Journal for Recent advances in Built Environment (JRABE)

ISSN: 2583-3901

In Association with Department of Civil Engineering
K.S, School of Engineering and Management

Volume 3 2024

Comparative Analysis of Compressive Strength of Masonry Units with Geo-Polymer Blocks and Concrete Blocks With And Without Horizontal Reinforcement

Shrujana[1], Manjunath B[2], Prashanth [3]

[1] PG Student, JSSCE, Bangalore-India,

[2, 3], Assistant Professor, K S School of Engineering and Management, Bangalore

Abstract

Reinforced masonry combines the advantage of masonry and reinforcement. The literature review clearly shows that compressive strength of normal block masonry without horizontal reinforcement is less as compared to masonry with horizontal reinforcement. The blocks were cast of size 400mmX200mmX150mm and compressive test for Geo polymer blocks is more compared to Normal blocks, an increase of 26% for 7 days and by 30% for 28 days. Geo-polymer prisms and normal block prisms were casted with and without horizontal mesh reinforcement and were tested for compression. From the experimental results it was observed that Geo-polymer blocks with horizontal mesh gave 33% higher compressive strength than the normal blocks with horizontal mesh. It can be concluded that the geo-polymer block prisms with reinforcement yield better compressive strength than the normal block prisms without reinforcement.

Keywords:- **Geo-polymer, Horizontal Reinforcement, Compressive strength**

1 INTRODUCTION:

Masonry can be used to build various forms of different sizes. Strength and elastic characteristics are the factors that structural designers consider as most important. These are further broken down into compressive strength, shear and flexural strength, elastic modulus, friction coefficient, creep, moisture, thermal expansion, and many more. Prism strength, unit strength, mortar strength, bed joint thickness, prism strength, prism height to thickness ratio, contributes to the compressive strength of the brickwork.

The performance of plain masonry under gravity loading is good but is poor under lateral load such as wind loads, and seismic loads. This can be improved by introducing reinforcement into the masonry. This improves the load carrying capacity as well as performance under lateral loading.

1.1 Geo-polymer concrete

Geo-polymer concrete is relatively a new material and has the potential to replace the conventional concrete. Geo-polymer is an inert polymer that is developed at a specific temperature by using industrial waste materials to form a binder which possess similar properties that of ordinary

Portland cement. The fly ash is mixed with alkaline solution to produce binder. The Geo-polymer paste binds the fine aggregates, coarse aggregates and unreacted particles to form Geo-polymer concrete. Fly ash is used as replacement to Ordinary Portland cement and reacts with calcium hydroxide during the hydration of cement to form calcium silicate hydrate gel.

1.2 Advantages of Geo-polymer concrete

- Raw materials available easily.
- Using of geo-polymer saves energy and
- it is environmentally friendly.
- Preparation of geo-polymer is easy.
- Good volume stability.
- Excellent durability.
- Applications of Geo-polymer concrete
- It is used in heat resistant composites.
- It is used in manufacturing bricks and ceramics.
- Geo-polymer used in fibre glasses used for fire protection.
- Concrete road repair works.
- Mainly used in construction of wind tunnels and irrigation structures.

1.3 Durability of Geo-polymer concrete

Durability of Geo-polymer concrete is the ability to resist weathering abrasion, chemical attacks etc. The durability tests are conducted on geo-polymer concrete to know the effect of weathering on concrete.

2 LITERATURE REVIEW

Compressive strength and Modulus of elasticity of masonry are significant parameters when considering structural masonry design. Masonry properties were determined experimentally by Ida Ayu Made Budiwati [3]. Three types of prism specimens are made of clay brick and concrete block masonry are prepared. Prisms were tested to check the properties of structural units and the mortar. Results show that mean compressive strength of the mortar, clay brick units and concrete block units are 4.2 N/mm^2, 6.3 N/mm^2 and 12.8 N/mm^2 respectively. The characteristic compressive strength of clay brick and concrete block masonry is 11.2 N/mm^2 and 7.2 N/mm^2. It is concluded that the failure of the masonry tested in compression was due to development of tensile cracks parallel to the axis of the loading. Reinforced masonry was introduced to increase the durability and strength of free masonry to overcome the tensile strength. The prism specimens, masonry triplets and masonry wallets were casted using the hollow concrete blocks of dimension 400x200x200mm. Totally six specimens were cast , out of which three specimens were cast with unreinforced Hollow Concrete Block Masonry (UHCBM) and three specimens were cast with

8mm diameter Vertical Reinforcement in Hollow Concrete Block Masonry (RHCBM). Anusha G Krishna [1] concluded that the Compressive strength of mortar cube (1:4) with w/c ratio of 0.7 is found to be 10.23 N/mm^2 for 28 days. The average compressive strength, shear strength and Flexure strength for reinforced masonry using 8mm dia bar is 10.24 N/mm^2, 2.91 N/mm^2 and 2.31 N/mm^2 respectively. The average compressive strength, shear strength and Flexure strength for Unreinforced masonry is 8.54 N/mm^2, 1.28 N/mm^2 and 1.02 N/mm^2 respectively.

The masonry prism specimens were cast using hollow concrete blocks of dimension 400×150×200 mm for Compression and Modulus of Elasticity test. Fe-415 steel of diameter 12 mm and 8 mm reinforcement is placed in Reinforced Hollow Concrete Block Masonry (RHCBM). Totally four number of RHCBM using 12 mm diameter bar, six number of RHCBM using 8 mm diameter bar and three number of unreinforced masonry prisms were cast and tested under compression. Madan Kumar & et.al. [4] Concluded that the average compressive strength and modulus of elasticity of Hollow concrete blocks is found to be 6.08 N/mm^2 and 5898 MPa. The average Compressive Strength for Unreinforced masonry, RHCBM using 12mm dia and RHCBM using 12mm dia is found to be 6.83 N/mm^2, 11.1 N/mm^2 and 9.09 N/mm^2 respectively. The average Modulus of elasticity for unreinforced masonry and RHCBM using 12mm dia is 17265 MPa and 22072 MPa.

3 TESTS ON CONCRETE BLOCK

Water absorption: According to IS: 2185 part 1, the average water absorption shall not exceed 10%. Three specimens were picked at random, and their weight was determined (W2). For 24 hours, the test specimens were submerged in water. The specimen was removed from the water and allowed to drain for one minute. Surface water was removed with a towel and weighed immediately (W1).

Water Absorption = (W1-W2) / W2x 100 %

4 TEST ON MORTAR

4.1 Compressive strength:

According to IS 2250, the mortar used to build the prism specimens' compression strength was assessed (1981). The 70.6 mm mortar test specimens with cement sand mixture of 1:3, 1:6, and 1:8 are tested. The cubes were tested after 28 days in a compression testing machine.

4.1.1 Fly ash

The properties of fly ash are found as per IS: 38122003 and are tabulated in Table 1

Table 1: Properties of fly ash

SL. No.	Nature of the Test	Results
1.	Fineness	6%
2.	Specific Gravity	2.28

Chemical composition (%)	
Binder	Fly Ash
Fe_2O_3	1.45
MgO	0.745
SO_3	0.54
Na_2O	0.75
CaO	3.21
SiO_2	61.13
Al_2O_3	31.225
Chlorides	0.065

4.2 Ground Granulated Blast Furnace Slag

The properties of Ground Granulated Blast Furnace Slag are shown in Table 2

Table 2 : Properties of ground granulated blast furnace slag

SL. No.	Nature of Test	Test Results
1.	Fineness	2.45%
2.	Specific Gravity	2.786

Chemical composition (%)	
Binder	Fly Ash
Fe_2O_3	0.64
MgO	8.645
SO_3	2.22
Na_2O	0.32
CaO	37.24
SiO_2	37.2
Al_2O_3	13.235
Chlorides	0.0035

4.3 Sodium Hydroxide

Sodium hydroxide commercially called as caustic soda, generally available in form of pellets, flakes or granular form as shown in 3.7. It is highly soluble in water and gives raise to exothermic reaction liberating large amount of heat. The basic tests done in laboratory are tabulated in Table 3

Table 3: properties of sodium hydroxide

SL. No	Nature of Property	Value
1.	Specific Gravity	2.13
2.	Purity	97%

4.4 Sodium silicate

Sodium Silicate also called as liquid glass or water glass and is available in the form of aqueous solution or in solid form. The composition of sodium silicate consists of sodium oxide, silicon dioxide and water. Sodium silicate is added to increase the rate of polymerization. The basic tests done in laboratory are tabulated in Table 4.

Table 3 :Properties of sodium silicate

SL. No	Nature of Property	Value
1.	Specific Gravity	1.39
2.	Composition:	Mass (%)
	a. Sodium Oxide (Na_2O)	14.7
	b. Silicon dioxide (SiO_2)	29.4
	c. Water	55.9

Table 4 : Geo polymer Concrete mix

Sodium Hydroxide Solution	58kg
Coarse aggregate	1069.25kg
M-Sand	575.75kg
Water	50.3kg
Molarity	10M

5 EXPERIMENTAL PROGRAM

The approaches and procedures adopted in the past to develop GPC mixes is reviewed and implemented in the study as standard GPC mix design is not mentioned in IS codes. The design mix has 70% of mixed aggregates, 30% alkaline solutions of the mass of concrete, the density of GPC was assumed to be 2350 kg/m^3 (a lower value was chosen because of the low bulk densities of FA and GGBS).Geo-polymer concrete is prepared by mixing Fly ash, GGBS, M sand and coarse aggregates with alkaline solution. The alkaline solution is prepared mixing NaOH solution and sodium silicate solution as shown in table 4. NaOH pellets are dissolved in distilled water and kept for 24 hours before mixing in the concrete. Sodium silicate is thoroughly mixed with NaOH solution at the time of casting. Fly ash, GGBS, M sand and coarse aggregate are mixed in dry state for 5min. Thereafter alkaline solution is and mixed for another 5min. The mixing of concrete is done in room temperature and specimens are casted without any delay. After many trials, the following mix is adopted with a compressive strength of 40MPa. The Quantity of materials required for 1m^3 of Geo-polymer concrete as shown in Table 5. The manufactured block size is 400mmX200mmX150mm. Total number of prisms 24 were casted with without horizontal mesh.

6 RESULT AND DISCUSSIONS:

6.1 Water absorption:

The Water absorption values at saturation for solid and hollow blocks were found to be 2.10%, 5.51%, respectively. The test results were also found to be in the specified range i.e., below 10% as per the IS: 2185 part 1.

6.2 Compressive Strength:

The compressive strength of conventional blocks was found to be 3.08 N/mm^2 and 4.01 N/mm^2 for 7days and 28 days respectively and 3.9 N/mm^2 and 5.07 N/mm^2 respectively for GPC blocks.

6.3 Tests on Prisms:

The compressive strength test was conducted on prisms. The prisms were placed on the loading frame and the Experimental setup as shown in Fig 1. the load displacement curve is shown in Fig2. The geo- polymer blocks without horizontal mesh for a maximum Load of 55kN at a Displacement of 11mm for 28days and Normal Blocks without horizontal Mesh Maximum Load of 50kN At a Displacement of 9mm for 28days.

Figure 1 ;Experimental setup -Structures Laboratory, KSSEM

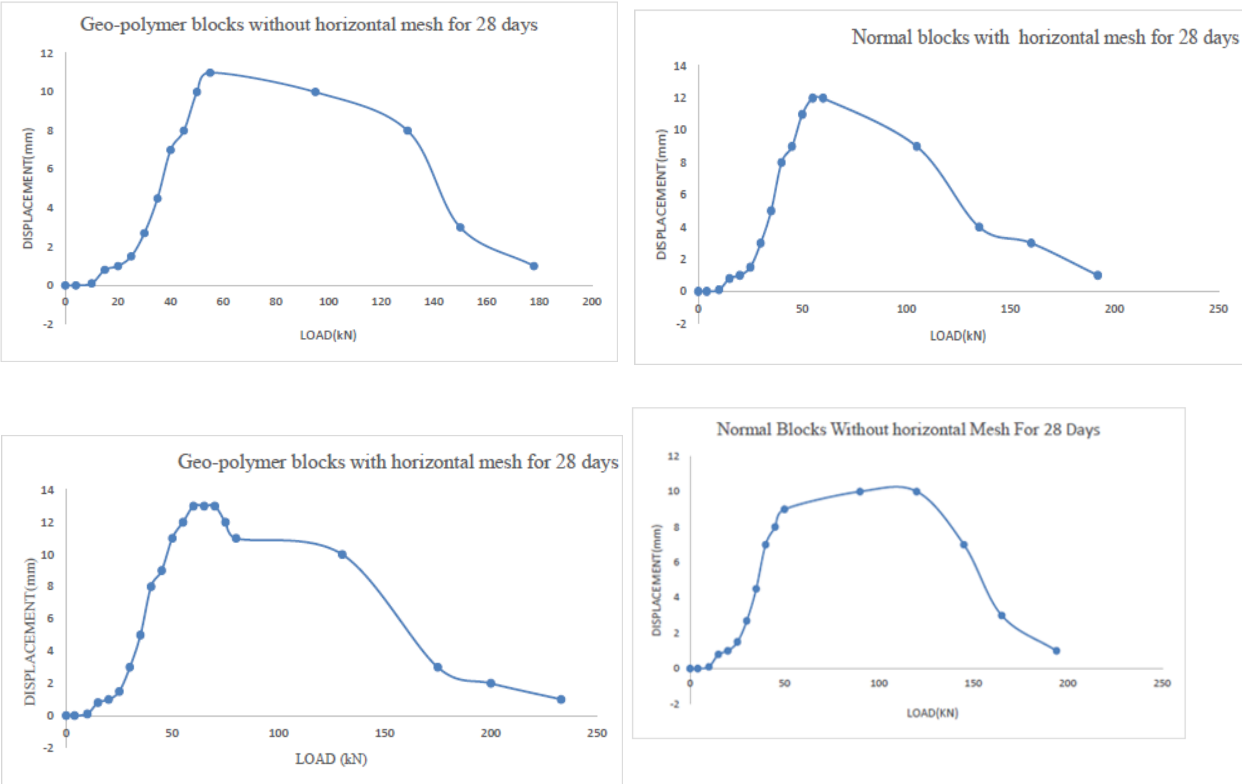


Figure 2: Load displacement curves for normal and Geo Polymer blocks

The geo-polymer blocks with horizontal mesh for a maximum load of 80kN showed a displacement of 13mm for 28days. 12mm displacement was observed for normal blocks under 60kN. The displacement for geo-polymer blocks without horizontal mesh under a maximum load of 55kN is 11mm and 9mm for Normal Blocks under 50kN load.

