PROBABILISTIC DESIGN INTERPRETATION OF CIVIL ENGINEERING USING ANOVA ANALYSIS

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ABSTRACT

A comparative analysis of a probabilistic approach and detrimental approach were made in the design of civil engineering structures and geotechnical. The analysis approaches were made on the basis of a deterministic approach, being the easiest, fastest and best-known approach to engineers. Even if deterministic design guarantees a certain structural safety proposed by standard prescriptions, it is of interest to consider a probabilistic approach in order to quantify structural safety and reliability that cannot be assessed with a deterministic approach. The differences between deterministic and probabilistic design approached will be studied and consequences for future related work in structural engineering will be drawn. Author reported detrimental approach and is divided in two parts is the theoretical followed with experimental part which exposes the concepts of deterministic design and probabilistic design in structural and geotechnical engineering and introduces the application of the theory and consists in an implementation of the with recent standard and modern techniques . The section on variables defined an independent variable as a *variable* manipulated by the experimenter. The experimental based analysis executed by the Author and the data have been analyzed based on ANOVAs for the design purpose. The independent variables in the analysis have been taken as supplementary materials (Fly ash, Lime, Gypsum, Quarry dust). The basic of measures are to produce low and high F-values. The prediction over the large number of design sample group, by using the graphical representation. The graphical representation when the base of the graph spreading more it shows the probabilistic data interpretation gives Concept to adopt most reliable, feasible, realistic and exact data for the design, in analysis when the value is one, gives better approach , however the higher value of F- statistics are reliable and exact analysis of the design .

INDEX TERM: Probabilistic Approach and Supplementary Materials, Multi-Factor Designs, ANOVAs Analysis, International Data, Fly Ash, Lime, Gypsum, Quarry Dust, Supplementary Materials

I.INTRODUCTION

The major advantage of designing structures with a probabilistic approach is the possibility to quantify the reliability of the structure. Instead of using characteristic values which correspond to upper or lower boundary values, a probabilistic approach allows engineers to quantify the reliability of the designed structures, as opposed to deterministic design which only allows to determine whether yes or no the structure is safe. In most cases, the probabilistic approach of designing a structure gives results that are closer to reality and thus less conservative than a deterministic approach. This could be of interest in structural design since it would allow to design structures differently and save on materials and on money, as well as assessing the reliability of an existing structure and determining how far it is from failure. Moreover, it is an useful tool for assessing the reliability of existing structures since parameters can be adapted with respect to target reliability or importance of the building[2].

II.PROBLEM IDENTIFICATION

Bricks whose solid ingredient is 40% fly ash have been manufactured. The manufacturing process uses techniques and equipment similar to those used in clay brick in laboratory to test the compressive strength. The fly ash bricks produced were lighter than clay bricks. The bricks manufactured from fly ash possessed compressive strength higher than 40 MPa. This exceeds some of the best of load carrying clay bricks available is more and is several times better than acceptable commercially available common clay bricks. Other important characteristics of the fly ash bricks have been evaluated. These included absorption capacity, initial rate of absorption, and modulus of rupture, bond strength and durability. The values of these characteristics for fly ash bricks are excellent and have exceeded those pertaining to clay bricks. The estimated optimum values of the process parameters are corresponding to water/binder ratio of 0.4, fly ash of 39%, coarse sand of 24%, and stone dust of 30%. The addition of fly ash up to 60% at a fixing temperature as 950ºc has no significant harmful effects on the brick quality[1]. It seems that the fly ash added building bricks show reasonably good properties and may become competitive with the conventional Use of fly ash as a raw material for the production of building bricks is not only viable alternative to clay but also a solution to difficult and expensive waste disposal. In the present work the attempt has made to find the optimum mix per compressive strength of fly ash brick admixed with lime, gypsum and quarry dust at various proportions[1]. The maximum limit of ingredient is subjected with Fly ash (70%), Lime (10%) ,Gypsum (5%) and sand(15%) are manually feed in required proportion for homogeneous mixing[1]. The proportion of raw material may vary depending upon quality of raw materials. After mixing, the mixture are allowed to belt conveyor through feed in to automatic brick Than the bricks are placed on wooden pallets and kept as it is for two days thereafter transported to open area where they are water cured for 10 formulated and published the specifications for maintaining quality of product and testing purpose. IS : 12894 :2002. Compressive strength achievable: 60 absorption: 5 –12 %; Density: 1.5 gm/cc consistency factor) Unlike conventional clay bricks fly ash bricks have high affinity to cement mortar though it has smooth surface, due to the crystal growth between brick and the cement mortar the joint will become stronger and in due course of time it the strength will be consistent. is mainly due to CaO–SiO2–H utilization of fly-ash could be in the product ingredient[1]. The manufacture of conventional clay bricks involves the consumption of large amounts of clay. In technical paper an attempt has been made to produce light weight bricks for structural applications using fly based on ANOVAs analysis with the data interpretation for realistic and exact design of structure .

