed Concrete Plant (Assume), 362 Consultants [Ref: Association of consulting Civil Engineers - India Ahmadabad Center Gujarat] and 55 Contractors [Ref: Gujarat Contractors Association].

To obtain statistically representative sample size of the population following equation is used:

$$n = \frac{m}{1+[\frac{m-1}{N}]} \qquad (1)$$

Where n, m and N represents the sample size of limited, unlimited and available population respectively. Here, m is calculated by following equation.

$$m = \frac{z^2 * p * (1-p)}{e^2} \qquad \ldots(2)$$

Where z= the statistic value for the confidence level used, i.e. 1.96 and 1.645 for 95% and 90% confidence level respectively; p= the value of population that estimated and e= the sampling error to estimated. Because the value of p is unknown. Sinich et al. (2002) suggest the value 0.5 to be used in sample size.

$$m = \frac{1.645^2 * 0.5 * (1-0.5)}{0.1^2} \qquad m = 67.65 \qquad \ldots \ (3)$$

Here confidence level is taken as 90%.Now,

$$n = \frac{67.65}{1 + [\frac{67.65-1}{467}]} \qquad n = 60 \qquad \ldots..(4)$$

Figure 1: Targeted City v/s Total Respondent

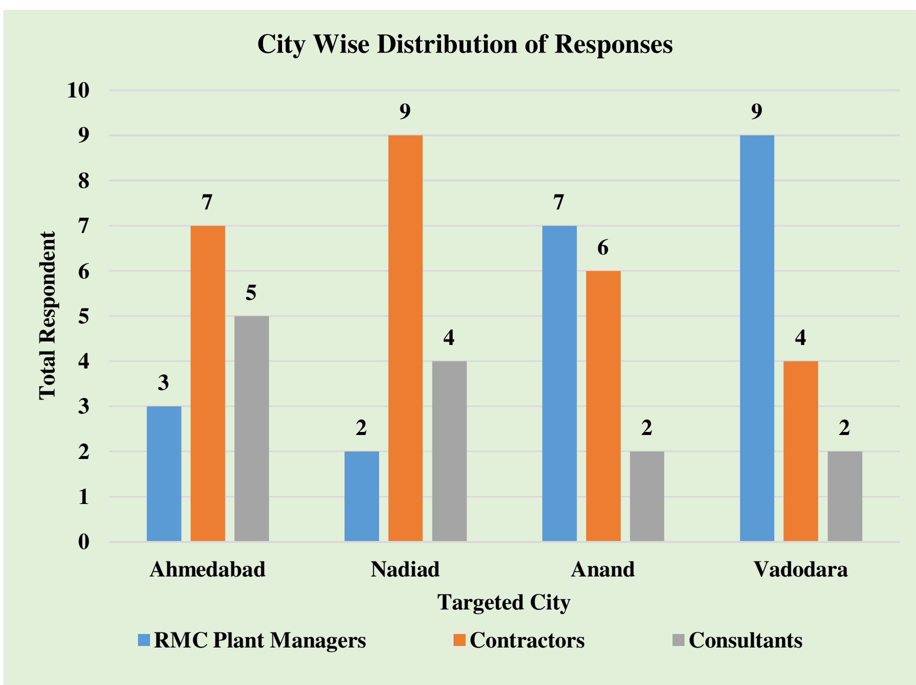


Table 1: City Wise Distribution of Responses

City/ Stakeholder	RMC Plant Manager	Consultant	Contractor
Anand	3	7	5
Nadiad	2	9	4
Vadodara	7	6	2
Ahmedabad	9	4	2
Total	21	26	13

