Autoclaved aerated concrete (AAC) shear and tensile bond strengths with various mortar formulations and thicknesses.

DOI : 10.36909/jer.ICMET.17169

Abhishek Thakur*, Saurav Kumar**

Jaypee Universityof Information Technology. P.O.Waknaghat, TehKandaghat,Distt. Solan PIN-173234

* Corresponding Author: abhishekthakur.research@gmail.com

ABSTRACT

For masonry walls, autoclaved aerated concrete (AAC) blocks are widely utilised. Compression and tension bonding must constantly be calculated for various mortar mixtures to evaluate the strengths of the AAC block-mortar contact a mortar with a polymer modification and conventional cement sand mortar (1:5 or 1:7) with a thickness of 12mm, 17mm, or 22mm are examined for binding strength on an AAC block mortar interface. Before pouring the cement sand mortar into the brickworks, On the block surface, a thin cement slurry covering was placed. A three-fold analysis was used to estimate the shear bond strength for all types of interfaces, while a cross-couples test was used to evaluate the tensile bond strength.The modified polymer mortar (PMM) had a shear bond strength of 0.15 MPa, with block failure of the vigorous failure type, whereas the cement sand mortar had the greatest shear bond strength of 0.14 MPa, with a cement-sand mortar ratio of 1:5 and a thickness of 17 mm. Since the tensile bond strength of all test specimens utilised in this study was evaluated, PMM had the greatest tensile bond strength of 0.22 MPa. Based on observed failure patterns and the strength of the tensile and shear bond of AAC mats, a 1:5 ratio cement sand or modified polymer mortar with a thickness of 17 mm can be selected from all possibilities for AAC brickwork.

Keywords: AAC block, cement sand mortar, polymer-modified mortar.

INTRODUCTION

AAC is the most often used residential and commercial building material. Because of their qualities, low density, and good fire resistance. It's gaining popularity as a potential replacement for clay and fly ash bricks. AAC blocks have been proven to be useful in a variety of applications and scenarios (Wittmann et al., 1983; Concrete & Wittmann, 1992).AAC block building is reasonably simple and quick due to the availability of large-size blocks. AAC may be made with a variety of cementitious materials, although the most common are Portland cement, fly ash, and sand. Sand can help achieve the necessary fineness, according to Hamad (2014). The amount of aluminium powder in the sample that gives the block its cellular structure also affects the density of the resultant block .The structure of the LCA is distinct from other lightweight concrete materials, with its simple and insulating characteristics, by including aluminium paste into the formula (Aroni et al., 1993) AAC is a versatile compression material of 1,50 to 10,00 MPa with a density of between three hundred,00 and three thousand and one thousand m3/kg. Due to its density and porosity, the AAC block is compressive. Porosity rises and density decreases stated Alex. A suitable quantity of cement material should be present in contact between blocks to ensure appropriate bond strength. Two kinds of cement-sand mortar and PMM joints have been applied. A thin covering of PMM (2-4mm) has been utilised in the building of AAC masonry. Thin layer polymer-based mortar for concrete masonry with a density of 2mm has been utilised by Thamboo & Dhanasekar (2015). It is used 1.5mm thick cementations grey glue joints to investigate the compressive and bending strengths of AAC masonry. Mallikarjune (2017) investigated the binding strength of AAC masonry using heavy sand-cement mortar joints. The strength of the binding and the compression of cement-based cement-sand mortar AAC mudstone thickness vary in reality from 10 mm to 18 mm using a pole (2019) (IS:2250-1981). It was confirmed in 2000 and 1981. The thickness of the cement sand mortar joint in AAC block construction, on the other hand, has received very little attention. The purpose of this study is to examine the effectiveness of AAC mazes in a variety of situations is 12-mm, 17-mm, and 22-mm sand-mixed mortars using 1:5 and 1:7 ratios.

Materials and Procedures

For this research, 108 AAC eco-blocs in 600 mm * 200 mm * 125 mm from one batch were made available by a local firm. The test specimens were evaluated at the Rajiv Gandhi Government Engineering Testing Laboratory. Three compressive strength blocks, 65 shear force blocks, and 45 tensile strength blocks were utilised for testing.

