SHEAR BEHAVIOUR OF GEO-POLYMER CONCRETE COLUMN BY USING ANSYS & MATLAB SOFTWARE

Abstract

The purpose of the project work is to study the shear behavior of a column made by reinforced cement concrete when they are subjected to uniaxial loading. The analysis of the reinforced cement concrete column is done by a Finite Element Software known as ANSYS. The prediction of the shear behavior is done through another software known as MATLAB by using artificial neural network. The inputs data for the software were collected from the experiments conducted on columns and the lateral ties are provided according to IS:456-2000 at clause number 26.5.3.2(c) also the failure of column's longitudinal reinforcement by shear failure without yielding. As the studies are made limited on this shear behavior analysis we are affordable with limited number of literature. Analysis of shear behavior are depending upon wrong assumptions on model used for the analysis, and the results are very much conservative, and the empirical conservative rules are essential for the technical codes. In this research, the analysis is done through ANSYS software and the prediction is done through the ANN technique for the created model to get the results of shear strength of columns. The analysis is done for Geo-polymer concrete Column (GPC). The analysis of physical model and shear strength values are obtained very accurately with minimized errors. Finally, it shows the ANASYS software displaying the shear behavior results specifically.

Keywords: Geo-Polymer, Matlab.

Authors

Prasad K. N
Amruta Institute of Engineering and Management Science, Bidadi.
prasadnagaraj144@gmail.com

Deepika K. P
Amruta Institute of Engineering and Management Science, Bidadi.
nandadeepa21@gmail.com

Arpitha G. C
Amruta Institute of Engineering and Management Science, Bidadi.
arpithagcgowda13@gmail.com

Copyright © 2024 Authors

I. INTRODUCTION

In recent days most of the construction work is done through RCC, Reinforced cement concrete. RCC increases the strength, rigidity of structures and cost reduction during construction. Hence it is widely used in entire construction field. Concrete is mixture of Course and fine aggregates, cement, Water and required admixtures. A reinforced concrete column is defined as a structural member with a steel frame [Reinforcement's] composed of concrete that is been designed to carry the compressive loads. Stiffness of building frames. Main reinforcement in columns is longitudinal, parallel to the direction of the axial load, and bars are arranged in square, circular or circular pattern. Design of columns consists of compression and bending moments about one or both axes of the cross section. Alkaline solution and absorbed the addition of that solution with aluminum and silicon with bi-products like GGBS, fly ash and he named that final product as Geo-polymer binder's. This type of concrete doesn't require any sort of cement as the binging agent for the manufacture of concrete. The binding property is the main variation parameter between OPC and GPC. The reaction between combination of silicon oxide and aluminum with fly ash will generate the geopolymer cement. As like cement the geopolymer cement will bind the both fine aggregate and coarse aggregate. 75% to 80% of coarse aggregate and fine aggregates will be present in the total mixture of concrete. Properties of aggregates like strength, grading and angularity are as similar both in OPC and GPC.In ANASYS both the modelling work and analytical work are represented with graphical representation. Here the entire structure is assembled by the combination of elements connected with a finite number of joints called Nodes or Nodal points. MATLAB stands for MATrix laboratory. It provides easy access for the matrix developed through LINPACK (Linear system package) & EISPACK (Eigen system package) projects. It's a computing language. For the technical computing this is one of the high computing language.it mainly includes the techniques like computation, visualization and programming. This is one of the modern programming language used in prediction. It supports the object-oriented programming, debugging tools and built-in editing options.

II. MATERIALS AND METHODS

MATERIALS

1. **Cement: OPC:** Ordinary Portland Cement of 53 grade.
2. **Fine Aggregate:** M. Sand of Zone II.
3. **Coarse Aggregate:** 20mm downsize Aggregates.
4. **Water:** Portable water.
5. **Steel:** 8mm,10mm,12mm & 16mm TMT bars were used

Table 1: Specific Gravity of Constituents

Sl. No	Material	Specific Gravity	IS Codal Limits	Related IS Code
1.	Cement	3.15	3.15	IS:2720 Part - 3
2.	Fine aggregate	2.57	2.5 – 2.9	IS:2386(Part-3):1963
3.	Coarse aggregate	2.65	2.6 - 3	IS:2386(Part-3):1963