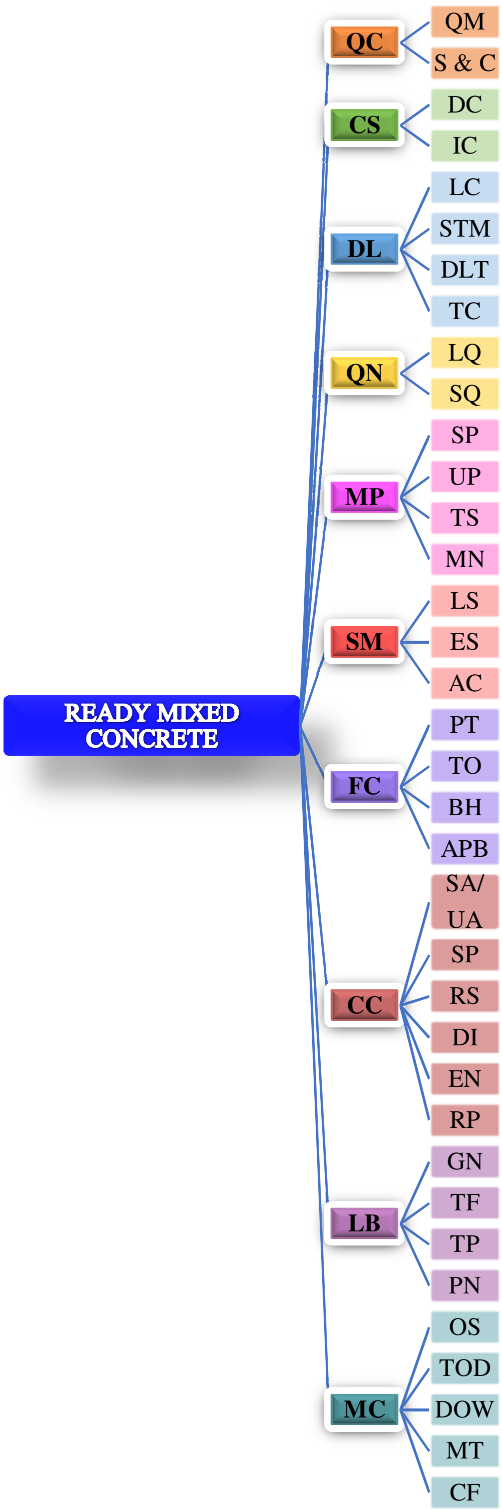
ANALYTIC HIERARCHY PROCESS (AHP)

Analytic Hierarchy Process has been a tool at the hands of decision makers and researchers; and it is the most widely used multiple criteria decision making tools. The AHP method is developed by Thomas L. Saaty in 1980. AHP is very popular and widely applicable in various fields due to its simplicity, ease of use and flexibility. AHP is a reliable tool to facilitate systematic and logical decision making processes and determine the significance of a set of Criterias and Sub-Criterias. AHP method is very suitable for complex social issue in which intangible and tangible factors cannot be separated. AHP helps in reducing bias in decision-making and it can minimize common pitfalls of team decision-making process, such as lack of focus, planning, participation or ownership, which ultimately are costly distractions that can prevent teams from making the right choice.Broad areas in which the AHP has been applied include alternative selection, resource allocation, forecasting, business process re-engineering, quality function deployment, balanced scorecard, benchmarking, public policy decisions, healthcare, and many more.

STEP BY STEP PROCEDURE OF ANALYTIC HIERARCHY PROCESS

Step-1: Model the problem as a hierarchy containing the decision goal, the alternatives for reaching it, and the criteria for evaluating the alternatives.
Step-2: Establish priorities among the elements of the hierarchy by making a series of judgments based on pair wise comparisons of the elements.
Step-3: Synthesize these judgments to yield a set of overall priorities for the hierarchy.
Step-4: Check the consistency of the judgments.
Step-5: Come to a final decision based on the results of this process.

CRITERIAS FRAMEWORK FOR READY MIXED CONCRETE SELECTION



- **QC - Quality Control**
  - QM - Quality of Material
  - S & C - Standard & Certification
- **CS - Cost**
  - DC - Direct cost
  - IC - Indirect cost
- **DL - Delivery**
  - LC - Location
  - STM - Size of Transit Mixture
  - DLT - Delivery Lead Time
  - TC - Time Consuming
- **QC - Quantity**
  - LQ - Large quantity
  - SQ - Small (Less) quantity
- **MP - Manpower**
  - SP - Skill person
  - UP - Unskilled person
  - TS - Technical staff
  - MN - Manager
- **SM - Safety Measures**
  - LS - Labor Safety
  - ES - Equipment Safety
  - AC - Accidents
- **FC - Financial Capability**
  - PT - Profit Trends
  - TO - Turnover
  - BH - Banking History
  - APB - Amount of Past Business
- **CC - Commercial Capability**
  - SA / UA - Sales / Utilization area
  - SP - Sales Policy
  - RS - Responsiveness
  - DI - Discipline
  - EN - Environment
  - RP - Reputation & Position
- **LB - Laboratory**
  - GN - General
  - TF - Test Facility
  - TP - Testing Procedures
  - PN - Personnel
- **MC - Managerial Capability**
  - OS - Organization Structure
  - TOD - Type of Decision Maker
  - DOW - Direction of Work
  - MT - Maintenance
  - CF - Customers Feedback

