BEHAVIOUR OF RC COLUMNS STRENGTHENED BY TENSILE REINFORCED CYCLIC MORTAR

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Abstract - In last decades, the issue of upgrading existing structures has been of great importance because of their deterioration, ageing, environmental induced degradation, a lack of maintenance, or the need to meet the current design requirements. TRM combines high-strength fibers in the form of textiles (with open-mesh configuration) with inorganic matrices, such as cementitious hydraulic-lime-based mortars. TRM is low-cost, friendly for manual workers, fire resistant, compatible with concrete and masonry substrate material and can be applied on wet surfaces or at low temperature. For all these reasons, the use of TRM is progressively becoming more attractive for the strengthening of existing structures. This project presents experimental program results in basalt TRM as retrofitting jackets to improve the seismic performance of square reinforced concrete columns.

Keywords: columns, TRM retrofitting, FRCM.

Introduction

Textile Reinforced Mortar (TRM) is a composite material used in structural strengthening of existing buildings, mostly in seismic retrofitting. Tensile Reinforced Mortar jacketing is quite effective as means of increasing the cyclic deformation capacity of old type reinforced concrete columns with poor detailing, by delaying bar buckling and prevents split bond failures in columns with lap-spliced bars. This research work aimed to investigate and evaluate the seismic performance of conventional and strengthened RC column under constant axial and reversed cyclic lateral loading. The response, including the failure modes, hysteretic behavior, lateral bearing capacity, and displacement are analyzed. A new group of TRM composites has recently appeared due to the availability of basalt fiber, which are obtained by extrusion from a basalt-based molten volcanic rock. The basalt fiber is non-toxic, natural, eco-friendly and environmentally safe. Characterized by their relatively superior modulus, highstrength, excellent stability and resistance to chemical erosion and high temperatures. Basalt fiber possesses higher material properties (such as tensile strength and elastic modulus) than glass fiber and are far cheaper than carbon fiber. Typical steel-reinforced construction is 100-300 mm thick, while a TRC structure is generally 50mm thick. Basalt fiber is made from a single material, crushed basalt, from a carefully chosen quarry source. Basalt of high acidity (over 46 % silica content) and low iron content is considered desirable for fiber production. The basalt is simply washed and then melted. The manufacture of basalt fiber requires the melting of the crushed and washes basalt rock at about 1,500^{0}C (2,730^{0}F). The basalt fibers typically have a filament diameter of between 10 and 20µm. Basalt textiles in mesh geometry are used for reinforcement and GFRC is used as the cement-based matrix of the formed composite jacketing.

Objectives

- To investigate the effectiveness of a new structural material, namely textile reinforced mortar (TRM).
- To improve the axial and shear strength of reinforced concrete columns by retrofitting TRM jackets.
- To increase the deformation capacity and strength of retrofitted columns by the use of TRM jackets.
- To found out the solution for confinement of RC columns, including poorly detailed ones with or without lap splices by TRM jacketing.

Materials

Cement is one of the most used material when it comes to construction. Ordinary Portland cement (53 grade) confirming to IS 8112-1989 was used. Specific gravity of cement is 3.16. Fineness percentage of cement is 0.1%. Initial setting time is 30 min. Final setting time for cement OPC 53 grade is 6 hours. Fine aggregate consists of natural sand or crushed stone. Specific gravity of fine aggregate is 2.6. Fineness modulus is 3.204. coarse aggregate is derived from rock, the shape, size, the texture, hardness and other properties may vary depending on locations. Specific gravity of coarse aggregate is 2.8. Fineness modulus of coarse aggregate is 5.28

Mix Proportion

Materials	**Quantity**
Cement	429 kg /m^3
Fine aggregate	716.25 kg /m^3
Coarse aggregate	953.75 kg /m^3

PVA Fiber

PVA fibers creating a multi-directional fiber network providing shrinkage control, thermal expansion, contraction and abrasion control. PVA fibers are monofilament fibers that disperse throughout the matrix. Fiber length used is 12mm.

