A Review Paper on : INTERLOCKING WALL BLOCK FOR TEMPORARY STRUCTURE

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Abstract:

Customary blocks are the most basic structure materials for houses development. Be that as it may, the quick development in the present development industry has obliged the common designs in hunting down another structure method that may result in considerably more prominent economy, increasingly proficient and sturdy as an option for the regular block. Additionally, the high requests for having an expedient and less work and cost building frameworks is one of the factor that cause the progressions of the workmanship traditional frameworks. These progressions have prompted improved constructability, execution, and cost also. A few interlocking blocks has been created what's more, actualized in structure developments and various looks into had examined the assembling of interlocking block and its basic conduct as burden bearing and non-load bearing component. This specialized paper expects to survey the improvement of interlocking block and its auxiliary conduct. All in all, the idea of interlocking framework has been generally utilized as a substitution of the regular framework where it has been used either as burden bearing or non-load bearing brick work framework.

Keywords—masonry wall; interlocking bricks; structural behaviour.

1. **Introduction :** Block stone work is an old material and a standout amongst the most huge development materials everywhere throughout the world. The regular strategies for blocks making has brought obvious disadvantages [1]. The antiquated and customary methodology of block making were by blending the crude materials, forming the blocks, and drying and terminating them till they acquire a specific dimension of solidarity [2]. Be that as it may, the assembling procedure of blocks on the most recent two decades slanted to new techniques in request to diminish the inadequacy of the old techniques for making blocks. Because of the present pattern inside the most recent two decades, blocks have been created in various characterizations specifically strong block and interlocking block. The present of interlocking mortarless block work has provoked a colossal addition in field productivity and viability, and furthermore a diminishment in the requirements for exceptionally specific work groups. In addition, the use of interlocking squares work has expanded quick predominance in various outside countries as a differentiating alternative to conventional squares for supportable and maintainable structures. Interlocking squares are interesting in connection to regular squares since the nonappearance of the mortar to be filled between the squares layers amid the development procedure. In light of this trademark, the path toward structure dividers and parcels is speedier and requires less gifted specialists as the squares are collected dry and stacked on each other. In any case, there are issues related with blocks which are low quality, higher water retention, low imperviousness to fire and high porosity[3]

   Major changes have been jumped out at the stone work development on the most recent couple of decades due to the expanding necessities of stone work to be contended with other auxiliary materials (for example steelwork, concrete). Then again, the levels of popularity for having a rapid and less work and cost building frameworks is one of the factor that reason the progressions of the brick work traditional frameworks. These progressions have prompted improved constructability, execution, and cost also. For that reason, a couple of inventive strategies, for example, surface bond brick work, fiber fortified polymer wrapping workmanship, grouted stone work, and interlocking mortarless stone work have been created and used for quick and reasonable development [4]. Be that as it may, interlocking mortarless framework is another imaginative idea

to render the brick work development progressively practical and quicker contrasted with the regular brick work development which has a mortar joints. Accordingly, this examination expects to audit the advancement of interlocking stone work blocks what's more, hinders from the past examinations just as the basic conduct.

2. **Development of interlocking brick:**Various sorts of interlocking squares and blocks have been delivered in the midst of the earlier years, fluctuating in the sythesis of material, measurement and shape, dependent upon the required qualities and utilization. These involve "Sparlock framework, Meccano framework, Sparfil framework, Haener framework, Putra square framework and the Solid Interlocking squares (SIB) or Hydraform squares", which are a change over the regular blocks and squares [5]. As revealed by Khan and Deshmukh [6] that the different interlocking squares dependent on materials are "soil-bond squares, rice quiet fiery remains bond squares, and solid squares". The dirt bond squares depend on the dirt and bond characteristics, the concrete to-soil proportion more often than not lies somewhere in the range of 1:6 and 1:10, by volume while the rice quiet fiery remains (RHA) concrete hinders, the bond to rice quiet powder proportion is 1:4 by volume. Moreover, for the solid obstructs, the particular blend amount of cement:sand:gravel is 1:5:3. Fay et al. [7] built up a mortarless interlocking soil-concrete square for stone work development. With the fitting square, the squeezing mold was set up and tests were adjusted in 3 blends of soil what's more, bond showing development plausibility. In agreement to the related gauges, pressure opposition, retention of water and estimating were tried. The outcomes uncovered that the ingestion of water is the main parameter that bungled with models necessities.