Materials for Joints

Before the research to assess the shear and tensile connection strengths of AAC brickwork began, the properties of the cement, sand, and AAC block utilised in the test were analysed. According to IS 4031 - 4, (2005) a Vicat instrument with a 10 mm plunger diameter was used to assess the typical consistency of cement paste. To test the binding strength of AAC, we employed two types of joint materials: pmm and cement sand mortar (CSM).A polymer, cement, and aggregate composite is called PMM. In an AAC block construction, a thin PMM covering of 2-4mm thickness is frequently employed. In the study, PMM was generated using combinations of 300 ml of water and 1 kilogram of dry mortar mix. The concrete sand mortar was mixed into two quantities: 1:5 and 1:7. Every cement mixture was sand mortar in thicknesses ranging from 12mm, 17mm and 22mm. The strength of the bond was then assessed on an AAC block surface. Before the cement sand mortar was placed on the block surface according to Raj et al., a concrete slurry was filled (2020). IS:2250 in 1:4 and 1:6 and PMM ratio evaluated the compressive strength of cement sander mortars (1981 Reaffirmed 2000, 1981).

Methods

The final aim of the study was to examine AAC masonry bond strength using 4mm PMM and Ratios of cement to sand in mortar 1:5 and 1:7 in 12mm, 17mm, and 22mm thicknesses. The entire procedure is illustrated in Figure 1.

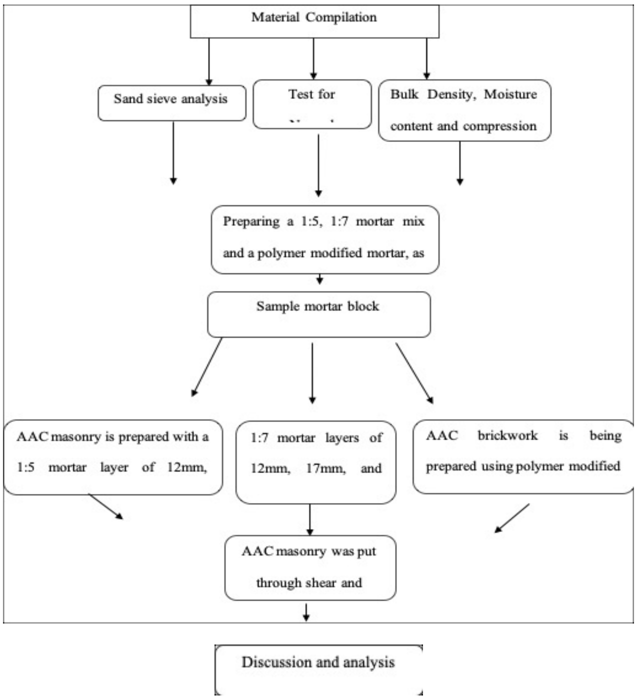

Figure 1: The study's overall flow

AAC blocks have certain characteristics

The physical characteristics of AAC blocks, such as mass and humidity, were examined in the IS 6441. (2001). The strength of the connection was measured using ASTM standards (1991). To assess bulk densities and water content the compression strength of the AAC block was established using equal blocs. This test was performed on three separate blocks using IS 6441 (2001). Three pieces, measuring 200 mm x 200mm x 100mm, was divided into samples. The compressive strength of the nine AAC components created was then measured using three samples.

AAC masonry tensile bond strength is evaluated.

The sample cross-couplet with AAC block and mortar bedded joints was provided. For the preparation of specimen and tensile bond resilience testing, ASTM standards were followed (1991).

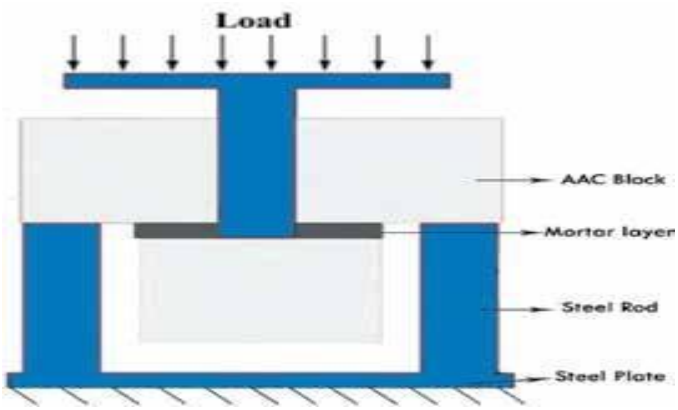

Figure 2: Tensile strength configuration for AAC

The strength of the AAC block and the mortar contact was determined using a cross-couplet test, as illustrated in Fig. 2. The maximum load supplied in the case of failure is: The strength of the tensile bond was computed as follows:

$$\tau_t = \left(\frac{(Pt)max}{A}\right).$$

(1)

Where, P_{max} At the point of failure, thepeak load, A is Contact area

AAC shear bond strength is evaluated.