Figure 2: Framework for Ready Mixed Concrete selection Criterias

RESULTS ANALYSIS

Consistency of Matrix	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19	R20
Matrix 1: Criterias	0.097	0.099	0.097	0.096	0.094	0.086	0.098	0.100	0.096	0.098	0.089	0.095	0.081	0.095	0.095	0.098	0.095	0.098	0.096	0.091
Matrix 2: Quality Control																				
Matrix 3: Cost																				
Matrix 4: Delivery	0.082	0.062	0.062	0.062	0.087	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062
Matrix 5: Quantity																				
Matrix 6: Manpower	0.045	0.072	0.087	0.058	0.062	0.062	0.057	0.074	0.062	0.062	0.061	0.082	0.082	0.062	0.082	0.082	0.023	0.082	0.062	0.045
Matrix 7: Safety Measures	0.053	0.053	0.053	0.053	0.053	0.053	0.020	0.053	0.053	0.053	0.053	0.020	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053
Matrix 8: Financial Capability	0.092	0.000	0.013	0.046	0.070	0.077	0.095	0.082	0.000	0.023	0.089	0.045	0.072	0.062	0.062	0.062	0.062	0.048	0.062	0.088
Matrix 9: Commercial Capability	0.018	0.024	0.076	0.039	0.039	0.063	0.098	0.036	0.092	0.021	0.005	0.067	0.095	0.073	0.081	0.070	0.052	0.074	0.080	0.044
Matrix 10: Laboratory	0.081	0.099	0.005	0.086	0.072	0.091	0.091	0.033	0.000	0.062	0.062	0.023	0.062	0.062	0.072	0.089	0.089	0.062	0.023	0.072
Matrix 11: Managerial Capability	0.090	0.091	0.091	0.098	0.091	0.084	0.089	0.056	0.066	0.085	0.067	0.057	0.090	0.065	0.085	0.035	0.048	0.066	0.090	0.098
Consistency of Matrix	**R21**	**R22**	**R23**	**R24**	**R25**	**R26**	**R27**	**R28**	**R29**	**R30**	**R31**	**R32**	**R33**	**R34**	**R35**	**R36**	**R37**	**R38**	**R39**	**R40**
Matrix 1: Criterias	0.098	0.078	0.097	0.099	0.093	0.096	0.094	0.097	0.098	0.092	0.099	0.089	0.094	0.094	0.096	0.089	0.098	0.095	0.094	0.083
Matrix 2: Quality Control																				
Matrix 3: Cost																				
Matrix 4: Delivery	0.985	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.048	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062
Matrix 5: Quantity																				
Matrix 6: Manpower	0.023	0.023	0.062	0.062	0.032	0.062	0.062	0.047	0.023	0.072	0.062	0.045	0.062	0.092	0.062	0.047	0.047	0.062	0.089	0.062
Matrix 7: Safety Measures	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.020	0.058	0.053	0.053	0.053	0.053	0.053
Matrix 8: Financial Capability	0.062	0.072	0.089	0.045	0.062	0.096	0.087	0.049	0.023	0.023	0.070	0.062	0.090	0.050	0.082	0.047	0.070	0.093	0.089	0.062
Matrix 9: Commercial Capability	0.024	0.042	0.028	0.038	0.020	0.028	0.036	0.070	0.005	0.054	0.109	0.030	0.088	0.028	0.095	0.094	0.069	0.082	0.030	0.033
Matrix 10: Laboratory	0.047	0.062	0.047	0.062	0.062	0.062	0.082	0.062	0.062	0.072	0.057	0.069	0.036	0.058	0.062	0.096	0.082	0.051	0.087	0.099
Matrix 11: Managerial Capability	0.052	0.087	0.054	0.074	0.081	0.082	0.084	0.037	0.059	0.066	0.099	0.089	0.091	0.095	0.089	0.065	0.098	0.092	0.093	0.089
Consistency of Matrix	**R41**	**R42**	**R43**	**R44**	**R45**	**R46**	**R47**	**R48**	**R49**	**R50**	**R51**	**R52**	**R53**	**R54**	**R55**	**R56**	**R57**	**R58**	**R59**	**R60**
Matrix 1: Criterias	0.097	0.097	0.099	0.093	0.097	0.088	0.089	0.096	0.088	0.089	0.092	0.081	0.085	0.094	0.099	0.096	0.097	0.094	0.088	0.089
Matrix 2: Quality Control																				
Matrix 3: Cost																				
Matrix 4: Delivery	0.062	0.048	0.048	0.048	0.048	0.048	0.062	0.062	0.048	0.062	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.047	0.062
Matrix 5: Quantity																				
Matrix 6: Manpower	0.062	0.062	0.062	0.062	0.087	0.072	0.079	0.087	0.071	0.023	0.062	0.023	0.089	0.072	0.023	0.062	0.062	0.023	0.082	0.023
Matrix 7: Safety Measures	0.053	0.053	0.053	0.053	0.057	0.053	0.053	0.020	0.037	0.020	0.053	0.053	0.021	0.053	0.053	0.021	0.053	0.053	0.021	0.053
Matrix 8: Financial Capability	0.079	0.082	0.062	0.072	0.079	0.083	0.048	0.079	0.082	0.062	0.079	0.062	0.045	0.045	0.072	0.072	0.048	0.039	0.062	0.048
Matrix 9: Commercial Capability	0.084	0.092	0.053	0.079	0.058	0.089	0.082	0.097	0.092	0.093	0.085	0.070	0.056	0.063	0.088	0.038	0.063	0.072	0.088	0.098
Matrix 10: Laboratory	0.062	0.082	0.096	0.072	0.062	0.099	0.062	0.062	0.072	0.062	0.096	0.070	0.023	0.048	0.072	0.072	0.082	0.062	0.072	0.023
Matrix 11: Managerial Capability	0.037	0.054	0.097	0.084	0.097	0.095	0.072	0.067	0.086	0.095	0.089	0.078	0.075	0.045	0.035	0.067	0.065	0.075	0.059	0.066

