Experimental Investigation of Bond strength Autoclaved Aerated Concrete (AAC) Masonry

DOI : 10.36909/jer.ICMET.17171

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ABSTRACT

Masonry walls can be load-supporting as well as non-supporting in which AAC blocks are utilized. Binding tenacity of autoclaved aerated concrete block-mortar interfaces formed of standard cement-sand mortars of various formulas and polymer-modified mortars is investigated in this study.It is presented a method for increasingnormal sand-cement mortar's binding strength without modifying the block surface qualities. Following the application of a thin cement-slurry coating to the block surfaces, a thick sand and cement mortar is poured. A triplet test was used to establish the brickwork's shear bond persistence, while a cross-couplet test was used to determine the tensile bond strength. Bond strength test's failure patterns were investigated. The costs of AAC walls with various types of interfaces were then calculated.

Keywords: AAC,polymer-modified mortar, cement slurry and Bond strength of mortar

1. INTRODUCTION

Strong link joining the mortar and brick units is essential for a masonry wall. Many factors impact the growth of the masonry unit-mortar bond [1]. Formerly various studies have been undertaken on the bond strength of masonry. Groot looked into the effect of surface texture on the formation of brick-mortar bonds and discovered that bricks having irregular harsh surface-area pattern had higher bond strength than bricks having uniform smooth area texture. [2-

4].several scholars [5-8] experimented with different strategies to improve the bond persistence of clay brick and cement & soil block masonry. Capillary suction transports cementations material and water to the interface, ensuring continuity of contact between the two components [8-10]. An optimal quantity of cementations material at the contact is necessary for acceptable bond strength. In India, masonry specimen preparation is done with a 11-13 mm strong cement-sand mortar joints [3, 5, 7]. Polymers are becoming increasingly important for the current repairing and constructing industries [11]. Polymers are utilised as a solitary binder or as part of a cement–aggregate mix. The polymers (latexes, redispersible powders and soluble in water homopolymers) increase the persistence, flexibility, adherence, water-resistant, chemical resistance, and constancy of mortars significantly [12]. Thamboo et al. [13-16] used thin polymer-based cement with a thickness of 3 mm to characterise concrete masonry. There are limited studies on AAC masonry compared to research on the bond strength of clay bricks, earth, and cement blocks.Ref. [8,15] used a broad cement and sand mortar joint.

In this work, both heavy cement and sand mortar and a light polymer-modified mortar were used to assess the shear and tensile bond durability of AAC masonry. Cement slurry coating is used to improve bond strength is being inquired. The outcomes of different joint materials are compared.AAC masonry bond strength test failure patterns are explored too. According to the cost calculation of many joint products & strength of bond's study, an advanced type of mortar is offered.

2. Samples Preparation

The varying quantities of sand-cement by weight were utilized in standard sand-cement mortar. On cement-slurry coated blocks, A PMM is used to test the bond strength of AAC masonry. Cement mortar and sand mortar mix were investigated.AAC blocks were obtained from a regional business *(Magicrete Building Solutions, Haryana, India*). Utilization of these blocks for making 20 cube shaped specimens of 250 mm sides to measure moisture content, dry density and compressive persistence following IS 6441 [17]. Six AAC blocks with dimensions of 600×250×200 mm^3 were cut into cubes from the bottom (mould base side), middle, and top (mould open side) sections. Specimens are dried at warmth of 115 ºC for about 27 hrs to evaluate the dry density and dampness amount. After 10 days at room-temperature curing, the compressive persistence of these cubic specimens was evaluated. In addition, six 200×100×75mm^3samples were constructed to determine the AAC block's initial rate of absorption (IRA). By submerging block in 3 to 5 mm of water content, IRA was evaluated. The block’s standard dry density ranged from 590 to 695 kg/m3, with a mean density of 631 kg/m3 and a coefficient of variation (CV) of 0.08. Blocks had standardhumidity content of 7.00 % (CV= 0.29). Seven AAC blocks had an IRA ranging from 3.20 per $kg.m^{-2}.min^{-1}$ to 5.90$kg.m^{-2}.min^{-}$, with standard of 4.20$kg.m^{-2}.min^{-1}$(CV is equal to 0.41).The compressive strength of 20 cubic AAC specimens ranged from 2.50 MPa to 3.00 MPa (CV = 0.20), with a mean of 2.76MPa.The blocks' splitting tensile strength ranged from 0.22 to 0.42 MPa, with 0.30 MPa and a CV of 0.23 average [20].Autoclaved aerated concrete blocks are available in a variety of sizes, with the biggest being 625×200×300 mm^3.SCM1 (Powerful mortar): cement to sand weight ratio: 1/3. SCM2 (Mortar with a medium tensile strength): 1/6 cement-to-sand weight ratio. SCM 3 (Mortar that is brittle): 1/8 cement-to-sand weight ratio. Sum of 20 mortar cube specimens with a 75.0 mm edge length were constructed, including 8 of each SCM1, SCM2, and SCM3 type. The mortar specimens were made with binder is Portland Pozzolana cement, and fine aggregate is local sand [21-22].The water-cement ratios for SCM1, SCM2, and SCM3 were kept at 62 percent, 76 percent, and 96 percent, respectively, to ensure a steady working flow of 100 percent. The compressive strength of 75.0 mm After curing in water for 28 days and drying for 3 days, cubes of these mortars were tested with a universal testing machine (UTM) with a capacity of 1000kN.For production and testing of sand-cement mortar, IS 2250

