International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878, Volume-8 Issue-3, September 2019

An Assessment of Brick Masonry Strengthening Practice by Special Methods

S. Kanchidurai, P.A. Krishanan, K. Baskar

Abstract*: This study aims to identify the best suitable method to enhance strength and the structural performance of masonry. There are different techniques available to strengthen the existing and new masonry structures. This paper deals the metal/mesh embedment in the masonry wall, strengthening by added different polymers and textile strips, masonry grout, engineered cementitious materials (ECC) and interlocking masonry method. The comparison of different unique masonry strengthening methods helps us to provide a better suggestion for construction issues. In contrast to the conventional method, welded wire mesh gives better results than all other ways. Also, embedment of TRM, ECC, FRP, GFRP, CFRP, and interlocking holds an excellent performance in some other aspects.

***Key words** Brick masonry, mesh embedment, polymers embedment, interlocking, ECC*

I. INTRODUCTION

Several research works have been completed, and plenty of are still happening to increase the overall performance of the masonry systems. This research review found, the well-organized and new technique of different methods. Masonry reinforcements and other embedment technique are very much helpful to improve flexural strength. A number of the works which might apply to the existing research are briefed underneath. Load resistance of brick masonry is directly proportional to the materials, method of brick stagnation, and unique ways, as shown in Figure 1. Considering many affecting factors, masonry structures must strengthen for a new or existing construction.

II. MASONRY EMBEDMENT

In general the following methods are broadly used to strengthen the existing of new brick masonry construction.

a. Using Engineered cementitious compounds (ECC)
b. Reinforced perforated brick masonry
c. Textile reinforced mortar (TRM), the strain-hardening cement-based composite (SHCC) and steel reinforced grout (SRG).
d. Embedding mesh, steel, net etc...
e. Wrapping or covering the brick surfaces by GFRP, CFRP, FRP, FRCM, BFRCM etc..
f. Jacketing by steel or reinforced concrete jackets.

In the above method, strengthening procedure if followed by using ECC, Reinforcement, grout and mesh embedment inner part of the masonry available for the new brick masonry structures. Remaining methods are adopted for the obtainable structures, skilled man power need to execute this masonry technique Results of such work presented in Table I.

III. MASONRY STRENGTHENING USING DIFFERENT GROUT

Generally, hollow blocks or perforated masonry blocks are filled by the different masonry grout. Grouting for obtainable and new masonry structure is classified in many ways.

1. Cement mortar grout
2. Lime-based grout
3. Normal strength concrete grout
4. High strength concrete Grout
5. Steel reinforced grout
6. Grouting with admixture
7. Concrete grouting with mineral admixture and waste materials, like

Perlite, fly ash, GGBS, Silica fumes etc…

Grout may give the durability, strength, well in performance to the historical structures or new buildings. Marcos Martinez et al. showed the compressive strength increment up to 107% and ductility of masonry up to 185% then the normal masonry [52]. The different masonry grout and its performance are discussed in Table II.

IV. MASONRY WITH INTERLOCKING MORTAR LESS TECHNIQUE

Most of the ancient structure have been used the interlocking methods and sealed the gaps by different filament like clay, lime, silica etc… now a days this technique is widely adopted for a good performance to the structures , it has many advantages

Manuscript published on 30 September 2019
* Correspondence Author
S. Kanchidurai,* School of Civil Engineering, SASTRA Deemed to be University, Tamil Nadu, India.
Dr. P.A. Krishanan, Department of Civil Engineering, National Institute of Technology, Tamil Nadu, India
Dr. K. Baskar. Department of Civil Engineering, National Institute of Technology, Tamil Nadu, India

a. Cost control
b. Reduction of CO2 emission during manufacturing cement
c. 3-5 times faster in laying bricks
d. Does not need skilled labors
e. Speed in construction
f. Water saving
g. Reduction in labor cost
h. Brick manufacturing cost remains constant

Drawbacks

a. Lateral strength of masonry comparatively less
b. Maintaining uniformity in dimension