III.FACTOR AND LEVELS

The section on variables defined an independent variable as a *variable* manipulated by the experimenter. The experimental based analysis executed by the Author and the data have been analyzed based on ANOVAs for the design purpose . The independent variables in the analysis has been taken as supplementary materials (Fly ash, Lime , Gypsum, Quarry dust).Therefore, "Type of supplementary materials " is the factor in this experiment. Since four types of supplementary were compared and level has been predicted. An ANOVA conducted on a design in which there is only one factor is called a *one way ANOVA*. If an experiment has two factors, then the ANOVA is called a *two-way ANOVA*. An experiment on the effects of % and Supplementary materials on conducted test using different ten % groups (2, 5,10,15, 20,25,35,40 ,48,50 ,53) and the four (Fly ash ,Lime , Gypsum , Quarry Dust). The factors would be % and Supplementary materials. The level of Fly ash level become 7 , level of lime become 6 ,level of Gypsum become 1 , and level of Quarry dust become 2. Where n= 16, N =84

Multi-Factor Designs: The ANOVAs analysis consists of one factor or otherwise more the one factor .The common design analysis of ANOVAs consists of more than one factors .The Author published international data based analysis of ANOVAs have been analyzed to understand of the effects of % and Supplementary materials on reading speed in which Fly ash , Lime ,Gypsum, Quarry dust from the % levels of 2, 5,10,15, 20,25,35,40 ,48,50 ,53 are tested. There would be a total of 84 different groups as shown in Table 1.

Table 1. Combination of Fly ash , Lime , Gypsum & Quarry Dust Design[1]

Sample		%		%		%		%
1	Fly ash	15	Lime	30	Gypsum	2	Quarry dust	53
2		20		25		2		53
3		20		30		2		48
4		25		20		2		53
5		30		15		2		53
6		35		10		2		53
7		40		05		2		53
8		40		10		2		48
9		50		25		2		53

Level of Fly ash level =7 , Level of Lime = 6 ,Level of Gypsum = 1 , Level of Quarry dust =2 , n= 16, N =64

This design has two factors: % and Supplementary materials. % has 16 levels and Supplementary materials have four levels. When all combinations of the levels are included (as they are here), the design is called a *factorial design*. A concise way of describing this design is as a % levels (16) x Supplementary materials (4) factorial design where the numbers in parentheses indicate, while designing to get appropriate and exact design analysis the testing as per probabilistic theory using ANOVAs may be utilized by keeping the factorial design of the data for about 64 combination where as the author published data shows 36 where the set back in the design of the structure. The table where published by Author in International journal. Recent trend while designing based on probabilistic Analysis is basic concern.

