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Retrofitting of Column by Concrete Jacketing

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***Abstract:** This study has been conducted through basic experimental research in order to analyze retrofitting of the structure is better alternative instead of total replacement of structure. It may even be economical to use Concrete Jacketing for damaged column While Replacing Coarse Aggregate With Broken Glass in Concrete Jacketing. It improves axial and shear strength of column and major strengthening of foundation may avoided. So to study Retrofitting Of RC Square Column By Concrete Jacket Made By Replacing Aggregate With Broken Glass which helps to increase the seismic resistance of a building in both orthogonal directions of a structure and advantages ventilation and natural light.*
***Keywords:** reinforced concrete column, concrete jacketing, glass*

I. INTRODUCTION

A. Retrofitting

There are several reasons why a structure may require repair and/or retrofit. Some of the most common ones include structural damage, often from seismic events or due to aging or durability issues, updated design codes, construction or design errors, reinforcement corrosion, and a change in building usage. Especially for structures where the need is limited to select members, repair and retrofit methods have gained popularity as compared to demolition and rebuilding. Repairing and retrofitting can conserve time, money, and materials. Once the decision has been made to retrofit a reinforced concrete (RC) beam, selecting the ideal method involves consideration of performance characteristics to improve strength, deformation capacity, and/or stiffness to a desired level, or to produce a 22 more ductile failure mode. Additionally, practical considerations such as cost, space required, and labor must be considered.

1) *Column Jacketing With Broken Glass:* Column jacketing is often the favourite choice due to its ability to increase the seismic resistance of a building in both orthogonal directions of a structure and advantages ventilation and natural light. Glass is a perfect material for reusing. The expanding familiarity with glass resuing speed up examinations on the utilization of waste glass with various structures in different fields. The broken glass as a substitute for coarse aggregate in concrete helps the society as one of the possible solutions to the increasing solid waste problem. The use of solid wastes in the production of concrete has most adoptable on aggregates because they make use of large quantities of waste materials. In this experimental study, Waste Glass gathered from scraps, beer bottles and other means was used as a partial replacement of coarse aggregates.

2) *Need of Retrofitting*

a) Building which are designed considering gravity loads only.
b) Development activities in the field of Earthquake Resistant Design (EQRD) of buildings and other structures result into change in design concepts.
c) Lack of timely revisions of codes of practice and standards.
d) Lack of revisions in seismic zone map of country.
e) In cases of alterations in buildings in seismic prone area i.e. increase in number of story, increase in loading class etc.
f) In cases of deterioration of Earthquake (EQ) forces resistant level of building e.g. decrease in strength of construction material due to decay, fire damage, and settlement of foundations.
g) The quality of construction actually achieved may be lower than what was originally planned.
h) Lack of understanding by the designer.
i) Improper planning and mass distribution on floors

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B. Reinforced Concrete Jacketing

RC jacketing has been used extensively for strengthening and repairing deficient and damaged RC columns, respectively. In traditional reinforced concrete jacketing, the section of the column is enlarged by casting a new reinforced concrete/mortar section over a part or the entire length of the column. The new section is bonded to the original section through anchor rebars or high-strength bolts. Jacketing is used to strengthen weak RCC columns which have been deteriorated over a period of time due to adverse atmospheric conditions or due to poor maintenance. Jacketing is the process whereby a section of an existing structural member is restored to original dimensions or increased in size by encasement using suitable materials. A steel reinforcement cage or composite material wrap can be constructed around the damaged section onto which shot-Crete or cast-in- place concrete is placed. Columns are designed to transfer loads from top to bottom. This concrete jacketing of column provides extra layer of reinforcement and concrete over and above the completed column is known as jacketing of column. It's generally used in case of buildings after earthquake or very old buildings to increase its life and strength.