   In Malaysia, Thanoon et al. [8] created interlocking burden bearing empty square framework called Putra Square. The squares are put on one another and 3D interlocking projections are given despite the squares to fuse the squares into brick work frameworks. 21 distinctive square models have been examined also, broke down as for weight, bearing and shear zones, shape, simplicity of creation, capacity to oblige vertical and level fortifying balancing out ties and proficiency of the interlocking component under forced burdens. Therefore, the framework created gives a quick, simple and an exact building framework. Additionally in Malaysia, Abang Ali and Abdul Kadir [9] set up other interlocking square (Figure 1), in light of the idea of LEGO. Singular units and indistinguishable divider boards have been tried at Universiti Putra Malaysia under fluctuates kind of stacking. It has been inferred that the compressive quality of the squares fulfills the necessities of the Malaysian gauges. This advanced square framework affirmed to be used to develop two story working with strength and security.

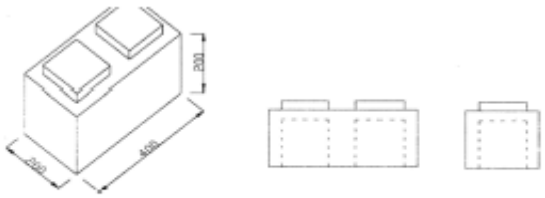

Figure 1. Interlocking Hollow Block System [9]

3. **Structural Behaviour of Interlocking Brick Systems:**
   Tang et al. [10] assessed the lingering compressive and shear qualities of novel "coconut-fibrereinforced-concrete" (CFRC) interlocking squares under powerful stacking. The examination inferred that the CFRC interlocking blocks have adequate leftover limit after subjection to a dynamic burdens and 15 long stretches of capacity. In this manner, the structures of CFRC interlocking blocks have the capacity to continue furthermore, be used constantly after any seismic occasions, if the demolition and damage in squares are imperceptible. Ali et al. [11] examined the in plane conduct of the mortarless coconut fiber strengthened cement interlocking squares structures experienced distinctive unique loadings. The substance of coconut fiber were 1% of solid mass. Four structures components were readied (two sections and two dividers both with what's more, without coconut fiber rope) and tried under push over, snap back, effect, consonant and seismic tremor loadings. It was exhibited that the bowing solidness and top uprooting of the structures with

fiber coconut rope were higher than those without rope. In the meantime, damping, vitality dissemination, and base shear of the structures with rope were littler than those structures without rope. In this way, the results affirmed that CFRC interlocking squares can possibly be utilized in districts presented to any seismic loadings. Osman et al. [12] built up an interlocking block framework named Brickcool and afterward examined the basic conduct of Brickcool dividers as burden bearing structure. In as per BS3921 and ASTMC67, physical and mechanical trial of the block unit (particulars, pressure quality and ingestion of water) were led. Haphazardly 10 blocks unit were grabbed and appropriately cleaned and after that experienced the particular test. The blocks were then laid in succession at a similar dimension. The units were at that point set in a similar dimension of line. Estimation tape was utilized to measurement every block. Same examples were inundated in clean water for twenty four hours where the heaviness of the examples previously, then after the fact inundating were recorded so as to decide the water ingestion. Pressure trial of ten interlocking blocks were led. The outcomes are appeared Table 1 and Table 2. In this investigation, two examples of burden bearing interlocking Brickool divider dimensioned by 1300 mm in tallness, 1000 mm long and 125 mm in width were built. The principal example was readied with no support while the second example was fortify with fortification of T10 mm. Results demonstrated that, the created block (Brickool) met the base qualities required by British and American models and can be utilized as burden holding on for or without fortification. Be that as it may, at the top of the examples, the disappointment heap of divider example with bars has higher incentive with lower relocation than the divider example without bars. In the meantime, fortifying the divider by support result in high pressure and pressure strain.

Table 1. Specification & water absorption of interlocking Brickool [12]

Brick Type	Brickool unit (mm)			Mean (mm)	Specification BS3921:1985		Water Absorption (%)	Compressive Strength (N/mm^2)
	1	2	3		Max	Min		
Full brick								
Length	6012.0	6012.0	6014.0	6012.7	6153.6	5846.5	Mean Value for 10 samples = 15.54	11.96
Height	2401.0	2402.0	2402.0	2401.7	2496.0	2304.0		
Width	3007.0	3007.0	3006.0	3006.7	3096.0	2904.0		
Half brick								
Length	3006.0	3006.0	3006.0	3006.0	6153.6	2904.0		12.10
Height	2401.0	2402.0	2402.0	2401.7	2496.0	2304.0		
Width	3007.0	3007.0	3006.0	3006.0	3096.0	2904.0		

