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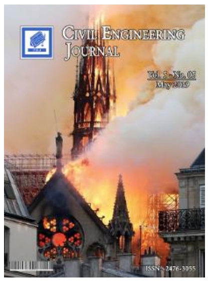
Civil Engineering Journal

Vol. 5, No. 5, May, 2019



Comparative Study on Breaking Strength of Burnt Clay Bricks Using Novel Based Completely Randomized Design (CRD)

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Received 09 February 2019; Accepted 10 May 2019

Abstract

The aim of this study is to present the results of breaking strength tests for burnt clay bricks from various historical deposits. The native clay bricks production technique is the known method of brick making, particularly in South Asian countries. Numerous studies have been conducted on hand-molded formed bricks. The clay bricks that were considered for the comparative study, were made from four different clays sources. Their breaking strength was determined using for examining the maximum load at failure and the effects were investigated subsequently. The basic objective of this experimental study was to compare the breaking strength of locally fired clay bricks using a novel based completely randomized design via a single factor with four levels of clay sources representing the factors. For this purpose, 24 brick samples were made from four different clay sources while the breaking strength of each sample was measured. Pairwise comparison trials, including Duncan's multiple range, Newman–keuls, Fisher's least and Tukey's tests were conducted. Based on experimental investigations, the results revealed that using analysis of variance at 95% CI, the difference in breaking strength between clay source of Hyderabad (A) and Rawalpindi (B), followed by Kohat (C) and Peshawar (D) was significant and also the difference among the means of these clay courses was significant which clearly exposed that the clay site and chemical composition has a great impression of the breaking strength of the burnt bricks.

Keywords: Breaking Strength of Burnt Clay Bricks; Experimental Design; Completely Randomized Design (CRD).

1. Introduction

Normally, a good burnt clay brick should be hard enough, well scalded, sound in texture and sharp in outline and measurement and should not break definitely. Burnt clay bricks used in the construction sphere must have certain desired properties that must be achieved [1]. These include density, porosity, breaking strength, thermal stability and fire resistance. Breaking strength is a mechanical property which has assumed greater prominence for various reasons. A greater breaking strength upsurges other properties like resistance to abrasion and flexure, hence this property should be determined more accurately [2]. Breaking strength relies on the chemical composition of clay used, the manufacturing techniques followed by the physical shape and dimension of the brick.

The crushing resistance differs from 3.5 N/mm^2 for normal soft facing bricks to 140 N/mm^2 for engineering clay bricks in case tested in the dry state. In general, breaking strength declines with increasing porosity, however strength is also affected by composition of clay and firing temperate [3]. As per mechanical characteristics regarding solid bricks materials as shown in Table 1, the bricks formed by hand as shown in Figure1 will have comparatively inferior quality, especially breaking strength, and will incline to have uneven dimensions. Bricks prepared in this way have been used in

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http://dx.doi.org/10.28991/cej-2019-03091320

structures which have lasted for centuries [4]. Their permanency has depended on the excellence of the constituents, the skill of the handicraft worker and the environment in which they were used [5].

Table 1. Bricks and clay mechanical characteristics (Breaking Strength)

Unit Type			Breaking strength, psi (MPa)
Solid brick	Forming method	Moulded	5293 (36.5)
		Extruded	11305 (77.9)
	Raw material	Fire Clay	15343 (106.8)
		Shale	11258 (77.6)
		Others	9159 (63.2)

The primary perilous element for producing burnt clay bricks is the determination of a good quality of clay. The composition of clay differs a wide range of alumina, iron, lime, sulfur, silica sand and some amount of phosphate. During the process of firing the temperature must remain constant to get the best quality product [6]. Obviously it will develop additional issues such as low breakage strength and increase rejection rate. When stresses present within a drying brick, cracks can appear to relieve them [7]. These stresses are developed when a brick does not dry stability. Therefore, when the later part needs to shrink, a sudden crack may appear to dismiss the stress. Minor drying cracks may normally develop during the process of firing, particularly if noteworthy firing shrinkage happens [8]. Cracking and defect problems occur due to plasticity of clay, pressing pressure, drying process time, kiln temperature [9]. Such a sample is shown in Figure 2. Although there could be certain questions, however assuming that the lower level of breaking strength is associated with the inadequate quality of clay used. Hence this research study is conducted to determine the best source of clay that can result in better output. To investigate and analyze the potential factors influencing on the breaking strength of the bricks, a novel based completely randomized design with single factor experiment has been designed to take additional annoyance aspects into account.

