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A Competitive Assessment on Fly-Ash Bricks and Clay Bricks in Central Gujarat Region of India Using Chi-Square Test($\chi 2$) through SPSS Software

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Abstract

Fly-ash bricks are well known bricks. Fly-ash bricks are slow but surely replacing conventional clay bricks for wall constructions. It is green and environmentally friendly material. Fly ash brick is a really good option against Clay brick. It is green and environmentally friendly material. The fly ash bricks are comparatively lighter in weight and stronger and less costly than common clay bricks. Fly- ash Bricks is low value and high volume product and transporting it over long distances is uneconomical. But due to less awareness of fly ash bricks the different agencies of the construction wing using clay bricks. This research paper presents a comparison of fly-ash bricks and clay bricks. Based on Fly-ash bricks and clay bricks the data collected, Data will be collected through questionnaires and personal interviews targeting residential building and infrastructure projects. We can easily able to analysis of fly ash bricks and clay bricks by using Chi-square test through statistical methods (SPSS SOFTWARE).

Keywords: Fly-ash bricks, Clay bricks, Chi-square test, Cost, Construction.

Introduction

Brick is the oldest manufactured building material, and much of its history is lost in antiquity. With the change of habits, choices as well as the change of the society the demand of Fly-Ash Bricks are gradually increasing day by day in the metropolitan cities. Fly Ash bricks are made of fly ash, lime, gypsum and sand. These can be extensively used in all building constructional activities similar to that of common burnt clay bricks. The fly ash bricks are comparatively lighter in weight and stronger than common clay bricks. Since fly ash is being accumulated as waste material in large quantity near thermal power plants and creating serious environmental pollution problems, its utilization as main raw material in the manufacture of bricks will not only create ample opportunities for its proper and useful disposal but also help in environmental pollution control to a greater extent in the surrounding areas of power plants. Comparison of Fly ash bricks and ordinary red clay bricks are shown in Table 1

TABLE 1 Comparison Between Fly Ash Bricks And Clay Bricks

FLY-ASH BRICKS	CLAY BRICKS
Uniform pleasing color like cement	Varying color as per soil
Uniform in shape and smooth finish	Uneven shape as hand made
Dense composition	Lightly bonded
No plastering required	Plastering required
Lighter in weight	Heavier in weight
The compressive strength is around 80-100 Kg/cm^2	The compressive strength is around 35 Kg/cm^2
Less porous	More porous
Thermal conductivity 0.90-1.05 W/m^2 ºC	Thermal conductivity 1.25 – 1.35 W/m^2 ºC
Water absorption 6-12%	Water absorption 20-25%
Less costly	More costly
Environmentally friendly	Not Environmentally friendly
Saving of fertile land, pure water	Wastage of fertile land, pure water

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Research Objectives

- The objective of the present research is to identify the factors affecting and make questionnaires the performance of fly ash brick and clay brick in the construction projects.
- To study Traders, consultants and contractors perceptions towards the use of fly ash brick and clay brick in construction projects.

Data Analysis and Interpretation

A Comparison of Fly-ash brick And Clay Brick Through their merits & Demerits and finally survey questionnaire is prepared and data analysis is done by Chi-square test through Microsoft Excel and Statistical Package for the Social Sciences (SPSS) software. Different Gujarat regions are included such as Vadodara, Ahmedabad, Nadiad, and Aanad.

About CHI-Square Test (χ^2)

The chi-square test is used to determine whether there is a significant difference between
The expected frequencies and the observed frequencies in one or more categories. Do the
Number of individuals or objects that fall in each category differ significantly from the
Number you would expect? Is this difference between the expected and observed due to
Sampling error, or is it a real difference?

Objective: To prove that Fly-ash brick is much better than Clay bricks.

- **Null hypothesis (H_0)** - Fly-ash Bricks are much better than Clay Bricks. ($\alpha \leq 0.05$)

Alternative hypothesis (H_1) - Fly-ash Bricks are not much better than Clay Bricks. ($\alpha > 0.05$)