7 CONCLUSIONS

1. It is observed from the compressive strength test results for both 7 and 28 days, the compressive strength for Geo polymer blocks is 3.9 N/mm^2 and 5.07 N/mm^2 and for Normal block is 3.08 N/mm^2 and 4.01 N/mm^2 for 7days and 28days respectively.
2. The compressive strength Geo-polymer blocks (3.9 N/mm^2) is more compared to normal blocks (3.08N/mm^2) by 26% for 7 days testing and by 30% for 28 days. Geo polymer blocks showed better results when compared to the normal blocks.
3. Geo polymer block prisms have shown higher compressive load carrying capacity when compared to normal block prism.
4. From the test results it is observed that the compressive load carrying capacity of geo polymer block masonry prisms with mesh horizontal reinforcement is 80kN and 60kN for

normal blocks.

5. The maximum displacement was 13mm for Geo polymer Blocks and 12mm for normal Blocks.
6. Typical compression failure was observed in prisms during testing. Vertically splitting cracks were observed in units.

REFERENCES

1 Anusha G Krishna, (2018) "Strength study on reinforced hollow concrete block masonry", *International Journal of Applied Engineering Researchx*, Vol.13, no.7, pp.270-273.

2 Haach, V G, Vasconcelos, G, Lourenço, P.B, (2014) "Study of the behaviour of reinforced masonry wallets subjected to diagonal compression through numerical modelling", 9th *International masonry society*, pp.1-11.

3 Ida Ayu Made Budiwati (2009) "Experimental compressive strength and modulus of elasticity of masonry", *Jurnal Ilmiah Teknik Sipil.* Vol.13, no.1, pp.71-81.

4 Madan Kumar L, S Raghunath, (2015**)** "Studies on reinforced hollow concrete block masonry", *International Journal of Research in Engineering and Technology.* Vol.4, pp.31-34.

5 Manish S Dharek, S Raghunath, Prashant C Sunagar,et al.,(2020) "Stress strain characteristics of reinforced hollow concrete block masonry melded with mesh reinforcement", Conf. Series: *Materials Science and Engineering*, Vol.814, pp.1-6.

6 Sandeep, M V Renukadevi, S Manjunath, Somanath, (2013) "influence of reinforcement on the behavior of hollow concrete Block masonry prism under compression-an experimental and Analytical approach", *International Journal of Applied Engineering Research*, Vol.4, pp.106- 110.

7 P.M.Vijaysankar, R. Anuradha, V.Sreevidya,et al.,(2013) "Durability Studies of Geopolymer Concrete Solid Blocks", *International Journal of Advanced Scientific and Technical Research*, Vol.2, pp.272-278.

Taguchi based optimization of Bond Strength in CFST Columns using Grey Relational Analysis

Chethan Kumar S1, Dr.N.S. Kumar2

1Assistant Professor, 2 Professor, Ghousia College of Engineering, Ramanagaram

Abstract

Concrete filled steel tubes are extensively used in high rise structures and bridges. The characteristics such as ease of construction, maintenance, resistance to corrosion makes the concrete filled steel tubes a potential application in many structures to satisfy the durability criteria. Extensive research was carried out in the past decades on the behavior of CFST columns. The studies on bond strength were conducted by Verdi and Dowling. Experimental investigations were carried out on concrete filled steel tube columns with concrete using glass fibers, of different lengths and diameter. Taguchi's approach of DOE is adopted to save the time and cost of the experiments. The push-out tests were performed to investigate the effects of parametric variations. The optimization of parameters considering the bond strength in CFST columns using grey relational analysis is presented. The diameter, L/D ratio, percentage of glass fibers is considered for evaluating the bond strength. Those process parameters closely correlate with the selected performance characteristics in this study. Experiments based on the appropriate L9 OA are conducted. The normalized experimental results of the performance characteristics are then introduced to calculate the coefficient and grades according to Grey relational analysis.

Keywords*: CFST, DOE, Pushout Test, Grey Relational analysis.*

1 Introduction:

Concrete Filled Steel Tubes are increasingly used in High-rise buildings and arch structures. The characteristics of aesthetic appearance, excellent durability, good seismic behavior and ease of construction as well as maintenance gives CFST a potential application in the onshore buildings, offshore platforms, bridges, and many more. Composite columns integrate the characteristics of steel and concrete materials, thereby providing high strength and stiffness, energy dissipation and economical. In composite columns, steel-concrete interface bond plays a major role in the regions at end connections where force transfer takes place. Past studies have indicated that a continuity of strains between steel and concrete can be assured if the concrete core and steel tube at the column ends are loaded simultaneously. In this case, the actual bond between the steel and the concrete has little or no significant influence on the performance of CFST. However, bond stress demand is excessively high where longitudinal shearing stresses are likely to be predominant.

Grey relational analysis was proposed by Deng in 1989, which is widely used for measuring the degree of relationship between sequences by grey relation grade. Several researchers adopted the grey relational analysis for optimizing the control parameters. To optimize the Bond Strength, Taguchi method with grey relational analysis is adopted. The following are the steps:

1. Identify the size of the tubes like length, diameter, thickness of the tube and grade of the concrete as infill.
2. Determine the number of levels for the Taguchi approach.
3. Select the appropriate orthogonal array.
4. Conduct the experiments based on the arrangement of the orthogonal array.
5. Normalize the experiment results of axial load and the deformation.
6. Perform the grey relational generating and calculate the grey relational coefficient.
7. Calculate the grey relational grade by averaging the grey relational coefficient.
8. Analyze the experimental results using the grey relational grade.

2 Experimental Datasheet:

The procedure for push out test to find the bond strength is described below. In this study a total of 27 specimens are tested using UTM under controlled loading of 0.2 kN/sec.

- CFST specimens are checked and prepared for the loading surface for horizontality.
- After the surface is made horizontal the specimen was placed in the UTM
- The solid steel cylinder is fixed in the loading frame and CFST column specimen to make sure the loading head is applied on the concrete.
- The initial load is applied on the concrete infill the load point is taken as zero with the dial gauge of accuracy of 0.01 is used to measure the slip of concert core.
- The load is applied and increased at a constant rate of 0.2 kN/sec is applied on the concrete to record the slip of concrete with respect to applied load on the CFST columns.

- Two cameras were used to record the slip with an accuracy of 0.01 mm and loading with an accuracy of 0.2 kN /sec. Once the CFST column fails under bond, the loading rate is increase to 2kN/min until the settlement reaches 30 mm.

Table:1 Pushout Test Results conducted on CFST columns for evaluating Bond Strength

Sl No	Grade of Concrete	Diameter of tube D in mm	Percentage of glass fiber	Thickness of the tube T in mm	L/D ratio	Pushout Load (Nu) KN	Bond Strength τu KN/mm^2
1	M20	33.7	0	2.6	12	66.36	1.5507
2		33.7	0.2	3.2	14	111.63	2.2360
3		33.7	0.4	4	16	108.8	1.9069
4		42.2	0	3.2	16	192.34	2.1498
5		42.2	0.2	4	12	39.45	0.5879
6		42.2	0.4	2.6	14	142.23	1.8168
7		48.3	0	4	14	111.69	1.0891
8		48.3	0.2	2.6	16	41.54	0.3544
9		48.3	0.4	3.2	12	99.2	1.1285
10	M25	33.7	0	2.6	12	58.35	1.3635
11		33.7	0.2	3.2	14	81.21	1.6266
12		33.7	0.4	4	16	96.7	1.6948
13		42.2	0	3.2	16	178.38	1.9938
14		42.2	0.2	4	12	50.84	0.7577
15		42.2	0.4	2.6	14	185.51	2.3697
16		48.3	0	4	14	82.05	0.8001
17		48.3	0.2	2.6	16	111.71	0.9531
18		48.3	0.4	3.2	12	54.762	0.6230
19	M30	33.7	0	2.6	12	60.22	1.4072
20		33.7	0.2	3.2	14	103.64	2.0759
21		33.7	0.4	4	16	92.7	1.6247
22		42.2	0	3.2	16	136.63	1.5271
23		42.2	0.2	4	12	54.71	0.8153
24		42.2	0.4	2.6	14	197.93	2.5283
25		48.3	0	4	14	104.83	1.0222
26		48.3	0.2	2.6	16	88.87	0.7582
27		48.3	0.4	3.2	12	134.85	1.5341

3 Grey Relation Analysis:

3.1 Data pre-processing:

The data pre-processing is the first step to be performed in the grey relational analysis to normalize the random grey data with different measurement units to transform them to dimensionless parameters. Thus, data pre-processing converts the original sequences to a set of comparable sequences. Different methods are employed to pre-process grey data depending upon the quality characteristics of the original data. The original reference sequence and pre-processed data (comparability sequence) are represented by $X_o^{(0)}(k)$ and $X_i^{(0)}(k)$, i=1,2,3,…..m; k=1,2,….,n respectively, where m is the number of experiments and n is the total number of observations of data. Depending upon the quality characteristics, the three main categories for normalizing the original sequence are identified as follows: If the original sequence data has quality characteristic as 'larger-the-better' then the original data is pre-processed as 'larger-the-best'

$$x_i^*(k) = \frac{x_i^{(0)}(k) - min\, x_i^{(0)}(k)}{max\, x_i^{(0)}(k) - min\, x_i^{(0)}(k)}$$

If the original data has the quality characteristic as 'smaller the better', then original data is pre-processed as 'smaller-the best':

$$x_i^*(k) = \frac{max\, x_i^{(0)}(k) - x_i^{(0)}(k)}{max\, x_i^{(0)}(k) - min\, x_i^{(0)}(k)}$$

However, if the original data has a target optimum value (OV) then quality characteristic is 'nominal-the-better' and the original data is pre-processed as 'nominal-the-better':

$$x_i^*(k) = 1 - \frac{|x_i^{(0)}(k) - OV|}{max\,\{max\, x_i^{(0)}(k) - OV, OV - min\, x_i^{(0)}(k)\}}$$

Also, the original sequence is normalized by a simple method in which all the values of the sequence are divided by the first value of the sequence.

$$x_i^*(k) = \frac{x_i^{(0)}(k)}{x_i^{(0)}(1)}$$

Where max $x_i^{(k)}$ and min $x_i^{(k)}$ are the maximum and the minimum values respectively of the original sequence $x_i^{(0)}(k)$. Comparable sequence $x_i*(k)$ is the normalized sequence of original data.

3.2 Grey relational grade:

Next step is the calculation of deviation sequence, Δoi(k) from the reference sequence of pre-processes data $x_i(k)$ and the comparability sequence $x_i(k)$. The grey relational coefficient is calculated from the deviation sequence using the following relation:

$$\gamma\left(x_0^*(k), x_i^*(k)\right) = \frac{\Delta min + \xi \Delta max}{\Delta oi(k) + \xi \Delta max} \quad 0 < \gamma(x_0^*(k), x_i^*(k)) \leq 1$$

Where Δoi(k) is the deviation sequence of the refernce sequence $x_o^*(k)$ and comparability sequence $x_i^*(k)$. and comparibility sequence $x_i^*(k)$.

$$\Delta oi(k) = |x_0^*(k) - x_i^*(k)|$$

$$\Delta max = \max_{\forall j \in i} \max_{\forall k} |x_0^*(k) - x_i^*(k)|$$

$$\Delta min = \min_{\forall j \in i} \min_{\forall k} |x_0^*(k) - x_i^*(k)|$$

ξ is the distinguishing coefficient ξ ϵ [0,1]. The distinguishing coefficient (ξ) value to be chosen as 0.5. A grey relational grade is weighed average of the grey relational coefficient and is defined as follows:

$$\gamma(x_0^*, x_i^*) = \sum_{k=1}^{n} \beta k \gamma((x_0^*(k), x_i^*(k)), \sum_{k=1}^{n} \beta k = 1$$

The grey relational grade γ (x_o^*, x_i^*) represents the degree of correlation between the reference and comparability sequences. If two sequences are identical, then grey relational grade value equals unity. The grey relational grade implies that the degree of influence related between the comparability sequence and the reference sequence. In case, if a particular comparability sequence has more influence on the reference sequence than the other ones, the grey relational grade for comparability and reference sequence will exceed that for the other grey relational grades. Hence, grey relational grade is an accurate measurement of the absolute difference in data between sequences and can be applied to appropriate the correlation between sequences.

The experimental results for ultimate load (P_u), Axial shortening (Δ_s) listed in the Table 2. Typically, larger values of P_u and nominal values of Δ_s are desirable. Thus the data sequences have the nominal-the-better characteristic, the "nominal-the-better" methodology, was employed for data pre-processing.

Table 2: Orthogonal array L_9 (3^3) of the experimental runs and results

sl no	A	B	C	D	Bond Strength τu KN/mm^2 (M20)	Bond Strength τu KN/mm^2 (M25)	Bond Strength τu KN/mm^2 (M30)
1	1	1	1	1	1.5507	1.3635	1.4072
2	1	2	2	2	2.2360	1.6266	2.0759
3	1	3	3	3	1.9069	1.6948	1.6247
4	2	1	2	3	2.1498	1.9938	1.5271
5	2	2	3	1	0.5879	0.7577	0.8153
6	2	3	1	2	1.8168	2.3697	2.5283
7	3	1	3	2	1.0891	0.8001	1.0222
8	3	2	1	3	0.3544	0.9531	0.7582
9	3	3	2	1	1.1285	0.6230	1.5341

The values of the τu are set to be the reference sequence $x_o^{(0)}$ (k), k =1–3.Moreover, the results of nine experiments were the comparability sequences $x_i^{(0)}$ (k), i=1, 2... 9, k =1–3. Table V listed all of the sequences after implementing the data preprocessing. The reference and the comparability sequences were denoted $x_0^*(k)$ and $x_i^*(k)$, respectively.