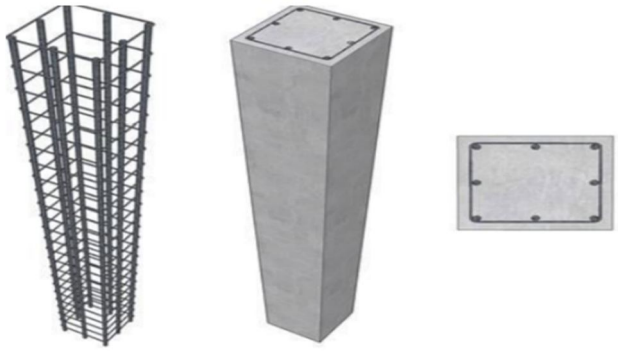


Figure 1: Reinforced Concrete Jacketing

C. Objectives

1) To check the compressive test of RC column.
2) To improve the load carrying capacity of rectangular RC column by retrofitting it with concrete jackets
3) To replace the coarse aggregate in concrete jacket by waste glass indifferent proportions and check its compressive strength.

II. LITERATURE REVIEW

This literature review focuses on recent contribution related to Concrete Jacketing Of Square column as well as Load carrying capacity of concrete cube with replacement of coarse aggregate with broken glass.

In this paper[1] Constantin.E. Chalioris and Constantin. N.Pourzitidis (2012)" introduces the application of a reinforced self-compacting concrete jacket for the structural rehabilitation of shear damaged reinforced concrete beams.

In this paper[2],"Eduardo N. B. S. J´ulio and Fernando A. B. Branco (2008) " introduces the influence of the interface treatment on the seismic behavior of columns strengthened by reinforced concrete (RC) jacketing to increase their ultimate bending moment.

In this paper[3],"Vikas Srivastava. et.al (2013)" studied that Waste glass can effectively be used as coarse aggregate replacement (upto 50%) without substantial change in strength. In order to study the effect of was3.te glass as partial replacement of coarse aggregate on the strength of concrete, fine aggregate, coarse aggregate

III. METHODOLOGY

Reinforced concrete columns of square shape were to be casted. Accordingly moulds were prepared for requirement of project. Materials were tested for different properties and mix proportions of M2 grade were fixed along with broken glass . Square columns were casted and kept for curing in curing tank for 28 days. After completion of curing period specimens were removed from curing tank and left for drying. Then axial loading was applied on the specimens through UTM machine until cracks were noticed on specimens ,readings were noted down. After that specimens were retrofitted using concrete jacket which consist of broken glass mixture in replacement of coarse aggregate and kept in curing tank for next 28 days. After curing period is over then the specimen were removed from curing tank and left for drying. Then axial load was applied on the retrofitted specimens through UTM machine and readings were noted down. Results were compared between jacketed and non-jacketed specimens and conclusions were made.

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A. Mix Design

The requirements which form the basis of selection and proportioning of mix ingredients are:

1) The minimum compressive strength required from structural consideration
2) The adequate workability necessary for full compaction with the compacting equipment available.
3) Maximum water-cement ratio and/or maximum cement content to give adequate durability for the particular site conditions.
4) Maximum cement content to avoid shrinkage cracking due to temperature cycle in mass Concrete.

B. Material Quantity

Sr. No.	Description	For 1 Column	For 12 Columns
1	Cement	3.12 kg	37.44 kg
2	Sand	4.6 kg	55.2 kg
3	Aggregate	9.3 kg	111.6 kg

Table 1 Quantities Calculations

When 10%, 20%, 30% broken glass replaces 100% aggregate volume, For 1 Concrete Jacket

% of broken glass	10%	20%	30%
Wt. in kg	$(10/100) \times 16.67 = 1.6$	$(20/100) \times 16.67 = 3.4$	$(30/100) \times 16.67 = 5$

Table 2 Calculations for 1 Jacket

Total Quantities Of Material Required For Casting 12 Columns including Concrete Jackets

Sr.no	Description	Weight in Kg
1	Cement	121.44
2	Sand	181.2
3	Aggregate	324.6
4	Broken glass	30

Table 3 Total Quantity for 12 Columns Concrete Jacket

C. Case Study

Design of reinforced concrete column using IS 456:2000. The experimental setup consists of the testing 12 reinforced concrete columns specimens with cross sections 150mm X 150mm with overall depth 500mm. Reinforced cage was placed in mould by providing 50mm covering on bottom and side face. The column was reinforced with 4 Nos. of 8mm dia. Tor steel bars. The lateral ties in the specimen are 6mm dia. @ 140mm c/c.