Table No 2 Approach of probabilistic approach in civil engineering, N = 4 For vertical line [1]

Proportions	Fly ash Kg	Lime kg	Gypsum Kg	Quarry dust Kg
I	.525	1.050	.2	1.855
II	.7	.875	.2	1.855
III	.7	1.05	.2	1.855
IV	.875	.7	.2	1.855
V	1.05	.525	.2	1.855
VI	1.225	.35	.2	1.855
VII	1.4	.175	.2	1.855
VIII	1.4	.35	.2	1.68
IX	1.750	.875	.2	.805
Total	9.625	5.95	1.8	15.47

Table No 3 Approach of Calculation of Mean and Degree Freedom

N = 4 For vertical line
X1 = 9.625/9 =1.069
X2 = 5.95/9 =.6611
X3 = 1.8/9 =.2
X4 = 15.47/9 =1.71
X(mean) = (1.069 + .6611 + .2 + 1.71)/4 = 0.9100
Degree of freedom = m*n-1= 4 *9 -1 = 35°

IV.ANASLYSIS OF F-STATISTICS

SST = $(..525-.911)^2 + (.7-.911)^2 + (.7-.91)^2 + (.875-.9100)^2 + (1.05-.9100)^2 + (1.225-.9100)^2 + (1.4-.9100)^2 + (1.4-.9100)^2 + (1.750-.9100)^2 + (1.05-.9100)^2 + (.875-.9100)^2 + (1.05-.9100)^2 + (.7-.9100)^2 + (.525-.9100)^2 + (.35-.9100)^2 + (.175-.9100)^2 + (.35-.9100)^2 + (.175-.9100)^2 + (.35-.9100)^2 + (.875-.9100)^2 + (.2-.9100)^2 + (.2-.9100)^2 + (.2-.9100)^2 + (.2-.9100)^2 + (.2-.9100)^2 + (.2-.9100)^2 + (.2-.9100)^2 + (.2-.9100)^2 + (.2-.9100)^2+(1.85-.9100\ ^2)^2+(1.85-.9100\ ^2)^2+(1.85-.9100\ ^2)^2+(1.85-.9100\ ^2)^2+(1.85-.9100\ ^2)^2+(1.85-.9100\ ^2)^2+(1.85-.9100\ ^2)^2+(1.68-.9100\ ^2)^2+(.805-.9100)^2$

SSB = $(1.069-.9100)^2 + (\mathbf{.6611}- .9100)^2 + (.200- .9100)^2 + (1.71- .9100)^2$=0.2313