Figure 1. Traditional way of making clay bricks

Figure 2. Defective brick sample

2. Completely Randomized Design

This approach is best suited for analyzing the effect of a single factor to consider other annoyance factor into account [10]. It basically associates the tenets of a specific response variable with other necessary levels while the levels of factors designed randomly [11]. The design strategy is based on three key factors, f = number of factors which is usually taken as 1 followed by L = number of possible levels and N = replications numbers. Starting design phase is to set the hypothesis using ANOVA making the objective to test the right hypotheses around the means of treatment and to approximate them[12]. If X_{ij} is the jth response observation for specific factor treatment level i; N observations, T_i. observations total, X_a. As the mean for treatment level, T the grand total and Ẋ the grand mean, then classic data of design of experiment for a single factor may look as shown Table 2.

$$T_i = \sum_{j=1}^{n} X_{IJ} \tag{1}$$

$$\dot{X}_i = \sum_{j=1}^{a} \frac{\dot{X}i}{n} \tag{2}$$

Table 2. Data orientation for single factor design of experiment

Factor level	Observations	Total (T)	Mean (X)
1.	X_{11} , X_{12} , X_{13} ,………. X_{1n}	T_1	$\dot{X}_1$
2.	X_{21} , X_{22} , X_{23} ,………. X_{2n}	T_2	$\dot{X}_2$
3.	X_{31} , X_{32} , X_{33} ,………. X_{3n}	T_3	$\dot{X}_3$
a.	X_{a1} X_{a2} X_{a3} ……… X_{an}	T_a	$\dot{X}_a$
	Total	T….	Ẋ….

2.1. Analysis of Variance

Considering the necessary parameters for segregating of total variability present in specific component parts that is: SS_{Total} = SS due to treatments + SS due to error:

$$SS_{Total} = \sum_{i=1}^{a} \sum_{j=1}^{n} (X_{ij} - \dot{X})^2 \tag{3}$$

Making appropriate hypothesis such as: Null Hypotheses (H0): = T1 = T2 = T3 ……. Tn = 0 and Alternative Hypotheses (H_1) Ti ≠ 0, at least for any one observation, then setting a 5% significance level (α = 0.05) for conducting ANOVA, if the test value (F_0) greater than critical value (Fc) based on levels of factors and degree of freedom then it is decided to reject null hypothesis (H_0) while the ANOVA computations results are presented using Table 3.

Table 3. ANOVA for single factor design of experiment

Source	SS	DF	Mean Square	F_0	F_{crit}
Treatments	SS_T	A-1	SS_T/A-1	MS_T/MS_e	Table value
Errors	SS_e	N-A	SS_e/N-A		
Total	SS_{Total}	N-1			

2.2. Estimation of Model Parameters and Residuals

Typically, a single factorial design of experiment model is expressed as:

$$X_{ij} = \mu + T_i + e_{ij} \tag{4}$$

Showing that the total mean is estimated by the grand average and the effect of treatment should be equal to the variance among the treatment and grand means[13].

$$e_{ij} = X_{ij} - \dot{X}_i \tag{5}$$

However, if these conventions are valid somehow then the ANOVA test is valid which is analysed by the observations and treatments residuals (R_{ij}).

$$R_{ij} = X_{ij} - \dot{X}_{ij}\ (error) \tag{6}$$

Reconsidering Equation 4 and expanding Equation 6:

$$R_{ij} = X_{ij} - \dot{X}_i \tag{7}$$

It means that estimation of any remark in the i^{th} usage is the consistent mean of treatment [14]. Conversely, If the current model is acceptable, then all the residuals must be structure fewer and analysed graphically [15].

2.3. Model Acceptability Checking

Normality check: Recognizes the process errors that must be distributed normally while the residuals plot for normal probability distribution would look like a straight line for the hypothesis to be valid [16]. Reasonable partings from this straight line may not be thoughtful because the sample extent might be trivial with no availability of outliers [17].

Independence check: If the scheme of errors pertain to design in data order determine an arbitrary strew, it will straight forward to identify the errors are self-determining [18]. If any correlation happens among the residuals it will show the defilement of the independent supposition [19]. However if the corresponding residuals are located randomly then it will show that they are autonomous [20].

Constant variance check: If the model is acceptable, the plot of residuals should be structure less and should not be related to any variable including the predicted response [21].The plots of residuals versus predicted response should appear as a parallel band centered about zero. If the spread of residuals increases , it will display that the error variance growths with the mean [22]. A valid model validation will show that no unusual structure is present that indicate that the model is correct [23].

2.4. Analysis of Treatments Mean

If the ANOVA result is to reject the null hypothesis that is, there exist variances among the means of the treatment but which means differ is not known. Hence, it is desirable to make comparison between the means of treatment [24]. This is also convenient to classify the finest and favored treatments for possible use in repetition. The best conduct is the one that resembles to the mean of treatment that optimizes the process response [25]. Other favored treatments of mean may be recognized over multiple comparison approaches and conducting ANOVA is performed [26]. They include:

Duncan's multiple range test: The test is suitable to compare the means of all pairs using a definite sequence.