Table2. Specification & water absorption of the interlocking brick [12]

Spacemen	Ultimate Load [kN]	Compressive Strain x 10^{-6}	Tension Strain x10^{-6}	Max. Displacement [mm]	Min. Displacement [mm]
Wall 1	347.40	644.00	69.00	18.16	2.90
Wall 2	259.60	794.00	169.10	21.15	4.40

Ahmad et al. [13] inspected the compressive quality of the divider made of solid interlocking blocks with mortar and non-mortar glue. Results demonstrated that the compressive quality of solid interlocking blocks with or without mortar were fulfilled the base compressive quality required by BS3921:1985 which is 5.2 MPa for the regular solid squares. He presumed that the compressive quality of solid interlocking blocks with mortar glue is higher than the compressive quality of the regular solid squares. In the interim, solid interlocking blocks expands the compressive quality by 30% when mortar glue was utilized. Ahmed et al. [14] researched the conduct of interlocking brick work dividers created from concrete, laterite soil and sand. A test tests (physical properties, uprooting, and compressive quality) for square units and unreinforced divider boards were done under pressure load at various whimsies as represented on Figure 2. The outcomes appeared Table 3 demonstrate that the square is delegated basic block in agreement to BS 3921 and serious enduring evaluation in understanding to ASTM C62. The greatest compressive pressure of the unreinforced divider board is 3.60 N/mm2 witch agree to the prerequisite for private structure.

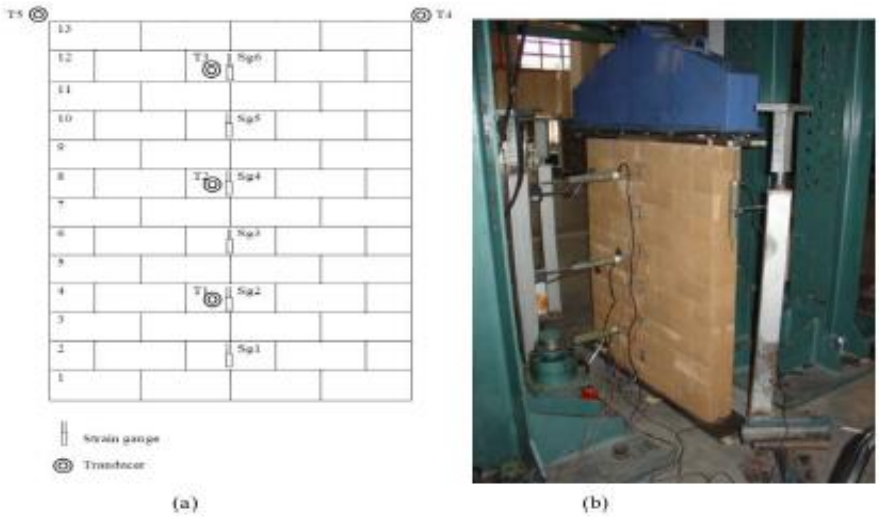

Figure 2. ILBW Test Arrangement (a) schematic diagram (b) actual [14]

Table 3. Compressive strength test of interlocking masonry walls with different eccentricities [14]

Sample	Eccentricity, e (mm)	Ultimate testing load (kN)	Ultimate design load (kN)	Compressive strength, f (N/mm^2)	Characteristics Compressive strength, f_k (N/mm^2)	Max. Displacement (mm)	Location of the displacemtn
ILBW1	0	443.05	131.35	3.56	3.0	5.79	T2
ILBW2	6.25	348.42	131.35	2.79	2.3	7.95	T5
ILBW3	12.5	271.63	108.36	2.17	1.8	7.18	T5
ILBW4	25	239.94	105.08	1.92	1.6	6.58	T5
ILBW5	50	6.03	32.84	0.048	0.04	11.63	T2

Safiee et al. [15] examined tentatively the conduct of mortarless divider examples made of Putra interlocking squares. Two diverse divider examples (empty and incompletely grouted) were built with similar sizes of 1000 mm in tallness, 1200 mm in width and 150 mm in thickness.

Both example were exposed to parallel burden (outof-plane) with consistent precompression load as appeared in Figure3. A few parameters have been explored, for example, conveying limit of parallel burden, mid-stature diversion, disappointment mode, strain trademark, and the opening of the dry bed joint of the divider board layers.The contemplate uncovered that the basic conduct of the interlocking divider boards under out of plane burden were altogether impacted by the precompression pivotal burden and the rebar. Additionally, the divider boards were ordered as burden bearing dividers.

