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A Review on Strength of Clay Brick Masonry

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Abstract: Clay brick masonry constructions are preferred in most of the undeveloped countries for low rise buildings. Also in our country clay brick masonry has been used in many historical monuments like Qutub Minar at New Delhi, Rajendra Chola Madhil at Gangaikonda Cholapuram, The Great Stupa at Sanchi, Santhome Church at Chennai etc. The weakest section of brick masonry is bonding between brick and masonry mortar. The cracks are formed due to the failure of mortar joint under the compressive, tensile, shear or fatigue loading. It is noticed that masonry buildings are exposed to the possibility of being damaged by earthquake forces. Hence various researchers performed several tests on brick masonry and studied the modes of failures. This paper contains a review of different tests conducted by several peoples on clay brick masonry and the factors affecting the strength of masonry are discussed.
Keywords: Brick Masonry, Compressive Strength, Flexure Strength, Shear Strength, Fatigue Strength

I. INTRODUCTION

The basic requirements for human survival are food, cloth and shelter and housing is one of those basic requirements. Brick masonry walls are used for the construction of all types of building in many parts of India and elsewhere because of the lower price, locally available raw materials, good strength, easy construction with less supervision, good sound, and thermal insulation properties, availability of skilled labor etc. Brick masonry is a composite material in which brick units are systematically arranged with the help of mortar joints. In India, various types of bricks or blocks are used as a masonry unit. They are clay brick, fly ash brick, solid concrete block, hollow concrete block, F-LAG Brick (Fly ash, lime, and Gypsum brick), CLC Block (Cellular Light Weight Concrete Block), AAC Block (Autoclaved Aerated Concrete Block) etc as shown in Figure-1. Now a days clay bricks and fly ash bricks are using in building the structure as a general practice. Also, several mortars are used in joints of two building blocks. They are strong in compression but weak in tension. Hence the cracks are easily propagated on the surface of the masonry structure due to having low ductility. Before using them as a building material, they must be satisfied the minimum strength. The different types of strength of clay brick masonry analyzed by various researchers are discussed here.

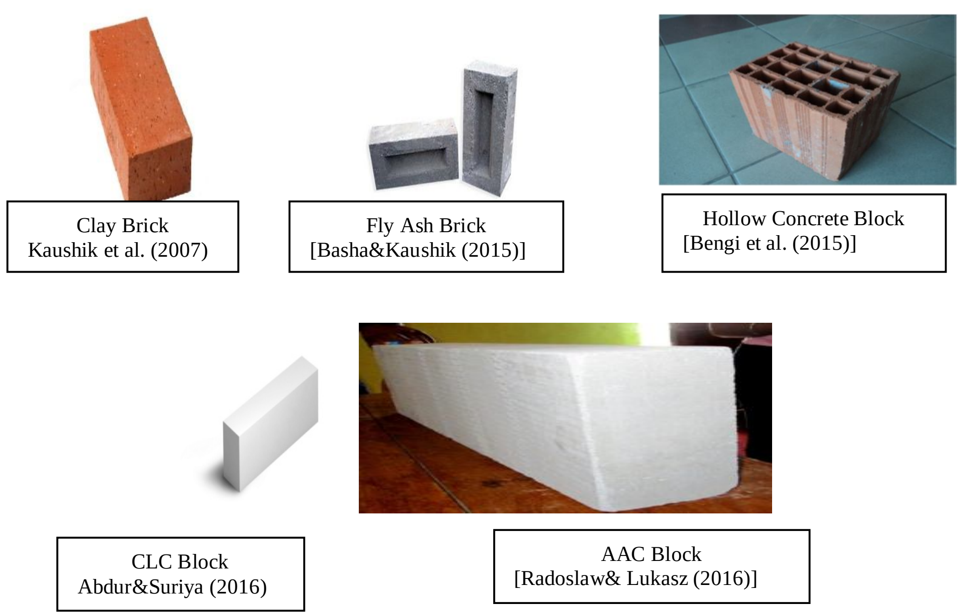

Figure-1: Different Types of Building Blocks

II. STRENGTH OF BRICK MASONRY

Masonry is a composite material of clay, rubble or concrete block units joined together by mortar. The important factor of the durability of masonry unit is an effective bond which causes cracking when subjected to lateral loading. The moisture will enter the crack which will accelerate the freeze-thaw damage and corrosion of metal connectors. Hence determination of appropriate ultimate strength of the masonry material is important for masonry designing. The different types of strength analyzed by various researchers are a compressive strength, flexural bond strength, shear bond strength and fatigue strength are discussed below.

