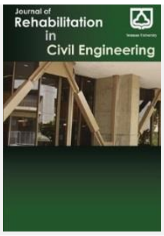
Journal of Rehabilitation in Civil Engineering 13-1 (2025) 48-65



Journal of Rehabilitation in Civil Engineering

Journal homepage: https://civiljournal.semnan.ac.ir/

The Impact of Mortar Properties on the Compressive Strength of a Masonry Prism

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ARTICLE INFO

Article history:
Received: 05 January 2024
Revised: 15 June 2024
Accepted: 01 August 2024

Keywords:
Mortar;
Cement to sand ratio;
Compressive strength;
Prism;
Failure pattern.

ABSTRACT

Masonry buildings remain popular worldwide due to their readily available materials, high compressive strength, ease of construction, and affordability. Therefore, understanding the impact of mortar on the compressive strength of masonry is essential. This study aimed to determine the compressive strength and failure patterns of masonry, focusing particularly on mortar. An experimental program was conducted, involving a total of 54 specimens: 27 cubes, 27 cylinders, and 9 masonry prisms. The cement-to-sand ratio (c/s) varied at ratios of 1:3, 1:4, and 1:5, while the water-to-cement ratio (w/c) remained fixed at 0.45. Each prism consisted of 5 bricks separated by a 10 mm mortar layer. Compressive strength data for cubes and cylinders were collected at 3, 7, and 28 days, while data for prisms were collected only at 28 days. The best results have been obtained at a c/s ratio of 1:3, with compressive strengths of 3555.5 psi for cubes, 3282.98 psi for cylinders, and a compressive force value of 129.33 kN for prisms at 28 days. The compressive strength of cubes and cylinders increases by approximately 68.19% and 64.61%, respectively, and the compressive force of masonry prisms increases by approximately 76.48% at 28 days when the cement-to-sand ratio is changed from 1:5 to 1:3. Stresses, graphs, and failure patterns have been analyzed and compared with the Bangladesh National Building Code (BNBC) 2020 and available literature, revealing a strong correlation.

E-ISSN: 2345-4423

How to cite this article:
Shuvo, R., Chowdhury, S., Ripa, R., Sabrin, S., & Shohag, F. (2025). The Impact of Mortar Properties on the Compressive Strength of a Masonry Prism. Journal of Rehabilitation in Civil Engineering, 13(1), 48-65. https://doi.org/10.22075/jrce.2024.32890.1971

1. Introduction

For thousands of years, masonry constructions have stood as enduring reminders of human creativity and skill. The use of mortar and stone has shaped the architectural landscapes of civilizations worldwide, from the majestic pyramids of Egypt to the imposing cathedrals of Europe [1].

Masonry is believed to have been used for over 6000 years, rendering it one of the oldest construction materials known to humanity [2]. Masonry construction is still a common technique nowadays and is still quite popular in many regions of the world.

A broad range of materials can be used to create masonry units, which come in both solid and hollow forms. In masonry construction, materials such as clay bricks, calcium silicate bricks, concrete blocks, soft mud bricks, hollow blocks, and compressed earth bricks are commonly employed. In this study, a masonry prism is constructed using clay bricks as the masonry units, which are joined together with mortar [3]. Mortar, a bonding agent, is typically created by blending fine aggregate (commonly sand) with water and a binding agent (such as lime or cement) [4]. Mortar corrects imperfections in the blocks, creates a more uniform distribution of loads, and accommodates deformations caused by thermal expansion and shrinkage [5]. Significant consequences for the construction industry are borne by previous research findings. Specifically, recommendations are offered regarding the selection of suitable mortar formulations and the optimization of building techniques to enhance the structural performance and longevity of masonry structures [6].

Masonry is often weak in tension because the two material phases are linked by a weak interface [7]. The strength of a masonry wall depends on both the bond strength at the brick-mortar connection and the compressive strength of the masonry unit [8].

In the design of masonry constructions, the primary factor is the compressive strength of the prism. Traditional design methods subject masonry buildings solely to compressive loads, underscoring the importance of accurately determining compressive strength.

A critical factor in structural design and evaluation is the compressive strength of a brick prism, which represents the maximum load the prism can support before failure [9]. Engineers and builders can design and construct buildings safely supporting their intended loads by understanding the compressive strength of masonry prisms, ensuring structural stability and safety.

This research involved conducting an experimental investigation using masonry prisms to examine how joints and specimen geometry affect masonry strength. The main objectives of the study are:

- To assess the compressive strength and failure mode of cement mortars, using two-inch (50mm) cube specimens.
- To evaluate the compressive strength and failure mode of cement mortars, using four-inch high by two-inch diameter (50 mm) cylinder specimens.
- To ascertain the masonry prism's compressive strength.

2. Review of literature

Some of the greatest architectural feats, such as the Taj Mahal in India, the Egyptian pyramids, the Colosseum in Rome, and the Great Wall of China, have been constructed using masonry techniques

[2]. Masonry's versatility, durability, and aesthetic appeal have made it a popular choice for builders and architects throughout history.

Masonry is used in more than 70% of all buildings worldwide [10]. By the fourth millennium BCE, Egypt had perfected the art of stonemasonry, leading to the creation of the pyramids, the most grandiose of all ancient constructions [11]. Most probably that was the first massive masonry structure in masonry history.

Masonry is the technique of arranging various masonry units, such as bricks, stones, and concrete blocks, with mortar in a specific order to create a cohesive component or building element. It is classified into different types based on the availability of materials and units.