Table 2: Consistency Ratio Values

SPEARMAN'S RANK CORRELATION COEFFICIENT

In order to test the relative agreement between the responses from different groups, the ranks of the calculated AHP weights corresponding to the factors affecting on Ready Mixed Concrete were analyzed using the Spearman's rank correlation method.

The rank correlation coefficient is a measure of correlation that exists between the two sets of ranks. It is a measure of association that is based on the ranks of the observations and not on the numerical value of the data. The value of Spearman's rank correlation coefficient will vary between -1 to 1 indicates a perfect positive correlation and indicates perfect negative correlation between two variables. It was worked out by following equation:

$$Rs = 1 - \frac{6\sum d^2}{n^3 - n} \qquad \text{............ (5)}$$

Here, d = difference between ranks, and n = number of parameters being ranked.

Table 3: Composite priority weights for Main Criterias – Sub Criterias of RMC

SN	Criterias	Local Weight	Sub Criterias	Local Weight	Global Weight	Rank
1.	Quality Control	0.106594	Quality of Material	0.729563	0.077767	3
			Standard & Certification	0.270437	0.028827	9
2.	Cost	0.114860	Direct Cost	0.242870	0.027896	11
			Indirect Cost	0.757130	0.086964	1
3.	Delivery	0.123720	Location	0.250787	0.031027	7
			Size of Transit Mixer	0.218065	0.026979	13
			Delivery Lead Time	0.322132	0.039854	4
			Time Consuming	0.209016	0.025859	14
4.	Quantity	0.094040	Large Quantity	0.856819	0.080575	2
			Small Quantity	0.143181	0.013465	36
5.	Manpower	0.104995	Skill Person	0.203484	0.021365	20
			Unskilled Person	0.263961	0.027715	12
			Technical Staff	0.234016	0.024570	16
			Manager	0.298538	0.031345	6
6.	Safety Measures	0.084066	Labour Safety	0.296069	0.024889	15
			Equipment Safety	0.364333	0.030628	8
			Accidents	0.339598	0.028549	10
7.	Financial Capability	0.085428	Profit Trends	0.273146	0.023334	17
			Turnover	0.235142	0.020088	22
			Banking History	0.255785	0.021851	19
			Amount of Past Business	0.235927	0.020155	21
8.	Commercial Capability	0.115751	Sales/Utilization area	0.331321	0.038351	5
			Sales Policy	0.132420	0.015328	34
			Responsiveness	0.133883	0.015497	33
			Discipline	0.130977	0.015161	35
			Environment	0.135433	0.015676	32
			Reputation & Position	0.135966	0.015738	31
9.	Laboratory	0.077953	General	0.299155	0.023320	18
			Test Facility	0.245302	0.019122	25
			Testing Procedures	0.227838	0.017761	27
			Personnel	0.227705	0.017750	29
10	Managerial Capability	0.092593	Organizational Structure	0.191797	0.017759	28
			Types of Decision maker	0.202453	0.018746	26
			Direction of Work	0.185494	0.017176	30
			Maintenance	0.208348	0.019292	24
			Customer Feedback	0.211908	0.019621	23