The AAC block shear bond strength and mortar contact were evaluated using a triplet test, as illustrated in figure 3.

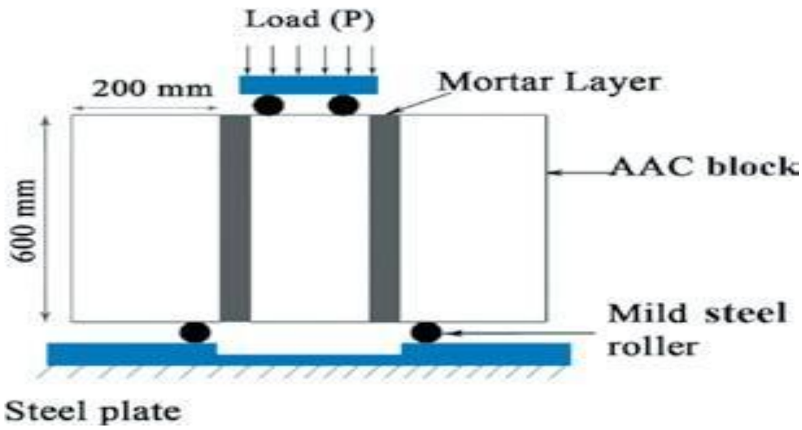

Figure 3: The AAC Shear Test was created. The shear bond's tensile strength is

$$\tau = \left(\frac{P_{max}}{2A_c}\right) \quad (2)$$

Where, P_{max} Peak shear load recorded at failure Ac is Contact area of thejoint

The Results and Discussed

In the AAC blocks, both the physicality and the requirement for joint materials were assessed (bulk density, humidity, and compressive strength). The MAA-containing PMM's shear and tensile bond strength could therefore be measured. AAC masonry showed equivalent results with cement sand mortar ratios of 1:5 and 1:7 and thicknesses of 12 mm, 17 mm, and 22 mm, as previously indicated.

AAC Block Physical Characteristics

1. The AAC blocks' average mass density was 522 kg/m^3 according to experimental data in the table.

2. As indicated in Table 2, the AAC block humidity was 44.44%. During the compressive strength test, the sample was loaded at a rate of 0.05 to 0.199N/mm2 until the force could

be stopped. The compression strength of the block AAC samples was averaged by 3.44 MPa, as stated in Table 3.

Joint material characteristics are identified

The usual consistency of cement was found to be 30 percent in the experiment. (Fig. 4a). Similarly, a study of the sieve found that the fine sand modulus was 2.74 (Fig. 4b); the average fine aggregate particle size was 0.4 to 0.7 mm, which was inside the sand-mortar BIS (2116) limit.

Table 1: AAC block density in bulk

Weight (before drying) in kg	Length (cm)	Breadth (cm)	Thickness (cm)	Volume cm^3)	Weight (after drying) in kg	Bulk density (g/cm^3)
8.83	59.88	19.82	9.97	11832.611	6.28	0.55

Table 2: AAC blocks' moisture content

Weight of blocks (before drying- W1 in kg)	Weight of blocks (after drying- W in kg)	Moisture content F (%)
8.83	6.28	43.75

Table 3: AAC blocks compressive strength (9 tests on average)

Weight of blocks in Kg	Area of blocks in mm^2	Thickness of Blocks in mm	Ultimate load in KN	Compressive strength in N/mm^2
2.00	39145.00	99.00	128.00	3.39

(A) (B) (C) (D)

Figure4: The following are the material properties: (A) normal cement consistency, (B) sand sieve analysis, (C) mortar samples, and (D) AAC block compression test.

The compressive strengths of the cement-sand mortars employed in the experiment (Fig. 4c) were 15.00 N/mm2 and 8.99 N/mm2, according to Table 4, where as the PMM's compressive strength was 12.39 N/mm2.

