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Modified Failure Load for Brick Masonry Columns Encased With Ferrocement-An Experimental Study

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Abstract: *The presents work includes experimental study on enhancement in behavior of conventional brick columns under compressive as well as eccentric load with and without ferrocement encasement. The experimental program includes testing of column specimens having square and rectangular cross sections under axial compressive loadings and eccentric loading. The test samples comprise of six designation series for both rectangular and square shapes to make comparative study between conventionally used brick masonry columns and columns encased with welded steel mesh with spacing (19.05X19.05)mm. The main variables are the gauge of wire mesh, shape of cross section of columns and type of loading (axial/eccentric). The main objective is to evaluate the effectiveness of employing the wire mesh in reinforcing the conventional brick columns. The results of experiments are reported and discussed including strength, cracking and failure patterns. The results proved that encased brick columns can be developed with high strength, resistance to crack propagation and decrease in width of crack as compared to plain specimen. However, premature failure is possible when bond at the interface of brick masonry column and ferrocement is poor*

Keywords: *ferrocement, wiremesh, confinement, axial load, eccentric load.*

1. Introduction

Ferrocement is defined as a composite material in which the basic properties of combined materials are best made use of. Ferrocement is constructed of layer of continuous and small size wire mesh and covered with mortar. It differs from conventional concrete primarily by manner in which reinforcement is distributed. Ferrocement came into existance when Joseph.

Louis Lambot of France used it in 1848 for construction of rowing boats, seats, plant pots, and other items [12]. Later, in the early 1940s, Professor Pier Luigi Nervi of Italy achieved few basic characteristics of ferrocement through a series of tests. By 1960s, ferrocement construction became popular in Australia, New Zealand, and the United Kingdom [13]. It is a well known fact that ferrocement is reinforced in two directions hence creates more homogeneous and uniform characteristics in comparision to the traditional reinforcement techniques. Ferrocement shows better ductility and modulus of rupture due to uniform distribution of reinforcement [1]. Improved ductility leads to reduced crack propagation and stronger bond between reinforcement and matrix [2]. . Ferrocement has achieved popularity not only as construction material but also as a retrofitting or repair material. However, it has been observed that there is difference in behaviour of ferrocement encased specimens if the type of wire mesh is woven or welded and the gauge of wire mesh [3]. The reason behind is the effective modulus of elasticity, Ferrocement has low maintenance cost and easy fabrication hence it is preferred to be used for water tanks, boats, housing wall panels, roofs ,form work and retrofitting[14]. In ferrocement, the stresses are initially taken by wiremesh hence cement matrix does not crack [15]. Ferrocement has a higher tensile strength because of more uniform distribution of reinforcement of the mesh system on a per volume basis [4] and undergo large deformations before ultimate failure [16-18]. The increased ductility of structure has been witnessed through an underground ferrocement shell structure built in 1993 at Ahmedabad, India that has not only withstood the 2001 earthquake but also has remained crack-free till date [16]. Ferrocement is more durable than wood/ timber and cheaper than imported steel [13]. The increased use of ferrocement led to ACI design guidelines. Now a days steel mesh have been replaced by fiber reinforced plastic (FRP) meshes [18].

2. Research Significance

As per the census report of World Bank in 2013 rural population of India is 67.97% of the total population [11]. The data shows that the percentage use of convention construction methods is still quite high. Traditionally in rural and semi-urban areas we are still using the brick columns instead of concrete columns. Brick columns are capable of resisting the compressive forces but insufficient to resist tensile stresses during lateral forces like earthquake. Being unreinforced such columns pose danger to the

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building occupants. The main objective of this research is to evaluate the capability of ferrocement for strengthening un-reinforced brick masonry columns under axial loading and eccentric loading and understand its effect experimentally. Moreover the structural components may require improvement in strength during service life due to deficiencies in design, construction techniques, unskilled labour and poor maintenance of structures. Hence, Ferrocement can be an answer to better performance of brick masonry columns and retrofitting of damaged brick columns. The present experimental work aims to evaluate the potential of ferrocement for strengthening and improvement in the overall performance of the strengthened member.