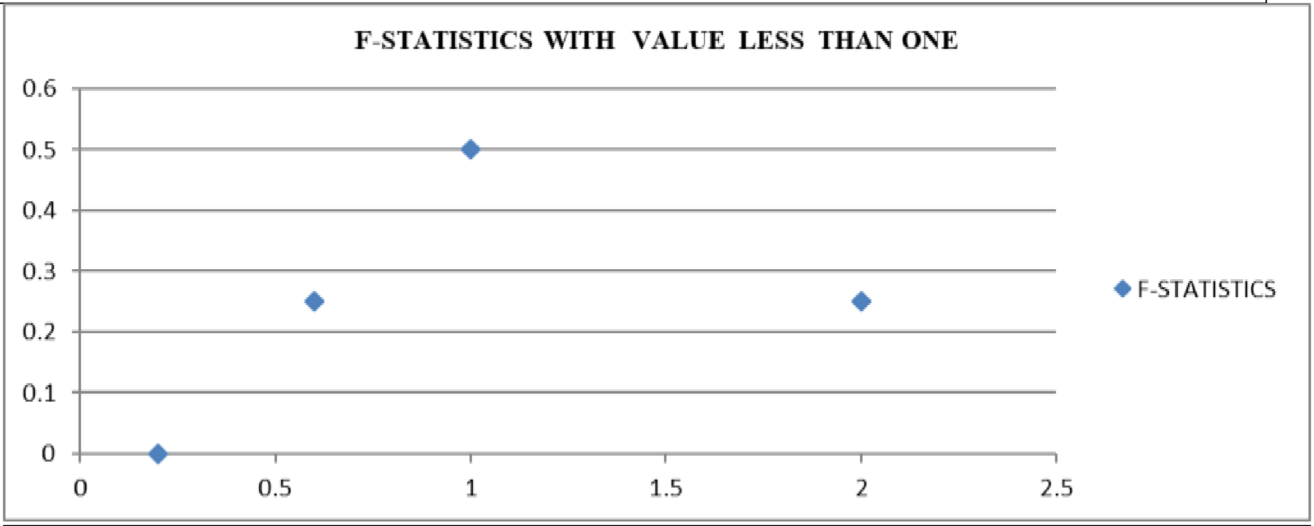
Degree of freedom = m-1 =(4-1)°= 3°

SSW = $(.525-1.069)^2 + (.7-1.069)^2 + (.7-1.069)^2 + (.875-1.069)^2 + (1.05-1.069)^2 + (1.225-1.069)^2 + (1.4-1.069)^2 + (1.4-1.069)^2 +(1.750-1.069)^2 + (1.05-.66)^2 + (.875-.66)^2 + (1.05-.66)^2 + (.7-.66)^2 + (.525-.66)^2 + (.35-.66)^2 + (.175-.66)^2 + (.35-.66)^2 +(.175-.66)^2 + (.35-.9100)^2 + (.875-.9100)^2 + (.2-.20)^2 + (.2-.200)^2 + (.2-.200)^2 + (.2-.200)^2 + (.2-.200)^2 + (.2-.200)^2 + (.2-.200)^2 + (.2-.200)^2 + (.2-.200)^2+(1.85-1.71)^2+(1.85-1.71)\ ^2+(1.851.71)^2+(1.85-1.71)^2+(1.85-1.71)^2+(1.85-1.71)^2+(1.85-.9100)^2+(1.68-1.71)^2+(.8051.71)^2$

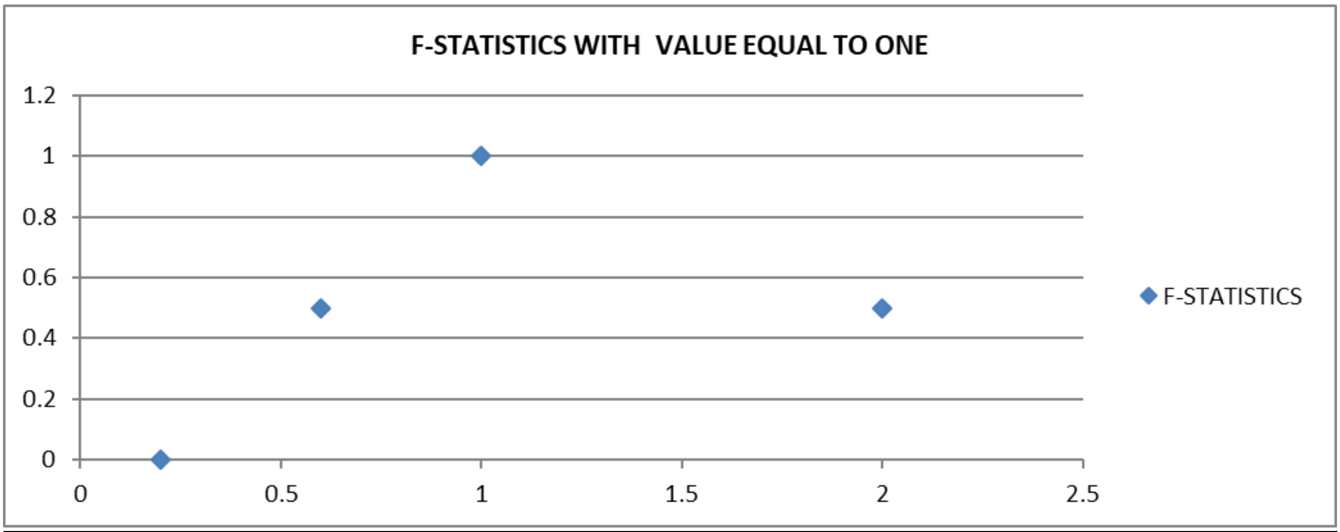
SSW	=	4.5129

Degree of freedom = m*(n-1)= 4*(9-1)° = 32°

F-statistics = (SSB/(m-1)) /(SSW/m(n-1))	
=.2313/(4-1)/4.5129/(4*(9-1))	**= .5466 less than 1.0**
α = .10	