Table: 3-a Data Processing Results

Comparability Sequence	Reference Sequence		
Run No	Bond Strength τu KN/mm^2 (M20)	Bond Strength τu KN/mm^2 (M25)	Bond Strength τu KN/mm^2 (M30)
1	0.6358	0.4240	0.3667
2	1.0000	0.5746	0.7444
3	0.8251	0.6136	0.4895
4	0.9542	0.7848	0.4344
5	0.1241	0.0771	0.0322
6	0.7772	1.0000	1.0000
7	0.3905	0.1014	0.1491
8	0.0000	0.1890	0.0000
9	0.4114	0.0000	0.4383

Table: 3- b Data Processing Results (contd…)

Comparability Sequence	Reference Sequence		
Run No	Bond Strength τu KN/mm^2 (M20)	Bond Strength τu KN/mm^2 (M25)	Bond Strength τu KN/mm^2 (M30)
1	0.36419	0.57601	0.63335
2	0.00000	0.42539	0.25558
3	0.17491	0.38637	0.51050
4	0.04580	0.21521	0.56563
5	0.87591	0.92290	0.96775
6	0.22277	0.00000	0.00000
7	0.60954	0.89861	0.85088
8	1.00000	0.81099	1.00000
9	0.58859	1.00000	0.56169

Table 4: Calculated Grey Relational Coefficient and Grey Relational Grade

Comparability Sequence	Reference Sequence				
Run No	Bond Strength τu KN/mm^2 (M20)	Bond Strength τu KN/mm^2 (M25)	Bond Strength τu KN/mm^2 (M30)	Grey Relational Coefficient	Grey Relationa l Grade
1	0.5786	0.4647	0.4412	0.4948	5
2	1.0000	0.5403	0.6617	0.7340	2
3	0.7408	0.5641	0.4948	0.5999	4
4	0.9161	0.6991	0.4692	0.6948	3
5	0.3634	0.3514	0.3407	0.3518	8
6	0.6918	1.0000	1.0000	0.8973	1
7	0.4506	0.3575	0.3701	0.3928	7
8	0.3333	0.3814	0.3333	0.3494	9
9	0.4593	0.3333	0.4709	0.4212	6

4 Conclusions:

1 The push out test conducted on CFST columns in this study showed that the bond strength is dependent on the type of concrete mixes is used as an in-fill material in the CFST column the

reason is that the different adhesive force in different concrete due to the fines content variation in different type of concrete.

2 It was also found that the use of conventional concrete with Glass fibre as a in fill material in CFST columns is highly disadvantage, as it reduces bond strength.

3 Generally, as Length of the section increases, the bond strength increases. The highest Grey relational grade of 1.0000 was observed for the experimental run 5, shown in response table (Table No. 4) of the average Grey relational grade, which indicates that the optimal combination of control factors and their levels. D_2, T_1, and L/D_2 will gives nominal bond strength.

4 From this research work, parametric optimization and Factors influencing the response can be well predicted.

5 REFERENCES:

1. Shakir-Khalil, H. (1991). ‘‘Bond strength in concrete-filled steel hollow section.’’ Int. Conf. of Steel and Aluminum Struct., Elsevier Science
2. Abe H, Wakida T, Yuda T. Experimental investigation of bond strength of concrete – filled centrifugally cast stell tubes. In: Proceedings of 3rd international conference on steel–concrete, Fukuoka, Japan; 1991, p. 207–12.
3. Shakir-Khalil H, Hassan NKA. Push out resistance of concrete-filled tubes. In: Grundy P, Holgate A, Wong B, Balkema AA (Eds.), Proceedings of the sixth international symposium on tubular structures. 1994.
4. Parsley MA, Yura JA, Jirsa JO. Push-out behavior of rectangular concrete-filled steel tubes. Composite and hybrid systems, ACI SP-196. Farmington Hills, Michigan: ACI;2000.
5. Han L-H, Yang Y-F. Influence of concrete compaction on the behavior of concrete filled steel tubes with rectangular sections. Adv Struct Eng 2001
6. GB/T 228-2002. Metallic materials—tensile testing at ambient temperature. Chinese standard; 2002.
7. Gourley BC, Tort C, Denavit MD, Schiller PH, Hajjar JF. A synopsis of studies of the monotonic and cyclic behavior of concrete-filled steel tube members, connections and frames. Report No. NSEL-008. Urbana-Champaign: Newmark Structural Engineering Laboratory, Department of Civil and Environmental Engineering, University of Illinois; 2008.

8. Chen ZH, Qu XS,Wang XD, Sun RR, Li LM. Experimental study on the interface bearing capacity on concrete-filled square steel tube. J Harbin Inst Tech 2009
9. Antanas Kudzys, Romualdas Kliukas “Reliability Index Design In Reinforced Concrete Structures Of Annular Cross Sections”
10. N. Natural, Y. Yamaha, High speed machining of Inconel 718 with ceramics tools, Ann. CIRP 42 (1) (1993) 103-106.
11. M. Alauddin, M.A. EI Baradie, M.S.J. Hashmi, End milling machinability of Inconel 718, J. Eng. Manuf. 210 (1996) 11-23.
12. T.I. Elwardany, E. Mohammed, M.A. Elbestawi, Cutting temperature of ceramic tools in high speed machining of difficultto cut materials, Int. Journal of mechanical Tool Manufact 36 (5) (1996) 611–634.
13. E.O.Ezugwu, Z.M. Wang, A.R. Machado, The machinability of nickel-based alloys: a review, J. Mater. Process. Technol. 86(1999) 1-16.

RETROFITTING WITH BASALT FIBER: IS GREENER THAN EVER- A REVIEW

Kavyashree R R. [1], Dr. K N Vishwanth [2] and Dr H N Jagannatha Reddy [3], Hrithik R[4]

1,3,4Department of Civil Engineering, BIT, K R Road, Bangalore – 560004, India

2 Department of Civil Engineering, DSAT&M, Bangalore, India

Abstract

Maintenance, repair and rehabilitation of civil engineering structures is an important aspect post construction. The industry often is looks for optimal solutions in terms of finance as well as eco friendliness of the materials and process used. There is an augmented scope for the usage of green materials in the structural health monitoring system which causes less harm to the environment. The word green retrofit aims at reducing the emissions of carbon and usage of other harmful materials to the environment. One such naturally occurring eco-friendly material is Basalt Fiber. The Basalt fibre reinforced polymer performs on par with contemporary materials. This paper presents a short review on potential characteristics of Basalt fibers as a retrofitting material for various civil engineering structures. The increased trend of using greener materials for a sustainable environment led to this research. Repair & retrofitting is looked into, by investigating basalt fiber's mechanical behavior under various conditions and explore the possibilities of using it as an efficient & Sustainable material.

Keywords: Basalt Fiber; Eco-friendly; Retrofitting.

1 Introduction

The most common words used in this domain are Repair, Rehabilitation and Retrofitting. Generally these words are inappropriately used even though they confer a different meaning. Repair is to restore the structure to its previous condition. It performs same as earlier in an aesthetic way and doesn't cover the strength aspect of the structures .Rehabilitation of a building is to restore a structure to a useful state by means of repair, modification, or alteration not only in an aesthetic way but also keeping the strength aspects of the structures whereas retrofitting refers to enhancing the capacity of structural elements.

The statistics of the occurrence of Indian earthquake in the past two decades reveals that one earthquake of magnitude greater than 8.0 takes place every year and out of 97 such occurrences, the average magnitude is between 6.0 to 8.0 on the Richter scale [**Jain**, **S. K. 1998].** According to the new version of India Map of seismic zones, the earthquake resistant design code of India [**IS 1893-1 2016]** assigns 4 levels (Zone II to Zone V) of seismicity for India in terms of zone factors.

Jacketing is the most common method adopted in strengthening individual members or elements in the structure. Jacketing techniques are of several types namely steel jacketing, steel concrete jacketing, fibre reinforced polymer composite jacketing and jacketing with high tension materials like carbon fibre, glass fibre, basalt fibre, natural fibers etc.

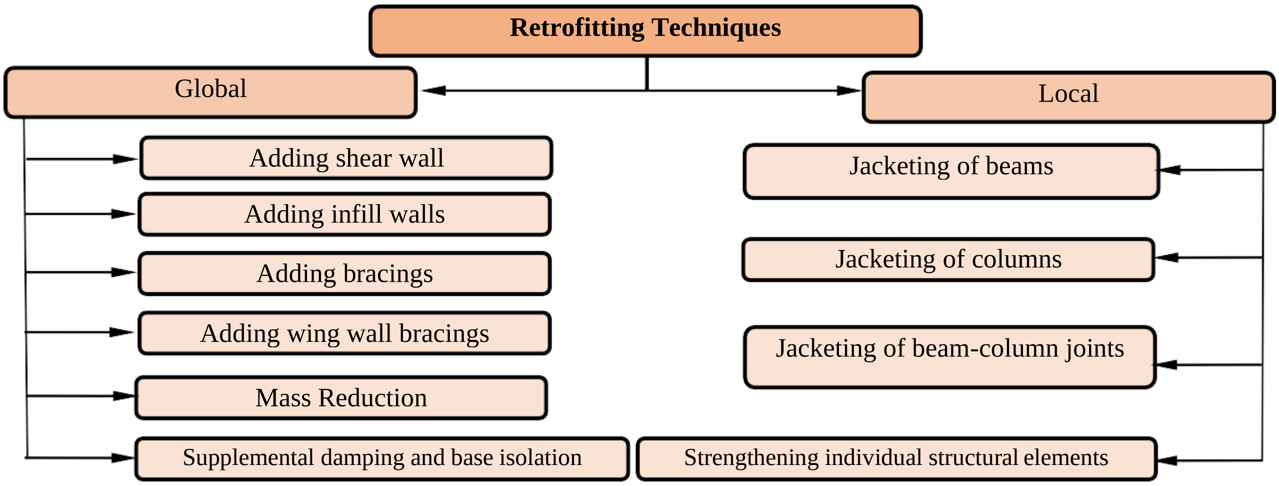


Figure 1:Classification of Retrofitting Techniques

2 Fiber Reinforced Polymer

Fibre reinforced polymer (FRP) is a composite consisting of large number of small, continuous, unidirectional, multidirectional, nonmetallic fibers as shown in the figure 2. They are packed in a polymer or resin matrix and are a very commonly used jacketing material.

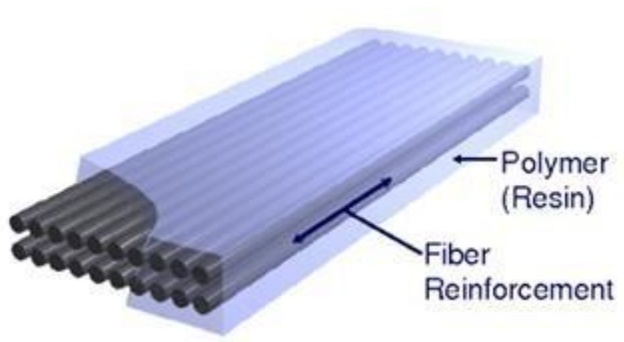


Figure 2 : Schematic description of unidirectional composite (Courtesy Nanni, A. 2004)

In recent times, the fibre reinforcing composites are used in retrofitting and rehabilitation of existing structures. The application of the composites is increased since new advanced forms of FRP's are developed. In new buildings, it is used as a primary reinforcing material replacing steel in reinforced concrete. It has also been found to be most promising material.

Fibre Reinforced Polymer (FRP) composites offer mechanical insulation and thermal properties **[Bedon C 2016].** Fibre reinforced polymer is a composite which is made by combining the fibers like carbon, Aramid, Basalt and glass with the polymer matrix **[Hag-Elsafi, O, 2001].** FRP is commonly used in automobile, aerospace and marine industries as low and high strength material. FRP had also found its place in the construction industry in a non-structural and non-reinforced application like finishing, cladding and decoration **[Weaver 1999].** The construction industry is one of the largest sectors in the world and in the recent past years it is ranked second in consuming the polymer composites **[Kendall,D 2007].**

The Mechanical properties of the FRP make them advantageous over the other materials and are

- High strength to weight ratio
- High durability, Resistance to damping
- High stiffness
- Resistance to damping
- High flexural strength
- High corrosion resistant, High Electromagnetic Permeability
- Unlimited availability in terms of geometry and sizes.
- Easy Procedure for installation and application, Short period for execution.

The disadvantages are

- They are difficult to apply on moist surfaces and at low temperatures.
- Poor fire resistance.
- Low reversibility and lack of vapour permeability.

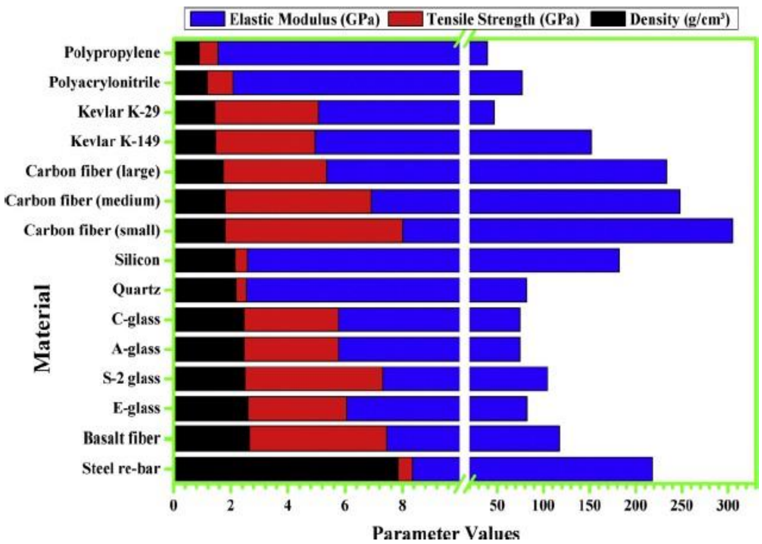


Figure 3: Mechanical properties of various fibres [Dhand,V 2015]

2.1 Types of Fibers used in FRP

FRP is a composite which consists of Fibre and polymer. The type of fibre used in these composites plays an important role in influencing the performance of the FRP. There are various types of fibers and they find application in many areas.