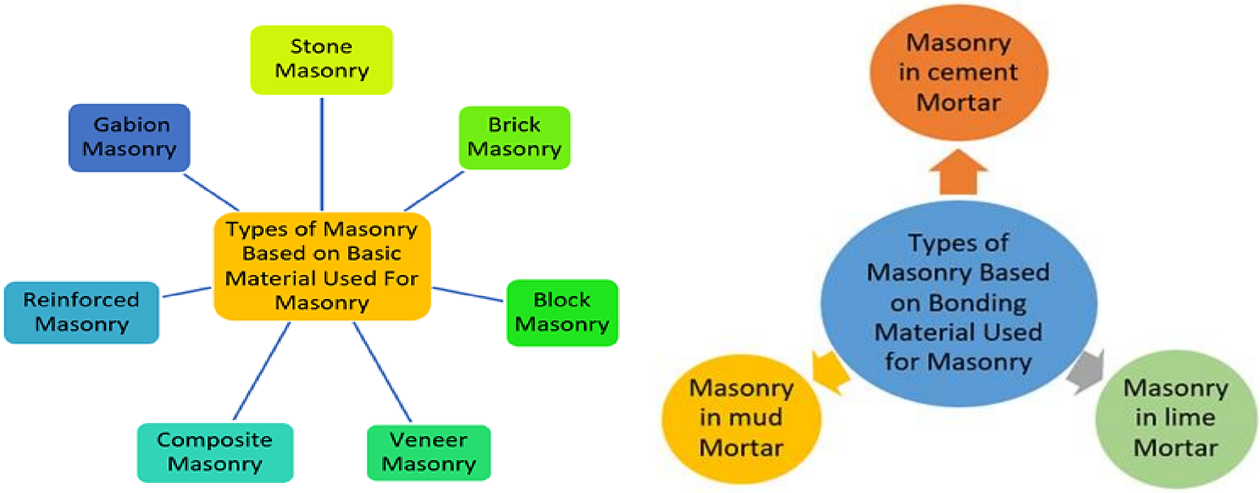


Fig. 1. Different types of masonry.

According to Fig. 1, there are several categories of masonry, including (i) the basic material, i.e., the masonry unit used for masonry, and (ii) the bonding material used for masonry. Among all these types, brick and concrete masonry with cement mortar are widely used worldwide due to material availability. Therefore, it is important to acknowledge the compressive strength of cement mortar and the strength of masonry prisms from various literature sources that have been previously researched.

The compressive strength evaluations of cement mortar available in the literature are provided below:

Kim et. al. (2014) [12]found that when the cement mortar's w/c ratio was raised from 0.45 to 0.60, the porosity increased by 150%, and the compressive strength decreased to 75.6%.

Zhou et al. (2011) [13]found that reducing the water content in cement mortar led to an increase in its dynamic compressive strength. The saturated specimen exhibited a 23% reduction in dynamic compressive strength in comparison to the dry specimen.

Haach et al. (2011) [14] examined how mortar's workability and compressive strength are influenced by the aggregation of grading and water-to-cement ratio. Furthermore, it was noted that higher water-to-cement ratios reduced mechanical properties while enhancing workability.

The compressive strength of concrete, a crucial attribute in constructing concrete buildings, was examined by Nikbin et al. (2014) [15]. This property is often specified and evaluated using control specimens. Concrete specimens of different sizes, shapes, and similar compositions exhibit varied compressive strength due to the use of examples with varying shapes and sizes in different nations.

The strength evaluation of the Masonry prism from various researchers are:

Singh et al. (2017) [16] observed that the compressive strength of masonry prisms is affected by the strength of both the bricks and the mortar, showing a direct correlation to their combined compressive strength. Brick masonry typically exhibits weaker bonding compared to burnt clay brick masonry due to its smaller contact area. However, the bond strength of brick masonry can be enhanced by incorporating a frog or applying a surface coating with higher material strength.

Kaushik et. al. (2007) [17] noticed that the compressive strength of the masonry prism increased with the increase of the compressive strengths of bricks and mortar. However, in the case of brickwork built with weaker mortar, the improvement in masonry strength was more pronounced. It is therefore improbable that stronger masonry will be produced by utilizing a mortar than is necessary.

Gumaste et al. (2007) [18] identified the breakdown of the bond between the brick and mortar as the primary cause of failure in their study of masonry specimens. They found that specimens using a 1:6 cement-sand mortar failed due to brick cracking. In practice, masonry strength is often assessed by breaking the weakest brick in the specimen rather than by considering the interaction between brick and mortar. This is mainly because there is a high coefficient of variation for brick strength (40%) in practice.

Wu et al. (2013) [19] examined the uniaxial compressive stress-strain behavior of the block masonry prisms unstabilized using various mortar formulations. They also observed that the ratio of mortar strength to block strength influences the compressive strength, Young's modulus, and Poisson's ratio of the prisms.

3. Methodology

In this study, 2 different types of tests are performed; such as

- Compressive strength test of cement mortar (cube and cylinder),
- Compressive strength test of Masonry Prism.

3.1. Materials used for preparing test specimen

Test specimens for the compressive strength test of cement mortar (cube, cylinder) are prepared using cement, sand, and water. Masonry prisms are constructed using whole bricks and mortar. The materials utilized to make test specimens are shown in Fig. 3.

Fine Aggregate: River sand, locally accessible, and passing through a 4.75 mm sieve while retained on a 75-micron sand screen, serves as the fine aggregate in this experiment. Figure 2 depicts the gradation curve of the sand.