Graph No. 1 F-statistics Value less than 1



Graph No.2 F-statistics Value equal to 1

Table No 4 Approach of probabilistic approach in civil engineering , M =3 for Vertical Line line

Proportion	7 days	14 days	21 days	Remarks
I	1.98	3.95	7.91	
II	1.68	3.36	6.78	
III	1.81	3.43	6.97	
IV	1.44	3.08	5.98	
V	1.22	2.43	5.34	
VI	1.03	1.97	5.04	
VII	1.12	2.23	5.14	
VIII	1.21	2.67	5.28	
IX	1.34	2.62	5.45	
Total	12.83	25.74	53.89	

Table No 5 Approach of probabilistic approach for mean and F-statistics

N = 3 For vertical line
X1 (mean) = 12.83/9 = 1.456
X2 (mean) = 25.74/9 = 2.86
X3 (mean) =53.89/9 = 5.99
X (mean) = (X1+X2+X3) /3 = 3.449
Degree of freedom = m *n -1 = 3*9 -1 = 26°

V.ANALYSIS OF F-STATISTICS

SST = $(1.98-3.449)^2 + (1.68-3.449)^2 + (1.81-3.449)^2 + (1.44-3.449)^2 + (1.22-3.449)^2 + (1.03-3.449)^2 + (1.12-3.449)^2 + (1.21-3.449)^2 + (1.34-3.449)^2 + (3.95-3.449)^2 + (3.36-3.449)^2 + (3.43-3.449)^2 + (3.08-3.449)^2 + (2.43-3.449)^2 + (1.97-3.449)^2 + (2.23-3.449)^2 + (2.67-3.449)^2 + (2.62-3.449)^2 + (7.91-3.449)^2 + (6.78-3.449)^2 + (6.97-3.449)^2 + (5.98-3.449)^2 + (5.34-3.449)^2 + (5.04-3.449)^2 + (5.14-3.449)^2 + (5.28-3.449)^2 + (5.45-3.449)^2$

SST = 2.157+ 3.129 + 2.686 +4.036+4.968+5.851+5.424+5.013+4.447+.251+.0079+.000361+.136+1.038 +2.187+1.485+.606+.687+19.900+11.0995+12.397+6.405+3.575+2.531+2.859+3.352+4.004

SST = 110.2318

SSB = $(1.456-3.449)^2 + (2.86-3.449)^2 + (5.99-3.449)^2$

SSB = 3.972+.3469+6.456 = 10.779

Degree of freedom = m-1 =(3-1)°= 2°

SSW = $(1.98-1.4561)^2 + (1.68-1.4561)^2 + (1.81-1.4561)^2 + (1.44-1.4561)^2 + (1.22-1.4561)^2 + (1.03-1.4561)^2 + (1.12-1.4561)^2 + (1.21-1.4561)^2 + (1.34-1.4561)^2 + (3.95-2.861)^2 + (3.36-2.861)^2 + (3.43-2.861)^2 + (3.08-2.861)^2 + (2.43-2.861)^2 + (1.97-2.861)^2 + (2.23-2.861)^2 + (2.67-2.861)^2 + (2.62-2.861)^2 + (7.91-5.921)^2 + (6.78-5.921)^2 + (6.97-5.921)^2 + (5.98-5.921)^2 + (5.34-5.921)^2 + (5.04-5.921)^2 + (5.14-5.921)^2 + (5.28-5.921)^2 + (5.45-5.921)^2$