A. Compressive Strength

The various uses of masonry walls are as load-bearing walls, external claddings, partition wall etc. Generally, several researchers determined the compressive strength of brick masonry by prism test. In prism test, five bricks are assemblage with mortar joints as shown in Figure-2. The strength of brick masonry depends upon the strength of brick and strength of mortar. Prism is the combination of two different materials i.e. brick and mortar distributed at regular intervals of the prism. The strength and stiffness of brick are more than mortar. Hence bond between mortar and bricks are a week. So the masonry can resist strongly the compressive stress than shear and flexure. Again the strength of brick through the country is not same. From Figure-3 it is seen that the strength and stiffness of southern part of India are very low. Moreover, these bricks are very soft which causes different state of stresses to develop in masonry unlike in the masonry with stiffer and stronger bricks.

Figure-2: Brick Prism Specimen [Rath, Deo and Ramtekkar (2016)]

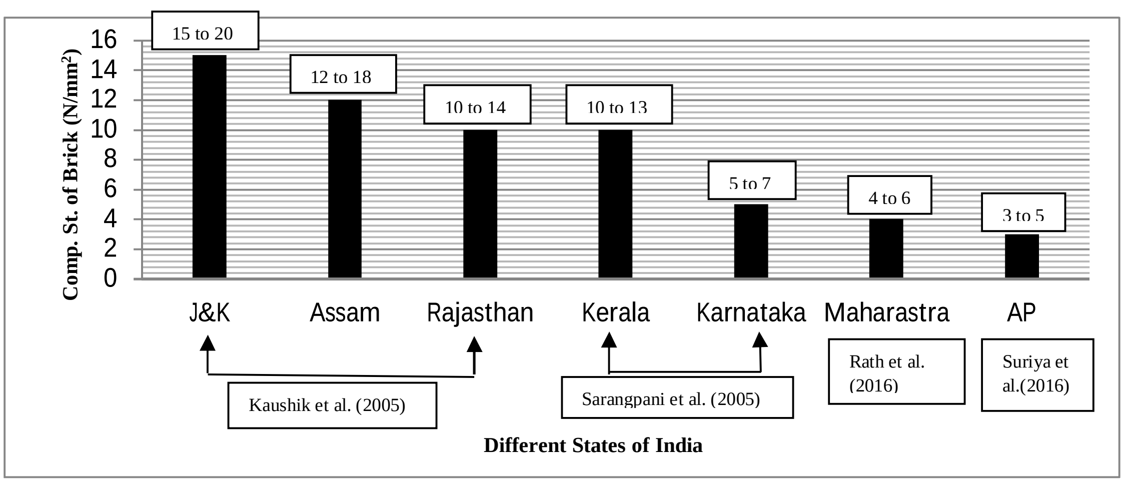

Figure-3: Variation in Compressive Strength of Brick of Different States across the India

Sarangpani et al. (2005) conducted a series of tests on brick masonry prism with different grades of mortar. They found that the compressive strength of prism increased as the grade of mortar increased. They found that as the prism compressive strength increased gradually, flexural strength and shear strength improved accordingly. Kaushik et al. (2007) conducted compressive strength of brick, mortar and brick masonry prism and plotted nonlinear stress-strain curve. Several factors such as water absorption, the initial rate of absorption, and the addition of lime in the mortar on the strength and ductility of masonry are also studied. He

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prepared mortar using cement lime and sand of 1:0.5:4.5 ratios and found that failure strain was about 45% more than that the mortar of 1:3. Using regression analysis they developed a simple analytical model has been proposed for obtaining the stress-strain curves for masonry which can be used in the analysis and design procedures. Costigan and Pavia (2009) studied compressive, flexure and bond strength of brick masonry wallet with hydraulic and non-hydraulic lime mortar. Two cases of failures are observed. One is vertical splitting where mortar is stiffer than brick and bond failure when the brick is stiffer than mortar. They reported that compressive strength of masonry wallet is not sensitive to bond strength when masonry unit is stiffer than mortar. Palanisamy and Premalatha (2012) compared the compressive strength of clay brick and fly ash brick masonry prism by using three types of mortar (i.e. 1:4, 1:5 and 1:6) and concluded that the compressive strength and elastic modulus of fly ash brick masonry is more than the clay brick masonry. Ravi et al. (2014) tried to establish a stress-strain relationship between brick, mortar cube and masonry triplets by taking four types of mortar (i.e. 1:2, 1:3, 1:4 and 1:5). Using these test results they studied the behavior of masonry by performing finite element modeling in ANSYS. Vimala and Kumarasamy (2014) found the compressive strength of brick masonry in both wet and dry state. They found that dry and wet strength of prism increased with increasing of mortar strength. The dry compressive strength of prism was higher than the wet compressive strength.