Design of Reinforced concrete column jacket using IS 15988:213 After observing the crack pattern of damaged specimen, the same was cleaned by removing the crack portion. For developing the bond between original specimen and outer jacketed layer, surface was made rough. 8 longitudinal reinforcement bars of 10mm dia. At each corner and middle of the surface were tied with 6mm lateral ties 100mm c/c spacing and proper covering on all sides. In this study, concrete jacketing is carried out as per recommendations of Indian standard code IS 15988:2013: Seismic evaluation and strengthening of existing reinforced concrete buildings Guidelines published by Bureau of Indian Standards. Reinforced column jackets improve column flexural and ductility.



Figure 2: Mould & Reinforcement for virgin Specimen

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Figure 3: Virgin specimen under axial load



Figure 4 : Virgin specimen after testing



Figure 5: Virgin specimen with concrete jacket



Figure 6: Mixture including waste glass

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Figure 7: Filling of concrete in mould

D. Minimum Specification for Jacketing Column

1) Strength of the new materials shall be equal or greater than those of the existing column. Concrete strength shall be at least 5 MPa greater than the strength of the existing concrete.

2) For columns where extra longitudinal reinforcement is not required, a minimum of 12φ bars in the four corners and ties of 8φ @ 100 c/c should be provided with 135° bends and 10φ leg lengths.

3) Minimum jacket thickness shall be 100 mm.

4) Lateral support to all the longitudinal bars shall be provided by ties with an included angle of not more than 135°.

5) Minimum diameter of ties shall be 8 mm and not less than one-third of the longitudinal bar diameter.

IV. RESULTS

The study focuses on compressive strength of broken glass and plain concrete. This study also gives emphasis on the environmental concerns and not on its economic aspect. In addition, study is also delimited to durability, creep, shrinkage and water tightness. These four properties of hardened concrete are time-dependent properties which will entail so much time to determine.

All the columns were tested on universal testing machine (UTM) according to the above details. When the retrofitted columns were tested under UTM it has been seen that there is significant increase in load carrying capacity of columns as compared to virgin column. The load carrying capacity of each column under axial loading is given in below tables:

Column No.	Dimensions of column (mm)	Grade of concrete	Load (KN)	Average	Compressive strength (N/mm^2)
1	150 x 150 x 500	M20	456.8	461.13	20.49
2	150 x 150 x 500		458.7		
3	150 x 150 x 500		467.9		
4	150 x 150 x 500		457.8	465.13	20.67
5	150 x 150 x 500		444.1		
6	150 x 150 x 500		493.5		
7	150 x 150 x 500		497.4	487.53	21.66
8	150 x 150 x 500		488.4		
9	150 x 150 x 500		476.8		
10	150 x 150 x 500		467.8	469	20.84
11	150 x 150 x 500		449.9		
12	150 x 150 x 500		489.3		

Table 4: Specimen details for without jacketing

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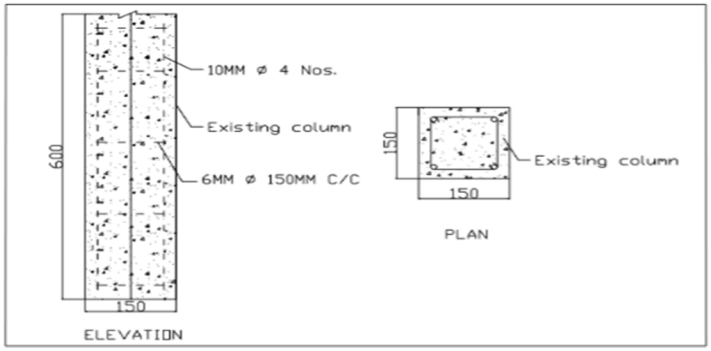