Copyright © 2024 Authors

Table 2: Mix Proportion for NSC M-20,M-30,M-40

Materials	Proportion-M-20	Proportion-M-30	Proportion-M-40
GGBS + Fly Ash (kg/m^3)	368	381	395
M-Sand (kg/m^3)	554	554	554
Coarse Aggregate (kg/m^3)	1294	1294	1294
Sodium Silicate (ml)	92	85.5	78.5
Sodium Hydroxide (ml)	92	85.5	78.5
Superplasticiser (kg/m^3)	8	8	8

METHODOLOGY

1. Collecting the experimental data's and using it as inputs for MATLAB & ANSYS.
2. Preparation of Column for the analysis by using Solid Edge v19.
3. Importing the Inputs and Results into MATLAB to perform Artificial Neural Network (ANN) Technique.
4. Importing the prepared model into the ANSYS to perform the non-linear analysis.
5. Compare the MATLAB results with the Experimental results.
6. Perform the non-linear analysis and compare the results with Experimental Results.
7. Finally compare the Experimental Results, MATLAB Results and ANSYS Results to know the Shear Behavior Result.

III. RESULT AND DISCUSSION

This Chapter includes the experimental data's of column casted for different concrete mixes like GPC(Geo-Polymer Concrete), of mix proportion M-20, M-30 & M40. With Main bar reinforcements 8mm, 10mm,12mm and 16mm diameter with 8mm diameter Lateral ties and results compared with the MATLAB/ANN results. Also includes FEM analysis data's in ANSYS for GPC-M-30 for #4-10mm diameter main bars with lateral ties 8mm diameter spaced at 100mm c/c.

Table 3: Experimental Input Data's of GPC Columns

CA(Kg/m^3)	Fck(N/mm^2)	Spacing(mm)	Ast(%)	Sup.Plr(Kg/m^3)
1294	27.93	100	1.29	8
1294	37.93	100	1.29	8
1294	47.45	100	1.29	8
1294	27.93	200	1.29	8
1294	37.93	200	1.29	8
1294	47.45	200	1.29	8
1294	27.93	300	1.29	8
1294	37.93	300	1.29	8
1294	47.45	300	1.29	8
1294	27.93	100	2.01	8
1294	37.93	100	2.01	8

Copyright © 2024 Authors

1294	47.45	100	2.01	8
1294	27.93	200	2.01	8
1294	37.93	200	2.01	8
1294	47.45	200	2.01	8
1294	27.93	300	2.01	8
1294	37.93	300	2.01	8
1294	47.45	300	2.01	8
1294	27.93	100	2.89	8
1294	37.93	100	2.89	8
1294	47.45	100	2.89	8
1294	27.93	200	2.89	8
1294	37.93	200	2.89	8
1294	47.45	200	2.89	8
1294	27.93	300	2.89	8
1294	37.93	300	2.89	8
1294	47.45	300	2.89	8
1294	27.93	100	5.15	8
1294	37.93	100	5.15	8
1294	47.45	100	5.15	8
1294	27.93	200	5.15	8
1294	37.93	200	5.15	8
1294	47.45	200	5.15	8

Table 4: Experimental Result Data's of GPC Columns by using ANSYS

Pcr(kN)	Δcr(mm)	Py(kN)	Δy(mm)	Pu(kN)	Δu(mm)
311.10	5.50	362.95	6.16	518.50	8.61
323.70	4.92	377.65	6.2	539.50	7.82
336.30	4.62	392.35	5.34	560.50	7.39
272.04	5.56	317.38	6.91	453.40	8.89
280.44	4.79	327.18	6.2	467.40	8.16
287.58	4.87	335.51	6.17	479.30	7.60
239.04	5.42	278.88	6.39	398.40	9.12
241.62	5.67	281.89	6.46	402.70	8.41
255.66	4.79	298.27	5.78	426.10	7.82
325.20	5.25	379.4	5.89	542.00	8.42
336.60	5.04	392.7	5.56	561.00	7.36
353.64	3.45	412.58	5.16	589.40	6.96
280.50	5.90	327.25	6.6	467.50	8.67
291.18	4.68	339.71	5.33	485.30	8.10
303.78	5.03	354.41	5.5	506.30	7.74
257.64	5.42	300.58	6.6	429.40	8.94