B. Flexural strength

The brick masonry is a brittle material. The structural limitations of clay brick masonry like poor shear and tensile strength. Hence flexural strength should be determined for lateral loading. Figure- 4(a) shows the arrangement of flexural strength test. A brick prism of five bricks is generally kept on flexural strength machine. Two point load or four point load is applied to the brick masonry prism.

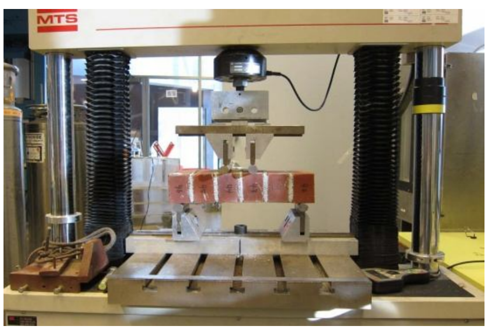


Figure-4(a): Flexural Test Arrangement of Brick Masonry

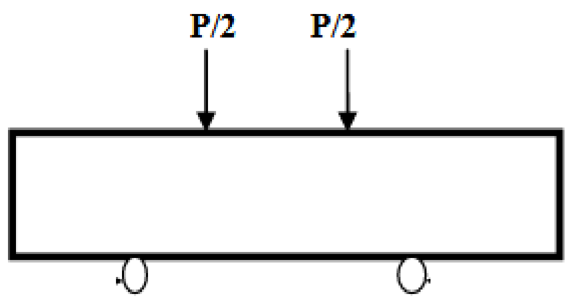


Figure-4 (b): Top View of Flexural Testing Arrangement

Sarangpani et al. (2005) defined three types of flexural failure of prisms. They are (i) failure at the brick-mortar interface indicating bond failure (ii) failure of brick in flexure with the brick-mortar interface intact (iii) combination of above. They found that the flexural strength mortar present in bed joint is higher than the flexural strength of brick and brick mortar interface. They suggested that to increases the flexural bond strength of masonry one can use either high-grade mortar or providing cement slurry or epoxy coatings. Yuen and Lissel (2007), investigated the influence of several factors such as types of brick, construction methods etc on the flexural bond strength of brick masonry. But they failed to correlate between bond strength and the sorptivity property of brick units. Zeljka et al. (2015) analyzed the mechanical properties of masonry walls. They found that the compressive strength of mortar used in brick masonry plays compressive strength brick masonry. Mortar higher compressive strength increased the compressive strength and flexural strength. The lime mortar used in brick masonry improves the ductility of the wall than cement mortar. Pavia and Hanley (2010) conducted flexural strength of brick masonry using three grades of natural hydraulic mortar whose specific flows were 165, 185 and 195 mm. They concluded that natural hydraulic mortar possesses high water retention and its flexural bond strength is more as compared to cement mortar or cement-lime mortar. Also, the flexural bond strength of mortar depends upon the binder’s hydraulic strength, but it increases proportionally to the mortar’s water retention.

C. Shear Strength

Shear failure in masonry building is a dominant mode of failure due to lateral loadings of wind, earthquakes, unsymmetrical vertical loading and unequal settlements of support. This shear force generally acts due to compressive force with a combination of self-weight and floor loads [Rahman and Ueda (2014)]. Since Indian Building Codes allows low values of shear resistance, hence most of the Indian contractors and builders give less importance to concerning shear strength and shear load-displacement behavior of masonry as compared to behavior in compression. Recently some researchers introduced the terms softening and dilatancy and developed an analytical model to describe the plane behavior of masonry wall. Figure-5 indicates several experimental approaches have been adopted by those researchers to determine the shear behavior of joints of brick masonry on couplet, triplet, and prism.