Step 1: Arranging the means of treatment means in ascending form;

Step 2: Calculating the standard errors (S_e) of means ($S\dot{X}$);

$$S_{\dot{X}} = \sqrt{\frac{MS_e}{N}} \tag{8}$$

Step 3: Computing the values of r (p, f) for p = 2, 3… a, from Duncan's multiple ranges considering α as significance level and f as the degrees of freedom of error;

Step 4: Compute least significant ranges (Rp) for p = 2, 3… a;

$$R_p = (S_X)\, r_\alpha(p, f) \tag{9}$$

Step 5: Test the observed differences between the means against the least significant ranges (Rp) as follows;

Cycle 1: Compare the difference between largest and smallest mean with R*a*. Compare the difference between largest mean next smallest mean with R*a* –1 until all comparisons with largest mean [27].

Cycle 2: Test the variance between the second major and the minor mean with R*a* –1 until all possible pairs of means *a (a-1)/2* are tested.

Inference: If the observed difference between any two means exceed the least significant range, the difference is considered as significant [28].

Newman – Keuls test: Normally, the process of this test is similar to that of Duncan's multiple range test excluding that studentized ranges are used [29]. That is, in Step 4 of Duncan's procedure R_p is replaced by K_p, where q (p, f) values are obtained from studentized range table.

$$K_p = q_\alpha(p, f) \tag{10}$$

Fisher's Least Significant Difference (LSD) test: In this test means of all possible pairs are compared with LSD, where

$$LSD = t_{\alpha/2}, N - A\,\sqrt{[\frac{1}{N_I} + \frac{1}{N_j}]} \tag{11}$$

If the absolute variance between any two means surpasses LSD, then two means are considered as significantly different [30]. Using a balanced design, $n_1 = n_2 = \ldots = n$. hence,

$$LSD = t_{\alpha/2}, N - A\,\sqrt{\frac{2MS_e}{N}} \tag{12}$$

Tukey's test: In this test studentized range statistic is used and the possible pairs of means are then compared with Tα.(Risch, 1981). If the absolute alteration between any two means surpass Tα, then it is concluded that the two means differ significantly [31].

$$T_\alpha = q_\alpha(a, f)\sqrt{\frac{2MS_e}{N}} \tag{13}$$

2.5. Comparison of Means Using Contrasts Approach

A contrast presents a linear grouping of treatment totals and the addition of its coefficients may be equal to 0. A simple comparison of means with contrasts is equation based, while the sum of square of an individual contract is determine using expression [32].

$$C1 = T1 - T2 \tag{14}$$

$$SS_C = \frac{(\sum_{i=1}^{a} C_i T_i)}{N\sum_{i=1}^{a} C_i} = \frac{{C_i}^2}{N\sum_{i=1}^{a} C_i} \tag{15}$$

Here Ci represents the contrast of totals. However if $F_0 > F\alpha,1, N\text{-}A$, then the decision is to reject the null hypotheses (H_0) [33]. Orthogonal Contrast: In any contrast if on of the treatment level is absent, its corresponding coefficient will be 0 that is $C_1 = T_1 + T_2$ and $C_2 = T_3 + T_4$.

3. Methodology

For better and easy understand of the research methodology workflow and finding out which step is excessive and which improvement should be initiated, the experimental work was conducted in accordance to the research methodology process flowchart as shown in Figure 3. This flowchart will assure visual clarity, instant communication, effective coordination, effective analysis and a better decision making. The steps are described in sequence.

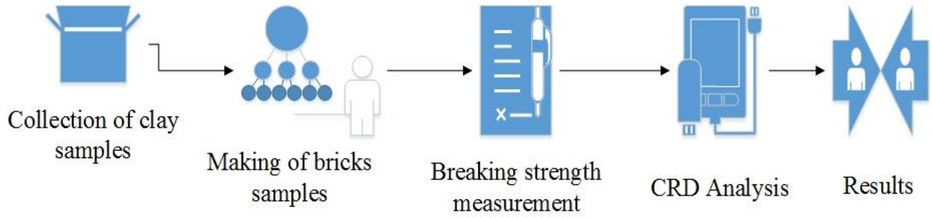

Figure 3. Flowchart steps for conducting research work

During the initial phase, four different samples of clays were acquired from four different cities of Pakistan, namely Hyderabad (A), Rawalpindi (B), Kohat (C) and Peshawar (D) as presented in Figure 4. It is intended to govern the unsurpassed source of clay that results in comparatively enhanced breaking strength. During the next phase a single-factor design of experiment was designed in order to consider the four clay sources as the four levels of the factor. Later, six different samples of bricks were made from each clay source. Finally, the corresponding breaking strength was measured. Using Equations 1 and 2 the mean breaking strength of each source has determined and result values are shown in Table 4. Figure 5 describes the graphical comparison of breaking strength of four clay sources while Figure 6 shows empirical cumulative distribution function CDF Plot to assess the fit of distributed data values of each individual observation contrary to the percentage of the values that are smaller or equal to that specific value. The plot examines the distribution of breaking strength of each single brick made from different clay source. It has well observed from the graph that the stepped line follows the fitted distribution line thoroughly, it means that the data fits the distribution well.