Table 2: Chi-square ($\chi 2$) Test for Consultant

Level of significance (α)	Calculated	Tabulated	Criterion	Result	Hypothesis
[1] Consultant					
1: Fly-ash Bricks more cheaply than Clay Bricks					
0.005	16.600	14.860	Reject the null hypothesis if χ^2(Calculated)> 14.860, the value of $\chi^2_{0.005}$ for 5-1= 4 degree of freedom	Rejected	**Not Accepted**
2: More usage of Clay Bricks compare to Fly-ash bricks					
0.05	9.400	9.488	Reject the null hypothesis if χ^2(Calculated)> 9.488, the value of $\chi^2_{0.05}$ for 5-1= 4 degree of freedom	Cannot be rejected	**Accepted**
3: Fly-ash Bricks more Environmental friendly than Clay Bricks					
0.05	9.400	9.488	Reject the null hypothesis if χ^2(Calculated)> 9.488, the value of $\chi^2_{0.05}$ for 5-1= 4 degree of freedom	Cannot be rejected	**Accepted**
4: Fly-ash Bricks less manufactured in Central Gujarat					
0.05	4.200	9.488	Reject the null hypothesis if χ^2(Calculated)> 9.488, the value of $\chi^2_{0.05}$ for 5-1= 4 degree of freedom	Cannot be rejected	**Accepted**
5: Lack of Suppliers of Fly-ash Bricks for its less usage					
0.05	9.400	9.488	Reject the null hypothesis if χ^2(Calculated)> 9.488, the value of $\chi^2_{0.05}$ for 5-	Cannot be rejected	**Accepted**

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			1= 4 degree of freedom		
6: Fly-ash Bricks Cost Saving due to Breakage and Wastage					
0.05	9.000	9.488	Reject the null hypothesis if χ^2(Calculated)> 9.488, the value of $\chi^2_{0.05}$ for 5-1= 4 degree of freedom	Cannot be rejected	**Accepted**
7: Less utilization of Fly-ash Bricks due to lack of acceptance to change					
0.005	23.400	14.860	Reject the null hypothesis if χ^2(Calculated)> 14.860, the value of $\chi^2_{0.005}$ for 5-1= 4 degree of freedom	Rejected	**Not Accepted**
8: Better finishing of plaster in Fly-ash Bricks compare to Clay Bricks					
0.005	14.400	14.860	Reject the null hypothesis if χ^2(Calculated)> 14.860, the value of $\chi^2_{0.005}$ for 5-1= 4 degree of freedom	Cannot be rejected	**Accepted**
9: Less mortar requirement of Fly-ash bricks compare to Clay Bricks					
0.01	13.000	13.277	Reject the null hypothesis if χ^2(Calculated)> 13.277, the value of $\chi^2_{0.01}$ for 5-1= 4 degree of freedom	Cannot be rejected	**Accepted**
10: Increased supply of Fly-ash Bricks of Central Gujarat Region					
0.005	14.600	14.860	Reject the null hypothesis if χ^2(Calculated)> 14.860, the value of $\chi^2_{0.005}$ for 5-1= 4 degree of freedom	Cannot be rejected	**Accepted**
11: High Compressive Strength of Fly-ash Bricks compared to Clay Bricks					
0.05	8.600	9.488	Reject the null hypothesis if χ^2(Calculated)> 9.488, the value of $\chi^2_{0.05}$ for 5-1= 4 degree of freedom	Cannot be rejected	**Accepted**
12: Lower resistance of Fly-ash Bricks compare to Clay Bricks					
0.005	14.000	14.860	Reject the null hypothesis if χ^2(Calculated)> 14.860, the value of $\chi^2_{0.005}$ for 5-1= 4 degree of freedom	Cannot be rejected	**Accepted**
13: Costly Initial set up of Fly-ash Bricks compare to Clay Bricks					
0.005	14.800	14.860	Reject the null hypothesis if χ^2(Calculated)> 14.860, the value of $\chi^2_{0.005}$ for 5-1= 4 degree of freedom	Cannot be rejected	**Accepted**