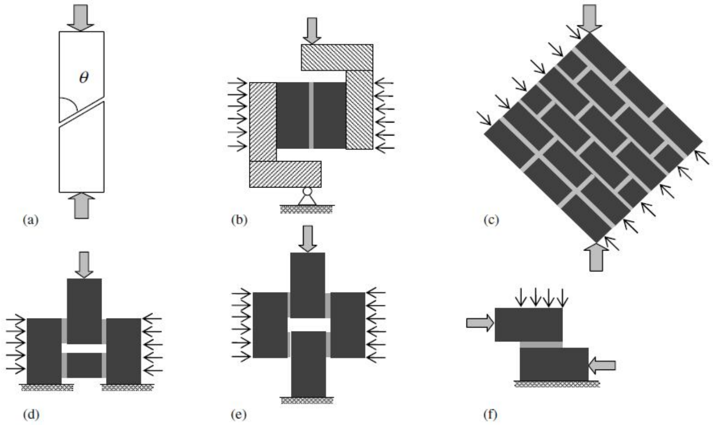


Figure-5 Different Types of shear Test Specimens: (a) Nuss Shear Test, (b) Van der Pluijm Test, (c) Diagonal Tension Test, (d) Triplet Test, (e) Meli Test, (f) Direct Shear Test [Rahman and Ueda (2014)]

Armaanidis (1998) conducted a direct shear test on solid clay couplet bricks with lime mortar. He stated that shear strength of lime mortar provided between two bricks be a combined effect of internal friction angle and dilatancy angle and proposed the following equation.

$$\tau_u = c + \sigma_n \tan(\phi + \varphi)$$

Where τ_u = Ultimate shear strength, σ_n = Normal pre compression, ϕ = Initial friction angle, φ = Dilatancy angle. Van der Pluijm (1993) applied compressive force applied at three different levels as shown in Figure-5(b) namely 0.1, 0.5 and 1 MPa and measured uplift or displacement normal to the shear joint i.e. dilatancy. Hansen (1999) performed a similar test on couplet clay bricks and found maximum ultimate shear strength and angle of friction as 0.68 MPa and 23.9 degrees. Lourenco et al. (2004); Rahman and Ueda (2014) conducted triplet test as shown in Figure-5(d) studied the shear load-displacement behavior of horizontal brick masonry joints due to constant compressive load and verified the Mohr-Coulomb criteria with a cohesion value of the order of 1.4 MPa, and the initial friction coefficient (tan ϕ) of 1.03. Also, they stated that the shear strength not only depends upon the grades of mortar but also it varies with strong mortar with weak brick and weak mortar with a strong brick. Abdou et al. (2006) conducted a shear test on both solid and hollow bricks as shown in Figure-5(f) and found that ultimate shear strength and angle of friction are not depended upon the types of bricks. Also, he found that shear stiffness values of solid bricks are lesser than the hollow bricks. In hollow bricks, mortar entered the holes and act as an abutment, which increased the shear strength value. Meli (1973), Hamid and Drysdale (1980) investigated the bond and friction of joints as shown in Figure-5(e) and studied the shear response of both grouted and un grouted concrete masonry. They found that as the confining (compressive) stress increases the coefficient friction decreases. Some researchers like Gabor et al. (2006); Calvi et al. (1985); Yokel and Fattal (1975) conducted shear strength of clay brick masonry by diagonal compression test as shown in Figure-5(c). The shear strength obtained from the test gives the average value of progressive failure events. Sherafati and Sohrabi (2017) explained that shear strength of clay brick masonry gradually decreased as the time lapsed. They formulated a linear model for the evolution of strength degradation as

$$s = -0.00547t + 0.5293 \qquad and \qquad s = \frac{1}{b + t^c}$$

Where, s=shear strength and t= time period and a, b, c are constants and taken as 2.048, 2.955X10^{-4} and 2.295 respectively for yield density. They predict the uncertain long-term shear resistivity of clay brick walls by keeping results obtained from the numerical analysis of the above derived suitable resistance degradation functions. Christy et al. (2012) explained that there are two lateral forces named in the plane and out plane force act on masonry wall during an earthquake. According to them, the shear bond strength of masonry is the main source of resisting force for these lateral loads. They suggested that in earthquake-prone areas shear strength of masonry should be well analyzed for designing of structure.