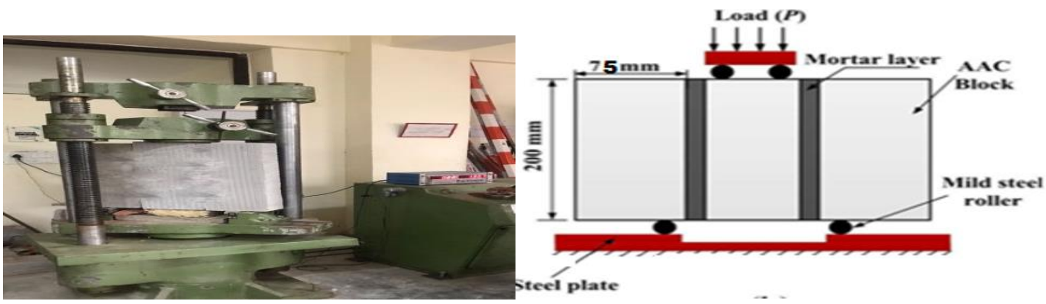
[23] was used specimens. Fly ash, cement, polymer additives and sand were used to make the PMM mortar. Fine sand made up 70% of the mix, cement made up 26%, fly ash made up 12%, thermoplastic polymers (vinyl acetates) made up 2.5 percent, and methyl hydroxyl ethyl cellulose made up 1.5 percent. During the specimen preparations, a 13 mm thick sand cement mortar layer was applied to the coated block surface. On all of the specimens' block-mortar contacts, a layer was placed. CSCM1, CSCM2, and CSCM3 are the distinct mixes of cement slurry coatings with SCM1, SCM2, and SCM3 mortars, respectively.

Table.1 Test results for mortars' compressive strength

Type of Mortar	Compressive strength on average (MPa)	Elasticity modulus (MPa)	Failure strain
SCM1	35.0[0.10][a]	1999 [0.35]	0.022 [0.35]
SCM2	20.0 [0.13]	1066 [0.50]	0.021 [0.42]
SCM3	10.0 [0.22]	699 [0.30]	0.016 [0.45]
PMM	7.44 [0.09]	300 [0.20]	0.040 [0.25]

The coefficient of variance is indicated in brackets. [a] Values in [ ]

After specimen preparation, AAC masonry bond strength is evaluated. A total of six specimens were examined for bond strength using each kind of joining material. Three-block units and two mortar coatings were used to create the triplet specimens. To deliver an uniform vertical (without pre-compression) load to the centre block, a 25 mm thick mild steel plate and two 15 mm diameter rollers were utilised, as illustrated in Fig. 1.



(A) (B)

Fig. 1. (A) Experimental setup Image (B) A view of the triplet test setup from the front.

The shear bond strength was calculated using the peak load during the test. Figure 3 shows the weights approaching the block, as well as a free body representation of the middle block. The tensile bond strength of the block-mortar contact was determined using a cross-couplet test. Two block units and one mortar layer were used to make the cross-couplet examples.