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14: Lake of availability of Fly-ash in Central Gujarat Region					
0.05	7.000	9.488	Reject the null hypothesis if χ^2(Calculated)> 9.488, the value of $\chi^2_{0.05}$ for 5-1= 4 degree of freedom.	Cannot be rejected	**Accepted**
15: Easier maintenance and low cost of Fly-ash Bricks structure compare to Clay Bricks					
0.05	7.200	9.488	Reject the null hypothesis if χ^2(Calculated)> 9.488, the value of $\chi^2_{0.05}$ for 5-1= 4 degree of freedom.	Cannot be rejected	**Accepted**
16: Less porous Fly-ash Bricks compare to Clay Bricks					
0.005	14.400	14.860	Reject the null hypothesis if χ^2(Calculated)> 14.860, the value of $\chi^2_{0.05}$ for 5-1= 4 degree of freedom.	Cannot be rejected	**Accepted**
17: Low thermal conductivity of Fly-ash Bricks compare to Clay Bricks					
0.05	7.000	9.488	Reject the null hypothesis if χ^2(Calculated)> 9.488, the value of $\chi^2_{0.05}$ for 5-1= 4 degree of freedom.	Cannot be rejected	**Accepted**
18: Low water absorption of Fly-ash Brick compare to Clay Bricks					
0.05	26.600	9.488	Reject the null hypothesis if χ^2(Calculated)> 9.488, the value of $\chi^2_{0.05}$ for 5-1= 4 degree of freedom.	Rejected	**Not Accepted**
19: No breakage during transportation of Fly-ash Bricks compare to Clay Bricks					
0.05	30.400	9.488	Reject the null hypothesis if χ^2(Calculated)> 9.488, the value of $\chi^2_{0.05}$ for 5-1= 4 degree of freedom.	Rejected	**Not Accepted**
20: Need of skilled labour for handling of Fly-ash Bricks plant					
0.05	5.800	9.488	Reject the null hypothesis if χ^2(Calculated)> 9.488, the value of $\chi^2_{0.05}$ for 5-1= 4 degree of freedom.	Cannot be rejected	**Accepted**
21: Dense composition of Fly-ash Bricks compare to Clay Bricks					
0.05	27.800	9.488	Reject the null hypothesis if χ^2(Calculated)> 9.488, the value of $\chi^2_{0.05}$ for 5-1= 4 degree of freedom.	Rejected	**Not Accepted**

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22: Manufacturing of Fly-ash Bricks harmful to human health					
0.005	16.400	14.860	Reject the null hypothesis if χ^2(Calculated)> 14.860, the value of $\chi^2_{0.05}$ for 5-1= 4 degree of freedom.	Rejected	**Not Accepted**
23: Low durability of Fly-ash Bricks compare to Clay Bricks					
0.005	19.600	14.860	Reject the null hypothesis if χ^2(Calculated)> 14.860, the value of $\chi^2_{0.05}$ for 5-1= 4 degree of freedom.	Rejected	**Not Accepted**
24: Dumping problem of Fly-ash Bricks more Eco-friendly compare to Clay Bricks					
0.05	5.400	9.488	Reject the null hypothesis if χ^2(Calculated)> 9.488, the value of $\chi^2_{0.05}$ for 5-1= 4 degree of freedom.	Cannot be rejected	**Accepted**
25: Better Quality of Fly-ash Bricks compare to Clay Bricks					
0.05	5.000	9.488	Reject the null hypothesis if χ^2(Calculated)> 9.488, the value of $\chi^2_{0.05}$ for 5-1= 4 degree of freedom.	Cannot be rejected	**Accepted**
26: Inclusion of fiber in Fly-ash Bricks is more helpful than inclusion in normal Clay Bricks					
0.005	18.600	14.860	Reject the null hypothesis if χ^2(Calculated)> 14.860, the value of $\chi^2_{0.005}$ for 5-1= 4 degree of freedom.	Rejected	**Not Accepted**
27: Better Exposed brick work of Fly-ash Bricks compare to Clay Bricks					
0.05	5.400	9.488	Reject the null hypothesis if χ^2(Calculated)> 9.488, the value of $\chi^2_{0.05}$ for 5-1= 4 degree of freedom.	Cannot be rejected	**Accepted**
28: Use of Value Engineering for Fly-ash Bricks and Clay Bricks					
0.05	5.400	9.488	Reject the null hypothesis if χ^2(Calculated)>9.488, the value of $\chi^2_{0.05}$ for 5-1= 4 degree of freedom.	Cannot be rejected	**Accepted**
29: More merits of Fly-ash Bricks compare to Clay Bricks					
0.005	14.000	14.860	Reject the null hypothesis if χ^2(Calculated)> 14.860, the value of $\chi^2_{0.005}$ for 5-1= 4 degree of freedom.	Cannot be rejected	**Accepted**

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Final Result of Consultant by Chi-square Test:-	
Accepted Variables: 72.41 %	**Not Accepted Variables:** 27.59 %
Null hypothesis: Approved	