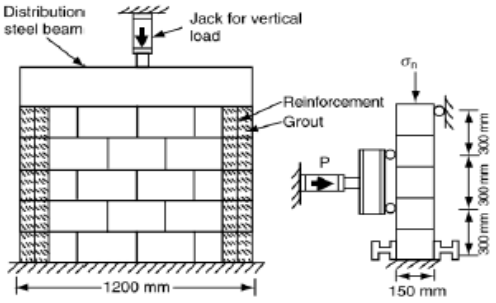

Figure 3. Test Set-up [15]

In planning the mortarless divider boards made of interlocking empty obstructs, the divider quality trademark must be surveyed. Stone work compressive quality considers the most noteworthy factor in planning block work structures and it chiefly oversees by the individual block unit quality. In this way, Jaafar, et al. [16] utilized Putra interlocking empty squares to create quality connection the unit empty squares (fcb), crystals (fcp) and dividers (fcw) exposed to pressure load for burden bearing. The person empty squares were comprised of three kinds (stretcher, corner and half squares) and forty unit of each type were experienced a pressure test. Ten examples of crystals, every crystal comprises of 2 stretcher squares and 2 half squares, were developed and tried under vertical pressure stacks so as to assess the crystal compressive quality. In the meantime, 4 divider examples with measurement of 1200 mm stature and1200 mm length were developed and afterward exposed to vertical pressure loads. In expansion, the system of the interlock, breaking and disappointment methods of the all examples were assessed. Thus, compressive quality connection between the square unit (fblock) and the crystal (fprism) observed to be fprism = 0.47fblock and the relationship between's the quality of the square unit and the divider board (fwall) observed to be fwall = 0.39fblock lastly the quality connection among's crystal and divider observed to be fwall = 0.83fprism. Interlocking conduct and square quality for burden bearing were fulfilled all the models necessities.

4. Behaviour of Contact Area Between Brick Layers :

Because of the nonappearance of mortar and the filling material between the workmanship block joints, the contact region should be examine with consideration. Likewise, the dry joint conduct is an indispensable structure parameters that must be estimated, hence just compressibility of dry joint ought to be explored. Past examinations has led tests to decide the conduct of contact zone between block layers and its impacts on the in general conduct of brick work frameworks. Ayed et al. [17] utilized a picture examination technique. A plain white paper gauging 80 g/m2 also, free of physical or compound impact on square has been utilized. The interface of the interlocking squares was painted and the white paper between the squares were put to print the contact region (Figure 4). A picture investigation was created on MATLAB so as to gauge the level of the contact surface imprinted on the paper.It changed the picture of the printed paper in white and dark pixels. Checking of pixels prompts the level of the contact region.Another ongoing examination done by Rekik et al. [18] utilized Digital Image Correlation technique to explore the compressibility of dry joints. Compressive tests on examples that cut from Magnesia-Carbon mortarless blocks were done. Tests were directed utilizing a heap cell of 200 kN (Figure 5) with an exactness of 0.2 % of the accomplished burden and 0.0330 mm/minute uprooting rate. 2-dimentioal advanced picture connection was used to quantify the dry joint conduct under pressure. Correspondingly, Andreev et al. [19] researched the dry joint conclusion of the stubborn blocks under pressure. The general reason for the test was to obtain information on the conclusion conduct of the dry bed joint under pressure load so as to get an unmistakable picture of the pressure and the joint circumstance amid the heater administration cycle. Along these lines, the joint conclusion conduct was observed in-straightforwardly through the pressure of the examples with and without joints in broad temperature assortment.

Figure 4. Identification of contact area [17]

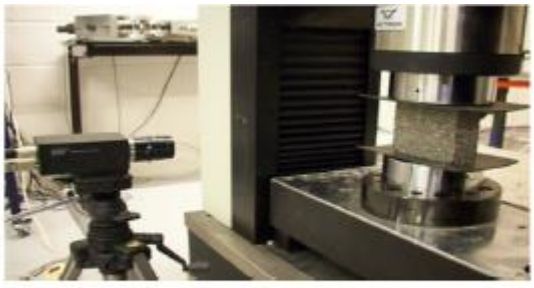

Figure 5. Experimental test set up on dry joint test [18]

Ayed et al. [17] broke down the impact of contact zone and the leeway between the squares on the mechanical conduct of interlocking settled earth square (ISEB). The ISEBs were put dry without grouting and tried under pressure load tests to the mechanical conduct and the contact zone impacts while, the impact of the nearby worry around the leeway were performed by limited component displaying. The ISEB fabricated by red earth, sand, and 8 percent of bond. The compressive tests were led on individual square, single joint which comprises of two interlocking squares, and different joints that comprises of three interlocking squares as appeared in Figure 6.