Table 4: After 28 days of curing, the cement sand mortar was tested for strength**.**

Mortar Ratio	**Cube's weight**	**Ratio of water to cement**	**The area of a cube's cross-section (mm^2)**	**Maximum Capacity**	**Compressive strength (N/mm^2)**
1:5	0.80	0.70	4900.00	74644.44	17.19
1:7	0.78	0.90	4900.00	45555.00	10.00
PMM	0.70	0.36	4900.00	58888.88	12.00

Masonry Triplet Shear Bond Strength

As illustrated in Figs. 5a and 5b, three specimens were created and analyzed. The test comprised of three unique failure patterns for the triplet specimen. Shear joints were predicted to fail early and be feeble. The block failure mechanism was discovered in at least three cases. According to the triplet test, the block mortar interface failed in any arrangement. Mortar failure (Type B, Figure 6b) and block failure (Type A, Figure 6a) (Type C as shown in Fig. 6c) For AAC brickwork using cement sand mortar, the shear bond strength should be in the range of 0.07-0.15 MPa, according to triple test findings in Table 5, while AAC masonry employing PMM exhibited a maximum shear bond strength of 0.14 MPa. The majority of failure patterns for the 1:7 cement sand mortar blend were Type B or Type C, or both. The connection with 17 mm mortar thickness demonstrated a maximum shear binding resistance of 0.15 MPa in a 1:5 cement sand mortar coupled with a failure type A.

Thus, the optimum choice for shear bond strength for all mortar joints utilized in this research seems to be cement-sands with a ratio of 1: 5 and 17mm thickening.

Table 5: The triplet test of AAC masonry yielded the following results.

Mortar Ratio	Thickness (mm)	Area in cross-section (mm^2)	Load in Kg	Shear Bond Strength (N/mm^2)	Failuretype
1:5	12.00	58888.99	1174.55	0.12	Type A has one while Type C has two.
	17.00	60000.00	1614.22	0.16	Type A has two, while Type C has only one.
	22.00	59956.99	765.31	0.08	Type A has one while Type C has two.
1:7	12.00	59366.50	1178.80	0.12	Type B: 2; Type C: 1
	17.00	59334.60	1123.40	0.12	Type A has one and Type B has two.
	22.00	58999.99	992.70	0.10	Type B: 2; Type C: 1

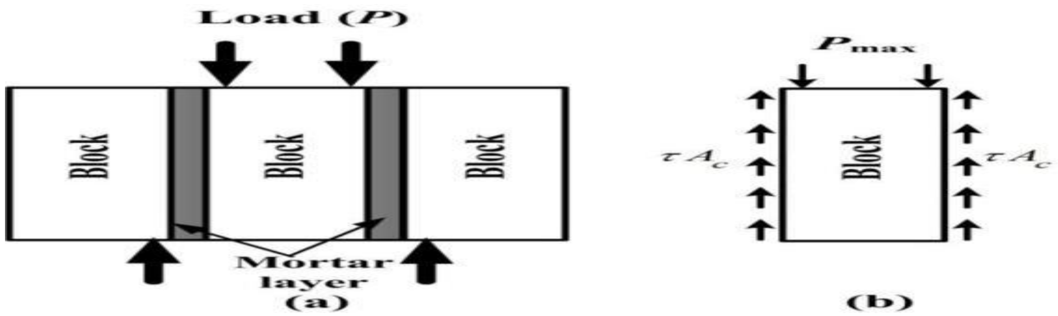

Figure 5: AAC triplet sample: (a) preparation of the triplet sample, (b) testing of the triplet sample

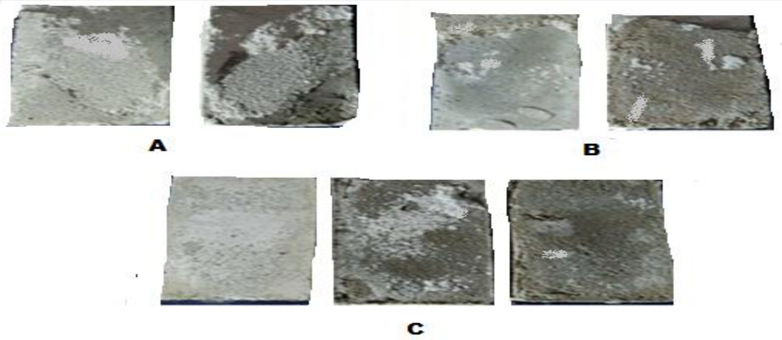

Figure 6: Failure patterns of AAC triplet specimens: (a) block failure (type-A), (b) mortar failure (type-B), and (c) block-mortar interface failure (type-C)

Masonry Cross-Couplet Tensile Bond Strength

In Fig. 7a and 7b, cross-coupling specimens were built and analysed. Figures 8A and 8B show the failure patterns found during the test. The joint failed fast and was fragile in stress. The failure patterns of the cross-couplets were:

1. Complete failure of the block-to-mortar interaction (Type I),
2. Failure of the block-mortar interaction in part (Type II),
3. The block's partial tensile failure (Type III),
4. The block has fully tensile failure (Type IV).