Copyright © 2024 Authors

261.18	5.16	304.71	5.7	435.30	7.98
269.86	4.59	314.83	5.42	449.76	7.80
333.60	4.14	389.2	4.73	556.00	8.18
354.00	5.66	413	6.19	590.00	7.20
386.52	3.80	450.94	4.36	644.20	6.92
287.04	5.03	334.88	6.29	478.40	8.52
307.50	5.44	358.75	6.17	512.50	7.64
332.64	4.59	388.08	5.13	554.40	7.40
272.64	5.00	318.08	6.56	454.40	8.84
276.84	4.47	322.98	6.54	461.40	7.90
287.47	4.48	335.38	5.52	479.12	7.78
355.80	4.23	415.1	4.89	593.00	7.40
385.20	4.99	449.4	5.4	642.00	6.54
412.07	3.04	480.75	3.44	686.78	5.94
307.50	5.03	358.75	5.63	512.50	5.45
320.76	5.56	374.22	6.08	534.60	6.98
353.85	3.34	412.83	3.9	589.75	6.24
287.70	6.04	335.65	6.66	479.50	8.52
294.24	5.50	343.28	6.14	490.40	7.60
305.93	3.79	356.92	4.13	509.89	6.58

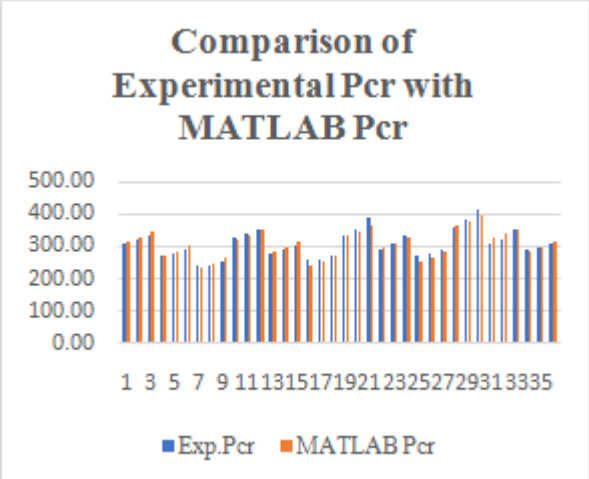
Table 5: MATLAB Result Data's of GPC Columns

Pcr(kN)	Δcr(mm)	Py(kN)	Δy(mm)	Pu(kN)	Δu(mm)
313.8997	5.2982	346.1404	6.2113	523.018	8.5366
325.8526	5.244	360.0865	6.0975	542.942	7.8799
343.5204	4.2855	380.6999	5.0852	572.391	7.4189
273.7397	5.5382	299.2804	6.5713	456.078	8.8966
285.6926	5.484	313.2265	6.4575	476.002	8.2399
303.3604	4.5255	333.8399	5.4452	505.451	7.7789
233.5797	5.7782	252.4204	6.9313	389.138	9.2566
245.5326	5.724	266.3665	6.8175	409.062	8.5999
263.2004	4.7655	286.9799	5.8052	438.511	8.1389
323.4652	5.2075	346.1405	6.0341	538.961	8.2731
335.4181	5.1533	360.0866	5.9203	558.885	7.6164
353.0858	4.1949	380.7	4.908	588.334	7.1554
283.3052	5.4475	299.2805	6.3941	472.021	8.6331
295.2581	5.3933	313.2266	6.2803	491.945	7.9764
312.9258	4.4349	333.84	5.268	521.394	7.5154
243.1452	5.6875	252.4205	6.7541	405.081	8.9931
255.0981	5.6333	266.3666	6.6403	425.005	8.3364
272.7658	4.6749	286.98	5.628	454.454	7.8754
335.1563	5.0967	346.1406	5.8175	558.447	7.9511
347.1092	5.0425	360.0867	5.7037	578.371	7.2944
364.777	4.0841	380.7001	4.6915	607.82	6.8335
294.9963	5.3367	299.2806	6.1775	491.507	8.3111