Figure 4. Clay samples of the four sites

Table 4. Breaking strength of burnt bricks (Kg/cm²)

Source	Observations						Ti	Xi
Hyderabad (A)	98	91	96	96	100	103	584	97.33
Rawalpindi (B)	84	86	89	90	86	88	523	87.17
Kohat (C)	90	91	94	86	88	92	541	90.17
Peshawar (D)	77	81	84	80	78	85	485	80.83
							2133	355.50

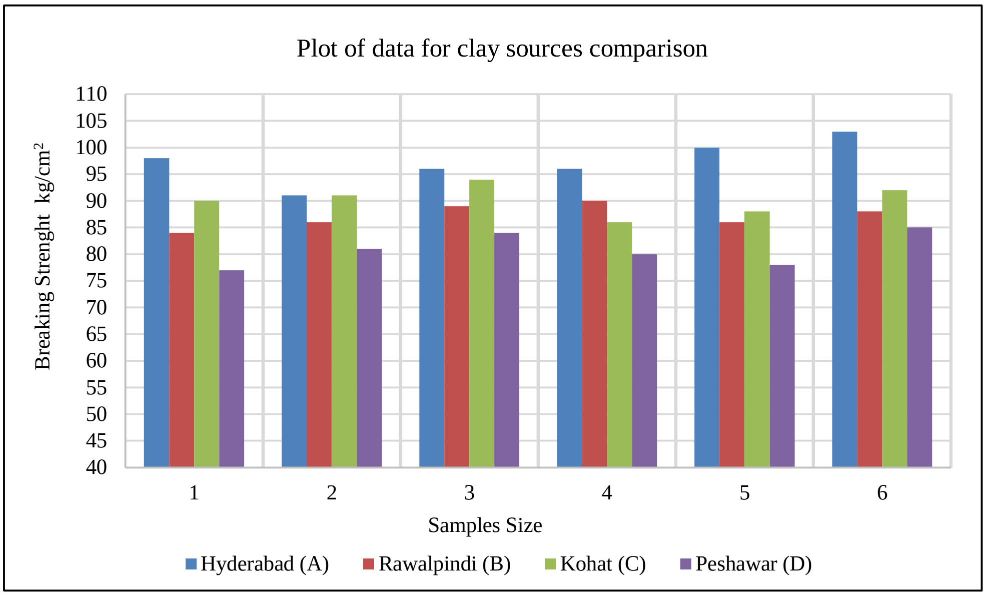

Figure 5. Comparison of breaking strength

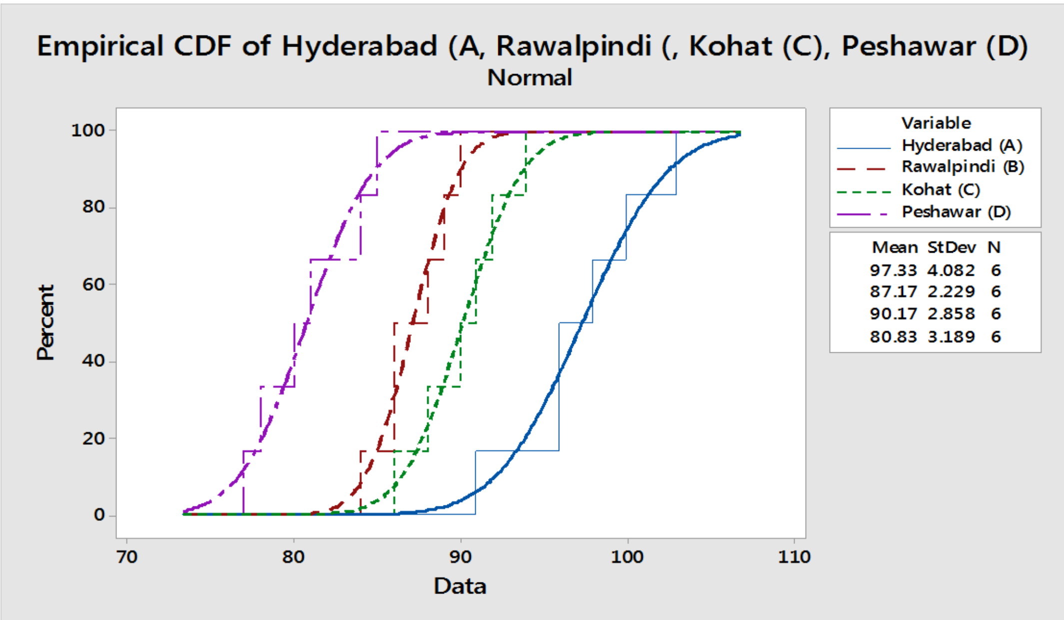

Figure 6. Cumulative distribution function of clay sources

4. Results and Discussions

4.1. Data analysis (ANOVA)

The calculations required for ANOVA are computed on the basis of Equations 1, 2 and 3 while other supplementary variables along with the hypothesis tested in this case are: H0: = T1 = T2 = T3 ……. Tn = 0 that is there is no significant different between the mean of breaking strength of four cities clay source. H1: Ti $\neq$ 0, that is mean of breaking strength of four cities clay source differ significantly. At 5% significance level (α = 0.05) and degree of freedom as 3 and 20 for the given data and using the proportion arguments of the F distribution (F0.05) value, the critical value (F critical) = 3.10 which clearly shows that F0 > F (crit) that is 28.18 > 3.098 hence it is decided to discard the null hypothesis (H0) and admit the alternative hypothesis (H1) [34]. Therefore, it is concluded that mean of breaking strength of four clay source differ significantly. ANOVA test results are presented in Table 5.

Table 5. Summary of ANOVA

Source of Variation	SS	DF	MS	F	P	F_c
Between Groups	844.79	3	281.60	28.18	2.2E-07	3.0