Cement: CEM II – Test specimens were prepared using Portland composite cement material. This class of cement is produced using high-quality clinker, fly ash as a pozzolanic material, slag, and limestone. Approximately 20% of the clinker is replaced by this pozzolanic material.

Water: Potable water from the lab was used to mix and cure the concrete samples.

Brick: 1st Class bricks were utilized for making masonry prism.

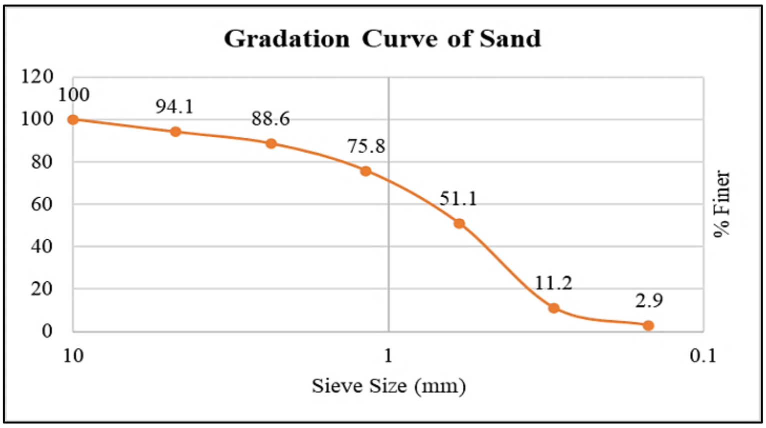


Fig. 2. Gradation Curve of Sand.

Cement Brick Sand

Fig. 3. Materials used for Preparing Test Specimen.

3.2. Compressive strength of cement mortar (cube and cylinder)

A total of fifty-four specimens, including cubes and cylinders, were fabricated, with a water-to-cement ratio of 0.45 and three different mortar ratios: 1:3, 1:4, and 1:5. The specimens were tested at 3, 7, and 28 days. The procedures outlined in Figure 4 are followed consistently throughout the entire study project. The selection of specimen numbers followed the specifications outlined in ASTM C109.

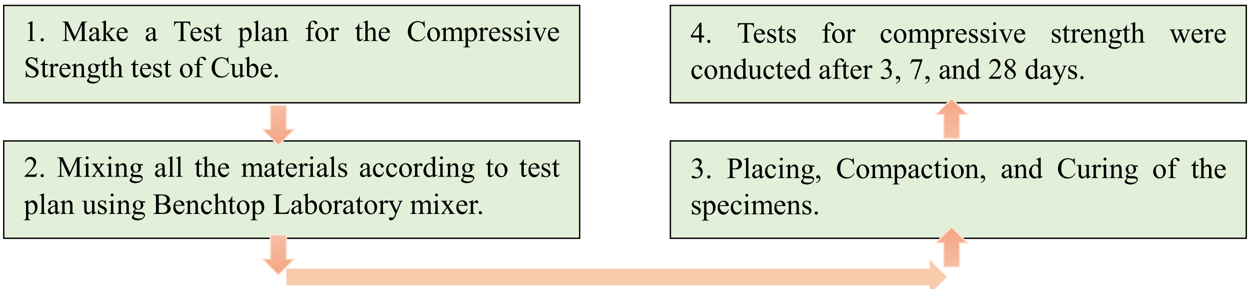


Fig. 4. Working plan.

3.2.1. Test plan

The experimental test plan, detailed in Table 1, outlines the methodology for determining the compressive strength of the cubes. Specifically, 2×2×2 inch cubes were utilized to measure the compressive strength of the mortar.

Table 2 outlines the test plan for this experimental investigation, aimed at determining the compressive strength of cylinders for cement mortar. Two-inch diameter and four-inch height cylinders were used for assessing the compressive strength of the mortar.

Table 1. Test plan for the compressive strength test of the cube.

Days	No. of Specimen	Mortar A Cement/Sand (c/s) ratio=1:3			Mortar B Cement/Sand (c/s) ratio=1:4			Mortar C Cement/Sand (c/s) ratio=1:5			Total No. of specimen	Water/cement (w/s) ratio
		For 1 Cube			For 1 Cube			For 1 Cube				
		Cement (kg/m^3)	Sand (kg/m^3)	Water (kg/m^3)	Cement (kg/m^3)	Sand (kg/m^3)	Water (kg/m^3)	Cement (kg/m^3)	Sand (kg/m^3)	Water (kg/m^3)		
3	3										9	
7	3	0.046	0.156	0.0207	0.037	0.167	0.017	0.031	0.174	0.014	9	0.45
28	3										9	
Total	9	0.414	1.404	0.1863	0.333	1.503	0.153	0.279	1.566	0.126	27	

Table 2. Test plan for the compressive strength test of the cylinder.

Days	No. of Specimen	Mortar A Cement/Sand (c/s) ratio=1:3			Mortar B Cement/Sand (c/s) ratio=1:4			Mortar C Cement/Sand (c/s) ratio=1:5			Total No. of specimen	Water/cement (w/s) ratio
		For 1 Cylinder			For 1 Cylinder			For 1 Cylinder				
		Cement (kg/m^3)	Sand (kg/m^3)	Water (kg/m^3)	Cement (kg/m^3)	Sand (kg/m^3)	Water (kg/m^3)	Cement (kg/m^3)	Sand (kg/m^3)	Water (kg/m^3)		
3	3										9	
7	3	0.0865	0.295	0.0389	0.069	0.314	0.031	0.0576	0.33	0.0259	9	0.45
28	3										9	
Total	9	0.7785	2.655	0.3501	0.621	2.826	0.279	0.5184	2.97	0.2331	27	

3.2.2. Mixing of materials for the preparation of mortar

To produce large, uniform volumes of mortar mix, mortar mixers are essential. Precise material proportioning and thorough mixing are necessary for the production of high-quality mortar. A benchtop laboratory mixer is used for preparing mortar according to the test plan outlined in Tables 1 and 2. The mortar mixing process adheres to ASTM Standard C305 Specification criteria [20]. Figure 5 depicts the benchtop laboratory mixer used for mortar mixing.