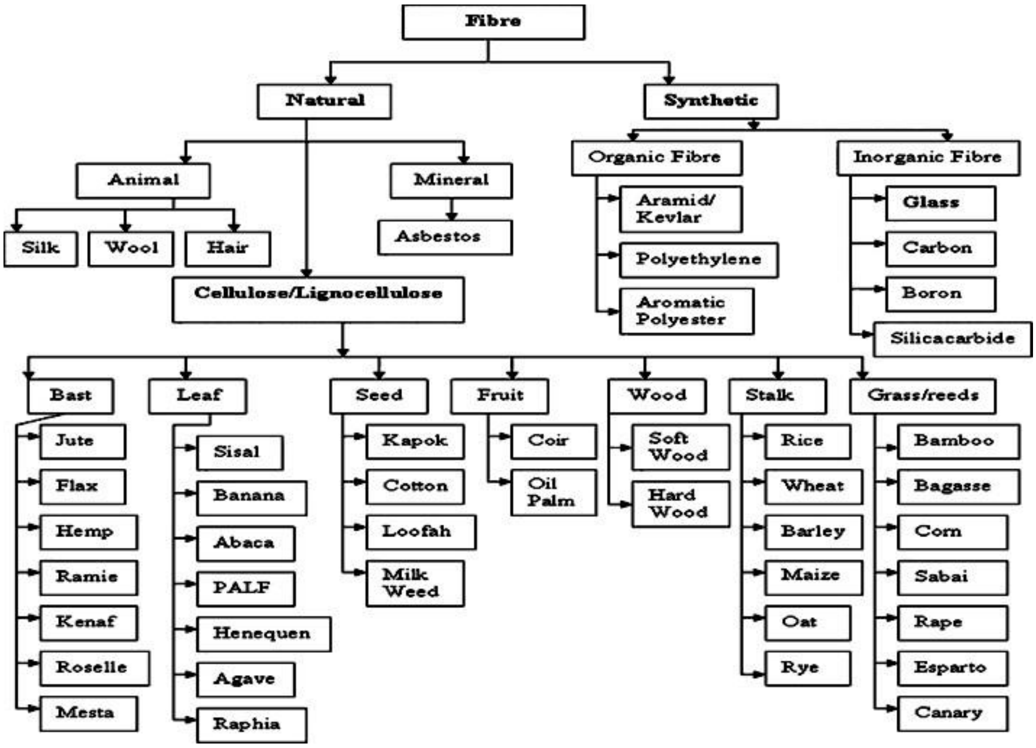


Figure 4: Various types of Fibers [Jawaid,M 2011]

Carbon fibre is superior in tensile strength compared to all other fibers. Basalt fibre, when compared with Glass fibre, possesses better stiffness and strength and has more ductility compared to carbon fibre, making it a suitable as reinforcing material.

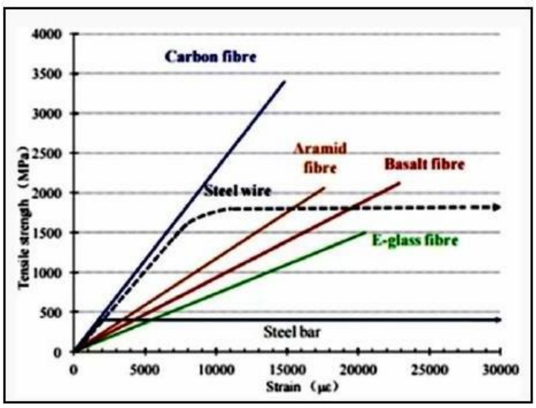


Figure 5:Tensile stress vs. strain of different Fibres

3 Green Material:

Basalt is a natural and environmental friendly material. Basalt is an igneous rock which comprises of various minerals like plagioclase, pyroxene and olivine. Basalt fibers (BF) are made from a single stone which is crushed washed and heated in an oven at a high temperature, through a platinum-rhodium alloy [**Czigány, T. 2005**]. BF is also known as green industrial material. It is informally known as the "Nonpolluting green material of the 21st century" .Basalt fibers are inert and 100% natural and the products do not react with air and water and they are also non-combustible. When Basalt fibers come in contact with other chemicals, harmless reactions are produced which do not damage the environment and health **[Jamshaid,H 2016].**The ozone depletion potential of basalt fiber is zero **[Willoughby, J 1987]** and emission of CO_2 to the atmosphere is less**.** Basalt fibers along with resin when recycled same material is obtained .As the melting point of the basalt fiber is about 1500^{o} C, the other composites present i.e. the resin turn to ashes during the process **[Kamenny V 2015]**

4 Energy Consumption:

The energy required for the production of basalt fiber is around 5 kWh/kg in an electric furnace and the amount for steel is around 14 kWh/kg **[Fazio P 2011]. C**ommercially available manufacturing methods estimate the primary energy intensity of Carbon fiber is 50.8–79.4 kWh/kg [**Suzuki T 2005**] and glass fiber is 3.6–8.89 kWh/kg [**Cebon, D 1992**, **Pellegrino, J 2022].** Base composites of basalt can replace steel (9.6 kg of steel can be replaced by 1kg of basalt) and the mechanical properties are comparable. As a result lighter buildings can be achieved by using basalt rebar instead of steel rebar. This will lead to energy savings in terms of production of Basalt Fiber.

Table 1:Comparison of Energy consumption in manufacturing

Fibre	Basalt	Steel	Carbon	Glass
Energy Consumption in manufacturing process (kWh/kg)	5	14	50.8-79.4	3.6-8.89

4.1 Cost Comparison of Materials

The major drawback in the carbon composite industry is the expense of production, resulting in less usage **[Dhand V 2015,Czigany T 2006].** BF is less expensive. It is a high strength and a cost-effective material [**Botev, M. 1999**, **Dalinkevich A 2009, Liu,Q 2006, Militky J 2002]** which is used as reinforcement material and used for other applications in the construction Industry [**Manewa A 2016].**

Table 2: Cost Comparison of fibers

Parameter	Carbon Fiber	Basalt Fiber	Glass Fiber
Chopped Fiber	14-17 USD /kg	2.01-2.96 USD /kg	2.01-2.96 USD /kg
Roving	5-33 USD /kg	0.4-4 USD /kg	0.8-1.1 USD /kg
Grid/Fabric	17.50 USD /square meter	4.40-5.60 US / square meter	14.93-25.99 USD / square meter
Rebars	0.5-20 USD /meter	0.5-15 USD /meter	0.27-2 USD /meter

4.2 Chemical Composition

Basalt fiber has higher chemical stability, thermal, and mechanical properties than glass fibers [**Artemenko, S. E. (2003)**]. Fiber property of the basalt fiber differs amongst countries as it is a natural product thus chemical composition varies with mining region **[SubramanianR V 1980]. M**echanical properties of the basalt fiber are influenced by high amounts of silicon oxide (SiO_2) and aluminum (Al_2O_3) and similarly heat resistance of the Glass depends on the amounts Iron oxide. Other properties like thermal and chemical resistance are influenced by different oxides **[Deak,T 2009].** Table 3 shows the comparison of chemical compounds between basalt fiber, E-Glass fiber and S-Glass Fibre.

The chemical composition of these E and S type of Glass fiber consist of compounds which are either Eco-friendly and cause minimum damage to the Eco-system.

Table 3: Comparison of chemical compounds in glasses and basalt (in weight % = w %)

Parameter	**Na_2O [wt%]	*MgO [wt%]	*Al_2O_3 [wt%]	*SiO_2 [wt%]	**K_2O [wt%]	*CaO [wt%]	**TiO_2 [wt%]	***FeO/Fe_2O_3 [wt%]
Basalt	2.5-6.4	1.3-3.7	16.9-18.2	51.6-57.5	0.8-4.5	5.2-7.8	2.1	-
E-Glass	0.8	0-5	12-16	52-56	0.2-0.8	16-25	0.41	< 0.3
S-Glass	0-0.3	9-11	24-26	64-66	-	0-0.3	-	< 0.3

*Eco Friendly, **Acceptable, ***Not Eco Friendly

5 CONCLUSIONS

.

1 Carbon fibre has good required Mechanical properties for construction industry but it is the need of the hour for the industry to get sustainable in its construction process as well as materials used. Henceforth other than mechanical property, Cost Effectiveness and Environment friendliness of the material itself along with the footprints in the manufacturing process are to be closely monitored in choosing the right fibre for the future.

2. To overcome the Ecological liabilities of Carbon Fibers some of the options are Glass fibers and Basalt Fibers. The chemical compositions of both glass fibre and basalt fibre show compounds that have minimum detrimental effects on the Environment. The energy consumption during the process of manufacturing also is found to be very much similar. However the glass fibers are more brittle than basalt fibers.
3. The abundance of the totally unexplored basalt rock in the Deccan plateau region of India has opened up a whole new market to produce an alternate material for fibers in Indian Construction Industry. There are quite a few developments in research suggesting the success of the basalt fibers used in Retrofitting as well as new construction.
4. It would be safe to conclude that Basalt Fibre performs at par with glass fibers. The mechanical performance of the basalt fibre are relatively lower than carbon fibre, but the cost effectiveness and environmental sustainability of the Basalt fibers makes it a case to provide tough competition to Carbon fibre.

6 References

[1] Artemenko, S. E. (2003). Polymer composite materials made from carbon, basalt, and glass fibres. Structure and properties. Fibre Chemistry, 35(3), 226-229.

[2] Botev, M., Betchev, H., Bikiaris, D., & Panayiotou, C. (1999). Mechanical properties and viscoelastic behavior of basalt fiber‐ reinforced polypropylene. Journal of Applied Polymer Science, 74(3), 523-531.

[3] Cebon, D., & Ashby, M. F. (1992). Materials selection for mechanical design. In Computerization and Networking of Materials Databases: Third Volume. ASTM International.

[4] Czigány, T., Vad, J., & Pölöskei, K. (2005). Basalt fiber as a reinforcement of polymer composites. PeriodicaPolytechnica Mechanical Engineering, 49(1), 3-14.

[5] Czigány, T. (2006). Special manufacturing and characteristics of basalt fiber reinforced hybrid polypropylene composites: mechanical properties and acoustic emission study. Composites science and technology, 66(16), 3210-3220.

[6] Dalinkevich, A. A., Gumargalieva, K. Z., Marakhovsky, S. S., &Soukhanov, A. V. (2009). Modern basalt fibrous materials and basalt fiber-based polymeric composites. Journal of Natural Fibers, 6(3), 248-271.

[7] Deák, T., &Czigány, T. (2009). Chemical composition and mechanical properties of basalt and glass fibers: a comparison. Textile Research Journal, 79(7), 645-651.

[8] Dhand, V., Mittal, G., Rhee, K. Y., Park, S. J., & Hui, D. (2015). A short review on basalt

fiber reinforced polymer composites. Composites Part B: Engineering, 73, 166-180.

[9] Fazio P. Basalt fibra: from earth an ancient material for innovative and modern application. EAI 2011;3: 89-96.

[10] Gadow, R., &Weichand, P. (2014). Novel intermediate temperature ceramic composites, materials and processing for siloxane based basalt fiber composites. In Key Engineering Materials (Vol. 611, pp. 382-390). Trans Tech Publications Ltd.

[11] Inman, M., Thorhallsson, E. R., &Azrague, K. (2017). A mechanical and environmental assessment and comparison of basalt fibre reinforced polymer (BFRP) rebar and steel rebar in concrete beams. Energy Procedia, 111, 31-40.

[12] Jain, S. K. (1998). Indian earthquakes: an overview. Indian Concrete Journal, 72, 555-562.

[13] Jamshaid, H., & Mishra, R. (2016). A green material from rock: basalt fiber–a review. The Journal of the Textile Institute, 107(7), 923-937

[14] Jeevan, N., & Jagannatha Reddy, H. N. (2018). Strengthening of RC beams using externally bonded laminate (EBL) technique with end anchorages under flexure. Asian Journal of Civil Engineering, 19(3), 263-272.

[15] Jeevan, N., Reddy, H. N., & Prabhakara, R. (2018). Flexural strengthening of RC beams with externally bonded (EB) techniques using prestressed and non-prestressed CFRP laminate. Asian Journal of Civil Engineering, 19(7), 893-912.

[16] Kapoor, S. P., & Chauhan, B. C. (2013). Earthquake and Geothermal Energy. arXiv preprint arXiv:1309.7738.

[17] Liu, Q., Shaw, M. T., Parnas, R. S., & McDonnell, A. M. (2006). Investigation of basalt fiber composite mechanical properties for applications in transportation. Polymer composites, 27(1), 41-48.

[18] Mathur, V. K. (2004). Microzonation Studies for Delhi, Jabalpur & Dehradun as Impacted by Bhuj Earthquake.

[19] Militký, J., Kovačič, V., &Rubnerova, J. (2002). Influence of thermal treatment on tensile failure of basalt fibers. Engineering fracture mechanics, 69(9), 1025-1033.

[20] Pellegrino, J. (2002). Glass Industry of the Future: Energy and Environmental Profile of the US Glass Industry.

[21] Petrullo, M., Morton, B. and Director, S.J.A. 2015, “World green building trends: 2016, Developing markets accelerate global green growth produced in partnership with contributing partners”.

[22] Sheth, A., Chaudhari, R.D., Khan, E.A., Gupta, D., & Saini, M. (2002). SEISMIC RETROFITTING OF MANI MANDIR COMPLEX AT MORBI , GUJARAT , INDIA.

[23] Sim, J., & Park, C. (2005). Characteristics of basalt fiber as a strengthening material for concrete structures. Composites Part B: Engineering, 36(6-7), 504-512.

[24] Subramanian, R. V., & Austin, H. F. (1980). Silane coupling agents in basalt-reinforced polyester composites. International Journal of Adhesion and Adhesives, 1(1), 50-54.

[25] Suzuki, T., & Takahashi, J. (2005, November). Prediction of energy intensity of carbon fiber reinforced plastics for mass-produced passenger cars. In Proceedings of 9th Japan International SAMPE Symposium (pp. 14-19).

[26] Thorhallsson, E., Erlendsson, J. Ó., &Erlendsson, Ö. (2013). Basalt fiber introduction. Reykjavik University & Iceland GeoSurvey, 6.

[27] Willoughby, J. (1987). Insulation and energy efficiency. Architect (London);(United Kingdom), 94(10).

[28] https://www.thehindu.com/features/homes-and-gardens/how-to-keep-a-tab-on-the-quality-of- your-buildings-construction/article7433863.ece

[29] IS 1893-1 (2016): Criteria for Earthquake Resistant Design of Structures

[30] Yahaya, R., Sapuan, S. M., Jawaid, M., Leman, Z., & Zainudin, E. S. (2016). Effect of fibre orientations on the mechanical properties of kenaf–aramid hybrid composites for spall-liner application. Defence Technology, 12(1), 52-58.

[31] Bedon, C. (2016). Review on the use of FRP composites for facades and building skins.

[32] Hag-Elsafi, O., Alampalli, S., & Kunin, J. (2001). Application of FRP laminates for strengthening of a reinforced-concrete T-beam bridge structure. Composite structures, 52(3-4), 453-466.