(A) (B)

Figure7: (A) cross-couplet samples, (B) tensile bond strength

test on cross-couplet specimen

Table 6 shows the cross-coupled test findings. (Fig. 7(a) and 7(b) as demonstrated). AAC block masonry has been shown to have tensile bond strengths of 0.03 MPa to 0.20 MPa. The tensile strength of PMM brickwork is 0.20 MPa, with the most frequent type IV failure.

On the other hand, a Type II failure was usually indicated with cross-couplet specimens' tensile bond strength, which had a 1:7 cement-sand mortar ratio and a 22mm thickness. Type IV failure was observed in all other cement sand mortar combinations. Any of the combinations of cement sand, mentioned in table 6 may be used for building AAC blocks, except for the 1:7 mortar ratio of a thickness of 22mm. Type IV shows that the tensile strength of an AAC masonry junction exceeds the strength of the tensile block, the majority of AAAC masonries failed. Therefore, all potential mortar combinations may be supplied (excluding cement sand mortar 1:7, 22mm thickness).

Table 6: AAC masonry cross-couplet test results

Mortar Ratio	Thickness (mm)	Area in cross-section(mm^2)	Load (Kg)	Strength of tensile bonds (N/mm)	Failuremode
1:5	12.00	33999.99	98.88	0.05	3 in Type IV
	17.00	36666.66	149.00	0.06	3 in Type IV
	22.00	35954.54	120.66	0.05	3 in Type IV
1:7	12.00	37777.87	78.44	0.04	3 in Type IV
	17.00	32999.99	110.88	0.03	3 in Type IV
	22.00	35646.66	88.66	0.04	Type II: 2; Type IV: 1
PMM	2-4	29800.00	182.00	0.26	Type IV in 3

With 1:7 mortar, a partially failing interface with a thickness of 20 mm was created (Type II, as shown in Fig. 8A). A section of the block or mortar is cemented together in this type of failure. The block collapsed completely under tension, yet a full tensile failure did not affect the joint (Type IV as illustrated in Figure 8B). When the block mortar contact's bond strength surpasses the block's tensile strength, this type of failure occurs. With 12 mm and 17 mm thick joints, the sort of failure pattern (IV) was found with PMM Morter, 1:5 Mortier, and 1:7 mortar.

(a) **(b)**

Figure8: (a) Incomplete block-mortar block (Type-II) interface failure, (b) tensile failure of the whole block (Type IV)

Bond Strengths Variation

The shear and tensile binding strength of the cement-sand mortar maceration in AAC were less than the shear and tensile binding strengths in PMM as shown in Tables 5 and 6. Although the shear bond strength for the 1:7 mortar was low, it was equal to the tensile bond strength of the 1:5 mortar at a joint thickness of 17mm. Compared to other combinations, the PMM or cement sands Mortier rate of 1:5 was determined to be best for shear bond strength in 17 mm thickness. All the combinations were nonetheless considered acceptable for the strength of the tensile bond (except for the cement sand mortar with a ratio of 1:7 and a thickness of 22mm).

Conclusions

The AAC Masonry shear and tensile strength were studied by triple and cross-coupling specimens. To evaluate the strength of the bond, AAC maceration was constructed in combination with the cement slurry covering with either conventional sand-cement mortar or PMM. The main results are as follows:

With a 1:5 mortar thickness of 17 mm, the heaviest shear bonded mix had a shearing strength of 0.16 MPa, whereas the PMM mortar had a shearing strength of 0.14 MPa. In both mortar mixes, the most common type of failure occurred. The tensile bond strength of the PMM mortar has been determined to be 0.26 MPa, the highest of all mortar mixes. Among the cement-sand mortars, the 1:5 mortar mix with a thickness of 17 mm had the highest tensile strength of 0.06MPa.

For the AAC brickwork the 1:5 and 17 mm thick PMM or cement-sand mortar can be utilized, taking the strengths and heavy bonding equipment in the AAC Massage into consideration and all combinations examined in this test's failure patterns.