Fig. 5. Mixing of Mortar using a mixer machine in the laboratory.

3.2.3. Placing, compaction and curing of specimens

After proper lubrication, the mortar was placed into the mold for both the cube and cylinder, as depicted in Fig. 6. Then, all sections of the cube and cylinder were filled with a layer of mortar which is approximately one inch (25mm) thick. As shown in Fig. 8, the mortar was tamped 32 times in each cube compartment in four rounds of approximately 10 seconds each. Each round was performed at right angles to the previous one and consisted of eight contiguous strokes over the specimen's surface. Once the first layer in each cube and cylinder specimen had been properly tamped, the compartments were filled with the remaining mortar and heated according to the instructions for the first layer. After leveling, curing was conducted for 3, 7, and 28 days, as shown in Fig. 10 and 11.

Fig. 6. Lubrication of Mold.

Fig. 7. Placement of mortar in mold.

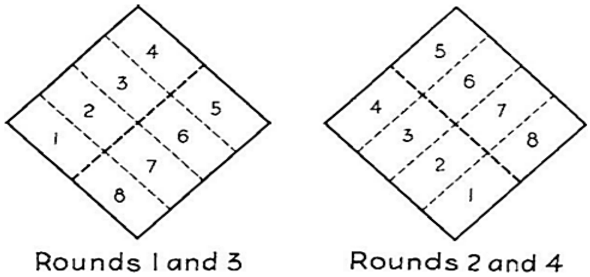


Fig. 8. Order of Tempering in Molding of Test Specimens [21].

Fig. 9. Tamping.

Fig. 10. Curing of Specimen (cynider).

Fig. 11. Curing of Specimen (cube).

3.3. Prism test

An assembly of masonry units and mortar is known as a "masonry prism," crafted to serve as a test sample for identifying the characteristics of masonry assemblies. As outlined in the ASTM A-447 Standard Test Methods, masonry prisms are specifically designed and constructed to assess the compressive strength in this research. This standard ensures that the prisms are made under controlled conditions to provide accurate and consistent results during compressive strength testing.

In this investigation, nine specimens were created with water-to-cement ratios of 0.45 and three distinct mortar ratios of 1:3, 1:4, and 1:5. They were then cured for 28 days. Five bricks were placed with 10 mm mortar between 2 bricks. The procedures outlined in flow chart 2 were followed consistently throughout the entire study project. The entire laboratory procedure is illustrated in Fig. 14.

1. Mixing all the materials according to mix design using Benchotop Laboratory mixer.
2. Prism Construction: 5 nos. bricks are placed using 10 mm mortar between 2 bricks.
3. Perform Compressive strength test of Prism using Universal Testing Machine(UTM).

Fig. 12. Methodology for Compressive strength of Cement mortar.

Fig. 13. Masonry Prism construction.

Fig. 14. Prism Test using Universal Testing Machine (UTM) in Laboratory.

4. Data analysis & discussion

According to the BNBC 2020 code [22], Part VI, Chapter 7, Table 6.7.1 provides various mix proportions of cement/sand ratio and minimum compressive strength requirements. These criteria must be met.

Table 3. Mix the Proportion and Strength of Commonly used Mortars (BNBC, 2020) [22].

Grade of mortar	Mix Proportion by Volume		Minimum Compressive Strength at 28 Days, N/mm^2
	Cement	Sand	
M1	1	3	10
M2		4	7.5
M3		5	5
M4		6	3
M5		7	2
M6		8	1

4.1. Compressive strength test (cube)

A total of twenty-seven specimens were examined, with a water-to-cement ratio of 0.45 and three distinct mortar ratios of 1:3, 1:4, and 1:5. The samples were analyzed after 3, 7, and 28 days.

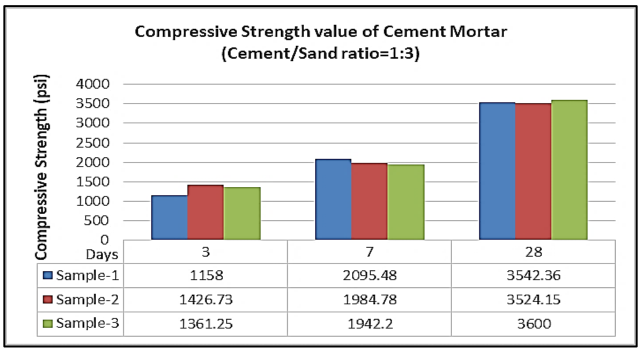


Fig. 15. Compressive Strength value of Cement Mortar Cube (Mortar A).