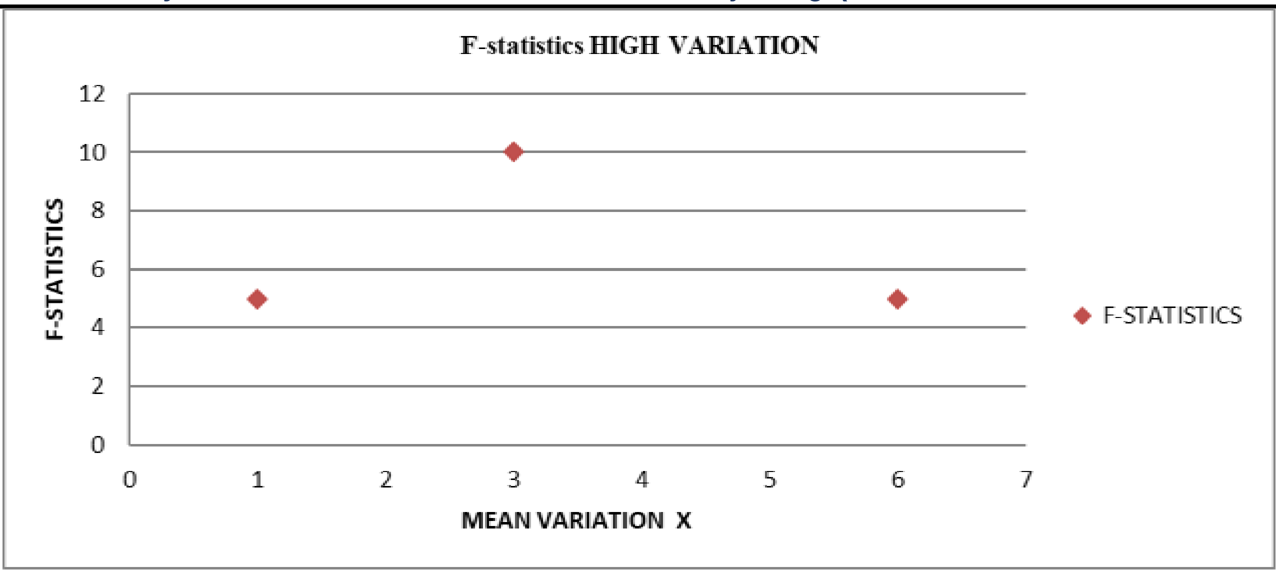
SSW = 12.30772

Degree of freedom = m*(n-1)= 3*(9-1)° = 24°

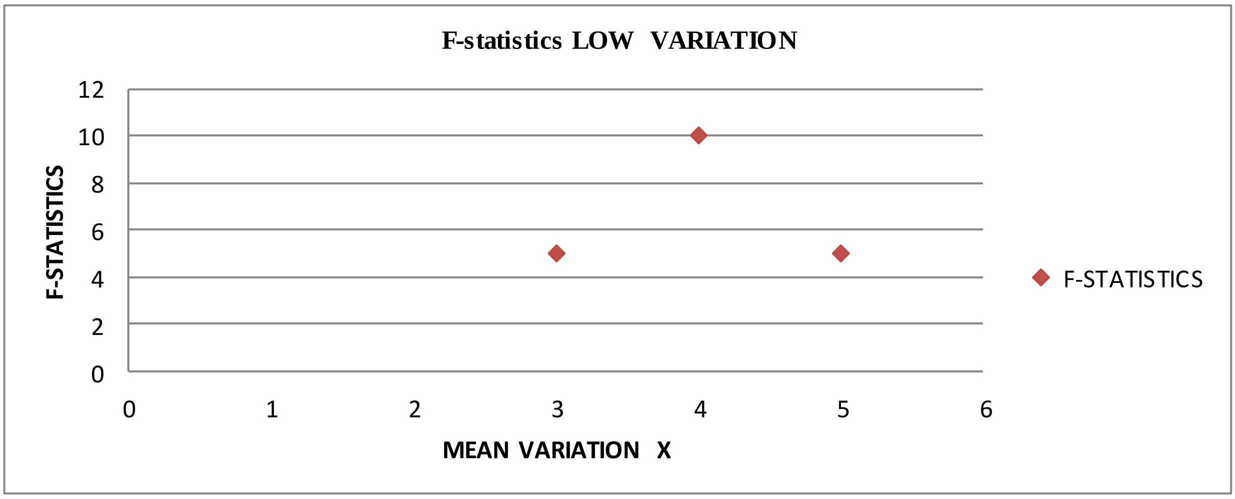
F-statistics = (SSB/(m-1)) /(SSW/m(n-1))