Figure 8: Virgin specimen without jacketing

Column no.	Dimensions	Grade of concrete	Percentage of waste glass replacement	Load (KN)	Average	Compressive strength (N/mm^2)
1	250 X 250 X 500	M20	0%	1411.13	1415.46	22.64
2	250 X 250 X 500			1413.03		
3	250 X 250 X 500			1422.23		
4	250 X 250 X 500		10%	1484.04	1485.68	23.77
5	250 X 250 X 500			1485.02		
6	250 X 250 X 500			1488		
7	250 X 250 X 500		20%	1411.46	1412.56	22.63
8	250 X 250 X 500			1414.01		
9	250 X 250 X 500			1412.22		
10	250 X 250 X 500		30%	1147.01	1145.08	18.32
11	250 X 250 X 500			1142.12		
12	250 X 250 X 500			1145.11		

Table 5: Specimen details for jacketing layer

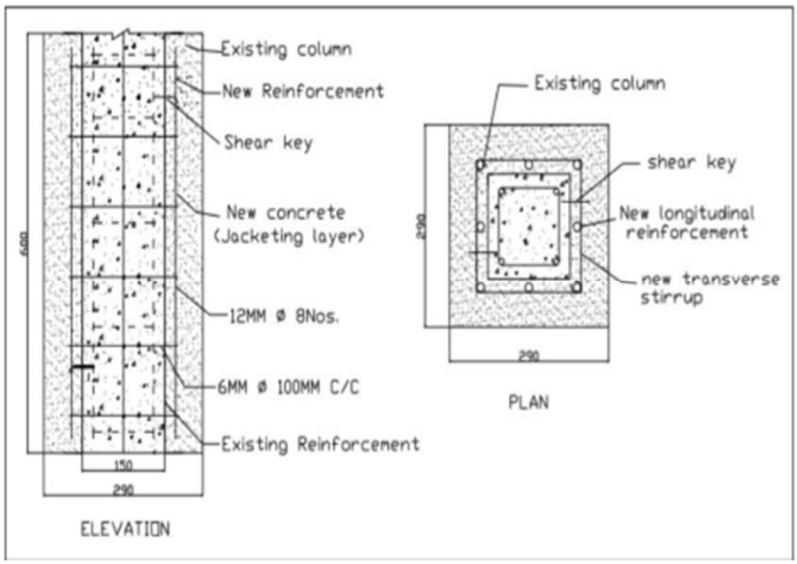


Figure 9 : Virgin Specimen with jacketing layer

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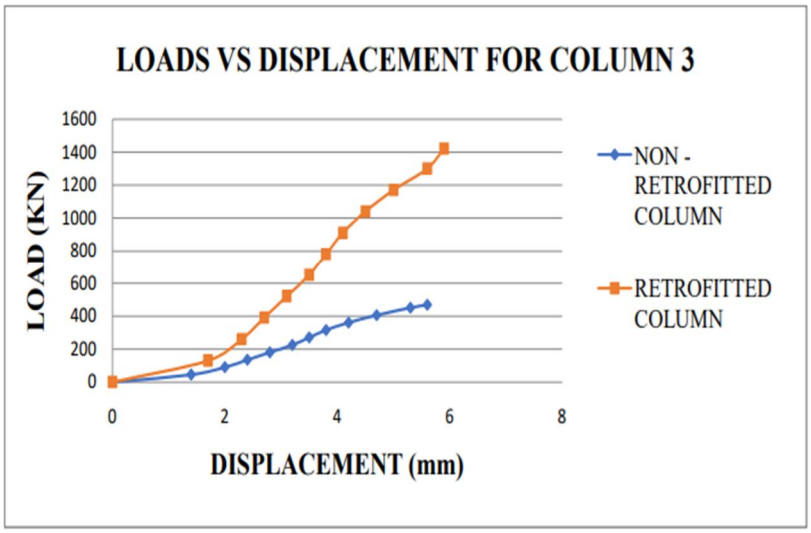