Table 3: Chi-square (χ^2) Test for Engineers

Level of significance (α)	**Calculated**	**Tabulated**	**Criterion**	**Result**	**Hypothesis**
PART 2: Data analysis and interpretation regarding Engineers point of view					
1: Fly-ash Bricks more cheaply than Clay Bricks					
0.05	4.833	9.488	Reject the null hypothesis if χ^2(Calculated)> 9.488, the value of $\chi^2_{0.05}$ for 5-1= 4 degree of freedom	Cannot be rejected	**Accepted**
2: Fly-ash Bricks more Environmental friendly than Clay Bricks					
0.005	14.167	14.860	Reject the null hypothesis if χ^2(Calculated)> 14.860, the value of $\chi^2_{0.005}$ for 5-1= 4 degree of freedom	Cannot be rejected	**Accepted**
3: Manufacturing of Fly-ash Bricks faster than Clay Bricks					
0.05	6.000	9.488	Reject the null hypothesis if χ^2(Calculated)> 9.488, the value of $\chi^2_{0.05}$ for 5-1= 4 degree of freedom	Cannot be rejected	**Accepted**
4: Fly-ash Bricks Cost Saving due to Breakage and Wastage					
0.05	3.500	9.488	Reject the null hypothesis if χ^2(Calculated)> 9.488, the value of $\chi^2_{0.05}$ for 5-1= 4 degree of freedom	Cannot be rejected	**Accepted**
5: Finishing of plaster better in Fly-ash Bricks than Clay Bricks					
0.05	9.433	9.488	Reject the null hypothesis if χ^2(Calculated)> 9.488, the value of $\chi^2_{0.05}$ for 5-1= 4 degree of freedom	Cannot be rejected	**Accepted**
6: Less requirement of mortar for Fly-ash Bricks compare to Clay Bricks					
0.005	14.667	14.860	Reject the null hypothesis if χ^2(Calculated)> 14.860, the value of $\chi^2_{0.005}$ for 5-1= 4 degree of freedom	Cannot be rejected	**Accepted**
7: High Compressive Strength of Fly-ash Bricks compared to Clay Bricks					
0.01	13.167	13.277	Reject the null hypothesis if χ^2(Calculated)> 13.277, the value of $\chi^2_{0.01}$ for 5-	Cannot be rejected	**Accepted**

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			1= 4 degree of freedom		
8: Lower resistance of Fly-ash Bricks than Clay Bricks					
0.05	6.167	9.488	Reject the null hypothesis if χ^2(Calculated)> 9.488, the value of $\chi^2_{0.05}$ for 5-1= 4 degree of freedom	Cannot be rejected	**Accepted**
9: Costly Initial set up Cost of Fly-ash Bricks than Clay Bricks					
0.005	14.833	14.860	Reject the null hypothesis if χ^2(Calculated)> 14.860, the value of $\chi^2_{0.005}$ for 5-1= 4 degree of freedom	Cannot be rejected	**Accepted**
10: Easier maintenance of Fly-ash Bricks structure and less costly than Clay Bricks					
0.05	7.500	9.488	Reject the null hypothesis if χ^2(Calculated)> 9.488, the value of $\chi^2_{0.05}$ for 5-1= 4 degree of freedom	Cannot be rejected	**Accepted**
11: Less porous Fly-ash Bricks than Clay Bricks					
0.05	8.500	9.488	Reject the null hypothesis if χ^2(Calculated)> 9.488, the value of $\chi^2_{0.05}$ for 5-1= 4 degree of freedom	Cannot be rejected	**Accepted**
12: Low thermal conductivity of Fly-ash Bricks than Clay Bricks					
0.05	22.500	9.488	Reject the null hypothesis if χ^2(Calculated)> 9.488, the value of $\chi^2_{0.05}$ for 5-1= 4 degree of freedom	Rejected	**Not Accepted**
13: Low Water absorption Fly-ash Bricks than Clay Bricks					
0.05	32.167	9.488	Reject the null hypothesis if χ^2(Calculated)> 9.488, the value of $\chi^2_{0.05}$ for 5-1= 4 degree of freedom	Rejected	**Not Accepted**
14: No Breakage during transportation of Fly-ash Bricks compare to Clay Bricks					
0.05	22.667	9.488	Reject the null hypothesis if χ^2(Calculated)> 9.488, the value of $\chi^2_{0.05}$ for 5-1= 4 degree of freedom.	Cannot be rejected	**Accepted**
15: Need Skilled labour for handling of Fly-ash Bricks Plant					
0.05	6.833	9.488	Reject the null hypothesis if χ^2(Calculated)> 9.488,	Cannot be rejected	**Accepted**