D. Fatigue Strength

Most of the arch bridges in our country are subjected far heavier repeatable service loading. But till now the fatigue load has not been positively identified in masonry arch bridges. According to some researchers and maintenance engineers, the repeated applications heavy loads may decrease the life span of those bridges. There is very limited availability of the fatigue behavior of masonry under shear. Generally, fatigue test is done on five-course prisms, which is centrally loaded up to 5 million load cycles at 5 Hz frequency under laboratory dry, wet and submerged test conditions. Under quasi-static loading, 5 million cycle loads are subsequently loaded up to failure. Roberts et al. (2006) conducted fatigue test on three types of test specimen named S, F1, and F2 as shown in Figure-6 aiming to investigate the serviceability requirements for brick masonry arch bridges. They applied seven million cycles with frequency 5 Hz to the specimen. They concluded that quasi-static compressive strength of brick masonry is directly proportional to the compressive strength of mortar and inversely proportional to the degree of saturation. They assumed that no tension stress distributions increases with an increase in the load eccentricity. Joan R. Casas (2009) developed a model for fatigue resistance of brick masonry using Weibull distribution. He has shown that fatigue resistance of brick masonry is not only depending on the magnitude of the stress cycles, but also on the magnitude of the minimum stress level. According to Wang et al. (2013), several factors affecting on fatigue strength of brick masonry. They are a degree of saturation, material properties, load eccentricity ratio and rate of loading. The dry specimen can resist more than a double number of cycles of fatigue loading than the submerged and saturated specimen. The specimen using mortar mix i.e. 1:1:10 cement: lime: sand ratio with smaller eccentricity ratio of e/d=0.163 is much higher than large eccentricity ratio 0.256. There is no influence of loading rate on fatigue strength. Table-I shows different strength parameters of clay brick masonry achieved by different researchers from laboratory testing.

Table-I: Strength of Clay Brick Masonry Achieved by Different Researchers

Author's Name	Specimen Types	t_m (mm)	f_{cb} (MPa)	f_{cm}(MPa)	f'_m (MPa)	Flexural Strength (MPa)	τ_u(MPa)	c (MPa)	ϕ (Deg)
Kaushik et al. (2005)	Clay Brick Prism (1:3)	10	28.9	20.6	8.5	NA	NA	NA	NA
Sarangpani et al. (2005)	Clay Brick Prism (1:4)	10	10.67	10.57	3.2	0.205	0.138	NA	NA
Costigan&Pavía (2009)	Clay Brick Wallet (1:3)	12	12	4.39	5.3	1.08	NA	NA	NA
Palanisamy&Premalatha (2012)	Clay Brick Prism (1:4)	10	3.74		1.156	NA	NA	NA	NA
Van der Pluijm (1993)	Clay Bricks with couplet	15	11	9	NA	NA	1.69	0.87	42.9
Hansen (1999)	Clay Bricks with couplet	12	32	3.8	NA	NA	0.89	0.68	23.9
Hansen (1999)	Perforated clay bricks with couplet	12	46	3.8	NA	NA	1.15	0.68	45
Lourenço et al. (2004)	Hollow clay bricks with triplet	25	31.8	30.3	NA	NA	2.0	1.39	37.6
Abdou et al. (2006)	Hollow clay bricks with couplet	10	24	20	NA	NA	2.31	1.5	23.9
Chaimoon (2007)	Clay Bricks with couplet	10	11.1	7.3	NA	NA	1.02	0.43	30.4
Rahman and Ueda (2014)	Clay Brick with Triplet (1:4)	10	17	10	NA	NA	2.28	0.12	60.8
SuriyaPrakash et al. (2016)	Clay Brick with Triplet and	10	4.15	25	2.2	NA	0.0026	NA	NA

	Prism(1:3)								
Ronald et al. (2014)	Clay Brick with Triplet and Prism(1:3)	10	27.3	14.7	6.65	NA	1.104	NA	NA

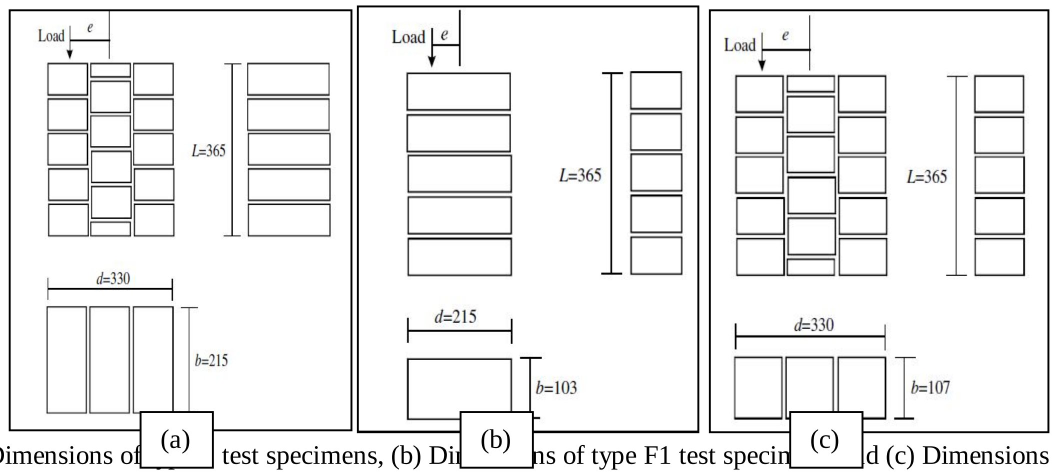


Figure-6: (a) Dimensions of ... test specimens, (b) Di...ns of type F1 test specin...d (c) Dimensions of type F2 test specimens [Roberts et al. (2006)]