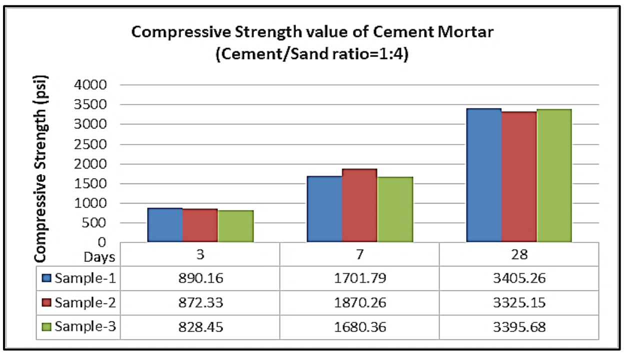


Fig. 16. Compressive Strength value of Cement Mortar Cube (Mortar B).

Based on Figure 15, when using a Cement/Sand (c/s) ratio of 1:3 and a Water/Cement (w/c) ratio of 0.45, the mortar cubes exhibited average compressive strengths of 1315.33 psi, 2007.49 psi, and 3555.5 psi after 3, 7, and 28 days, respectively. On the other hand, for the Cement/Sand (c/s) ratio of 1:4 and Water/Cement (w/c) ratio of 0.45, it can be deduced from Fig. 16 that the average compressive strength of mortar cubes is 863.65 psi, 1750.8 psi, and 3375.36 psi for 3, 7, and 28 days, respectively.

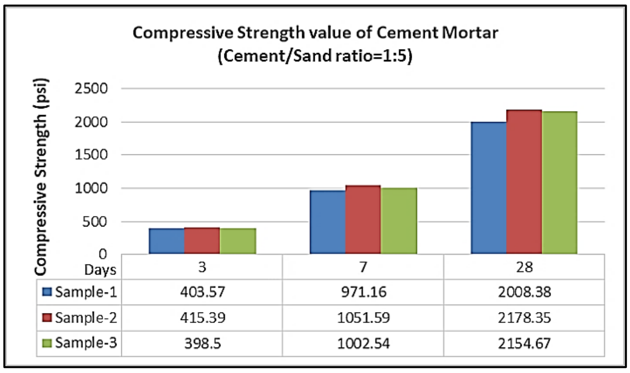


Fig. 17. Compressive Strength value of Cement Mortar Cube (Mortar C).

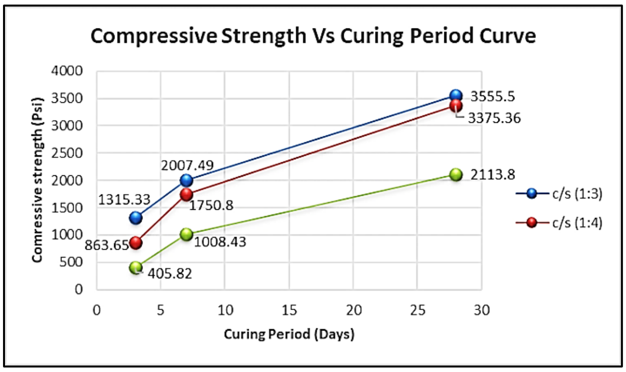


Fig. 18. Average compressive strength of mortar cube at their different Ages.

As observed in Fig. 17, for the Cement/Sand (c/s) ratio of 1:5 and Water/Cement (w/c) ratio of 0.45, the average compressive strength of cubes was found to be 405.82 psi, 1008.43 psi, and 2113.8 psi for 3, 7, and 28 days, respectively.

In this study, the cement-to-sand (c/s) ratio was 1:3 and the water-to-cement (w/c) ratio was 0.45 for the 28 days. The average compressive strength was measured at 24.51 MPa. According to BNBC 2020, for a c/s ratio of 1:3, the minimum compressive strength is 10 MPa (BNBC, 2020). For c/s ratios of 1:4 and 1:5, the compressive strengths were found to be 23.27 MPa and 14.57 MPa, respectively, in this study. From BNBC 2020, the corresponding minimum compressive strengths are 7.5 MPa and 5 MPa (BNBC, 2020). Therefore, the results found in this study satisfy the criteria set by the BNBC code.

Figure 18 displays variations in average compressive strength for various c/s ratios at various ages. The reduction in the cement/sand ratio (c/s) leads to a drop in the compressive strength of mortar cubes, as seen in Figure 18. A higher cement content may be utilized, which facilitates the proper development of strength in the mortar, potentially explaining this phenomenon.

4.2. Compressive strength test (cylinder)

A total of twenty-seven specimens were tested with a w/c ratio of 0.45, along with three different mortar ratios: 1:3, 1:4, and 1:5. Testing was conducted on the specimens at 3, 7, and 28 days.

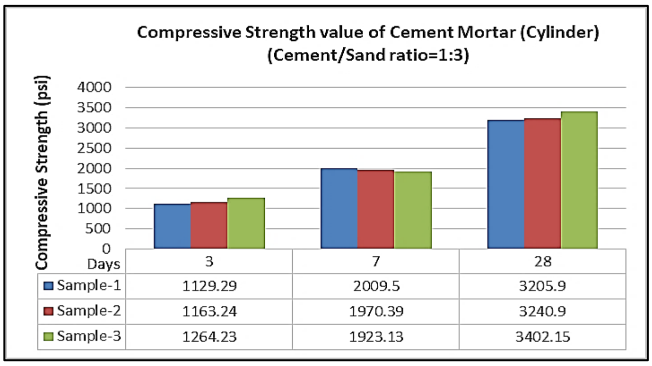


Fig. 19. Compressive Strength value of Cement Mortar Cylinder (Mortar A).