3. Effect of Confinement on Masonry

Masonry may be said to be confined, when under compression its tendency to expand transversely is resisted by lateral confining pressure. This effect can be observed as increase in compressive strength of structural component due to increase in cross-sectional area and improvement in resistance to cracks of material. The increase in compressive strength is affected by confinement effectiveness coefficient. The confinement effectiveness coefficient has value less than 1 for square and rectangular columns and equal to 1 for circular column. This is because of the reason that confining pressure in case of circular columns is uniform and non-uniform for square and rectangular columns [10].

Figure, images and corresponding text should be clear.

4. Experimental Programme

Brick columns were prepared with class B bricks using mortar ratio of 1:4. Cement used is OPC of grade 43 and locally available river sand used as fine aggregate. In this case the brick masonry columns were prepared with specifications as per Table 1. The failure loads obtained for each specimen has been given in Table2. The encased specimens were covered with 5-10 mm plaster of 1:2 ratio. The axial compressive load was applied at slow rate by the universal testing machine of 2000 KN capacity. The top and bottom surface of column specimens was covered with thin layer of mortar and adjustments were made for vertical alignment before applying the load. The specimens were covered with a thin layer of whitewash for better visibility of cracks. The observations of individual specimens and results are given in the form of table 1 to table 3.

***Table 1:** Designation of specimen cast*

Specimen Designation	No. of specimens	Remarks
R-16	3	Rectangular specimen encased with 16 gauge
R-18	3	Rectangular specimen encased with 18 gauge
R-P	3	Rectangular specimen with platerings only no wiremesh
R-NP	3	Rectangular specimen with no platerings and no wiremesh encasement
S-16	3	Square specimen encased with 16 gauge wiremesh
S-18	3	Square specimen encased with 18 gauge wiremesh
S-P	3	Square specimen with platerings only no wiremesh encasement
S-NP	3	Square specimen with no platerings and no wiremesh encasement
RE-16	3	Rectangular specimen encased with 16 gauge wiremesh and eccentric loading (shorter cross section dimension /3)
RE-18	3	Rectangular specimen encased with 18 gauge wiremesh and eccentric loading (shorter cross section dimension /3)
SE-16	3	Square specimen encased with 16 gauge wiremesh and eccentric loading (cross section dimension /3)
SE-18	3	Square specimen encased with 18 gauge wiremesh and eccentric loading(cross section dimension /3)

Table 2: Size of specimens with loading type

Specimen Designation	Dimensions (in mm)	Type of loading
R-16	225x350x1000	Axial
R-18	225x350x1000	Axial
R-P	225x350x1000	Axial
R-NP	215x340x1000	Axial
S-16	225x225x1000	Axial
S-18	225x225x1000	Axial
S-P	225x225x1000	Axial
S-NP	215x215x1000	Axial
RE-16	225x350x1000	Eccentric
RE-18	225x350x1000	Eccentric
SE-16	225x225x1000	Eccentric
SE-18	225x225x1000	Eccentric

Table 3: Details of Failure loads (in KN)

Specimen Designation	Average Failure load for specimen (KN)	Ratio of Encased specimen to plain column(without plaster)
R-16	245	1.92
R-18	220	1.72

R-P	150	1.17
R-NP	127.5	1
S-16	190	1.93
S-18	170	1.73
S-P	120	1.22
S-NP	98.3	1
RE-16	190	1.49
RE-18	170	1.33
SE-16	150	1.52
SE-18	120	1.22

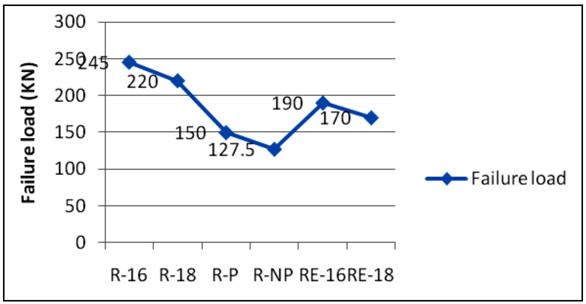

Figure 1. *Failure load for rectangular specimens*

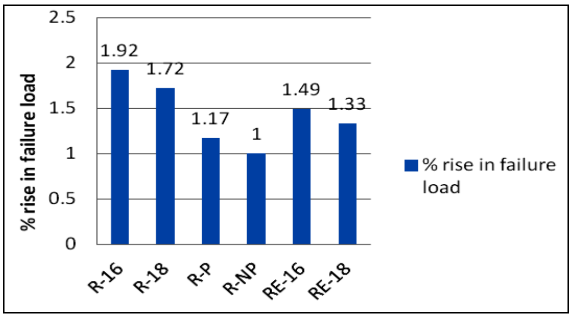

Figure 2. *% rise in failure load for rectangular specimens w.r.t. non-plastered rectangular specimen*