[33] Weaver, A. (1999). Composites: world markets and opportunities. Materials Today, 2(1), 3-6.

[34] Kendall, D. (2007). Building the future with FRP composites. Reinforced plastics, 51(5), 26-33.

SEISMIC ANALYSIS OF MULTI STORED BUILDING WITH SHEAR WALLS AT DIFFERENT LOCATION

Naveen J [1], Shashi Prasad N [2] Vijayalakshmi Akella [3]

1 PG Student, 2 Assistant Professor,

3 Professor, Department of Civil Engineering, KSSEM, Bangalore

Abstract

In multi-story buildings, shear walls are employed as a horizontal load-resisting element. In residential construction, they serve as vertical walls that often take the form of a box and support the building's horizontal axis. These walls are made to be structural walls that are incorporated into structures to resist lateral stresses brought on by wind, earthquakes, and other factors. They also have a high degree of stiffness and strength to do so. A shear wall has a major axis that is stiffer than its other axis. It is regarded as having a basic structure that offers rather stiff resistance to forces acting in its plane from the vertical and horizontal directions. A shear wall experiences axial, shear, torsional, and flexural strains, under the combined loading, leading to a complex internal stress distribution. Loads are transferred vertically to the foundation from the building in this manner. In this paper the effectiveness of shear wall is checked by changing the location. Two cases are considered such as bare frame and in-filled frame with and without shear walls. Ten different models are considered for each of the cases. The structural elements for multi-story buildings with G+9 are designed for seismic zone V with soft soil and are analyzed as per the code IS 1893:2016 by using E-TABS. The different models will be modelled and analyzed using equivalent static and response spectrum methods for earthquake loads by providing the shear walls at different locations with mass irregularities. The various parameters, such as lateral displacements, storey drift, and base shear, are determined. The results are checked to see if they are within the permissible limits. Infill frames with shear walls at the core and re-entrant corners outperform all other models in lateral displacement and story drift; the results were found to be twice as good as other models in lateral displacement and story drift. Models 1 and 6 have longer times periods due to the lack of shear walls. The base shear of the first five models is higher compared to other models due to the symmetry of their structures. .

1 Introduction:

Earthquakes vary in intensity and magnitude from place to place, causing minor to severe damage to structures and life. Shear walls take both flexural and lateral forces, to overcome this phenomenon. Shear walls serve a good purpose in high-rise buildings because they reduce steel consumption and provide more carpet area than the column system.

2 Literature review:

Five models of twelve storey are considered in zone III by changing the locations of the shear wall. Model one was a bare frame, and the remaining four models had shear walls in different positions. The models were analysed by the linear static method. Parameters like storey drift, storey shear, and displacement were compared and calculated by using ETABS. It was concluded that it was more effective to provide shear walls to resist lateral forces. (1)

Work is also carried out to determine the shear wall position in multi-story buildings based on both elastic and elasto-plastic behaviour. A 15-story building, which was located in seismic zone IV, was considered. STAAD Pro and SAP 2000 software are both used to conduct elastic and elasto-plastic analyses. Shear force, bending moment, storey drift, and shear wall location were estimated in both the cases. It was concluded that shear walls may added in the shorter direction between the sixth and seventh frames or the first and twelfth frames. (2)

In order to determine the best location for the shear wall in a multi-story building, five models of 25- story buildings in seismic zone V were taken into consideration. One model had a bare frame, and the others had shear wall models in various locations. The models were analyzed using linear static and linear dynamic methods, considering building's central concrete core wall using ETABS. The various variables such as displacement, storey shear, and storey drift were analyzed. The study concludes that Model 5 performs better than the other models. (3)

RC-framed buildings with six, twelve, twenty-four, and thirty-six stories at different positions were taken into account. Eight models were analyzed. Model 1 is infilled framed structure but with no shear walls, while the other models had shear walls. To determine the parameters such as time period, lateral displacement, damping, and base shear by using ETABS, the seismic performance evaluation was carried out using the response spectrum , elastic analysis, as well as nonlinear static pushover, or in-elastic analysis. It was determined that model 7 and 8 exhibited improved lateral stiffness. (4)

A six-story structure in seismic Zone IV was examined using various shear wall forms and positions. In order to calculate characteristics like axial force and moments in the Y and Z directions, four models were considered, with one being a bare frame and the other three being shear walls of the same length at various locations. STADD-pro analytic software was used to complete the analysis. It was determined that the presence of a shear wall in a different position had an impact on the axial stress on the column. (5)

3 Modelling

A regular building with a 10 (G+9) number of stories is considered for the purpose of studying the seismic behavior of high-rise buildings by providing shear walls at different locations. The description and plan of the buildings is shown below.

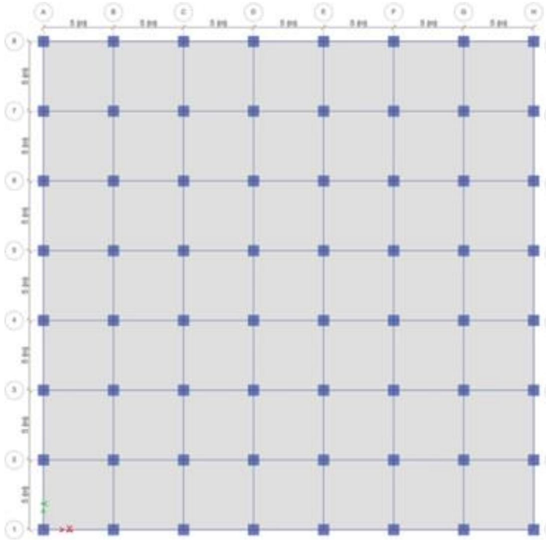
3.1 Building Description

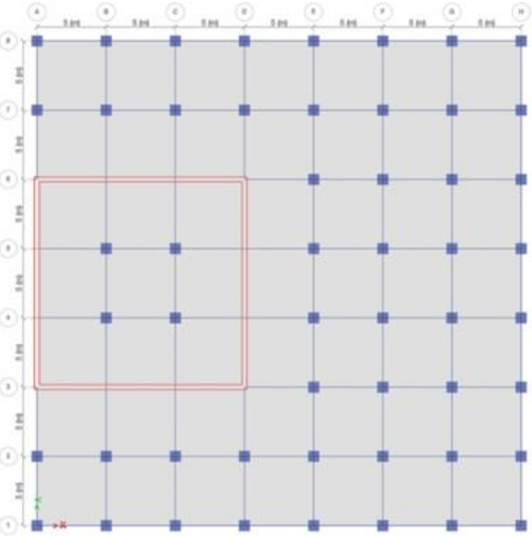
Table 1:Model Description

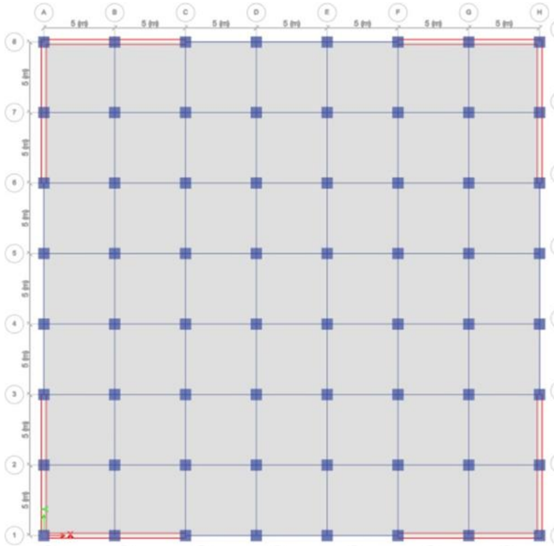
Parameters	
Seismic Zone	V
Seismic Zone Factor (Z)	0.36
Response Reduction Factor(R)	5
Height of the building	30 m
Storey to storey Height	3 m
Thickness of Shear Wall	0.35 m
Thickness of Infill Wall	0.2 m
Thickness of Slab	0.225 m
Column Size	0.8 X 0.8 m
Beam Size	0.6 X 0.6 m
Live Load	4 kN/m^2
Floor Finish	1.7 kN/m^2
Unit weight of Reinforced Concrete and masonry	25 kN/m^3 20 kN/m^3
Poisson's Ratio of concrete and Masonry Infill (u)	0.2 and 0.2
Damping	5%
Material Properties	M40Grade of Concrete (f_{ck})
Material Properties	Fe500i Grade of Steel (f_y)

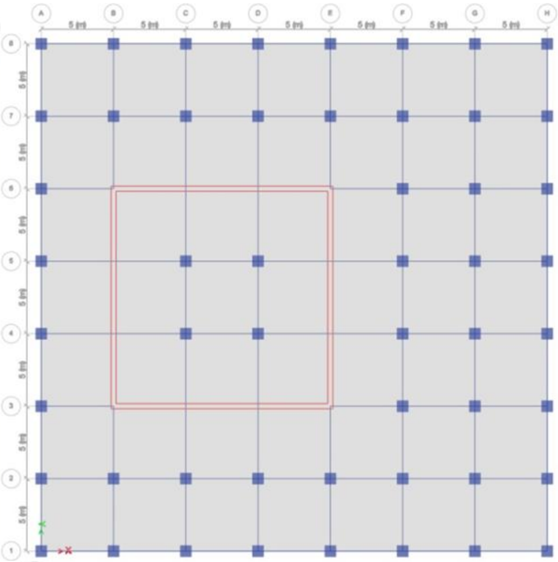
3.2 Plan of Models

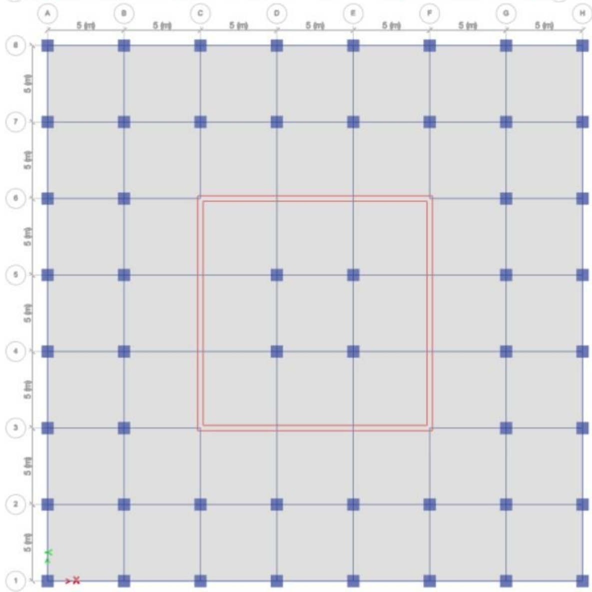
The figures shown below from fig 1 to 10 show the eight models considered for this study. Figure 1 is the model with no shear walls whereas Fig 2 to Fig 10 shows models with shear walls. Fig 11 and 12 show the grid and 3D view of the model in E-TABS