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			the value of $\chi^2_{0.05}$ for 5-1= 4 degree of freedom.		
16: Dense composition of Fly-ash Bricks than Clay Bricks					
0.05	7.667	9.488	Reject the null hypothesis if χ^2(Calculated)> 9.488, the value of $\chi^2_{0.05}$ for 5-1= 4 degree of freedom.	Cannot be rejected	**Accepted**
17: Manufacturing of Fly-ash Bricks harmful to human health					
0.05	31.167	9.488	Reject the null hypothesis if χ^2(Calculated)> 9.488, the value of $\chi^2_{0.05}$ for 5-1= 4 degree of freedom.	Rejected	**Not Accepted**
18: Low durability of Fly-ash Bricks than Clay Bricks					
0.05	5.833	9.488	Reject the null hypothesis if χ^2(Calculated)> 9.488, the value of $\chi^2_{0.05}$ for 5-1= 4 degree of freedom.	Cannot be rejected	**Accepted**
19: Eco-friendly Dumping problem of Fly-ash Bricks than Clay Bricks					
0.05	42.500	9.488	Reject the null hypothesis if χ^2(Calculated)> 9.488, the value of $\chi^2_{0.05}$ for 5-1= 4 degree of freedom.	Rejected	**Not Accepted**
20: Quality of Fly-ash Bricks better than Clay Bricks					
0.05	6.500	9.488	Reject the null hypothesis if χ^2(Calculated)> 9.488, the value of $\chi^2_{0.05}$ for 5-1= 4 degree of freedom.	Cannot be rejected	**Accepted**
21: More helpful of Inclusion of fiber in Fly-ash Bricks than normal Clay Bricks					
0.005	14.167	14.860	Reject the null hypothesis if χ^2(Calculated)> 14.860, the value of $\chi^2_{0.005}$ for 5-1= 4 degree of freedom.	Cannot be rejected	**Accepted**
22: Better Exposed Brick works of Fly-ash Brick than Clay Bricks					
0.05	61.333	9.488	Reject the null hypothesis if χ^2(Calculated)> 9.488, the value of $\chi^2_{0.05}$ for 5-1= 4 degree of freedom.	Rejected	**Not Accepted**
23: Use of Value Engineering for Fly-ash Bricks and Clay Bricks					
0.05	9.167	9.488	Reject the null hypothesis if χ^2(Calculated)> 9.488,	Cannot be rejected	**Accepted**

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			the value of $\chi^2_{0.05}$ for 5-1= 4 degree of freedom.		
24: More Merits of Fly-ash Bricks than Clay Bricks					
0.05	41.333	9.488	Reject the null hypothesis if χ^2(Calculated)> 9.488, the value of $\chi^2_{0.05}$ for 5-1= 4 degree of freedom.	Rejected	**Not Accepted**
Final Result of Engineer by Chi-square Test:-					
Accepted Variables: 75 %			**Not Accepted Variables:** 25%		
Null hypothesis: Approved					

Table 4: Chi-square (χ2) Test for Traders

Level of significance (α)	**Calculated**	**Tabulated**	**Criterion**	**Result**	**Hypothesis**
PART 3: Data analysis and interpretation regarding Traders point of view					
1: Easy availability of Clay Bricks compare to Fly-ash Bricks					
0.05	9.400	9.488	Reject the null hypothesis if χ^2(Calculated)> 9.488, the value of $\chi^2_{0.05}$ for 5-1= 4 degree of freedom	Cannot be rejected	**Accepted**
2: Familiarity of Clay Bricks utilization compare to Fly-ash Bricks					
0.05	4.400	9.488	Reject the null hypothesis if χ^2(Calculated)> 9.488, the value of $\chi^2_{0.05}$ for 5-1= 4 degree of freedom	Cannot be rejected	**Accepted**
3: Less manufacturing of Fly-ash Bricks in Central Gujarat					
0.05	9.000	9.488	Reject the null hypothesis if χ^2(Calculated)> 9.488, the value of $\chi^2_{0.05}$ for 5-1= 4 degree of freedom	Rejected	**Accepted**
4: Faster Manufacturing of Fly-ash bricks compare to Clay Bricks					
0.05	5.000	9.488	Reject the null hypothesis if χ^2(Calculated)> 9.488, the value of $\chi^2_{0.05}$ for 5-1= 4 degree of freedom	Cannot be rejected	**Accepted**
5: Lack of suppliers of Fly-ash Bricks					
0.005	14.000	14.860	Reject the null hypothesis if χ^2(Calculated)> 14.860, the value of	Cannot be rejected	**Accepted**