Figure 10 : Load vs Displacement for Column 3

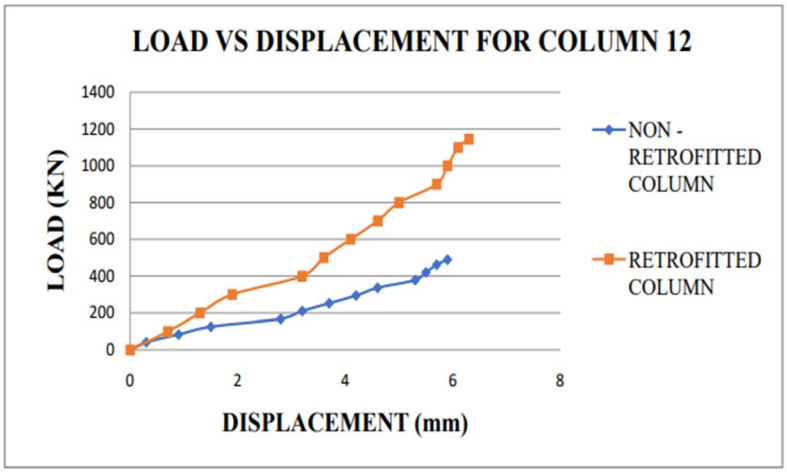


Figure 11 : Load vs Displacement for Column 12

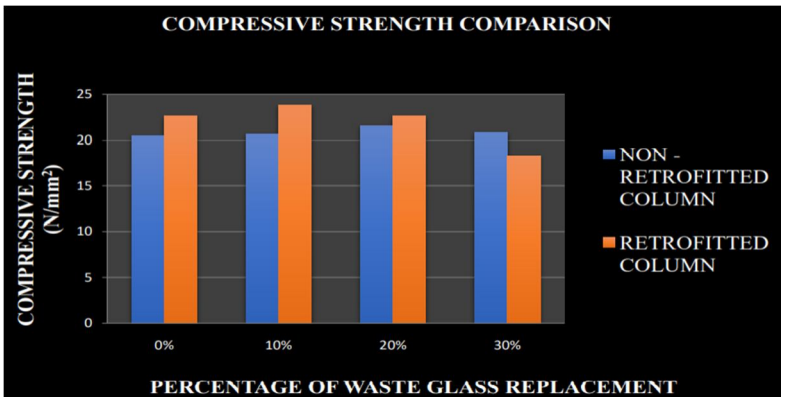


Figure 12 : Comparison between Retrofitting and Non-Retrofitting column

Comparison between compressive strength of both retrofitted (with broken glass replacement and non – retrofitted column, it has been seen that the highest strength for retrofitted column is upto 10% replacement, lowest strength is upto 30 % replacement and moderate strength upto 20 % replacement under axial load.