t_m: Thickness of Mortar, f_{cb}: Compressive Strength of Brick, f_{cm}: Compressive strength of Mortar, f'_m: Compressive Strength of Prism, τ_u: Ultimate Shear Strength, c: Interface Cohesion, ϕ=Friction Angle, NA: Not Available

III. CONCLUSION

Based on a brief review of literature it is noticed that the strength of brick masonry depends upon both strengths of brick and strength of masonry mortar. As the strength of brick and mortar are increased the strength of brick masonry increased. The strength of brick masonry mortar becomes more when the lime mortar is used instead of cement mortar. Both compressive strength of mortar and thickness of joint plays important role in the shear bond strength of brick masonry. As the thickness of mortar joint increases, shear strength value increases up to certain limit. The shear strength of higher thickness joint remains unchanged. Also, some researchers found that fatigue strength also depends wet upon the condition of brick i.e. dry brick, saturated brick and submerged brick. Further research should be required to confirm it. However, based on the experimental data the eccentricity ratio influences to the fatigue strength of brick masonry. The fatigue strength corresponding to smaller eccentricity ratio is much higher than those with larger eccentricity ratio.

REFERENCES

[1] Abdou, L., Saada, R. A., Meftah, F., and Mebarki, A, “Experimental Investigations of The Joint-Mortar Behavior” Mechanics Research Communication, Vol-33(3), pp-370–384, (2006).

[2] AbdurRasheed and SuriyaPrakash, “Effect of Synthetic Fiber Reinforcement on Compressionand Tension Behavior of Cellular Lightweight Concrete”, 9th RILEM International Symposium on Fiber Reinforced Concrete - BEFIB 2016, Vancouver, Canada, 201

[3] Armaanidis, V. I, “A model for the shear strength of rough rock discontinuities under low normal stress.” M.Sc. dissertation, School of Civil Engineering and Geosciences, Univ. of Newcastle, Upon Tyne,U.K, 1998

[4] Basha Syed Humayun and KaushikHemant, “Evaluation of Nonlinear Material Properties of Fly Ash Brick Masonry under Compression and hear”, Journal of Material of Civil Engineering (ASCE), Vol-27(8), pp-1-11, 2015.