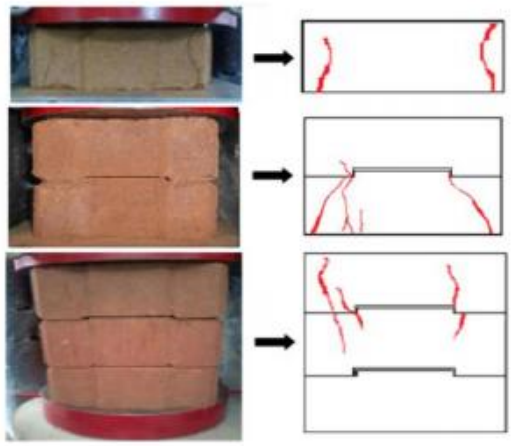

Figure 6. Compressive tests and cracking pattern for individual block, single, and multiple joints [17]

Therefore, the compressive quality for individual square, two squares, and three squares were 11.9 MPa, 8.2 MPa, and 5.5 MPa, individually. That implies the contact region and the freedom between the squares impact the stone work's compressive quality, making it decline. Jaafar et al. [20] examined the conduct of the dry joints of interlocking brick work (Figure 7) exposed to hub pressure load and thusly their effects on the basic conduct of crystals made of mortarless interlocking squares in both grouted and un-grouted. The basic conduct of the reaching zone between blocks layer (dry joint) were assessed by directing single and numerous joints tests with the thought of geometric insufficiencies in that faces. The outcomes demonstrated that, geometric blemishes were altogether influenced the conduct of the dry bed joint between the block layers. Verities of misshapening shapes were distinguished in both grouted and un-grouted mortarless interlocking crystals. In the un-grouted crystal, the twisting were embraced place till the connected pressure fellow achieves 0.57 of the maximum. load. Dry bed joint was for the most part influenced the distortion of un-grouted crystal till the pressure load achieves 0.570 of the decided burden. Be that as it may, this conduct was most certainly not regularly occurred in the early stacking of the grouted crystals where it initiated just when 0.380 of the maximum. load was connected. Moreover, grouted crystals accomplished high quality and lower twisting contrasted and the un-grouted crystals.

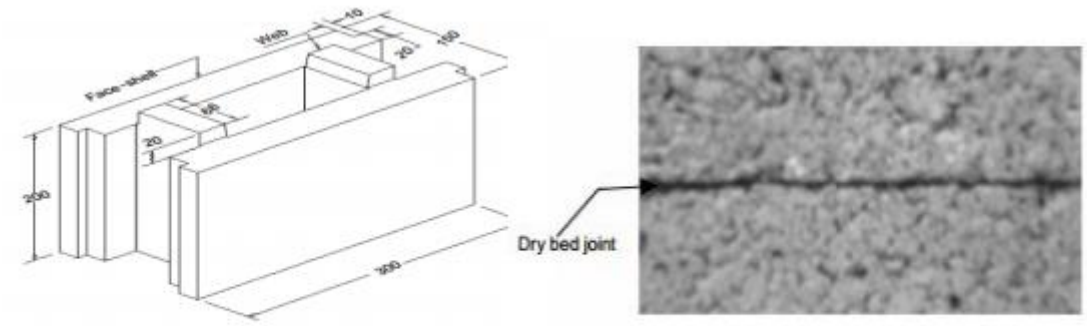

Figure 7. Details of interlocking block unit and the dry bed joint [20]

In addition, Safiee et al. [15] inspected the dry joint opening of interlocking mortarless divider subject to out-of-plane burden. Amid testing, the dry joint opening component around mid-tallness of divider was overwhelmed. The opening was estimated by Demec focuses at a few areas along the divider surface. The opening of center courses of divider expanded as horizontal burden expanded for all arrangement of examples. The absolute opening might be influenced by both sidelong burden and higher pre-compressive burden.