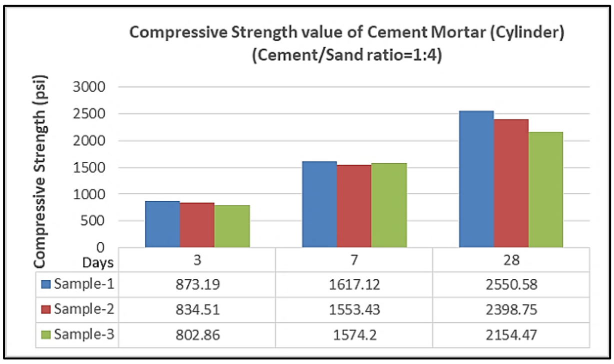


Fig. 20. Compressive Strength value of Cement Mortar Cylinder (Mortar B).

For the Cement/Sand (c/s) ratio of 1:3 and Water/Cement (w/c) ratio of 0.45, based on Fig. 19, the average compressive strength of mortar cylinders was observed to be 1185.59 psi, 1967.67 psi, and 3282.98 psi at 3, 7, and 28 days, respectively. These values illustrate the progressive increase in strength over the curing period.

Conversely, with a Cement/Sand ratio of 1:4 and Water/Cement ratio of 0.45, it is evident from Fig. 20 that the average compressive strength of mortar cylinders was 836.85 psi, 1581.58 psi, and 2367.93 psi at 3, 7, and 28 days, respectively.

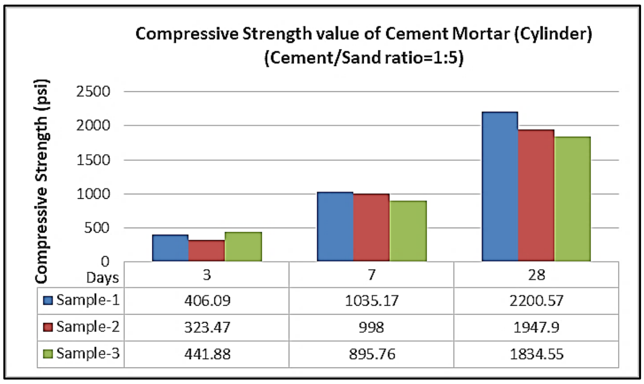


Fig. 21. Compressive Strength value of Cement Mortar Cylinder (Mortar C).

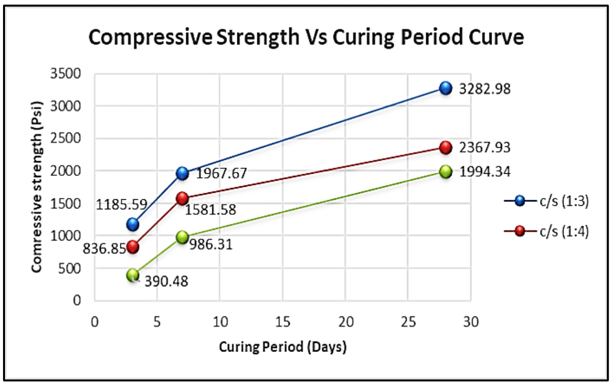


Fig. 22. Average compressive strength of mortar cylinder at their different Ages.

According to Fig. 21, when using a Cement/Sand (c/s) ratio of 1:5 and Water/Cement (w/c) ratio of 0.45, the average compressive strength of cylinders was measured at 390.48 psi, 986.31 psi, and 1994.34 psi after 3, 7, and 28 days, respectively. These findings illustrate the progressive development of compressive strength over the specified curing periods.

In this study, the cement-to-sand (c/s) ratio and water-to-cement (w/c) ratio for 28 days were 1:3 and 0.45, respectively. The average compressive strength was found to be 22.63 MPa. According to BNBC 2020, for a c/s ratio of 1:3, the minimum compressive strength is 10 MPa (BNBC, 2020). For c/s ratios of 1:4 and 1:5, the compressive strengths were found to be 16.33 MPa and 13.75 MPa, respectively, in this study. From BNBC 2020, the corresponding minimum compressive strengths are 7.5 MPa and 5 MPa (BNBC, 2020). Therefore, the results found in this study satisfy the criteria set by the BNBC code.

Fig. 22 displays the variations in the cylindrical specimens' average compressive strength at various ages and for various c/s ratios. As the cement/sand ratio (c/s) rises, the mortar cylinder's compressive strength increases, as seen in Fig. 22. This can occur when a larger cement content is used in a higher cement/sand ratio, causing the mortar to properly build strength.

4.3. Comparison between cube and cylinder strength

In this investigation, it is noticed that the Cube strength is larger than the cylinder. The mortar cube has a higher compressive strength than the cylinder for the following reasons:

• The conventional cube mold had a larger contact area with the upper platen of the testing machine, which led to greater confinement during testing.

• With the greater depth of the cylinder, the load was distributed over its height. Therefore, it can also be argued that the cube's strength is greater than that of the cylinder.

Based on Figures 23, 24, and 25, it can be observed that the compressive strength of the mortar cube exceeds that of the mortar cylinder across all cement-to-sand (C/S) ratios.

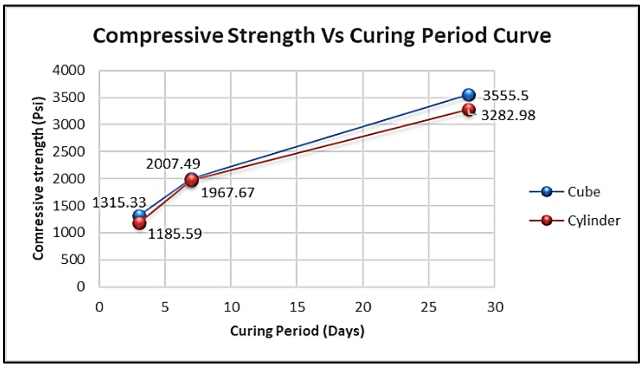


Fig. 23. Compressive Strength (Psi) Vs Age (days); Mortar A.