Element Specification

The column used in the study is designed as short column with aspect ratio 0.1. The column specimen consists a portion of beam and footing. Two scaled columns are casted, one is conventional column and another column is retrofitted with five layers of basalt TRM.

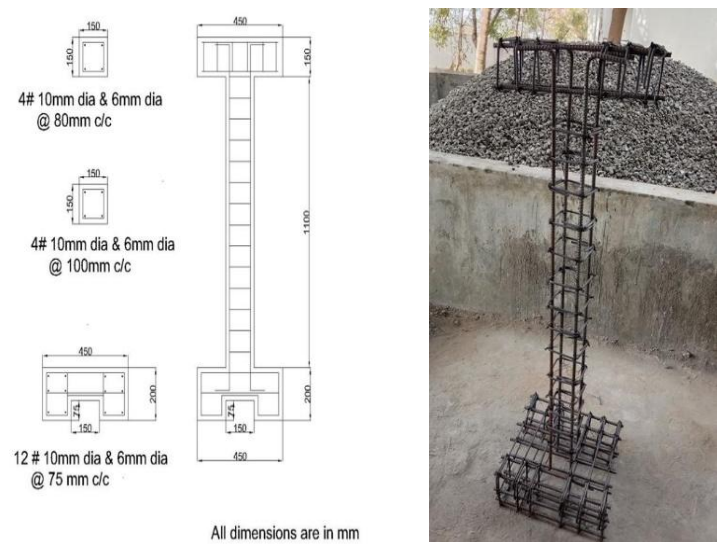


Fig. 1 Reinforced details of column

Retrofitting procedure

In retrofitting process the first step involves the thin layer of the concrete cover is removed and the surface is made rough. Then the basalt textile mesh is wrapped around the full height of the column and tied properly with the corners of the specimen receiving TRM were rounded off to radius in order to reduce the stress concentration. The first layer of thin mortar was applied over the textile mesh and the surface mesh and the surface is made even with the help of trowel. Then the mortar layer was allowed to set for few minutes. Until all the layers are applied this process is repeated. After retrofitting the specimen is cured with water for 28 days.

Fig 2

Roughening of surface

Fig 3

Wrapping of TRM

Fig 4

Application of cement matrix

Fig 5 Conventional Column

Fig 6 Retrofitted Column

Test setup

Each specimen was subjected to combined actions of cyclic loads and axial loads. In hydraulic jack the axial compression was applied and a load cell was connected to the control system of hydraulic jack to keep the load constant. The type of loading given by actuator is quasi-static loading. The axial load given through hydraulic jack is 20KN. The lateral displacement was applied with the help of horizontal actuator of 1000KN mounted to the steel reaction frame. By using Linear Voltage Displacement Transducer the imposed lateral displacement was measured. The schematic test setup and photograph of test setup was shown in Fig 7 & Fig 8.

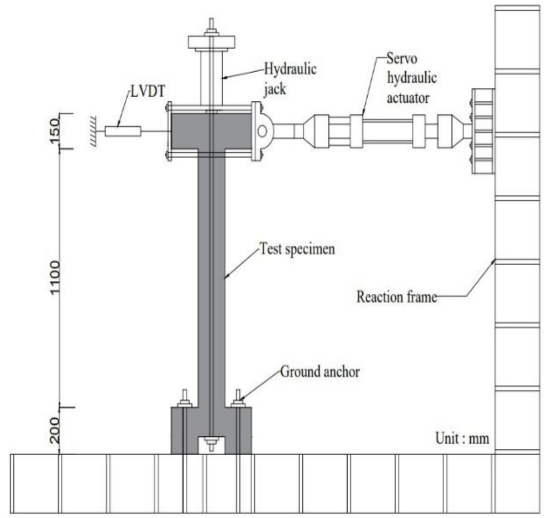


Fig 7 Schematic setup

Fig 8 Photograph of test setup

Crack Patterns

The crack patterns observed after testing, the conventional and retrofitted columns are shown in fig 9 & fig 10.