Copyright © 2024 Authors

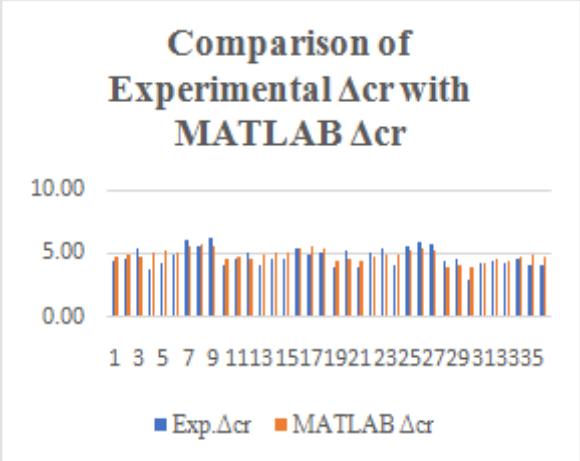
306.9492	5.2825	313.2267	6.0637	511.431	7.6544
324.617	4.3241	333.8401	5.0515	540.88	7.1935
254.8363	5.5767	252.4206	6.5375	424.567	8.6711
266.7892	5.5225	266.3667	6.4237	444.491	8.0144
284.457	4.5641	286.9801	5.4115	473.94	7.5535
365.1813	4.8122	346.1408	5.2613	608.489	7.1242
377.1342	4.758	360.0869	5.1475	628.413	6.4675
394.802	3.7995	380.7003	4.1353	657.862	6.0065
325.0213	5.0522	299.2808	5.6213	541.549	7.4842
336.9742	4.998	313.2269	5.5075	561.473	6.8275
354.642	4.0395	333.8403	4.4953	590.922	6.3665
284.8613	5.2922	252.4208	5.9813	474.609	7.8442
296.8142	5.238	266.3669	5.8675	494.533	7.1875
314.482	4.2795	286.98	4.8553	523.982	6.7265

Graph 1: Comparison of Experimental Pcr with MATLAB Pcr



From the above graph it is observed that the variation in the critical load of Experiment is almost nearer to the critical load obtained from MATLAB.

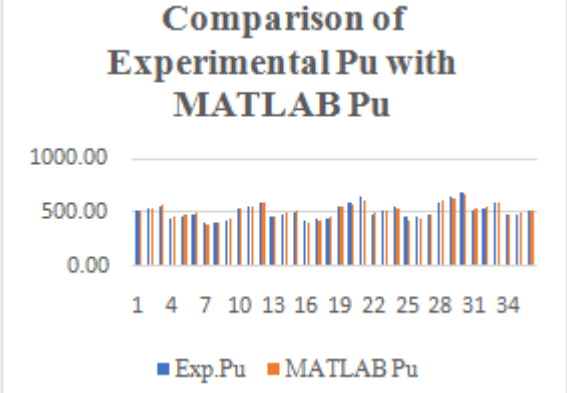
Graph 2: Comparison of Experimental Δcr with MATLAB Δcr



From the above graph it is observed that the variation in the critical deformation of Experiment and MATLAB are varied in high extent due to variation in network training.

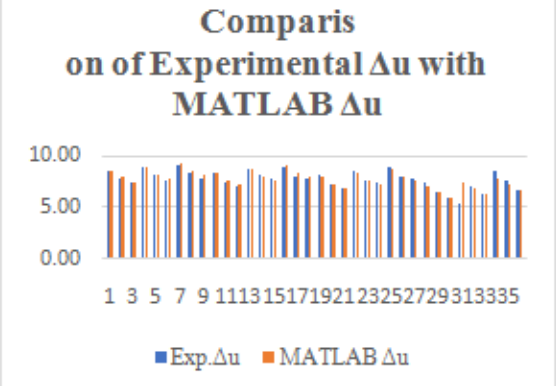
Copyright © 2024 Authors

Graph 3: Comparison of Experimental Pu with MATLAB Pu



From the above graph it is observed that the variation in the ultimate load of Experiment is almost nearer to the ultimate load obtained from MATLAB.