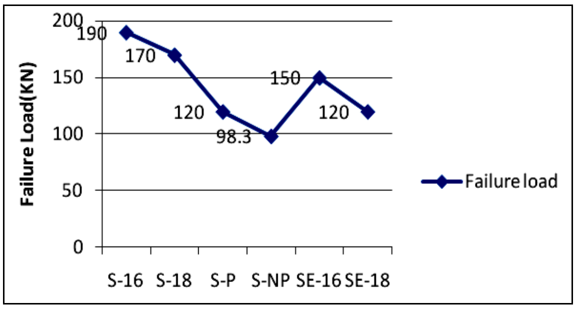

Figure 3. *Failure load for square specimens*

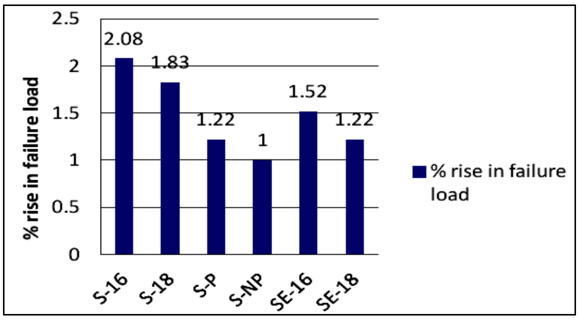

Figure 4. *% rise in failure load for rectangular specimens w.r.t. non-plastered square specimen*

Figure 5. *Wire mesh encasement of brick column in progress*

5. Discussion of results

- The failure load for each specimen has been compared to non-plastered columns under axial load
  (a)A rise by 92% of failure load is obtained for Rectangular column encased with wiremesh of grade 16 gauge.
  (b)A rise by 72% of failure load is obtained for Rectangular column encased with wiremesh of grade 18 gauge.
  (c)A rise by 17% of failure load is obtained for Rectangular column plastered with mortar.
- Similarly, The failure load for each specimen has been compared to non-plastered columns for square shaped non-plastered columns under axial load
  - A rise by 93% of failure load is obtained for square column encased with wiremesh of grade 16 gauge.
  - A rise by 73% of failure load is obtained for Rectangular column encased with wiremesh of grade 18 gauge.
  - A rise by 22% of failure load is obtained for Rectangular column plastered with mortar.
- The rectangular column specimens with wire mesh of 16 gauge under eccentric loading shown a rise by 49% as compared to non-plastered rectangular columns and 26% rise as compared to plastered rectangular columns.
- The rectangular column specimens with wire mesh of 18 gauge under eccentric loading shown a rise by 33% as compared to non-plastered rectangular columns and 13% rise as compared to plastered rectangular columns.
- The square column specimens with wiremesh of 16 gauge under eccentric loading shown a rise by 52% as compared to non-plastered square columns and 25% rise as compared to plastered square columns.

- The square column specimens with wiremesh of 18 gauge under eccentric loading shown a rise by 22% as compared to non-plastered square columns whereas it bears same failure load as for plastered square columns.
- In case of plain masonry columns the ultimate failure load occurs very shortly after appearance of first crack whereas in ferrocement encased columns, ferrocement casing takes initial compressive loads so that first crack appears much before the ultimate failure.
- The rate of crack propagation is faster in unreinforced columns whereas it showed reduced rate of crack propagation in columns reinforced with ferrocement as compared to the unreinforced columns.
- At failure load there is delamination of mortar at the mesh-mortar interface.
- Ferrocement imparts ductility to encased column specimens as ferrocement encased column specimens shown ability to withstand the eccentric loading.

6. **Conclusions**

It can be concluded from the experimental results obtained that the failure load can be enhanced significantly with the use of ferrocement encasement of brick columns. It has also been observed that there is improvement in crack resistance under axial and eccentric loads. Significant resistance to eccentric loads highlights the improved ductility of the brick columns. Hence, ferrocement encased brick columns can be recommended as an effective technique for improving behavior of conventional brick construction. It can also be used as a retrofitting technique to repair the defects in brick columns.

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