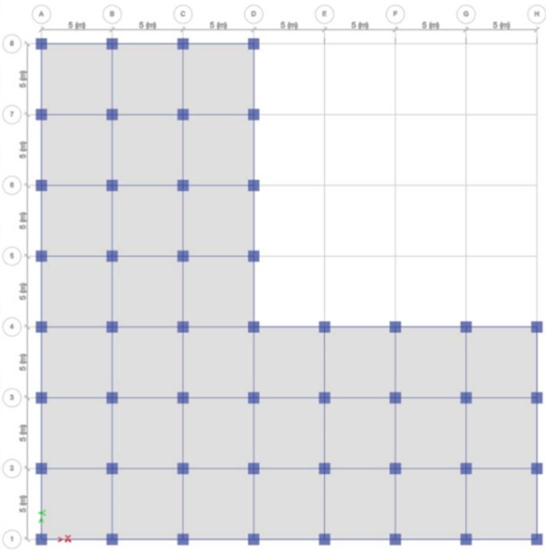












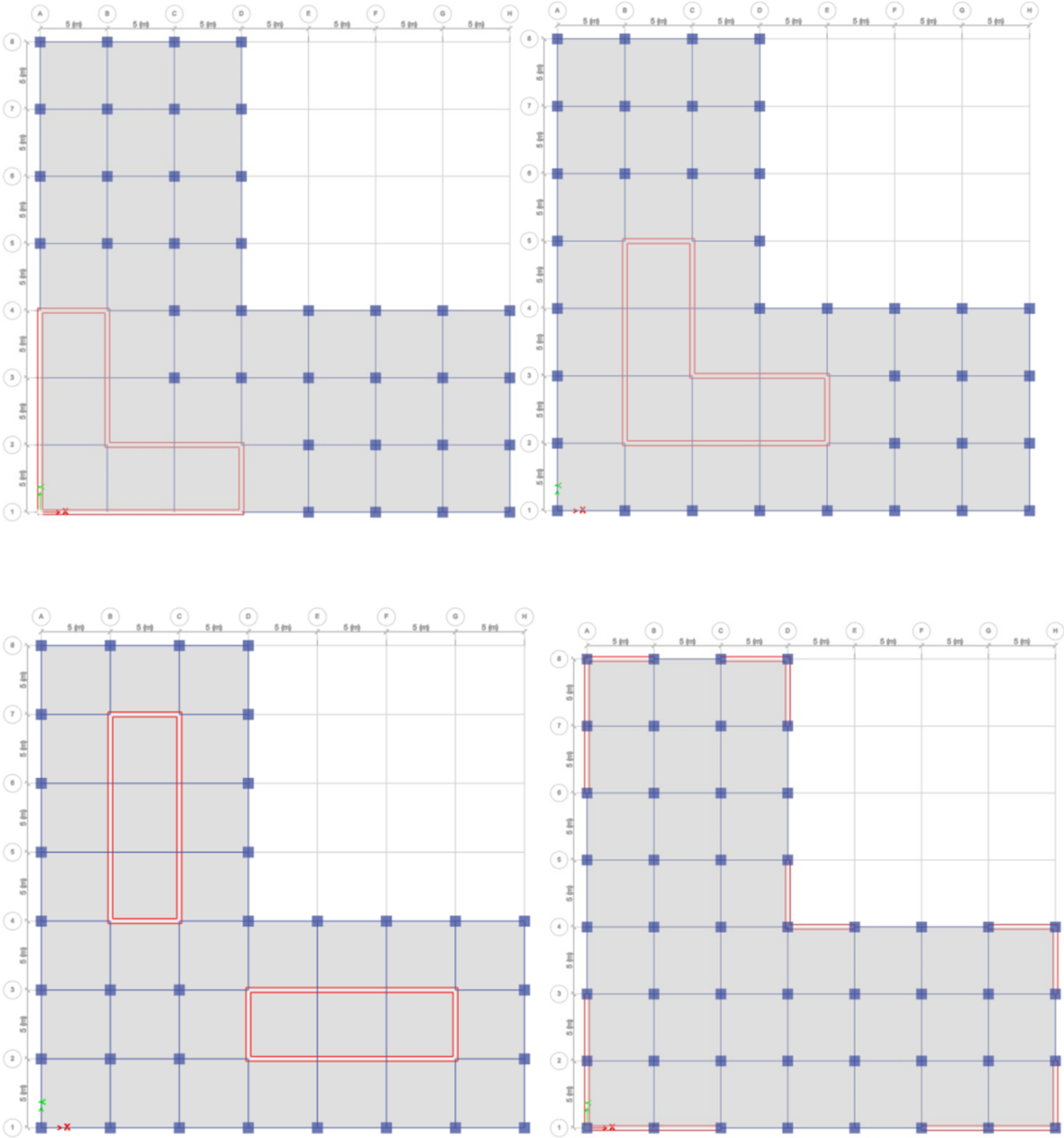


Figure 1-10 : Models with shear walls are various locations

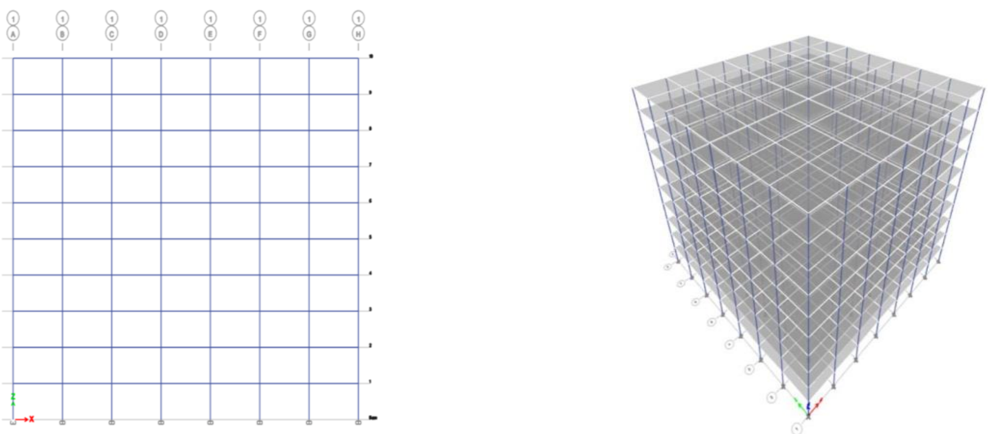


Fig 11 and Fig 12: Grid and 3D model.

4 RESULTS AND DISCUSSIONS

4.1 Time period

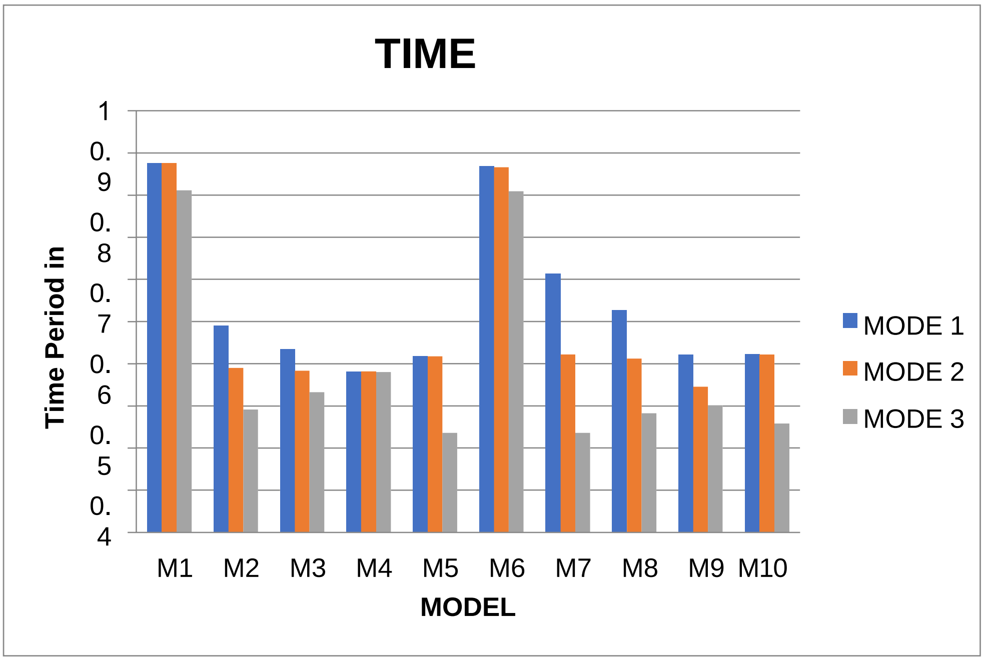


Figure 13: Time Period of Bare Frame Model

Figure 13 shows the time period for the bare frame model. Model-1 and Model -6 have more time period compared to shear wall models for all three different modes, this is because the base shear is less in Model-1 and Model-6 compared to other models. This shows that the bare fame models without shear walls are more susceptible to seismic action than the models with shear walls. This also indicates that the base shear of the model increases with the decrease in time period.

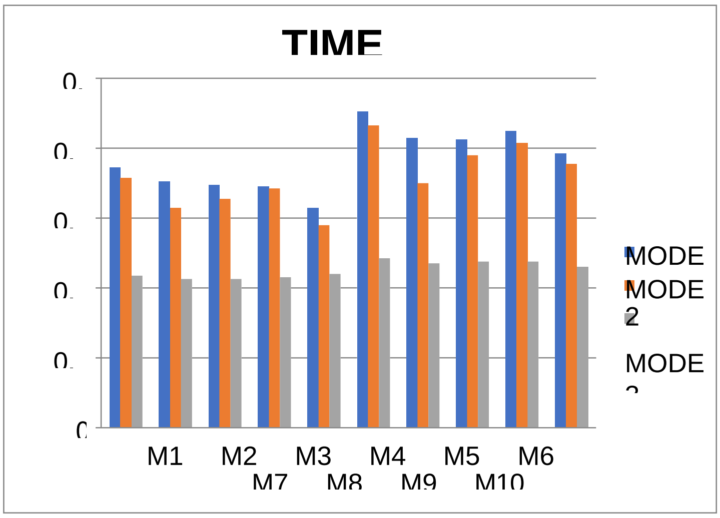


Figure 14: Time Period of Infill Frame Model

Figure 14 shows the time period for the Infill Frame Models. Model- 6 has more time period compared to other models, this is due un-symmetry of the structure and absence of shear wall.

4.2 Base shear

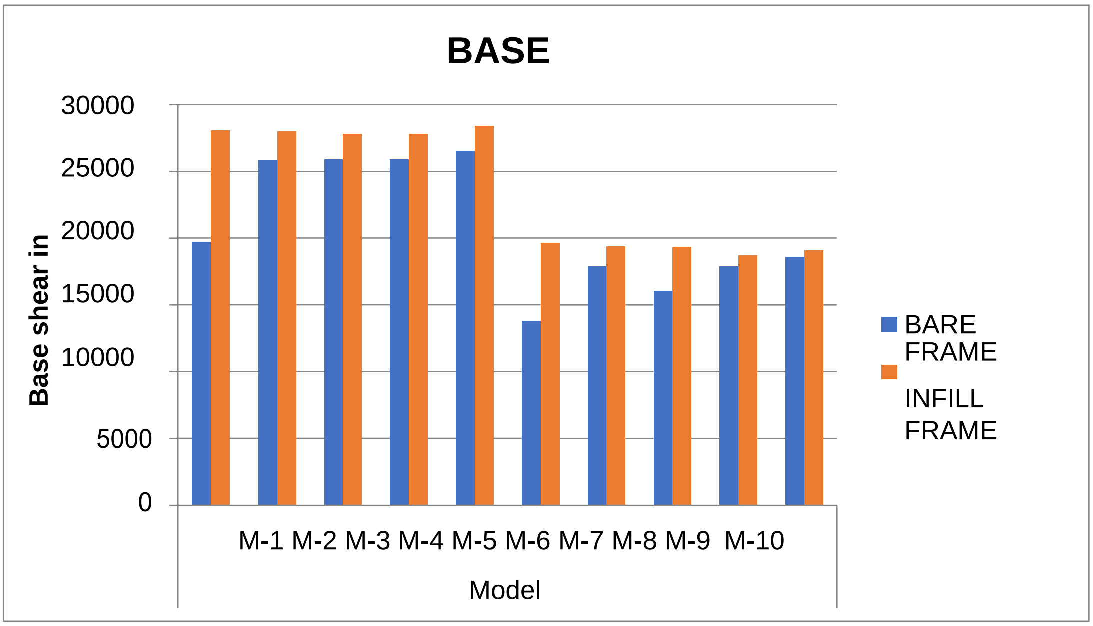


Figure 15: Base Shear of Bare Frame and Infill Frame

Figure 15 shows the base shear for different models with a bare frame and an infill frame. The first five models show higher base shear with higher structural stability as compared to the other models; this is due to symmetrical structures. When comparing base shear between an infill and bare frame, the infill frame has a higher base shear.

4.3 Lateral displacement

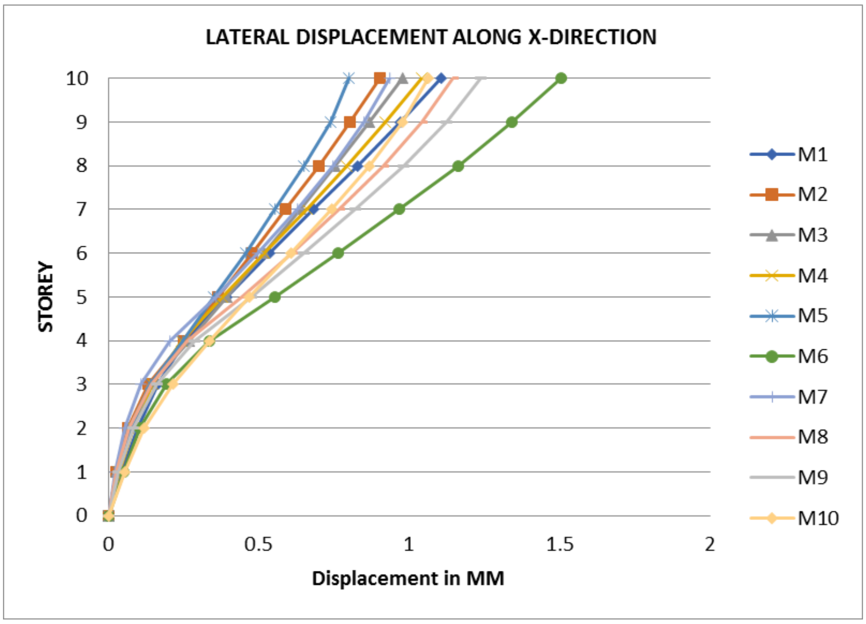


Figure 16: Lateral Displacement of Bare Frame

It is observed in figure 16 that the lateral displacement is more in Model-1 and Model-6 .This is mainly due to less rigidity in the bare frame model. As the base shear of the structure decreases, displacement increases. The strength and stiffness of the structure are increased by providing the shear wall in the building.

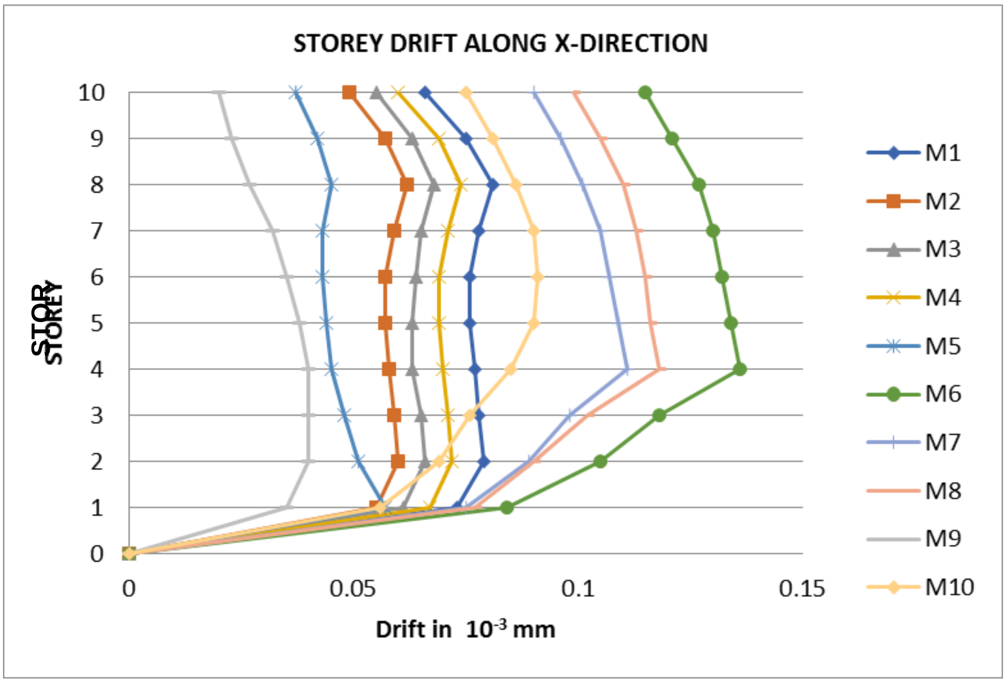


Figure 17 Lateral Displacement of Infill Frame

Figure 17 shows the lateral displacement for the infill frame models. It is observed that the lateral displacement in the Model-1 is less when compared to the Model-6; this is because the center of rigidity and centre of mass nearly co-inside in the Model-1.