Table 4: Summarizes of priority weights and ranking of each respondents

Anand			Nadiad			Vadodara			Ahmedabad		
Respondent	Total Scores	Rank	Respondent	Total Scores	Rank	Respondent	Total Scores	Rank	Respondent	Total Scores	Rank
R1	0.03484	58	R16	0.04034	9	R31	0.03510	56	R46	0.03903	29
R2	0.03861	36	R17	0.03887	33	R32	0.03805	45	R47	0.03803	46
R3	0.04151	3	R18	0.03946	22	R33	0.04130	4	R48	0.03910	27
R4	0.04162	2	R19	0.03943	23	R34	0.04317	1	R49	0.03890	32
R5	0.03389	40	R20	0.03860	37	R35	0.03437	59	R50	0.03977	18
R6	0.03578	54	R21	0.04077	5	R36	0.03599	53	R51	0.03894	31
R7	0.03949	21	R22	0.03842	39	R37	0.04052	7	R52	0.03782	48
R8	0.04062	6	R23	0.03939	24	R38	0.03501	57	R53	0.03999	13
R9	0.03868	35	R24	0.03844	38	R39	0.04028	11	R54	0.03751	49
R10	0.03919	25	R25	0.03907	28	R40	0.03994	14	R55	0.03839	41
R11	0.03672	52	R26	0.03985	17	R41	0.03717	50	R56	0.04016	12
R12	0.03802	47	R27	0.03812	44	R42	0.04047	8	R57	0.03915	26
R13	0.03702	51	R28	0.03957	20	R43	0.03993	15	R58	0.03958	19
R14	0.03899	30	R29	0.03818	43	R44	0.04030	10	R59	0.03386	60
R15	0.03889	34	R30	0.03987	16	R45	0.03819	42	R60	0.03548	55

Table 5: Comparison of Rank Correlation Coefficient

SN	Comparison	Rank Correlation Coefficient
1.	Ahmedabad - Nadiad	0.715
2.	Ahmedabad - Anand	0.857
3.	Ahmedabad - Vadodara	0.785
4.	Nadiad - Anand	0.835
5.	Nadiad - Vadodara	0.945
6.	Anand - Vadodara	0.855

CONCLUSIONS

- The main contribution of the work was the identification of the important Criterias for the Ready Mixed Concrete (RMC).
- According to the Analytical Hierarchy Process (AHP), development of the Criterias Framework in Indian context was prepared for Ready Mixed Concrete selection. Total 36 nos. of sub-criteria's were identified which affect the Ready Mixed Concrete which are divided into the 10 major groups: Quality Control, Cost, Delivery, Quantity, Manpower, Safety Measures, Financial Capability, Commercial Capability, Laboratory, Managerial Capability.
- With the help of Analytical Hierarchy Process (AHP) technique, relative importance of each criteria in the form of the numeric value was generated through the responses of three types of stakeholders: Ready Mixed Concrete Plant Managers, Consultants, and Contractors. Targeted cities were Anand, Nadiad, Vadodara, and Ahmedabad. According to population, Sample size was calculated as 60 responses.
- Consistency of the data were checked by spearmen correlation co-efficient. The Values of these co-efficient is near to 1 between city to city groups. Hence it was found that judgments of various stakeholders are not too much varied from each other. Inconsistent responses of some of the respondents were improved by 'Consistency Improvement Technique' given by Lamata.

- Top Ten Criterias which affects the Ready Mixed Concrete selection are Indirect Cost, Large Quantity, Quality of Material, Delivery Lead Time, Sales/Utilization Area, Manager, Location, Equipment Safety, Standard and Certification, Accidents.
- Hence, we can say that Utilization of Ready Mixed Concrete is very helpful if we mainly govern Indirect Cost, Large Quantity, Quality of Material, Delivery Lead Time, Sales/Utilization Area, Manager, Location, Equipment Safety, Standard and Certification, Accidents.
- For Ready Mixed Concrete selection, 60respondents were evaluated through AHP based approach. By Analytic Hierarchy Process, first rank was applied to respondent no. 34 and last rank was applied to respondent no. 59.
- By using Analytic Hierarchy Process (AHP) complete ranking with scores can be applied on selected Criterias.
- The proposed methodology can also be applied to any other selection problem involving multiple and conflicting Criterias.