5. Conclusion :

Taking everything into account, the interlocking block improvement is exhibited in this investigation and affirmed that this framework is used in brick work structures. As needs be, the idea of interlocking framework has been generally utilized as a substitution of the ordinary framework. It tends to be presumed that the state of the interlocking block shifts with effortlessness which result in simple and quick creation and get together in the workmanship frameworks. In addition, the interlocking component of all the various sorts of interlocking blocks is adequate to interlock the collected blocks in various ways. In view of the looks into of the basic conduct of interlocking blocks, it tends to be presumed that the interlocking squares have met the least particulars and necessities according to British and American Standards. Additionally, it confirmed that interlocking block can be used either as burden bearing divider or non-load bearing framework.

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References:

[1] Shakir A A and Mohammed A A 2013 Manufacturing of Bricks in the Past, in the Present and in the Future: A state of the Art Review Int. J. Adv. Appl. Sci. 2 145-56

[2] Allen E and Thallon R 2011 Fundamentals of residential construction (John Wiley & Sons)

[3] Irwan J, Zamer M and Othman N 2016 A Review on Interlocking Compressed Earth Blocks (ICEB) with Addition of Bacteria. In: MATEC Web of Conf.: EDP Sciences) pp 0-5

[4] Korany Y and Humphrey S 2010 Proc. of the 2nd Masonry Mini Symp.

[5] Anand K and Ramamurthy K 2005 Development and evaluation of hollow concrete interlocking block masonry system Masonry Soc. J. 23 11-9

[6] Khan S S and Deshmukh A S 2015 Mortarless Masonry with Interlocking Blocks Int. J. Res. Eng. Sci. Technol. 1 314-9

[7] Fay L, Cooper P and de Morais H F 2014 Innovative interlocked soil–cement block for the construction of masonry to eliminate the settling mortar Constr. Build. Mater. 52 391-5

[8] Thanoon W A, Jaafar M S, Abdul Kadir M R, Abang Ali A A, Trikha D N and Najm A M S 2004 Development of an innovative interlocking load bearing hollow block system in Malaysia Constr. Build. Mater. 18 445-54

[9] Abang Ali A and Abdul Kadir M 1987 Strength properties and structural performance of interlocking hollow block walls J. Inst. Jurutera Malya. 53 25-35

[10] Tang Z, Ali M and Chouw N 2014 Residual compressive and shear strengths of novel coconutfibre-reinforced-concrete interlocking blocks Constr. Build. Mater. 66 533-40

[11] Ali M, Briet R and Chouw N 2013 Dynamic response of mortar-free interlocking structures Constr. Build. Mater. 42 168-89

[12] Osman S A, Mohamed Z S, Sulaiman A and Ismail M F 2014 Experimental analysis of Interlocking load bearing wall brickool system Key Eng. Mater. 594-595 439-43

[13] Ahmad S, Hussain S, Awais M, Asif M, Muzamil H, Ahmad R and Ahmad S 2014 To Study The Behavior Of Interlocking Of Masonry Units/Blocks IOSR Journal of Engineering 4 39- 47

[14] Ahmed Z, Othman S, Yunus B and Mohamed A 2011 Behaviour of Masonry Wall Constructed using Interlocking Soil Cement Bricks World Acad. Sci. Eng. Technol. 60 1263-9

[15] Safiee N A, Jaafar M S, Alwathaf A H, Noorzaei J and Abdulkadir M R 2011 Structural behavior of mortarless interlocking load bearing hollow block wall panel under out-of-plane loading Adv. Stru. Eng. 14 1185-96

[16] Jaafar M S, Thanoon W A, Najm A M, Abdulkadir M R and Ali A A A 2006 Strength correlation between individual block, prism and basic wall panel for load bearing interlocking mortarless hollow block masonry Constr. Build. Mater. 20 492-8

[17] Ayed H B, Limam O, Aidi M and Jelidi A 2016 Experimental and numerical study of Interlocking Stabilized Earth Blocks mechanical behavior J. Build. Eng. 7 207-16

[18] Rekik A, Allaoui S, Gasser A, Blond E, Andreev K and Sinnema S 2015 Experiments and nonlinear homogenization sustaining mean-field theories for refractory mortarless masonry: The classical secant procedure and its improved variants Eur. J. Mech. A Solids 49 67-81

[19] Andreev K, Sinnema S, Rekik A, Allaoui S, Blond E and Gasser A 2012 Compressive behaviour of dry joints in refractory ceramic masonry Constr. Build. Mater. 34 402-8

[20] Jaafar M, Alwathaf A, Thanoon W, Noorzaei J and Abdulkadir M 2007 Behaviour of interlocking mortarless block masonry Constr. Mater. 159 111-8