4.4 Storey drift

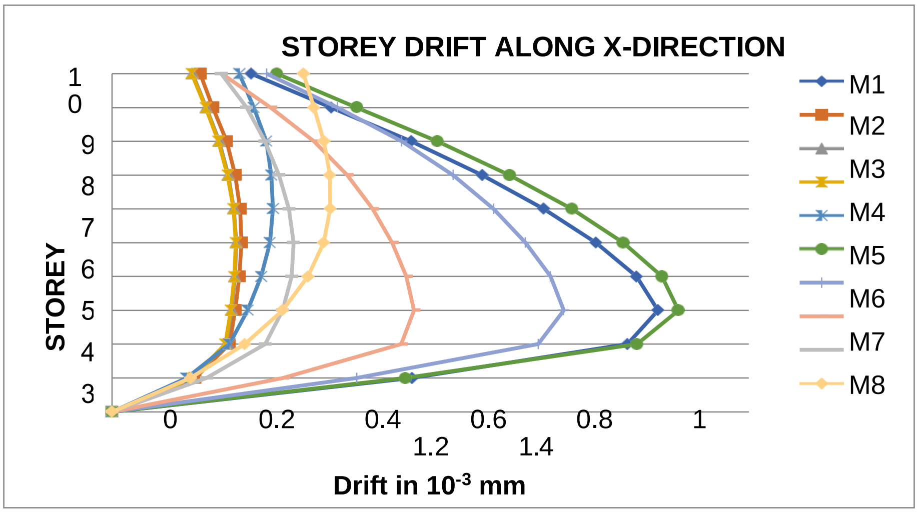


Figure 18 : Storey Drift of Bare Frame

Figure 18 shows the storey drift plot for bare-frame models. Model-1 and Model-6 shows the maximum storey drift, this is due to absence of shear wall. It is also observed that the storey drift decreases by providing the shear wall. It is also seen that when the shear wall is provided at the core of the symmetrical structure (where the centre of mass and rigidity co-inside), the storey drift is less for the structure.

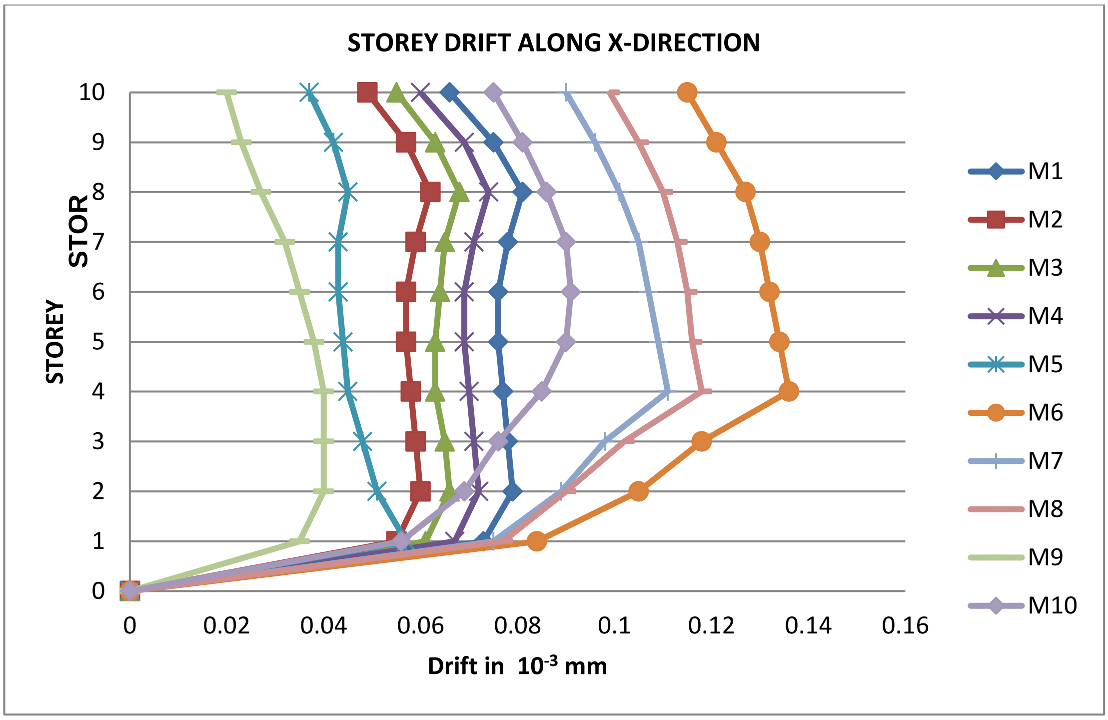


Figure 19: Storey Drift of Infill Frame

Figure 19 shows story drifts for infill frames. The storey drift is maximum in Model-6 and Model-1 has minimum drift this is due to the fact that the rigidity and mass centres nearly coincide.

4.5 Storey shear

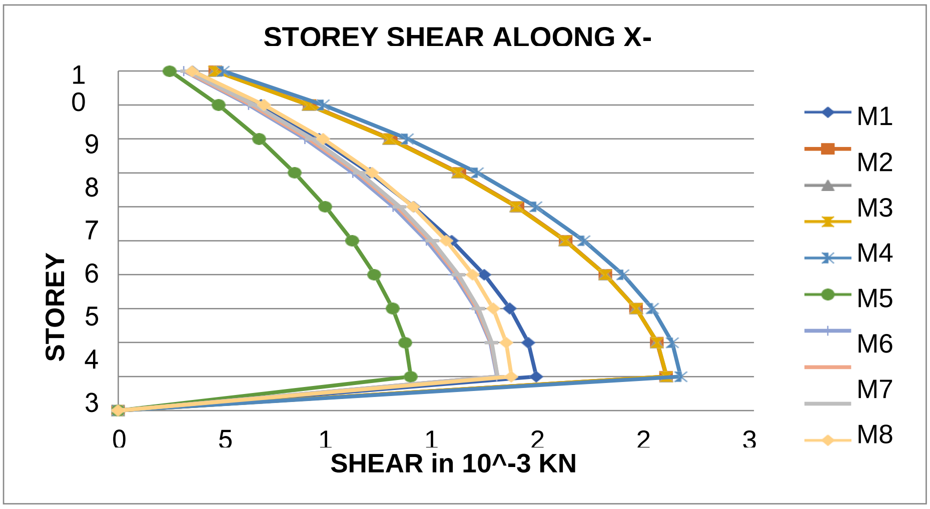


Figure 20 : Storey shear of Bare Frame

Figure 20 shows that the Model-6 has less storey shear and the Model-5 has higher storey shear when compared to other models; this is due to the Model-5 has high stability and stiffness.

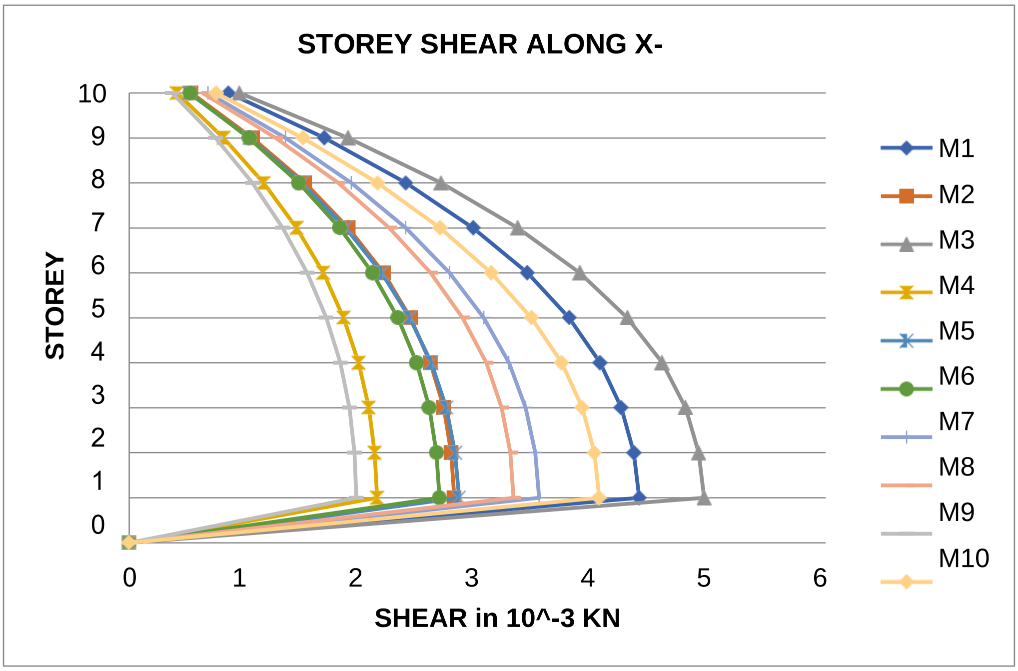


Figure 21 Storey shear of Infill Frame

The storey shear for an infill frame is shown in Figure 21; Model -9 has less storey shear. Because of the masonry structure's action, Model-3 has higher storey shear than all other models.

4.6 Storey stiffness

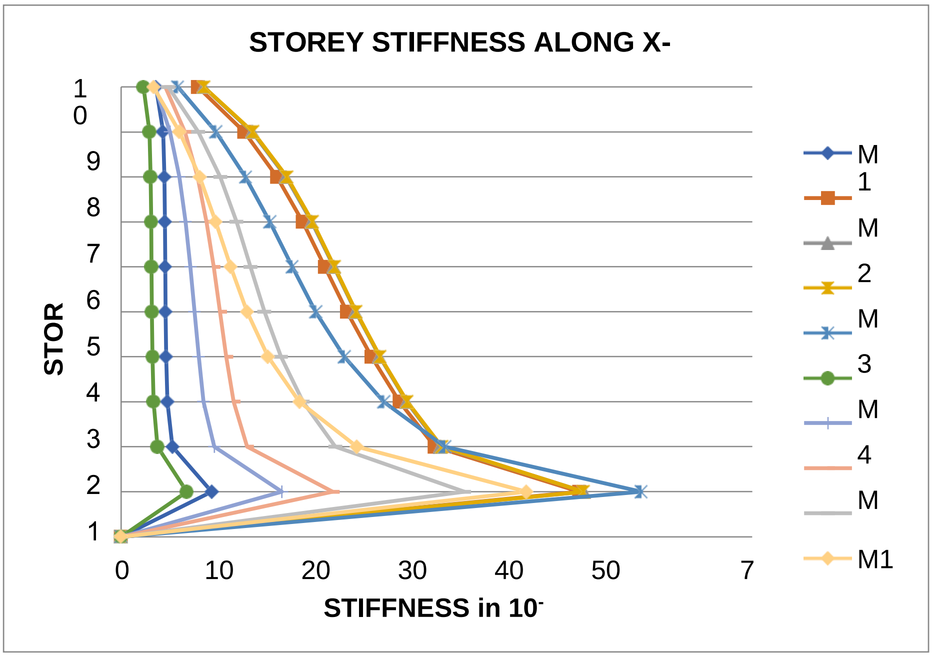


Figure 22: Storey stiffness of Bare Frame

Figure 22 shows the storey stiffness is maximum by providing a shear wall at the core for Model-2, Model-3, and Model-5 at the re-entrant corners.

5 Conclusions:

1. The time period for both bare frame and infill frame models were analyzed, and it was found that Model-1 has the maximum and Model-4 has the minimum time period.
2. The base shear found to be maximum from Model-1 to Model-5 for both bare frame as well as infill models; this is due to symmetrical shape which results in higher stability of the structure.
3. Model 6 has maximum lateral displacement and story drift in both bare frame and infill models.
4. Model-6 of the bare frame and Model-9 of the infill frame show less storey shear.
5. The storey stiffness of the infill frame is more than 4 times that of the bare frame; this is due to the strut action of the masonry wall, which retards the movements of the storey.
6. Storey drift for all models is within the permissible limits as per IS 1893 (Part 1): 2016, i.e., 0.004*h, where h is the story height.
7. From the work carried out, it is evident that the provision of shear walls and infills increases the performance of the building, i.e., the base shear will be more reducing the lateral displacement, story drift, and lateral stiffness.

6 References

1. Effectiveness of Changing Reinforced Concrete Shear Wall Location on Multi-storeyed Building. Saoji, P. S. Kumbhare and A. C. 5, s.l. : International Journal of Engineering Research and Applications, September- October 2012, International Journal of Engineering Research and Applications, Vol. 2, pp. 1072-1076.

2. Solution of Shear Wall location in Multi-Storey Building. Anshuman S, DipenduBhunia and BhavinRamjiyani. s.l. : International Journal Of Civil And Structural Engineering, 2011, Vol. 2.

Effect of change in shear wall location on storey drift of multistorey building subjected to lateral loads. 3. Karadi, ShahzadJamilSardar and Umesh. N. 9, s.l. : International Journal of Innovative Research in Science, Engineering and Technology, September 2013, Vol. 2.

Seismic Performance Evaluation of Multistoried RC framed buildings with Shear wall. VinodHosur, Shaik Kamal Mohammed Azam and. 1, s.l. : International Journal of Scientific & Engineering Research, January-2013, Vol. 4.

4. Design and analysis of multistoreied building with effect of shear wall. Satone, HimaleeRahangdale and S. R. 3, s.l. : International Journal of Engineering Research and Applications (IJERA), May-Jun 2013, Vol. 3.

AN INFLUENCE OF INDUSTRIAL AND AGRICULTURAL BY- PRODUCTS ON SELF- CURING CONCRETE – A REVIEW.

Rashmi H R[1], Preethi P[2], Salman Bashir[3], Siddanna Gouda[4], Suhail Altaf Dar[5]

1Associate Professor, KSSEM, Bangalore 2, 3, 4, 5- UG Students, KSSEM, Bangalore.

Abstract

Due to the rapid growth of the urban development projects, Concrete is the most commonly used construction material of the twenty-first century. Concrete's mechanical characteristics are influenced by its curing state. According to the ACI- 308(2014) Code, internal curing describes the process through which cement is hydrated due to the availability of additional internal water that is not included in the mixing water; curing concrete is thought to occur from the outside to the inside. Concrete's strength and durability will be hampered by any carelessness with the curing process. Shrinkage-reducing chemicals and lightweight aggregates like Leca, Polyethylene-glycol, Silica fume, and stone chips are used, to achieve effective curing results. This paper explains self-curing concrete techniques and earlier works carried out by the researchers on the subject. Super absorbent polymers, polyethylene glycol, and lightweight particles are among the components most frequently used to make self-curing concrete.

KEYWORDS: Self-Curing Concrete, PEG 400 , Rice husk, Pumice, Polymers.