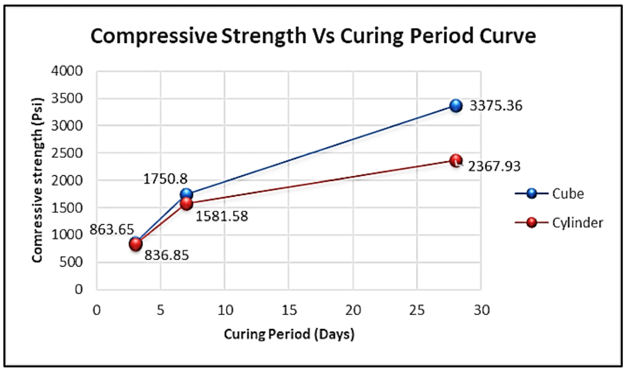


Fig. 24. Compressive Strength (Psi) Vs Age (days); Mortar B.

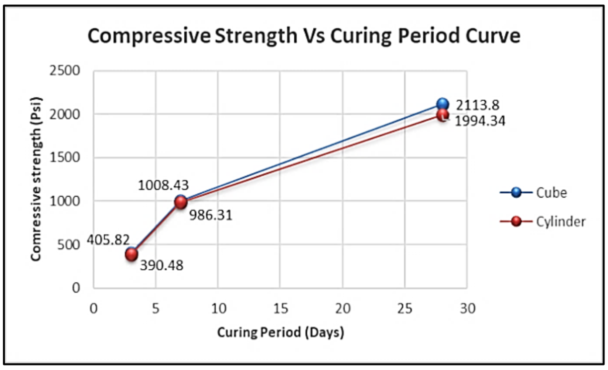


Fig. 25. Compressive Strength (Psi) Vs Age (days); Mortar C.

4.4. Prism test

A total of 9 specimens were tested, with a water-to-cement (w/c) ratio of 0.45 and three different mortar ratios: 1:3, 1:4, and 1:5. All the specimens were tested after 28 days.

Table 4. Compressive Force value of Prism Test.

C/S ratio	Compressive Force (KN) at 28 Days			
	Sample 1	Sample 2	Sample 3	Average
1:3	120	138	130	129.33
1:4	91.51	99.06	95.4	95.32
1:5	76.98	70.25	72.68	73.3

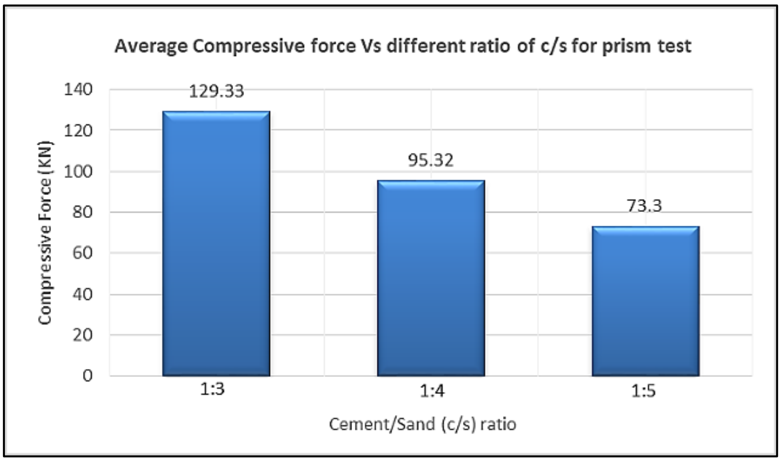


Fig. 26. Average Compressive force Vs different ratio of c/s for prism test.

The histogram shown in Fig. 26 was generated based on data from Table 4. It illustrates that as the cement-to-sand (c/s) ratio increases, so does the compressive strength. The histogram represents the average values across various ratios. The higher values indicate effective bonding between the cement-sand mixture and the bricks, with adequate cement content to withstand the applied load by the UTM (Universal Testing Machine).

According to Eurocode C-EN 1996 [23], masonry compressive strength may predict by using this formula:

$f_k = k\, f_b^{0.65} f_m^{0.25}$ (MPa)

where, f_b=Brick Strength, f_m= Mortar strength < 20 MPA, k= 0.4 to 0.6 depending upon brick properties and brick-mortar joint.

According to Kaushik et al. 2007 [17], masonry compressive strength can be predicted using the following formula:

$f'_m = 0.63 f_b^{0.49} f_j^{0.32}$ (MPa)

where, f_b= Brick strength, f_j= Mortar strength.

4.5. Failure mode

4.5.1. Failure mode of mortar cube and cylinder

Failure modes for Mortar Cube and cylinder at their different ages and cement/sand (c/s) ratios are shown in Table 5. The crack modes are also identified using Fig. 27 (a) cylinder fracture kinds in sketches (ASTM C 39) and (b) According to the standard test specimen cube failure mode (BS EN 12390-3, 2002, Neville and Brooks, 2010) [24].