Within Groups	199.83	20	9.99			
Total	**1044.6**	**23**				

Graphical presentation of results using Minitab are revealed in Figure 7 that shows the F-distribution value. Here shaded part characterizes the likelihood of perceiving the F-distribution value which is truly larger than the F-value that has been computed and obtained. F-value of 28.18 fall inside the rejection region. This prospect is high sufficient to castoff the null hypothesis at significance level of 0.05. Hence it is decided that not all the clay sources means are identical. Similarly, Figure 8 shows normal probability plot of the residuals of samples distribution which were computed using Equations 4 to 7. It represents the residuals against their predictable values when they are normally distributed. Since the plot of the residuals are arranged in such a way that they are making nearly a straight line, it thus confirm the hypothesis that the residuals are ordinarily dispersed while Figure 9 highlights the residuals plot versus fitted values of samples distributions [35]. Here the residuals are located on the vertical axis while the correspondent fitted values on the horizontal axis respectively. Since, preferably, the points ought to fall randomly on both sides of 0 and should have no perceptible patterns in the points. Therefore, it clearly confirms the hypothesis that the samples mean values residuals are randomly distributed with continuous variance [36].

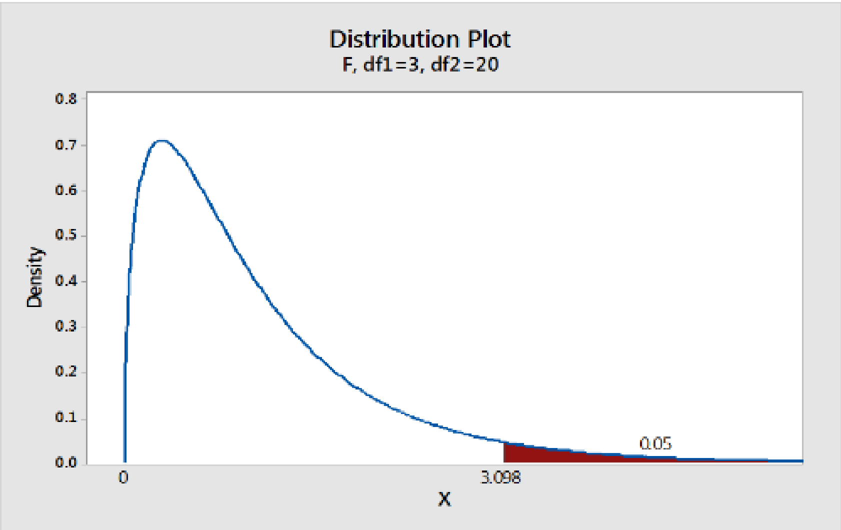

Figure 7. F distribuiton plot of means significanes at (α = 0.05)