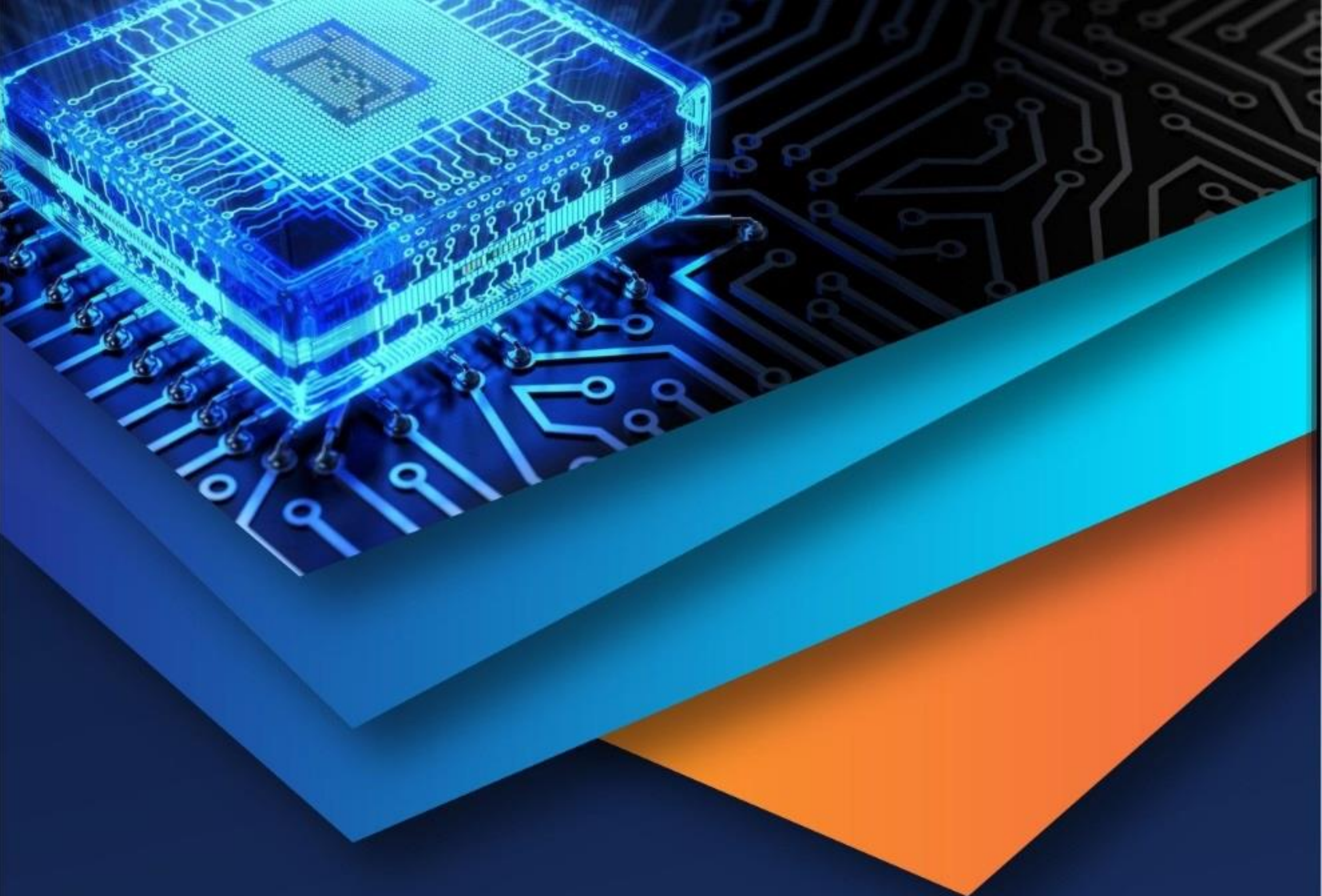
[5] BengiArisoy, EmreErcan and Ali Demir, “Strengthening of Brick Masonry with PVA Fiber Reinforced Cement Stucco”, Construction and Building Materials (Elsevier), Vol-79, pp- 255–262, 2015.

[6] Calvi, B. M., Macchi, G., and Zanon, P. “Random Cyclic Behavior of Reinforced Masonry under Shear Action.” Proceeding of 7th InternationalBrick Masonry Conference, Melbourne, Australia, 1985

[7] Chaimoon K., and Attard M. M, “Modeling of Unreinforced Masonry Walls Under Shear and Compression.” Journal of Structural Engineering,Vol-29, pp-2056–2068, 2007

[8] Christy C.F, Tensing D, and Shanthi R. M. “Experimental Study on Axial Compressive Strengthand Elastic Modulus of the Clay and Fly Ash Brick Masonry”, Journal of Civil Engineering, Vol-4(4), pp-134-141, 2013