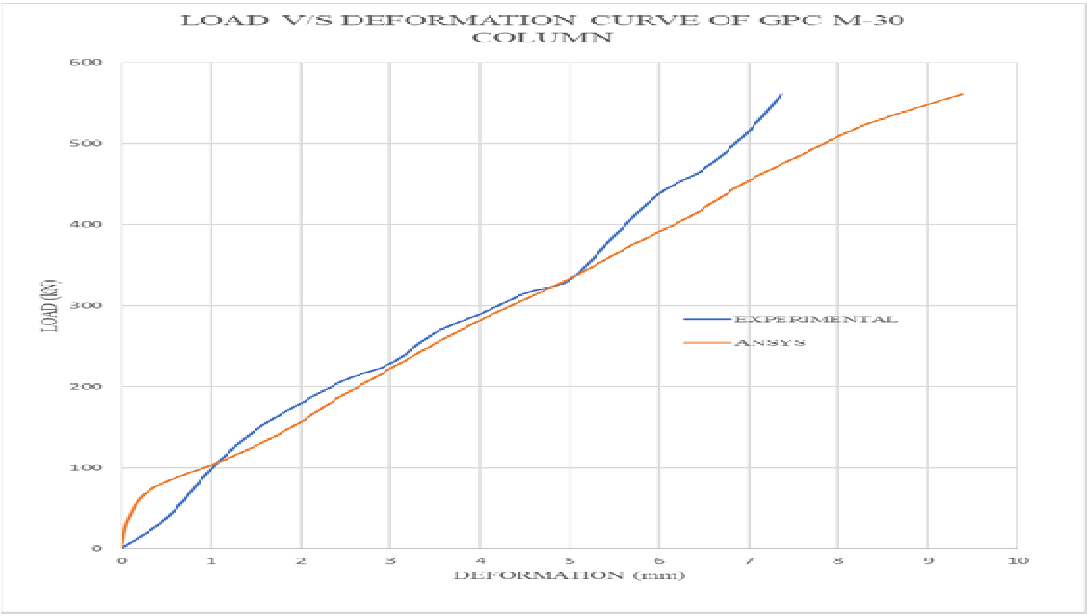
Graph 4: Comparison of Experimental Δu with MATLAB Δu



From the above graph it is observed that the variation in the ultimate deformation in Experimental and MATLAB are representing the nearer deformation plots.

1. **Comparison of GPC M-30 Column Experimental Results with ANSYS Results**

Graph 5: Comparison of Load v/s Deformation graph from Experimental with ANSYS of GPC M-30 Column



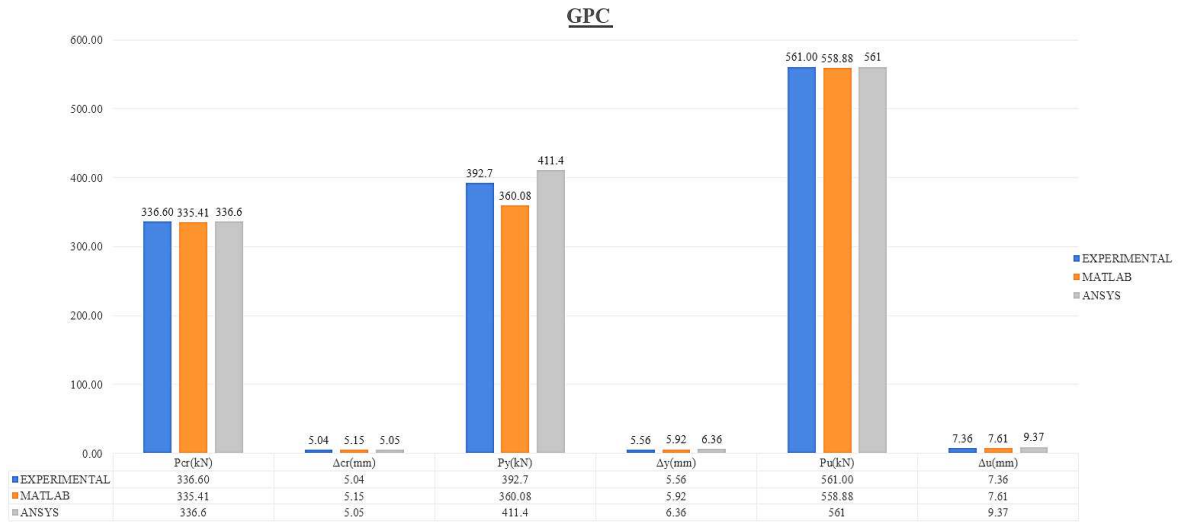
- From the above graph it is observed that ANSYS curve shows slight variation at the beginning and at end, curve differs after column resisting 400+kN axial load.

Copyright © 2024 Authors

In experiment, load values are taken for regular intervals of deformation and in ANSYS the deformations and critical, yield load are obtained for ultimate 561kN axial load

2. Comparison of GPC M-30 Column Experimental Results, MATLAB Results & ANSYS Results

Graph 6: Comparison of GPC M-30 Column Experimental Results, MATLAB Results & ANSYS Results



- From above graph it is observed that critical load values are similar in ANSYS and Experimental method, critical load in MATLAB model is with smaller difference also the critical deformation are almost similar in Experimental method and ANSYS but MATLAB model considered a higher deformation.
- From above graph it is observed that yield load value obtained for ANSYS is greater compared to MATLAB model and Experimental method and same changes for yield deformation also.
- From above graph it is observed that ultimate load values are similar in ANSYS and Experimental method, slight lower ultimate load is considered in MATLAB model and the ultimate deformation is seen more in ANSYS than Experimental method and MATLAB model.