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			$\chi^2_{0.005}$ for 5-1= 4 degree of freedom		
6: Less utilization of Fly-ash Bricks due to lack of acceptance to change					
0.05	33.400	9.488	Reject the null hypothesis if χ^2(Calculated)> 9.488, the value of $\chi^2_{0.05}$ for 5-1= 4 degree of freedom	Rejected	**Not Accepted**
7: Increased supply of Fly-ash Bricks of Central Gujarat Region					
0.05	9.400	9.488	Reject the null hypothesis if χ^2(Calculated)> 9.488, the value of $\chi^2_{0.05}$ for 5-1= 4 degree of freedom	Cannot be rejected	**Accepted**
8: Costly Initial set up cost of Fly-ash Bricks compare to Clay Bricks					
0.05	41.000	9.488	Reject the null hypothesis if χ^2(Calculated)> 9.488, the value of $\chi^2_{0.05}$ for 5-1= 4 degree of freedom	Rejected	**Not Accepted**
9: Lake of availability of Fly-ash in Central Gujarat Region					
0.05	30.600	9.488	Reject the null hypothesis if χ^2(Calculated)> 9.488, the value of $\chi^2_{0.05}$ for 5-1= 4 degree of freedom	Rejected	**Not Accepted**
10: No breakage during transportation compare to Clay Bricks					
0.05	32.200	9.488	Reject the null hypothesis if χ^2(Calculated)> 9.488, the value of $\chi^2_{0.05}$ for 5-1= 4 degree of freedom	Rejected	**Not Accepted**
11: Need of skilled labour for handling of Fly-ash Bricks plant					
0.05	50.200	9.488	Reject the null hypothesis if χ^2(Calculated)> 9.488, the value of $\chi^2_{0.05}$ for 5-1= 4 degree of freedom	Rejected	**Not Accepted**
12: Fly-ash Bricks manufacturing harmful to human health					
0.05	8.200	9.488	Reject the null hypothesis if χ^2(Calculated)> 9.488, the value of $\chi^2_{0.05}$ for 5-1= 4	Cannot be rejected	**Accepted**

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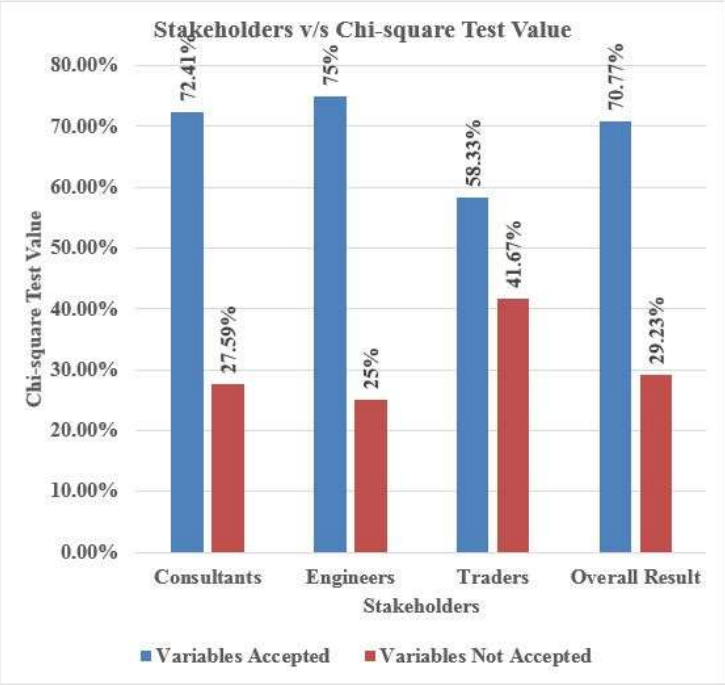
			degree of freedom		
Final Result of Traders by Chi-square Test:-					
Accepted Variables: 58.33 %			**Not Accepted Variables:** 41.67 %		
Null hypothesis: Approved					

Conclusion

Fly-ash brick is much better than Clay bricks. So Null Hypothesis is successfully proved by CHI-SQUARE TEST.

Table 5: Chi-square Test Result Summary

	Variables		Null hypothesis
	Accepted	Not Accepted	
Consultants	72.41 %	27.59 %	**Approved**



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