=10.779/(3-1)/12.30772/3(9-1) =10.56

$\alpha = .10$



Graph No 3 :Analysis of variance can be obtained for design purposes ,Based on F-statistics with larger mean variation



Graph No. 5 : Based on F-statistics with closure mean variation

VI.RESULT AND DISCUSSION

i) To identify the factor while analysis of ANOVAs is the basis of the parametric analysis .If the two factors were taken for the analysis as such % and Supplementary materials. % has 16 levels and Supplementary materials have four levels. While considering all combinations of the levels, the design is termed as *factorial design*.

ii) A concise way of describing this design is as a % levels is becoming one parameter x and Supplementary materials Y as second parameter , while designing to get appropriate and exact design analysis the testing as per probabilistic theory using ANOVAs may be utilized by keeping the factorial design of the data for about XY combination where as the author published data shows 36[1] with one way of analysis where the set back in the design of the structure.

iii) In the problem as mentioned the levels identified with different X Number of percentages for which test were conducted with other levels of combination as Y . The factors would be X and Supplementary materials as Y. The Fly ash level become A , level of lime become B ,level of Gypsum become C , and level of Quarry dust become D. Where n= total number of levels =A+B+C+D, N =combination becomes gives the probabilistic approach in design .

iv) The analysis may be made with Multi-Factor Designs. The ANOVAs analysis consists of one factor or otherwise more than one factor .The common design analysis of ANOVAs consists of more than one factors .The Author published international data[1] based analysis of ANOVAs have been analyzed to understand of the effects of % and Supplementary materials in which Fly ash , Lime ,Gypsum, Quarry dust from the % levels were tested. There would be a total of 84 different groups were the possible analysis as per the probabilistic approach for realistic and exact analysis of the design approaches as shown in table number 1 .

5) Approach of probabilistic approach in civil engineering were made while taking four number of vertical line (N = 4 For vertical line [1]) with estimation of mean of all parameter . The number of vertical line showing the number of the mean as such the present case showing number of mean become four as shown in the table number 2 of present technical paper .

6) Approach of Calculation of Mean and Degree Freedom were made in Table No 3 , Mean value of the level mentioned above become less than 1 and degree of freedom is becoming 35°.Higher degree of freedom showing lower value of F , Resulting lower variance of the probabilistic design .The design must not be realistic and further group are required to analyze .

7) While estimating F, SSB and SSW were taken into consideration, in both of the case degree of freedom were taken into account. As increasing the vertical column of the ANOVAs analysis provide lower value of F-Statistics, hence to obtained realistic and exact analysis for the design purpose of materials .

8) However when the base of the graph spreading less gives the low variability and gives the approach of analysis of design problem. The basic concept of analysis to adopt the higher value of F-statistics so the at the design analysis of the problem is safe and reliable as shown in Graph No. 1 F-statistics Value less than 1

9) However when the base of the graph spreading slightly higher gives the more variability compared to when it becomes less than 1 and gives the approach of analysis of design problem. The basic concept of analysis to adopt the higher value of F-statistics so the at the design analysis of the problem is safe and reliable as shown in Graph No.2 F-statistics Value equal to 1

10) Approach of probabilistic approach in civil engineering were made while taking three number of vertical line (N = 3 For vertical line [1]) with estimation of mean of all parameter . The number of vertical line showing the number of the mean as such the present case showing number of mean become three as shown in the table number 4 of present technical paper