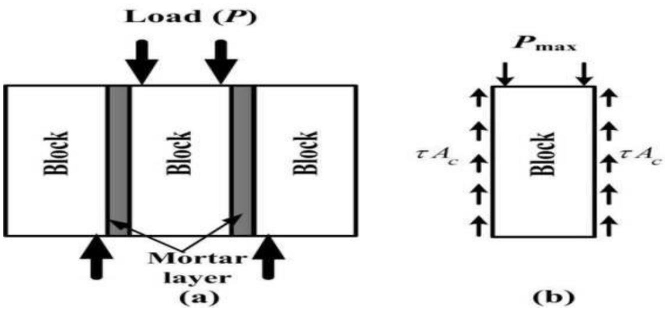
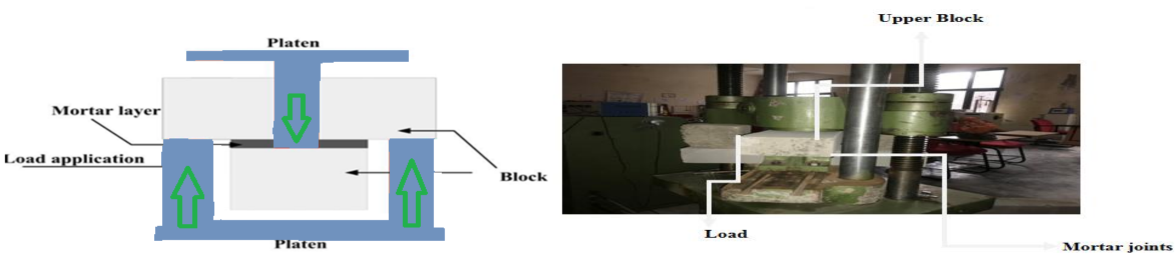


Fig. 2.(a) Loading factor (b) A schematic illustration of a triplet test.

Similar to the triplet specimens, an equal number of cross-couplet specimens were examined using various types of sand mortar and cement mortar, PMM mortar, and a mixture of sand mortar and cement mortar with cement slurry coating. The cross-couplet test setup is shown schematically in Fig.3. The specimen formation and testing procedures were executed according to the ASTM C 952 (ASTM 1991) standard.



(A) **(B)**

Fig 3:(A) Loading factor (B) A schematic design for a cross-couplet test

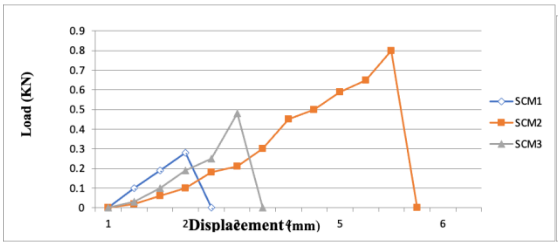
3. Results &Discussion

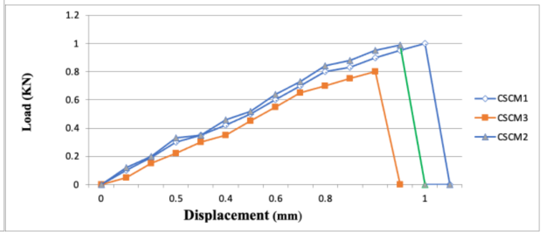
The findings of shear and tensile bond strength tests performed on various joining materials are given and compared. The triplet test results are listed in Table 2. All types of mortars have shear bond strengths ranging from 0.05 to 0.45 MPa. AAC masonry built using standard sand mortar & cement mortar has a poor shear bond strength, ranging from 0.03 to 0.11 MPa. Greater shear bond strength was observed in the range of 0.15 to 0.45 MPa using the mortars CSCM1, CSCM2, CSCM3, and PMM. Table 2 shows that the shear bond strength of all cement-coated specimens was of the equal order. The relative shear bond strength of the mortars CSCM1, CSCM2, and CSCM3 differed by 18% and 28%, sequentially. The dissimilarity in shear bond strength between SCM1 and SCM2 and SCM3 mortars was 45 and 60 percent, sequentially. The binding strength of brickwork generally improves as the cement component of sand-cement mortar increases. Figure 4 shows conventional load-displacement bend produced throughout the triplet test. The sliding failure was seen in the majority of the triplet specimens at the block-mortar contact. When using the triplet test, the block-mortar interface might fail in one of the following ways:1. Block failure (Type A),2. Mortar failure (Type B),3. Block-mortar interaction failure (Type C).The masonry triplets' unsuccessful patterns are represented in Fig.5, This depicts the surface of the bed from above. Strong joint materials, such as CSCM1, CSCM2, and PMM mortar, were found to have the highest rate of Type A triplet failure (Fig. 5 (a)). The block was sheared, and the following mortar layer trapped it. Mortar (type B) failure was mostly observed in CSCM3 mortar specimens (Fig. 5(b)).The deboning of the block-mortar interface produced block-mortar interface failure (type C). This kind of failure is most common in the fragile joints, such as in triplet specimens made with regular sand mortar &cement mortar mix.