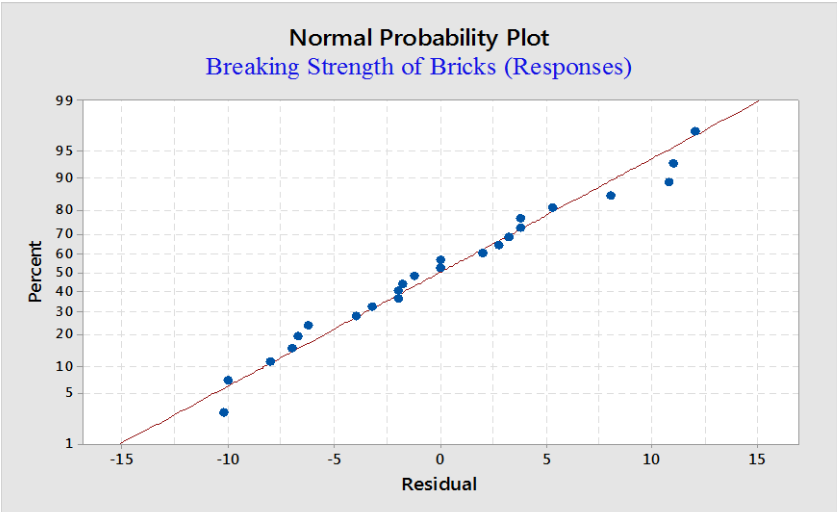

Figure 8. Normal Probability for residuals of samples distribution

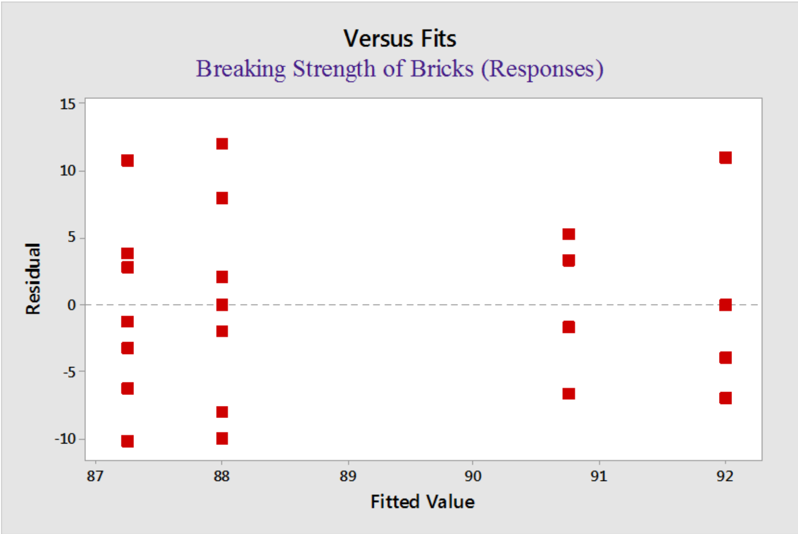

Figure 9. Residual plot vs fitted values of samples distribution

4.2. Duncan's Multiple Range Results

Step 1. Arranging the treatment means in ascending order:

Source	Peshawar (D)	Rawalpindi (B)	Kohat (C)	Hyderabad (A)
Mean	80.83	87.17	90.17	97.33

Step 2. Calculating the standar error (S_e) means using Equation 8 which yields 1.29

Step 3. Obtaining values of *r* (*p*, *f*) for *p* = 2, 3, and 4 from significant ranges for Duncan's multiple ranges test for $r_{0.05}$ (*p*, *f*) is:

$r_{0.05}$ (*p*,20)	2	3	4
	2.95	3.1	3.18

Step 4. Computing least significant ranges (LSR) = (*Rp*) for *p* = 2, 3 and 4 are calculated using Equation 9:

LSR	R2	R3	R4
	3.807	4.000	4.103

Step 5. Comparison of pairs mean and the absolute difference with LSR.

Cycle 1			
Hyderabad (A) vs Peshawar (D)	16.5	> 4.103	Significant
Hyderabad (A) vs Rawalpindi (B)	10.16	> 4.000	Significant
Hyderabad (A) vs Kohat (C)	7.16	> 3.807	Significant
Cycle 2			
Kohat (C) vs Peshawar (D)	9.34	> 4.000	Significant
Kohat (C) vs Rawalpindi (B)	3.00	< 3.807	**Not Significant**
Cycle 3			
Rawalpindi (B) vs Peshawar (D)	6.34	> 3.807	Significant

Thus it can be evidently judged that there exists not a significant difference between clay source of Rawalpindi *(B)* and Kohat *(C)* while mean of Hyderabad *(A)* and Peshawar *(D)* differ significantly from *B* and *C*. Figure 10 shows dunnet test control mean of the clay source. These are grouped as follows:

Hyderabad (A) | **Rawalpindi (B) & Kohat (C)** | **Peshawar (D)**

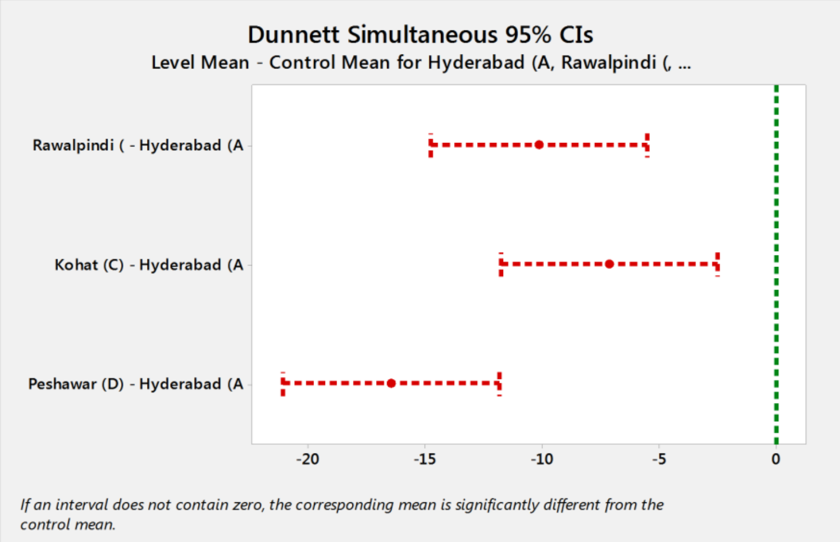

Figure 10. Duncan's multiple range results

4.3. Newman – Keuls Test Results

Step 1 and 2. are calculated using Equation 10 for Duncan's multiple range test results.