Sanewu Isaac Fundi [34] et al. investigated deflection of interlocking block walls with mortarless joint, notable augmentation in compressive strength , and the deviation was higher. Hesham Sokairge [35] et al. examine that the dry-stacked brick wall out of a plane performance. There is no difference in out of plane strength of the interlocking and conventional wall, whereas, the interlocking with post-tensioned grouted walls shows 1.6 times higher concentration than the conventional one. The geometrical adjustment can identify required groove for the blocks explained by I. Stefanou et al. C. Casapulla et al. [36-37], and the importance of masonry topology is related to the shear strength discussed by Shenghan Zhang [38] et al. Furqan Qamar [39] et al. proves the natural fibre plastering in the interlocking masonry work 5-21 times increase the out of plane strength of column. Mohamed Kohail [40] et al. investigated the dry-stacked interlocking masonry shear wall with post-tensioned grouted technique. Resulting improvement in energy dissipation, displacement ductility, 35% increment in deformation. Wang Guojue [41] et al. suggested that there is a need for providing transverse reinforcement in the interlocking solid block building construction. Also, the FE analytical program and compressive strength experimental results almost converge to zero by Waleed A.M. Thanoon et al. [42]

V. MASONRY MORTAR WITH ENGINEERED CEMENTITIOUS COMPOUND (ECC)

ECC materials made like the ductile material with strain hardening phenomenon, and it is also called Strain Hardening Cement-based Composites (SHCC). The ECC usually caused by the addition of polymers, admixtures, and fiber reinforcement. In masonry structures, the ductile nature will give maximum benefits. Table III shows the different type of ECC used for the masonry construction to enhance the performance.

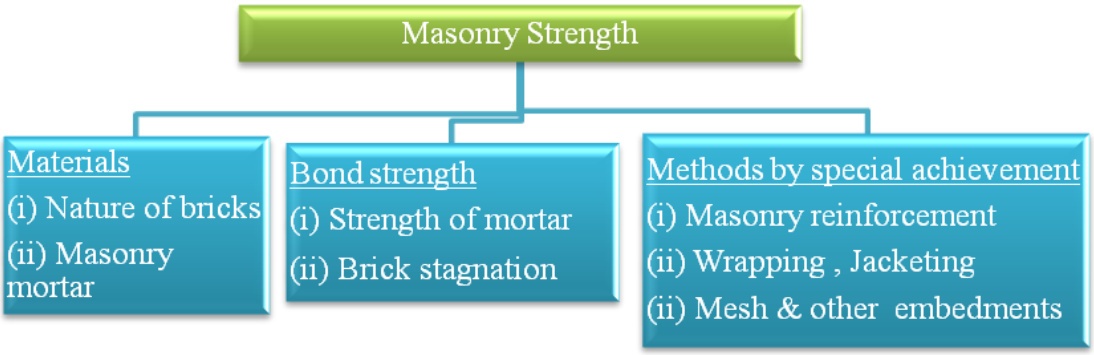

Fig.1 Strength of brick masonry

Table I. Overview of different mesh embedment

Reference	Description	Results
H. Sadak [1]	GFRP and geo grid bed joint embedment	lateral strength 54.7% higher
Shermi [2]	2mm, 2.5mm, 3mm steel grid welded wire mesh embedment	20 times greater in flexural test
Joao A.P.P. Almeida [3]	The fabric reinforced cementitious matrix	2.3 times shear strength was raise
Jiri Witzany [4]	CFRP and FRP strips	Strength increment
Najif Ismail [5]	Twisted reinforced bar of 6mm and 10mm	114 – 188% enhanced
I. Galman [6]	Glass fibre (GFRP)	60-90% shear was lifted
S. H. Alsayed [7]	Glass fibre (GFRP)	Significant strength improvement
S. Suriya [8]	GFRP retrofitting	higher load resistance
Susanna Casacci [9]	Fiber reinforced cementitious matrix (FRCM) by direct shear test	28% higher load resistance
Xuan Wang [10]	Textile reinforced mortar (TRM)	Greater, in-plane shear strength