Table No 2 : The AAC masonry triplet test results (average of 6 specimens)

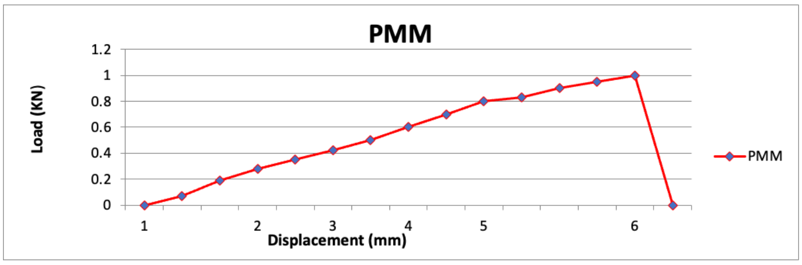
Types of joint	**The average load failure**	**Strength of the shear bond (MPa)**		**Type of triplet failure**
		Meanv	Range	

materials	(kN)	alue	Min	Max	
SCM1	3.00 [0.17]	0.08 [0.18]	0.07	0.10	Type C is found in six triplets.
SCM2	2.02 [0.38]	0.05 [0.38]	0.03	0.08	Type C is found in six triplets.
SCM3	1.12 [0.33]	0.04 [0.32]	0.03	0.05	Type C is found in six triplets.
CSCM1	9.99 [0.39]	0.28 [0.38]	0.22	0.45	Type A in five triplets and type C in one triplet
CSCM2	8.50 [0.12]	0.23 [0.12]	0.20	0.28	Type A in three triplets and type C in three triplets
CSCM3	8.00 [0.22]	0.20 [0.22]	0.15	0.28	Type B in four triplets and type C in two triplet
PMM	7.83 [0.24]	0.20 [0.24]	0.14	0.28	Type A in four triplets and type C in two triplets





(A) (B)



(C)

Fig. 4. During the triplet test, the load-displacement relationship was determined for the three types of mortar are sand-cement mortar, slurry coated with mortar and PMM

The results of the cross-couplet test in terms of tensile bond strength maximum, lowest, and mean values are shown in Table 3. Tensile bond strengths for all types of mortars range from 0.02 to 0.30 MPa. A typical load-displacement curve obtained throughout the test is shown in Figure 6.The cross-couplet produced by regular sand-cement mortar (SCM2, SCM3) has exceptionally low tensile bond persistence, varies from 0.02 to 0.08 MPa.

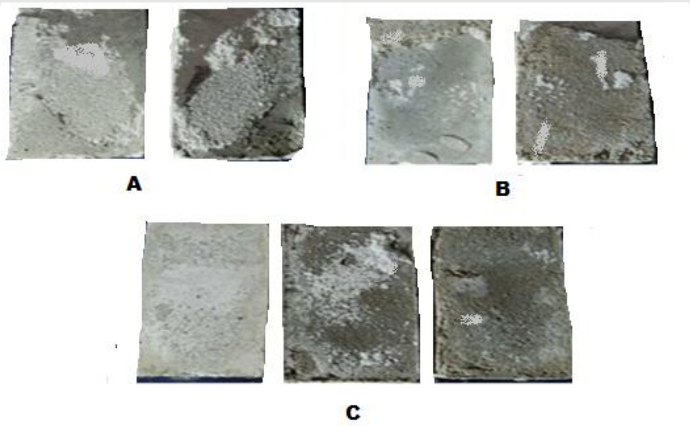
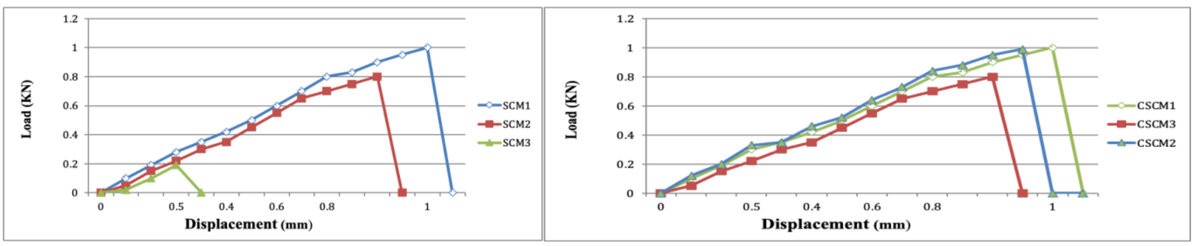
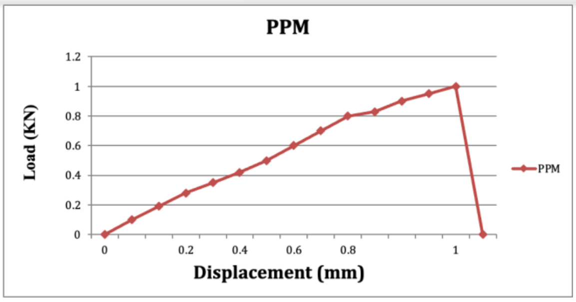