Step 3. Obtaining values of q (p, f) for p = 2, 3, and 4 from significant ranges for Newman – Keuls ranges, test using equation (10) for $q_{0.05}$ (p, f) is.

$q_{0.05}$ $(p,20)$	2	3	4
	2.95	3.58	3.96

Step 4. Computing least significant ranges (LSR)= (Rp) for p = 2, 3 and 4 and the *three* Least Significant Ranges are:

LSR	R2	R3	R4
	3.807	4.619	5.110

Step 5. Comparison of pairs mean and the absolute difference with LSR.

Cycle 1			
Hyderabad (A) vs Peshawar (D)	16.5	> 5.110	Significant
Hyderabad (A) vs Rawalpindi (B)	10.16	> 4.619	Significant
Hyderabad (A) vs Kohat (C)	7.16	> 3.807	Significant
Cycle 2			
Kohat (C) vs Peshawar (D)	9.34	> 4.619	Significant
Kohat (C) vs Rawalpindi (B)	3.00	< 3.807	**Not Significant**
Cycle 3			
Rawalpindi (B) vs Peshawar (D)	6.34	> 3.807	Significant

Hence, the final results of Newman – keuls test are similar to Duncan's multiple range test showing that there exists not a significant difference between clay source of Rawalpindi *(B)* and Kohat *(C)* while mean of Hyderabad *(A)* and Peshawar *(D)* differ significantly from *B* and *C*. These are grouped as follows:

Hyderabad (A) | **Rawalpindi (B) & Kohat (C)** | **Peshawar (D)**

4.4. Fisher's Least Significant Difference (LSD) Test Results

Since the absolute variance between any two means surpasses LSD hence Equations 11 and 12 are used to determine the value of LSD is equal to 3.81. Comparing the sources for any significance difference: Hyderabad Source (A): = $\dot{X}1$ = 97.33; Rawalpindi Source (B) = $\dot{X}2$ = 87.17; Kohat Source (C) = $\dot{X}3$ = 90.17; Peshawar Source (D) = $\dot{X}4$ = 80.83 and comparison of means of all possible pairs is carried out as follows.

Hyderabad Source (A)	Ẋ1	97.33
Rawalpindi Source (B)	Ẋ2	87.17
Kohat Source (C)	Ẋ3	90.17
Peshawar Source (D)	Ẋ4	80.83

The absolute dissimilarity in the two means for judgement:

Hyderabad (Ẋ1) vs Rawalpindi (Ẋ2)	10.16	> 3.81	Significant
Hyderabad (Ẋ1) vs Kohat (Ẋ3)	7.16	> 3.81	Significant
Hyderabad (Ẋ1) vs Peshawar (Ẋ4)	16.5	> 3.807	Significant
Rawalpindi (Ẋ2) vs Kohat (Ẋ3)	-3	> 3.65	**Not Significant**
Rawalpindi (Ẋ2) vs Peshawar (Ẋ4)	6.34	> 3.81	Significant
Kohat (Ẋ3) vs Peshawar (Ẋ4)	9.34	> 3.81	Significant

Similarly, this test also shows the same results describing that there exists not a significant difference between clay source of Rawalpindi *(B)* and Kohat *(C)* while mean of Hyderabad *(A)* and Peshawar *(D)* differ significantly from *B* and *C*. Figure 11 shows Fisher's Least Significant Difference (LSD) test results of the clay source. These are grouped as follows:

Hyderabad (A) | **Rawalpindi (B) & Kohat (C)** | **Peshawar (D)**

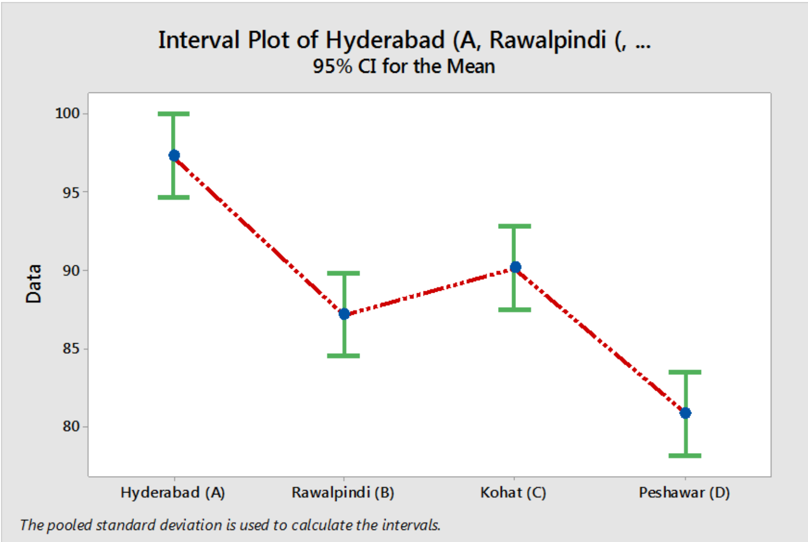

Figure 11. Fisher's Least Significant Difference (LSD) test results

4.5. Tukey's Test

Equation 13 is used to determine the value of LSD is equal to 5.11 and using the same strategy for comparing the sources for any significance difference as conducted in Fisher's Least Significant Difference (LSD) test, observing the absolute dissimilarity in the two means for judgement:

Hyderabad (Ẋ1) vs Rawalpindi (Ẋ2)	10.16	> 5.11	Significant
Hyderabad (Ẋ1) vs Kohat (Ẋ3)	7.16	> 5.11	Significant
Hyderabad (Ẋ1) vs Peshawar (Ẋ4)	16.5	> 5.11	Significant
Rawalpindi (Ẋ2) vs Kohat (Ẋ3)	-3	< 5.11	**Not Significant**
Rawalpindi (Ẋ2) vs Peshawar (Ẋ4)	6.34	> 5.11	Significant
Kohat (Ẋ3) vs Peshawar (Ẋ4)	9.34	> 5.11	Significant

Finally, this test also produces the same results describing that there exists not a significant difference between clay source of Rawalpindi (*B)* and Kohat (*C)* while mean of Hyderabad (*A)* and Peshawar (*D)* differ significantly from *B* and *C*. These are grouped as follows:

Hyderabad (A) | **Rawalpindi (B) & Kohat (C)** | **Peshawar (D)**

4.6. Contrasts Results

The results are based on Equations 14 and 15 respectively. Since there are four levels that four sources of clays used, thus three orthogonal contrasts may be formed easily.

C_1	$T_1 - T_2$	61
C_2	$T_1 + T_2 – T_3 – T_4$	81
C_3	$T_3 – T_4$	56

SS_{C1}	310.083
SS_{C2}	273.375
SS_{C3}	261.334
Total	**844.792**

Consequently, the sum of the contrast SS should be equal to SS_T on the basis of apportioned into three (A – 1) with a single degree of freedom. These results are summarized in Table 6. At F 5%, 1, 20 = 4.35, At 5% significance level (α = 0.05), all the three contrasts are significant. Thus it is concluded that the difference in breaking strength between clay source of Hyderabad (A) and Rawalpindi (B), and Kohat (C) and Peshawar (D) is observed to be significant and also the difference among the means of these clay courses is significant.

Table 6. Summary of ANOVA summary for testing contrasts

Source of Variation	SS	DF	MS	F
Between treatments	844.79	3	281.60	28.18
C1	310.083	1	310.08	28.67
C2	273.38	1	273.38	28.43
C3	261.33	1	261.33	28.51
Error	199.84	20	9.99	
Total	**1044.63**	**23**		

5. Conclusion

In this study it was assumed that the lower level of breaking strength is due to the poor quality of clay used. The innovation of the current work is the inclusion, experimental and numerical based investigation using completely randomized design approach. For the purpose of investigation four different clay samples were collected from four different cities, namely Hyderabad, Rawalpindi, Kohat and Peshawar. 24 brick samples were made from these four different clays sources. The breaking strength of each specimen was measured and considered for exploring any significance difference between the clay sources. In order to check the contrast of each clay effect, multiple comparisons of means using contrasts approach has also been conducted. Based on experimental investigations using completely randomized design (CRD) concerning breaking strength of the burnt clay bricks, the results may be summarized that using analysis of variance at 95% CI, the value of Fisher test at 5%, is 1, 20 = 4.35, hence at 5% significance level (α = 0.05), all the three contrasts were significant. Hence, the study revealed that the difference in breaking strength between clay source of Hyderabad (A) and Rawalpindi (B), followed by Kohat (C) and Peshawar (D) was significant and also the difference among the means of these clay courses was significant. Which clearly proved that the clay location and compositions have a vital role and a great impression of the breaking strength of the burnt bricks.

6. Acknowledgements

Current work has been facilitated by Sarhad University of Science and Information Technology, Peshawar Pakistan. We are really grateful to our supporting colleagues from Voronezh State University, Russian Federation who provided awareness and proficiency that helped in completing the research.

7. Funding

This research work was supported by Sarhad University of Science and Information Technology, Peshawar Pakistan.

8. Conflict of Interests

The authors declare no conflict of interest.

9. References

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