11) Approach of Calculation of Mean and Degree Freedom were made in Table No 5 , Mean value of the level mentioned above become less than 4 and degree of freedom is becoming 26°.Lower degree of freedom showing lower value of F , Resulting higher variance of the probabilistic design .The design must be realistic and exact ,different group for strength criteria in Table No 5 Approach of probabilistic approach for mean and F-statistics

12) While estimating F, SSB and SSW were taken into consideration, in both of the case degree of freedom were taken into account. As such corresponding to SSB, degree of freedom become less and similarly degree of freedom in case of SSW , become less compared to materials case , in the strength criteria the F-statistics become 10 . As decreasing the vertical column of the ANOVAs analysis provide higher value of

F-Statistics as the case , hence to obtained realistic and exact analysis for the design , higher value of F adopted for strength criteria .

13) The value having the larger magnitude are adopted for the design purposes and however the based on the probabilistic approaches. For the better prediction and the group combination. The basic of measures are to produce low and high F-values. The prediction over the large number of design sample group, by using the graphical representation. The graphical representation when the base of the graph spreading more it shows the probabilistic data interpretation gives Concept to adopt most reliable, feasible, realistic and exact data for the design, in analysis when the value is one, gives better approach as in Graph No 3 ,Analysis of variance can be obtained for design purposes

14)However when the base of the graph spreading less gives the low variability and gives the approach of analysis of design problem, while getting the value less than one . The basic concept of analysis to adopt the higher value of F-statistics so that at the design analysis of the problem is safe and reliable. The groups of sample were tested based on the experimental set up and adopting different materials for design analysis . The F-statistics incorporating the design problems for the better prediction and the group combination. The basic measures are to produce low and high F-values. The prediction over the large number of design sample group, by using the graphical representation in Graph No. 5 , Based on F-statistics with closure mean variation.

15) The F-statistics incorporating the design problems for the better prediction and the group combination. The basic measures are to produce low and high F-values. The prediction over the large number of design sample group, by using the graphical representation. The graphical representation when the base of the graph spreading more it shows the probabilistic data interpretation gives Concept to adopt most reliable, feasible, realistic and exact data for the design of the wall situated adjacent to the retaining wall in fly over

VII.CONCLUSION

i)The F-statistics incorporating the design problems , analysis of the design for exact and realistic analysis of the design . The higher value of F-statistics are more reliable and adopted accordingly .

ii)The spreading of the lower graphics gives a wider variables and the distribution is showing large with the unit value of the F- statistics , however the variation are more prominent in the higher value of F..

iii) The value having the larger magnitude are adopted for the design purposes and however the based on the probabilistic approaches. For the better prediction and the group combination, .

iv)The basic of measures are to produce low and high F-values. The prediction over the large number of design sample group, by using the graphical representation. The graphical representation ,when the base of the graph spreading more it shows the probabilistic data interpretation gives Concept to adopt most reliable, feasible, realistic and exact data for the design, in analysis when the value is one, gives better approach .

v)However when the base of the graph spreading less gives the low variability and gives the approach of analysis of design problem, while getting the value less than one . The basic concept of analysis to adopt the higher value of F-statistics so that at the design analysis of the problem is safe and reliable. The groups of sample were tested based on the experimental set up and adopting different materials for design analysis .

vi)The F-statistics incorporating the design problems for the better prediction and the group combination. The basic measures are to produce low and high F-values. The prediction over the large number of design sample group, by using the graphical representation.

vii)The graphical representation when the base of the graph spreading more it shows the probabilistic data interpretation gives Concept to adopt most reliable, feasible, realistic and exact data for the design of the wall situated adjacent to the retaining wall in fly over.

viii)However when the base of the graph spreading less gives the low variability and gives the approach of analysis of design problem.

ix)The basic concept of analysis to adopt the higher value of F-statistics so the at the design analysis of the problem is safe and reliable.

x)The groups of sample were tested based on the experimental set up and the strength of materials were examined based on the probabilistic analysis to obtain the desired residual strength of the structure during the service period.

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