Fig. 5 Various AAC triplet specimen failure patterns

Thereafter, the Cross-couplet specimen tensile bond strength has been evaluated. However, in the case of SCM1, there was a notable improvement in tensile bond strength, ranging from 0.17 MPa to 0.20 MPa. Table 3 illustrates that the variations in tensile bond strength values using the cement slurry coating are small, independent of the kind of mortar used. Figure 7 depicts the unsuccessful arrangement of cross-couplet specimens during a tensile bond strength test. The block collapsed under tension but the joint remained intact in the case of total tensile failure of the block (Type IV) (Fig. 7 (d)). Because the tensile strength (estimated based on the splitting tensile strength) of the AAC block ranges from 0.21 MPa to0.35 MPa, the failure pattern of type (III) and type (IV) was widely seen utilising the mortar PMM, CSCM1, CSCM2, and SCM1.



(A) (B)



(C)

Fig.6 During the cross-couplet test, the load-displacement relationship for (a) sand-cement mortar, (b) mortar with slurry coating, and (c) polymer-modified mortar.

Table 3

The findings of the AAC masonry cross-couplet test are as follows: (average of 6 specimens)

Material Joints Types	The average failure of load	Tensile strength of a bond (MPa)			Failure mode of a cross-couplet
		Mean	Range		
			Min	Max	
SCM 1	1.95 [0.08]	0.20 [0.08]	0.17	0.21	Type III in five couplets and type IV in one couplet
SCM 2	0.60 [0.21]	0.08 [0.21]	0.06	0.08	Type I in four couplets and type II in two couplets
SCM 3	0.23 [0.50]	0.04 [0.48]	0.02	0.04	Type I in 6 couplets
CSCM 1	1.97 [0.10]	0.20 [0.10]	0.20	0.24	Type IV in 6 couplets
CSCM 2	1.77 [0.15]	0.18 [0.15]	0.17	0.23	Type IV in four couplets, type III in two couplets
CSCM 3	1.50 [0.19]	0.17 [0.19]	0.13	0.22	In six couplets, type II is used, while in one couplet, type III is used.
PMM	3.79 [1.18]	1.28 [1.18]	1.20	1.30	Type IV in 6 couplets

Bracket specify the coefficient of variation [a] Values in [ ]

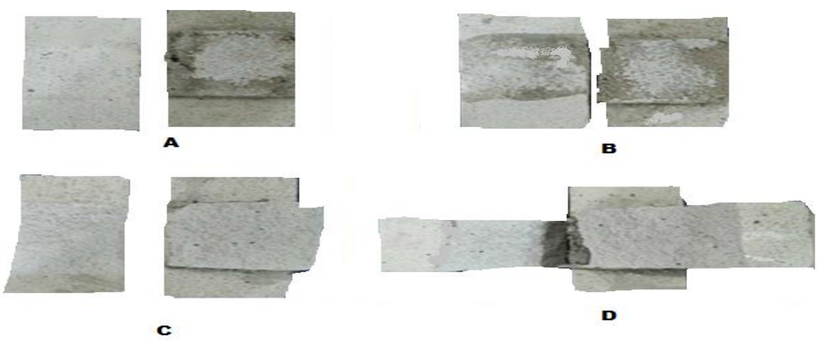


Fig. 7. AAC cross-couplet specimen failure patterns

Thereafter, a comparison has been made between bonding strength of different connecting materials. As demonstrated in Tables 2 and 3, AAC masonry made with typical sand-cement mortars, such as SCM2 and SCM3, has poor shear and tensile bond strengths. Then in next, an estimation of the AAC wall's dimensions of 1900·1000·250 mm^3mortar costs is made. Table 4 shows the comprehensive expenditure estimation. The wall assembly was made up of 15 AAC blocks of 600·250·200 mm^3 and 30 mortar joints (18-bed joints and 13 head joints), as illustrated in Fig. 8.