Fig 9 Crack patterns of conventional column

Fig 10 Joint failure of retrofitted column

Results and Discussion

Test Results

Table 1.Test results of conventional column

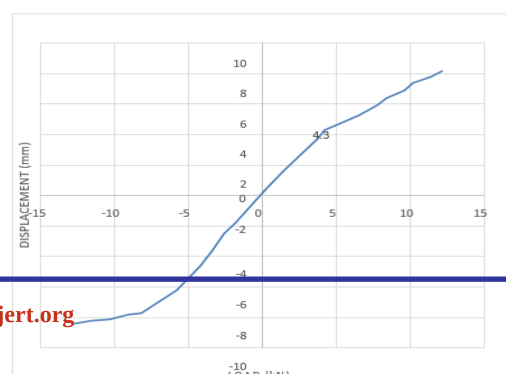
Load (KN)	STROKE(mm)	LVDT DISPLACEMENT (mm)
12.2	4.682	8.2
11.4	4.830	7.8
10.2	6.831	7.4
9.6	4.829	6.9
8.4	4.830	6.4
7.8	4.830	5.95
6.6	4.827	5.3
5.4	4.831	4.8
4.2	4.828	4.3
3.8	4.818	3.8
2.6	4.818	2.7
1.4	4.817	1.6
0.21	4.818	0.4
-1.8	4.819	-1.76
-2.6	4.818	-2.5
-3.4	4.818	-3.6
-4.2	4.817	-4.6
-5.8	4.817	-6.2
-8.2	4.808	-7.7
-9.1	4.813	-7.8
-10.3	4.805	-8.1
-11.6	4.817	-8.2
-12.8	4.820	-8.4

Table 2.Test results of strengthened column

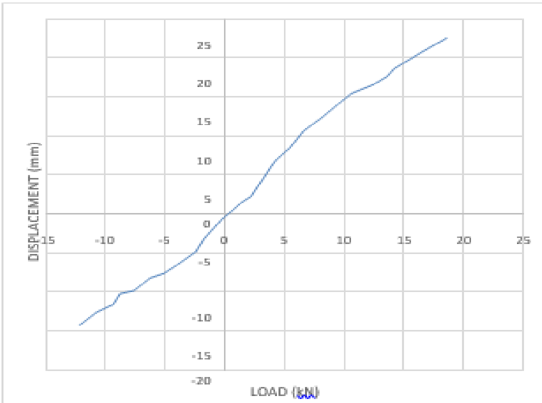
LOAD (KN)	STROKE (mm)	LVDT DISPLACEMENT (mm)
18.6	-9.875	22.5
16.4	-9.860	20.6
14.2	-9.880	18.6
13.6	-9.851	17.6
12.4	-9.852	16.5
10.6	-9.852	15.4
8.2	-9.851	12.4
6.6	-9.850	10.6
5.4	-9.852	8.4
4.21	-9.852	6.8
2.2	-9.853	2.24
1.4	-9.853	1.5
0.6	-9.853	0.4
-0.2	-9.853	-0.6
-1.8	-9.852	-3.2
-2.4	-9.853	-4.8
-4.2	-9.854	-6.7
-5.1	-9.850	-7.6
-6.3	-9.850	-8.2
-7.6	-9.864	-9.8
-8.8	-9.867	-10.2
-9.4	-9.883	-11.6
-10.8	-9.883	-12.6
-12.2	-9.883	-14.2

Load Displacement Graph

Load Displacement Graph for conventional column



Load Displacement Graph for retrofitted column



Conclusion

- The first crack was observed in the control specimen at a load of 8.4 KN under cyclic loading and the yield load was noted at 12.8 KN when the column is under yielding of reinforcement and concrete.
- Comparatively in strengthened specimen first crack was observed at 14.2 KN and the maximum displacement of column is 22.5 mm reached when the column takes the final load carrying capacity of 18.6 KN.
- The above conclusion prove that RC Column after strengthening is much more seismic resistant than that of the conventional column.

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