ACKNOWLEDGEMENT

The Authors thankfully acknowledge to Dr. C. L. Patel, Chairman, Charutar Vidya Mandal, and Er. V. M. Patel, Hon. Jt. Secretary, Charutar Vidya Mandal, Dr. F. S. Umrigar, Principal, B.V.M. Engineering College, Prof. J. J. Bhavsar, Associate professor and coordinator PG (Construction Engineering & Management), Civil Engineering Department, B.V.M Engineering College, Er. Yatinbhai Desai, Jay Maharaj Construction, Vallabh Vidyanagar, Gujarat, India for their motivations and infrastructural support to carry out this research.

REFERENCES

1. Ashish H. Makwana, Prof. Jayeshkumar Pitroda, "An Approach for Ready Mixed Concrete Selection for Construction Companies through Analytic Hierarchy Process", International Journal of Engineering Trends and Technology (IJETT), ISSN: 2231-5381, Volume-4, Issue-7, July 2013, Pg. 2878 - 2884.
2. Ashish H. Makwana and Prof. Jayeshkumar Pitroda, 2013, "Ready Mixed Concrete Selection for Infrastructure Development through Analytic Hierarchy Process (AHP) in the New Millennium", International Journal of Management (IJM), Journal Impact Factor (2013): 6.9071 (Calculated by GISI), Volume: 4, Issue: 5, Pages: 109-126.
3. Ashish H. Makwana, Prof. Jayeshkumar Pitroda, "An Approach for Ready Mixed Concrete Selection For Construction Companies through Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) Technique", International Journal of Innovative Technology and Exploring Engineering (IJITEE), Impact Factor: 1.00, ISSN: 2278-3075, Volume-3, Issue-5, October 2013, Pg. 92 – 96.
4. Bhavik K. Daxini, Prof. (Dr.) R.B. Bhatt, Prof. Jayeshkumar Pitroda, "An Approach for Supplier Selection for Construction Companies through Analytical Hierarchy Process", IJSR– International Journal of Scientific Research, Volume: 2 | Issue: 5 | May 2013 • ISSN No. 2277 – 8179.
5. IS 4926 - 2003, Indian Standard, Ready mixed concrete – Code of Practice (Second Revision), BIS, New Delhi.
6. M.S. SHETTY, Concrete Technology, Theory and Practice, S.Chand- New Delhi.
7. Saaty, T.L., 1980, "The Analytic Hierarchy Process: Planning, Priority Setting, Resource Allocation", 1st edition, Mcgraw-Hill, New York, ISBN: 0070543712, Alibris ID: 9503413947.

8. Vaidya, O. and S. Kumar, 2006, "Analytic Hierarchy Process: An overview of applications", European J. Operational Res., 169: 1-29.
9. Yaser N. Alsuwehri, "Supplier Evaluation and Selection by Using The Analytic Hierarchy Process Approach", Engineering Management Field Project, Masters of Science, the Graduate School of The University of Kansas.
10. Z. Lamata et al. (2002), "A method for improving the consistency of judgments", International Journal of Uncertainty volume 10 (6).

AUTHOR'S BIOGRAPHY

Ashish Harendrabhai Makwana was born in 1988 in Jamnagar District, Gujarat. He received his Bachelor of Engineering degree in Civil Engineering from the Charotar Institute of Science and technology in Changa, Gujarat Technological University in 2012. At present he is Final year student of Master's Degree in Construction Engineering and Management from Birla Vishwakarma Mahavidyalaya, Gujarat Technological University. He has published papers in National Conferences and International Journals.

Prof. Jayeshkumar R. Pitroda was born in 1977 in Vadodara City. He received his Bachelor of Engineering degree in Civil Engineering from the Birla Vishvakarma Mahavidyalaya, Sardar Patel University in 2000. In 2009 he received his Master's Degree in Construction Engineering and Management from Birla Vishvakarma Mahavidyalaya, Sardar Patel University. He joined Birla Vishvakarma Mahavidyalaya Engineering College as a faculty where he is Assistant Professor of Civil Engineering Department with a total experience of 12 years in the field of Research, Designing and education. He is guiding M.E. (Construction Engineering & Management) Thesis work in the field of Civil/ Construction Engineering. He has published papers in National Conferences and International Journals.