1 INTRODUCTION

Proper and adequate curing is required to attain the optimum strength and performance of concrete. In traditional concrete, curing occurs after number of steps, including mixing, placing, and finishing. Self-curing methods give the right amount of moisture content for optimum long-term hydration (Sharma et al., 2016). The concrete's self-desiccation content is decreased by the self-curing agent. The demand for curing water (internal or external) compared to a normal regular Portland cement concrete, the rate at which mineral admixtures completely react in a blended cement system may be much higher(Aielstein et al., 2013). When this water is not readily available, considerable autogenous deformation and (early-age) cracking may develop. The chemical shrinkage that occurs during cement hydration reduces the relative humidity within the substance and results in shrinkage that could cause early-age cracking, which results in the development of empty holes in the cement paste.

Although self-cured concrete is not frequently adopted in construction, work is continuously carried out. In the earlier research, the effectiveness of self-curing has been assessed using physical criteria such as intrinsic relative humidity, autogenous deformation, ring test strain, cracking, degree of hydration, compressive strength, and x-ray absorption (Alexopoulou et al., 2013). Self-curing method is often utilized in low water-cement ratio mixtures to improve the early-age behavior of concrete structures and to improve the qualities of high-performance concrete. For the purpose of enhancing the qualities of heat-cured concrete, internal curing is also used (Bentz et al., 2016). Additionally, concrete mixes with a water-to-cement ratio greater than 0.42 are used for self-curing. Self-compacting concrete also employs self-curing (Cusson et al., 2005).

Pumice, paraffin wax, crushed recycled concrete aggregates, crushed waste ceramic, demonstrated well as self-curing agents. To improve the of concrete quality, Diatomaceous earth, perlite, and lightweight expanded clay aggregates made of bentonite clay, polyethylene-glycol are used in various percentages by weight of cement, together with zeolite aggregates, rotary kiln expanded shale, C class fly ash, and crushed over burnt clay brick (Ruhal et al., 2018). To enhance internal curing, wet lightweight aggregates are used in place of some of the sand.

2 METHOD OF SELF-CURING

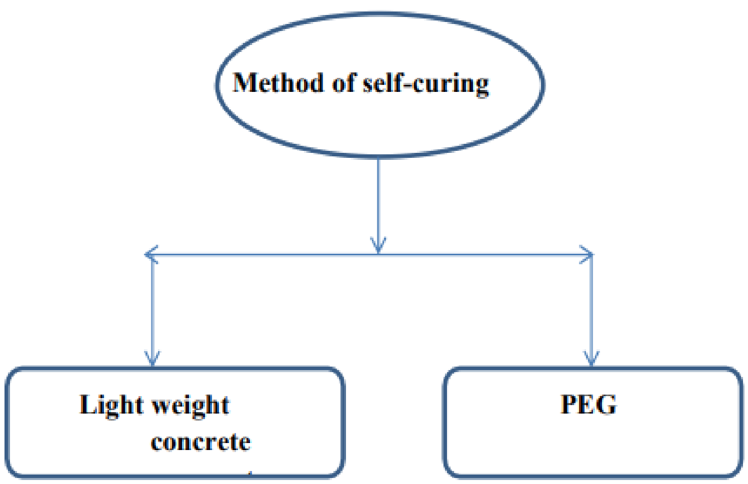


Figure 1: Methods of Self-Curing

2.1 Polyethylene Glycol

The common formula for polyethylene glycol is $H(OCH_2CH_2)nOH$, where n denotes the typical repetition of oxyethylene groups, which typically runs from 4 to about 180. A numerical suffix that identifies the average molecular weights is placed after the abbreviation (PEG). PEG is water soluble. Polyethylene glycol is non-toxic, odorless, neutral, lubricating, non-volatile, and non-irritating (Kartini et al., 2012).

The molecular weight of a substance affects a wide range of physical qualities, such as solubility, hygroscopicity, vapour pressure, melting or freezing point, and viscosity. Solubility of PEG in water and solvents decreases as its molecular weight increases (Nishant et al., 2017). Many polar organic solvents, including acetone and alcohols, are also compatible with PEG (Liu et al., 2017).

PEGs are hygroscopic, which indicates that they draw and hold onto atmospheric moisture. Reduction in hygrometry as molecular weight rises. Viscosity: Because PEGs are Newtonian fluids, their kinematic viscosity reduces with rising temperature (Jagannadha et al., 2012). Due to their low volatility, PEGs are thermally stable for a brief period of time below 300 °C and without oxygen.

2.2 Benefits of Self-Curing

The major benefit of self-curing is to provide moisture content so as to maintain the cement's hydration. Internal curing is a technique to hydrate the cement with water, to overcome the limitations of mixing water alone due to hydration and external curing. If self-curing admixtures are employed in the recommended dosage, concrete strength can be increased or maintained. If the optimum dosage is administered it creates a film that maximizes water retention. This also reflects sunlight to shield the concrete surface from heat and keep it cooler, which reduces the risk of thermal cracking. The self-curing concrete also has a compressive strength that is noticeably higher than that of normally cured concrete. Self-cured concrete also has increased resistance to salts and chemicals as well as corrosive and abrasive effects.

3 LITERATURE REVIEW

Paraffin was used as an external agent in concrete at weight percentages of 0%, 0.1%, 1%, and 2% for both liquid and solid cement, with a water-cement ratio of 0.35 and 0.45. Paraffin wax is a soft, white, or colorless material produced from petroleum, coal, or oil shale. It is made up of a mixture of hydrocarbon molecules with twenty to forty carbon atoms (Reddy et al., 2016). At room temperature, it is solid; however, at around 37 °C (99 °F), it starts to melt. When used sparingly as a self-curing ingredient in higher grade concrete, liquid paraffin wax has its advantageous. Due to its softness, it is not useful at high dosages, but at low dosages, it traps the water and prevents it from evaporating from concrete. It is a polymeric substance with the ability to absorb water from its environment and hold it within one of its structures (Jensen and Lura, 2006). SAP, a crushed crystalline partial sodium salt of cross-linked polypromancic acid, may absorb 2,000 times more clean water than regular water. To make handling easier and reduce gel clumping during initial polymer hydration, the polymer is coated with ground silica and blast furnace slag. The angular un-hydrated polymer has particles that range in size from 50 to 300 m. The SAP loses its ability to rehydrate and once it hydrates it expands, and releases the water it has retained. The newly laid concrete is cured with water and then dry SAP is added. During routine mixing, absorption takes place.

Lignin makes up the majority of wood-derived materials, but cellulose can be found in plant fibers as well as non-woody fibers like Kenaf. Wood-derived materials are employed in the form of fibers of various lengths and powder form too. Particles from kenaf served as a natural absorbent material. Kenaf core is regarded as a suitable raw material in binder-less board. When making bricks, kenaf core powder, which has a density of 0.1 to 0.2 g/cm3, is used to minimize the self-weight of the bricks (Ravikumar et al., 2011).

Kenaf is also used in the field of concrete technology to produce stronger and more resilient concrete utilized in polymeric composites and reinforced concrete beams. Kenaf fibre is also used as a self-curing agent due its high water absorption rate. Malaysia introduced kenaf as a partial tobacco replacement in the year 2010.

SAP, a crushed crystalline partial sodium salt of cross-linked polypromancic acid, has the potential to absorb 2,000 times more clean water. To make handling easier and reduce gel clumping during initial polymer hydration, blast furnace slag and ground silica are applied to the polymer. The angular un-hydrated polymer has particles that range in size from 50 to 300 nm. The SAP loses its ability to rehydrate once it hydrates, expands, and releases the water it has retained. The newly laid concrete is given more water, then dry SAP is added (Subramanian et al., 2015). During routine mixing, absorption takes place. It makes up 0.375% of the cement weight in earlier concrete.

The porous volcanic rock known as pumice resembles a sponge. The porosity and sorption characteristics of various pumice portions vary. The smaller portions absorb less water, but the relative humidity ranges are of practical importance. They exhale a larger proportion of the absorbed water. In mortar studies and simulation studies, it was found that the inclusion of tiny saturated pumice aggregates might produce mortars with increased strength, increased degree of hydration, and decreased autogenous shrinkage (Selvamony et al., 2009).

Rice husk ash has high glassy silica content, large pore volume, and specific surface area (SSA). RHA has a mesoporous structure, which considerably increases its capacity to absorb water compared to SF. In a Portland cement mixture including RHA-blend, it can absorb some of the free water to increase compressive strength. The mechanical properties of concrete can benefit greatly from the use of affordable, easily accessible RHA as mineral fillers. RHA produces environmentally friendly concrete composite that is durable, strongly resistant to harsh conditions, sustainable, and practical from an economic standpoint. The results of recent research provide comprehensive understandings of the potential use of RHA as a raw building material, for making greener concrete composites toward green buildings (Amran et al.,2021). RHA-based concretes with biomass can be created as a class of unique, lightweight fireproofing, which is a new application of RHA concretes that is worth researching.

4 CONCLUSIONS

1. Self-curing concrete is as strong as traditional concrete. Concrete that cures itself is the solution to many issues that arise from improper curing.

2. Concrete that self-cures can be used in arid areas where lack of water is a serious issue. In earlier studies natural, synthetic, recycled, or chemical materials were utilized as self-curing agents. As a result, it's not always possible to find enormous quantities of natural and recycled aggregates. Artificial aggregates and chemicals are hazardous, time-consuming, and bad for the environment. Therefore, it is necessary to introduce environmentally friendly, non-harmful self-curing agents.

3. Normal concrete has adequate water for hydration, but in some places, such hot climates, there may not be enough water accessible, and due to the position of the construction, such as on an incline or in a mountainous area, curing may be difficult.

5 REFERENCES

1. A.Aielstein Rozario, Dr.C.Freeda Christy, M.Hannah Angelin “Experimental Studies on Effects of Sulphate Resistance on Self-Curing Concrete” International Journal of Engineering Research & Technology (IJERT) ISSN: 2278-0181 Vol. 2 Issue 4, April – 2013.
2. ALEXOPOULOU E., PAPATHEOHARI Y., CHRISTOU M. & MONTI A. 2013. Origin, Description, Importance, and Cultivation Area of Kenaf. Kenaf: A Multi-Purpose Crop for Several Industrial Applications. Springer.
3. Bentz, D.P., Halleck, P.M., Grader, A.S., and Roberts, J.W., “Direct Observation of Water Movement during Internal Curing Using X-ray Microtomography” Concrete International, 28 (10), 39-45, 2006.
4. Cusson, D., and Hoogeveen, T., “Internally-Cured High- Performance Concrete under Restrained Shrinkage and Creep,” CONCREEP 7 Workshop on Creep, Shrinkage and Durability of Concrete and Concrete Structures, Nantes, France, Sept. 12-14, 2005, pp. 579-584.
5. De Jesus Cano Barrita, F.; Bremner, T.W.; Balcom, B.J., “Use of magnetic resonance imaging to study internal moist curing in concrete containing saturated

lightweight aggregate" High-performance structural lightweight concrete. ACI fall convention, Arizona, October 30, 2002. ACI SP 218.

6. KARTINI K., NORUL E. & NOOR B. 2012. Development of Lightweight Sand-Cement Bricks using Quarry Dust, Rice Husk and Kenaf Powder for Sustainability. International Journal of Civil & Environmental Engineering IJCEE-IJENS, 12.
7. LIU J., SHI C., MA X., KHAYAT K. H., ZHANG J. & WANG D. 2017. An overview on the effect of internal curing on shrinkage of high performance cement-based materials. Construction and Building Materials. 146, 702-712.
8. M. V. Jagannadha Kumar, M. Srikanth, Dr. K. Jagannadha Rao "Strength Characteristics Of Self-Curing Concrete" Ijret | Sep 2012.
9. NISHANT Y., SHIRISH V. D. & RAMTEKKAR G. D. 2017. Mechanism and Benefits of Internal curing of Concrete Using Light Weight Aggregates and its Future Prospects in Indian Construction Industry. International Journal Of Civil Engineering and Technology. 8, 323-334.
10. PATEL MANISHKUMAR, JAYESHKUMAR "self-curing concrete: new technique for concrete curing – a literature review." journal of international academic research for multidisciplinary, Volume 1, Issue 9, October 2013
11. Ravikumar M.S., Selvamony. C., Kannan S.U., Basil Gnanappa .S "SELF COMPACTED / SELF CURING/ KILN ASH CONCRETE" International Journal on Design and Manufacturing Technologies, Vol. 5, No.1, January 2011.
12. REDDY N. V. & REDDY I. A. 2016. STUDY ON SELF CURING CONCRETE USING LIQUID PARAFFIN WAX AS EXTERNAL AGENT. International journal of Engineering Research and General Science. 4, 29-34.
13. Ruhal Pervez Memon1, Abdul Rahman Bin Mohd. Sam1,2, Abdullah Zawawi Awang1,2,Ghasan Fahim Huseien2 and Uroosa Memon3 A REVIEW: MECHANISM, MATERIALS AND PROPERTIES OF SELF-CURING CONCRETEARPN Journal of Engineering and Applied Sciences, VOL. 13, NO. 24, DECEMBER 2018 ISSN 1819- 6608.
14. Selvamony. C., Ravikumar M.S., Kannan S.U., Basil Gnanappa .S "Development Of High Strength Self-Compacted Self-Curing Concrete With Mineral Admixtures" International Journal on Design and Manufacturing Technologies, Vol.3, No.2, July

2009.

15. SHARMA A. 2016. A Study On The Strength Characteristics Of Concrete On Replacing Water By Self Curing Compounds. Journal of Transportation Systems.
16. SUBRAMANIAN K. B., SIVA A., SWAMINATHAN S. & AJIN A. M. 2015. Development of High Strength Self Curing Concrete Using Super Absorbing Polymer. World Academy of Science, Engineering and Technology, International Journal of Civil, Environmental, Structural, Construction and Architectural Engineering. 9, 1574-1579.
17. ZHUTOVSKY S. & KOVLER K. 2017. Influence of water to cement ratio on the efficiency of internal curing of high-performance concrete. Construction and Building Materials. 144, 311-316.
18. Pietro Lura, Dale P. Bentz, David A. Lange, Konstantin Kovler and Arnon Bentur., (2004) Pumice Aggregates for Internal Water Curing. Proceedings. International RILEM Symposium, Evanston, IL, March 22-24, 2004, 137- 151 pp.,
19. Mugahed Amran, Roman Fediuk, Gunasekaran Murali, Nikolai Vatin et al., 2021. Rice Husk Ash-Based Concrete Composites: A Critical Review of Their Properties and Applications. Crystals 2021, 11, 168. https://doi.org/10.3390/cryst11020168.