[9] Costigan A and Pavia S. “Compressive, Flexural and Bond Strength of Brick/Lime MortarMasonry”, International Conference on Protection of Historical Buildings”, PROHITEC-09, Rome, pp-1609-1615, 2009
[10] Gabor, A., Ferrier, E., Jacquelin, E., and Hamelin, P. “Analysis and Modelling of the In-Plane Shear Behavior of Hollow Brick Masonry Panels.” Construction Building Materials, Vol-20(5),pp-308–321, 2006.
[11] Hamid, A. A., and Drysdale, R. G. “Behavior of Brick Masonry under Combined Shear and Compression Loading”, Proceeding of 2nd Canadian Masonry Symposim, Ottawa, Canada, 1980.
[12] Hansen, K. F. “Bending and Shear Test with Masonry” SBI bulletin 123, Danish Building research Institute, Horsholm, Denmark, 1999.
[13] IS: 1905 (1987),“Code of Practice for Structural Use of Unreinforced Masonry”, Bureau of Indian Standards, New Delhi, India.
[14] Joan R. Casas, “A Probabilistic Fatigue Strength Model for Brick Masonry Under Compression”, Construction and Building Materials, Vol-23, pp- 2964–2972, 2009
[15] Kaushik H.B;Rai D.C; Jain S.K;“Stress–Strain Characteristics of Clay Brick Masonry Under Uniaxial Compression”. Journal of Materials in Civil Engineering, Vol-19(9), pp-728–739, 2007.
[16] Lourenço, P. B., Barros, J. O., and Oliveira, J. T. “Shear Testing of Stack Bonded Masonry”, Construction and Build. Materials, Vol-18(2), pp-125– 132, 2004.
[17] Meli, R. “Behavior of Masonry Walls Under Lateral Loads.” Proc., 5th World Congress on Earthquake Engineering,
[18] Palanisamy M. and Premalatha J, “Experimental Study on Masonry Infill Material Properties”, International Journal of Scientific & Engineering Research, Vol-3, (7), pp-1-5, 2012.
[19] Pavia S and Hanley R, “Flexural Bond Strength of Natural Hydraulic Lime Mortar and Clay Brick”, Materials and Structures, Vol-43, pp-913–922, 2010
[20] RahmanAtaur and Ueda Tamon, “Experimental Investigation and Numerical Modeling of Peak Shear Stress of Brick Masonry Mortar Joint under Compression”, Journal of Material in Civil Engineering,Vol- 26(9), pp-1-13, 2014.
[21] RathBadrinarayan, DeoShirish and RamtekkarGangadhar**,** “Pond Ash: A Sustainable Building Material for Smart Cities”, Recent Trends in Civil Engineering & Technology, Vol-6(1), pp-53-59, 2016.
[22] Ravi S, Selvakumar V, Thanikasalapradeep N, Srinivas V, and Premavathi N, “Experimental and Numerical Investigations on Material Behaviour of Brick Masonry”, 2nd International Conference on Research in Science, Engineering and Technology, Dubai, 2014.
[23] Roberts T.M; Hughes T.G; Dandamudi V.R and Bell B. “Quasi-Static and High Cycle Fatigue Strength of Brick Masonry”, Construction and Building Materials, Vol-20, pp-603–614, 2006.
[24] Ronald Lumantarna, David T. Biggs and Jason M. Ingham, “Compressive, Flexural Bond, and Shear Bond Strengths of In Situ New Zealand Unreinforced Clay Brick Masonry Constructed Using Lime Mortar between the 1880s and 1940s”, Journal of Materials of Civil Engineering, Vol- 26(4), pp-559-566, 2014.
[25] Sarangapani G, Venkatarama Reddy BV, Jagadish KS,“Brick-Mortar Bond and Masonry Compressive Strength”,Journal of Materials of Civil Engineering, Vol-17(2), pp-229–237, 2005.
[26] Sherafati Mohammad Amir and Sohrabi Mohammad Reza, “An Investigation into the Time Dependency of Shear Strength of Clay Brick Walls; An Approximate Approach”, Construction and Building Materials, Vol-155, pp- 88–102, 2017.
[27] SuriyaPrakash S; Aqhtarudin M; SumanDhara J, “Behaviourof Soft Brick Masonry Small Assemblies With And Without
[28] Van der Pluijm, R. “Shear Behavior of Bed Joints” Proceeding of 6th North American Masonry Conference, Philadelphia, PA, pp-125–136, 1993)
[29] Van Zijl, “Modeling Masonry Shear-Compression: Role of Dilatancy Highlighted” J. Eng. Mech., Vol-130(11), pp-1289–1296, 2004.
[30] Vimala S and Kumarasamy K, “Studies on the Strength of Stabilized Mud Block Masonry usingDifferent Mortar Proportions”, International Journal of Emerging Technology and Advanced Engineering, Vol-4(4), pp-720-724, 2014.
[31] Wang Jiniyan, TomorAdrienn, Melbourne Clive and YousifSaad, “Critical Review of Research on High-Cycle Fatigue Behaviour of Brick Masonry” Construction and Building Materials, Vol- 38, pp-602–609, 2013
[32] Yokel, F. Y., and Fattal, S. G. “A Failure Hypothesis for Masonry Shear Walls” Rep. No. NBSIR 75-703, National Bureau of Standards, Washington, DC, 1975
[33] Yuen C. G. and Lissel S. L. “Flexural Bond Strength of Clay Brick Masonry”, WIT Transactions on Engineering Sciences
[34] ZeljkaRadovanovic, RadmilaSindicGrebovic, SretenaDimovska, Nina Serdar, Nikolai Vatin and Vera Murgul, “The Mechanical Properties of Masonry Walls - Analysis of the Test Results”, Procedia Engineering, Vol-117, pp-865-873, 2015.



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