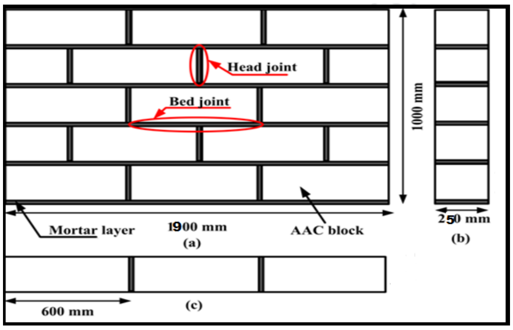


Fig. 8 (a) from the front, (b) from the side, and (c) from the top**.**

A total of 4107 mm^3 of sand-cement mortar is kept in the wall. when the block length is 600 mm, the width is 250 mm, the joint thickness is 13 mm, the total amount of head joints is 13, and the total amount of bed joints is 18. Table 4 shows that the sum of mass of SCM1, SCM2, and SCM3 used in the wall is 67.73 kg, 65.88 kg, and 60.90 kg, sequentially, due to the various densities of the sand mortar cement mortar mix.Cement, sand and PMM powder prices were obtained from the local market (Magicrete, Haryana, India). The costs of a 50-kilogram bag of cement, 1600 kg of sand, and a 30 kg bag of PMM powder, respectively, are $ 7.10, $ 31.00, and $ 11.99. In addition, the labour cost of preparing the mortar with all of the joint ingredients was taken into account. In India, one constructor and single assistant are usually needed to build a complete AAC wall of 1m^3 in 7-hour workdays. Mason and assistant everyday earnings are $ 9.99 and $ 6.89, respectively. Table 4 shows that the overall cost of utilising the SCM3 mortar is lowest; the most costly mortar is the CSCM1. When the worth and endurance of several mortars are compared, in Tables 4, 3, and 2, the mortar CSCM3 is determined to be the elite alternative for creating walls with AAC blocks.

Table 4 The cost of mortar for a large AAC wall of dimension 1900·1000·250 mm^3

Types of Mortar	Sand (kg)	Cement (kg)	PMM (kg)	Coating with cement (kg)	Total amount of mortar(kg)	The price of mortar	Cost of labour	Total cost ($)
SCM1	46.22	24.22	Nil	Nil	69.65	4.88	5.77	8.85
SCM2	53.77	14.99	Nil	Nil	68.88	3.99	5.27	7.86
SCM3	53.67	9.66	Nil	Nil	60.98	3.00	5.17	7.31
CSCM1	47.50	24.22	Nil	2.24	68.88	4.22	7.12	10.74
CSCM2	53.80	14.99	Nil	2.24	67.89	3.75	7.12	9.75
CSCM3	53.30	9.58	Nil	2.24	62.10	3.28	7.12	9.20
PMM	Nil	Nil	12.95	Nil	13.94	5.43	5.27	9.60

As a result, CSCM3 is the best option when it comes to pricing, supply chain, and bond strength. PMM mortar is viable option too by reason of its total price is just slightly higher than CSCM3; nevertheless, its availability could be an issue in some circumstances. Although PMM mortar has higher bond strength, the total cost of building a wall with CSCM1 and CSCM2 mortars is cheaper.

Conclusions

Using triplet and cross-couplet specimens, the bond strength of AAC masonry is examined. To evaluate the masonry bond strength, the AAC masonries were erected with a traditional sand-cement mortar and a polymer-modified mortar. A blend of sand-cement mortar and cement slurry coating was used to increase masonry bond strength. Additionally, the cost of mortar is calculated for a number of different joint materials. This study's findings might be used to draw these conclusions.

• The cement-sand mortar with the lowest cement content, SCM3, had the lowest shear bond strength, while the combination of the most abundant cement mortar and cement slurry covering, CSCM1, had the highest shear bond strength.

• The SCM3 mortar has the poorest tensile bond strength, whereas the PMM mortar has the greatest.

• Although there is 72 percent dissimilarity in between SCM1 and CSCM1, the shear bond strength value variance is just 19 percent.

• Ultra-highest bonding strength mortar isn't advised since AAC is a less in weight, permeable, and low-density product.

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