Hasim Ali Khan [11]	Carbon Fibre Composite Materials (CFRP)	Tensile strength of about 48%, and the stiffness of 22% higher
S. Babaeidarabad [12]	Fiber reinforced cementitious matrix (FRCM).	1.95 to 2.36 times higher shear value
G.Marcari [13]	basalt textile-reinforcing embedment	60% of strength increment
Susanta Banerjee [14]	wall wounded by polypropylene with steel wire mesh	1.6 times
Sachin B. Kadam [15]	welded wire mesh	Shear 7 and 24 times higher values
Padalu [16]	welded wire mesh	9.4 times in the flexural strength.
R.A. Iernutan [17]	CFR aluminum mesh	33 % compressive strength increment.
Xuan Wang [18]	Textile fibre reinforced mortars (TRM) embedded with masonry	Brittle failure may be avoided
A. Chourasia [19]	welded wire mesh and plastic bag	Compressive and flexural strength was 90-100% higher
K. D. Theofanis [20]	carbon textile fiber	Delay in the crack initiation

Table II. Strength Improvement Using Masonry Grout

Reference	Type of grout	Testing	Statement
Eduarda Luso [21] **Andrea C. Isfeld [22]**	Lime-based injected cylinder	Bond strength	Lower And there are many uncertainty during grout injection
R.O.G. Martins [23]	Concrete grout	Compressive and stiffness	Greater than the without grouted specimen
Stefano De Santis [24][25]	Steel reinforced grout	Deflection test	2-3 times higher
Fernando S. Fonseca [26]	High strength concrete grouted prism	-	Shrinkage compensative admixture is more effective than the normal
Vasiliki Pachta [27] **E.Vintzileou[28]** **Ana Bras [29]** **Anja Vavric uk [30]**	Lime – with perlite waste, metakaolin	Compressive strength	200-300% higher & good in shirinkage
Eduarda Luso [31]	Commercial grout products by granite, lime stone and schist	Tensile bond strength	High bond strength (0.8 MPa)
Fernando S. Fonseca [32]	55% fly ash and 85% GGBS	Compressive strength	Achieved minimum 13.8MPa
Rogiros Illampas [33]	Clay based grout injection	Load bearing capacity	Suitable for repair work, ,controlling the crack propagation path

Table III. Different types of ECC in masonry

Reference	Main constituent	Comments
Fuhai Li [43]	Polypropylene	Deformation of the column was increased up to 3.2%
Mingke Deng [44]	Fibre reinforced cementitious compound	Increases noted in the distribution of energy and the ductile performance was high compare to URM
Mingke Deng and Shuo Yang [45]	polyvinyl alcohol fibre (PVA), Fly ash and water-reducing admixture	Enhancement in lateral resistance 36-45% and 18-276% in energy dissipation.
M. Maalej [46]	Steel fibre 0.2mm and polyethylene 0.039mm	Impact resistance and sudden failure prevention.
Ayoub Dehghani [47]	PVA Fibre reinforced ECC	Lateral strength up to 2.74 times increased
S. Pourfalah [48-50]	Fibre reinforced polymers (FRP)	Significant improvement in ductility, load resistance and stiffness. Out of plane loading resistance. High impact resistance.
Ali N. AL-Gemeel [51]	FRP with textile fibre	Increases in 54-77%compressive strength
S.B. Singh [52]	Fly ash, super plasticizer and polymeric polyester fibers with epoxy bonded beam	Better flexural strength than the URM

VI. CONCLUSION

The conclusions are the following:

i. It is stated that the strength improvement technique in masonry can increase the durability of the structures drastically.

ii. The welded mesh embedded masonry units show the up to 16 time higher strength against flexural strength in lateral direction.

iii. The shear strength within the masonry plane of the masonry prism may be improved by GFRP, FRP, FRM, and TRM.

iv. Making ECC with polyvinyl alcohol fiber and fiber-reinforced mortar may increase the lateral strength is up to 250% than the control specimen.

v. The interlocking masonry with natural fiber plastering can improve the strength for new masonry up to 21 times than the conventional method

vi. Steel grouted masonry work gives the best performance against deflection and reduction in the shrinkage effect.

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AUTHORS PROFILE

S. Kanchidurai Assistant professor, School of Civil Engineering, SASTRA DEEMED TO BE UNIVERSITY, Thanjavur, Tamil Nadu , INDIA

Dr. P.A. Krishanan Professor, Department of Civil Engineering, NIT Trichy, Tamil Nadu , INDIA

Dr. K. Baskar (HoD) Professor, Department of Civil Engineering, NIT Trichy, Tamil Nadu , INDIA