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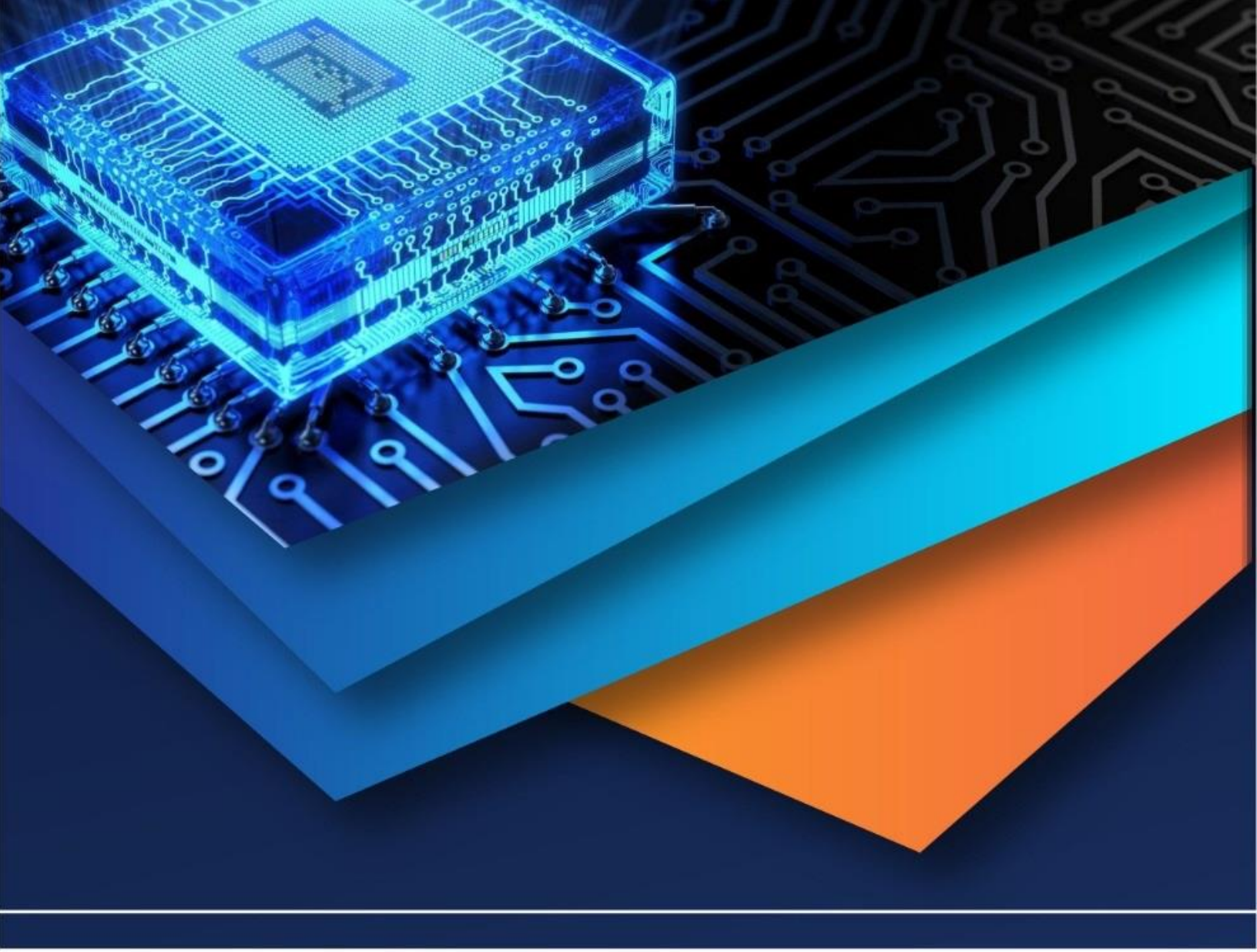
V. CONCLUSION

A. Concrete jacket proves to be very easy and effective method among other retrofitting methods.
B. Columns for M20 were casted and tested under axial load on UTM machine and the result shows that the strength of specimen with 10% and 20% replacement has increased.
C. Marginal decrease in strength with 30% replacement level of waste glass with coarse aggregate as compared to M20 concrete.
D. The waste glass can be efficiently used as coarse aggregate by partial replacement.
E. The most ideal replacement level of waste glass as coarse aggregate is to be 10%.
F. The use of waste glass in concrete can prove to be economical as it is non-use full waste and free of cost.
G. The main use of waste glass in construction industry will eliminate the dumping and land filling problem of waste glass and it will prove to be environmental friendly thus makes road map and planning way for greener concrete.
H. The use of waste glass in concrete will not disturbed the natural resources particularly river gravels and thus making concrete construction industry sustainable.

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