References

Albayrak,M., Yörükogˇlu,A., Karahan,S., Atlıhan, S., Aruntas, H.Y.andGirgin, I., 2007. Influence of zeolite additive on properties of autoclaved aerated concrete. Building and Environment, 42, 3161–3165.

Alberto, A., Antonaci, P. and Valente, S., 2011. Damage analysis of brick-to-mortar interfaces. Proceedia Engineering, 10,1151-1156.

Aldolsun, S., 2006. A Study on Material Properties of Autoclaved Aerated Concrete (AAC) and Its Complementary Wall Elements: Their Compatibility in Contemporary and Historocal Wall Sections, Master Thesis, Graduate School of Natural and Applied Sciences, Middle East Techical University,Turky.

Alecci, V., Fagone, M., Rotunno, T. and De Stefano, M., 2013. Shear strength of brick masonry walls assembled with different types of mortar. Cons. and Build. Mater., 40, 1038□1045.

Alexanderson, J., 1979. Relations between structure and mechanical properties of autoclaved aerated concrete. Cement and Concrete Research, 9, 507-514.

American standard test method for bond strength of mortar to masonry units, ASTM C 952-91, United State, (1991) American standard test method for bond strength of mortar to masonry units, ASTM C 952-91, 1991. American Society for Testing and Materials (ASTM), United State

American standard test method for splitting tensile strength of masonry units, ASTM C 1006-07, American Society for Testing and Materials (ASTM) West Conshohocken, United State, (2007)

American standard test method for splitting tensile strength of masonry units, ASTM C 1006-07, 2007. American Society for Testing and Materials (ASTM) West Conshohocken, United State.

American standard test methods for sampling and testing brick and structural clay tile, ASTM C67-00, 4th Edn., American Society for Testing and Materials (ASTM) Philadelphia, United State, (2001)

ASTM C 1006-07, Standard Test Method for Splitting Tensile Strength of Masonry Units, American Society for Testing and Material (ASTM), West Conshohocken, United State, 2007.

ASTM C 952-91, Standard Test Method for Bond Strength of Mortar to Masonry Units, American Society for Testing and Material (ASTM), Pennsylvania, United State, 1991.

ASTM.2017a. Standard specification for autoclaved aerated concrete (AAC).ASTMC1693. West Conshohocken, PA, UnitedState.

Ayudhya, N. and Israngkura, B., 2011. Compressive and splitting tensile strength of autoclaved aerated concrete (AAC) containing perlite aggregate and polypropylene fiber subjected to high temperatures. Songklanakarin Journal of Science & Technology, 33 (5),555□563.

Basha, S.H. and Kaushik, H.B., 2014. Evaluation of nonlinear material properties of fly ash brick masonry under compression and shear. Journal of Materials in Civil Engineering, 27,04014227.

Chen Y., Zhang Y., Chen T., Zhao Y. and Bao S., 2011. Preparation of eco-friendly construction bricks from hematite tailings. Construction and Building Material, 25, 2107–11.

Chen, W.F., 2007. Plasticity in reinforced concrete. J. Ross Publishing, Cengage learning

Comité euro-international du béton, 1978. Autoclaved aerated concrete: CEB manual of design and technology, Construction Press, 12.

Costa A.A., Penna A., Magenes, G., Galasco, A., 2008. Seismic performance assessment of Autoclaved Aerated Concrete (AAC) masonry buildings. In Proc. 14th World Conference on Earthquake Engineering, Beijing, China,05-04.

Costa, A.A., Penna, A. and Magenes, G., 2011. Seismic performance of autoclaved aerated concrete (AAC) masonry: from experimental testing of the in-plane capacity of walls to building response simulation. Journal of Earthquake Engineering, 15(1),1-31.

Crisafulli F.J., 1997. Seismic behaviour of reinforced concrete structures with masonry infills, Ph.D. Thesis, University of Canterbury, Christchurch, New Zealand.

D'Altri, A.M., Messali, F., Rots, J., Castellazzi, G. and de Miranda, S., 2019. A damaging block-based model for the analysis of the cyclic behavior of full-scale masonry structures. Engineering Fracture Mechanics, 209,423-448.

Dassault Systems. Abaqus analysis user's manual 6.13-3, 2013. RI2013; Dassault Systems Providence: Waltham, MA,USA.

Demir, I., 2006. An investigation on the production of construction brick with processed waste tea. Building and Environment, 41(9), 1274-1278.