IV. CONCLUSION

This investigation was conducted to find the shear behavior of various concrete mix columns like GPC [GEO-POLYMER CONCRETE] M-30. The reinforcement of column with main bar 10mm diameter with lateral ties of 8mm diameter spaced at 100mm c/c bought to know the shear behavior of different concrete mix columns. Highest ultimate load was taken by GPC M-30 column which reflects column showing higher shear behavior

Copyright © 2024 Authors

1. **Comparison of GPC M-30 Column Experimental Results With ANSYS Result:** The total deformation of GPC M-30 increases as the application of axial load increases.

   - The above graph shows the variation in the nature of curve initially and after resisting 350kN-400kN of both ANSYS curve and experimental curve.
   - The ultimate load of 561kN was found during experiment and same applied as the axial load in ANSYS.
   - The ultimate deformation obtained from the experiment was recorded as 7.36mm whereas ANSYS provided 9.31mm as result.

2. **Comparison of GPC M-30 Column Experimental Results, MATLAB Results & ANSYS Results:** Here to find the shear behavior of, GPC M-30 column with main reinforcement of #4-10mm diameter and lateral ties 0f 8mm diameter spaced at 100mm c/c are compared with one another.

   - GPC M-30 concrete column with main reinforcement of #4-10mm diameter and lateral ties of 8mm diameter spaced at 100mm c/c resists the ultimate load of 561kN by exhibiting an average total deformation of 8.33mm.

REFERENCES

[1] Sargin M., Gosh S. K., Handa V. K, (1971), “Effect of lateral reinforcement upon the strength and deformation properties of concrete”, Magazin of concrete research, Vol. 23, No. 75-76, 1971, p.p. 99-110. [10].
[2] Sheikh S.A. and Uzumeri S.M., (1980), “Strength and Ductility of Tied Concrete Columns, ASCE Journal of Structural Engineering” 1079-1102. [9].
[3] Saatcioglu, M., &Razvi, S. R (1987) “Study of High-strength concrete columns with square sections under concentric compression. Journal of Structural Engineering, 124(12), 1438-1447. [7].
[4] Abrams, D. P, Arturo Tena, (1987), “Influence of axial force variations on flexural behaviour of reinforced concrete columns”. Structural Journal, 84(3), 246-254. [8].
[5] Yong Yook-kong, Malakah G Nour, Edward G Nawy (1988) “Experimental studies on square column using normal strength concrete and determining of stress-strain relationship” [6].
[6] Ozawa, K., Maekawa, K, Kunishima, M., and Okamura, H. (1989). “Development of high performance concrete based on the durability design of concrete structures”. [12].
[7] Fumio, Minehiro Nishiyama, Beni Assa, (1995) “Study of column behavior by combining the high strength longitudinal bars and ordinary strength longitudinal bars’’ [5].
[8] Okamura, H. and Ozawa, K. (1995). “Mix-design for self-compacting concrete’’ proceedings of the Sixth East Asia-pacific Conference on structural engineering & construction. [13].
[9] Barbosa & Gabriel Ribeiro, Antonio F, (1998) “Analysis of reinforced concrete structures using nonlinear concrete model”. [29].
[10] Palomo A, M.W.Grutzeck, & M.T.Blanco, (1999) “ Alkali-activated fly ashes A cement for the future. Cement and Concrete Research, 29(8), 1323-1329”. [27].
[11] B. Creyel, Legrand C, Mouret M (2000), ‘’Performance of SCC on mechanical properties and development of database to obtain mix design, fresh and hardened properties’’. [17].
[12] Xu, H., & Van Deventer, J. S. J. (2000), “The Geopolymerisation of alumino-silicate minerals”. International journal of mineral processing, 59(3), 247-266. [25].
[13] Moehle J, P Jack, Kenneth J, (2003) “Experimental study of column subjected to axial loading and deterring the failure of column depending upon size of column and stirrups arrangement’’ [4].

Copyright © 2024 Authors