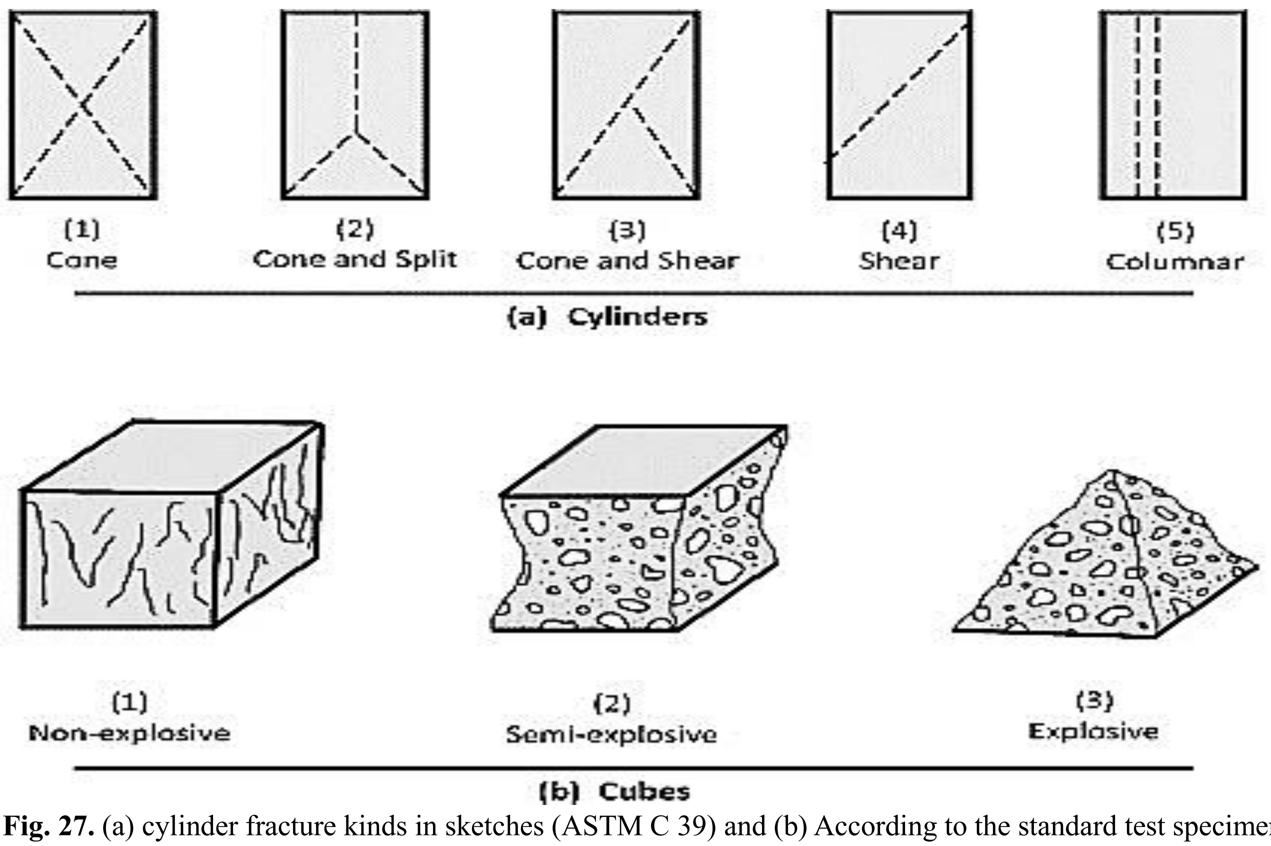
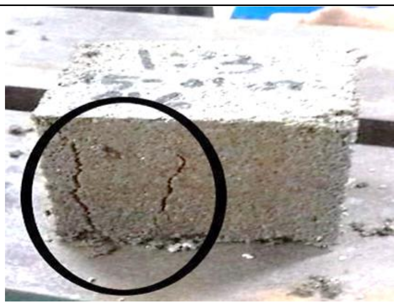
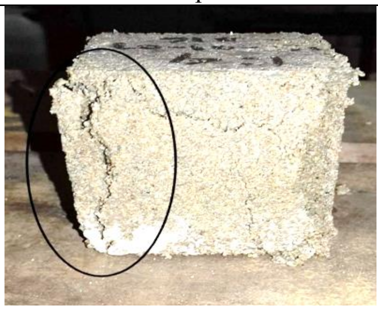
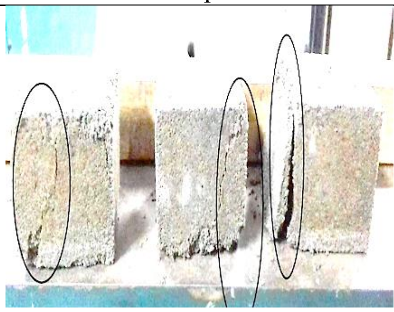
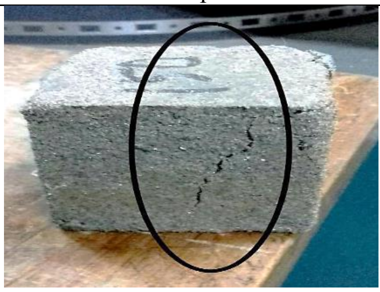
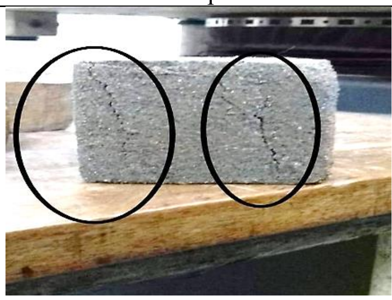
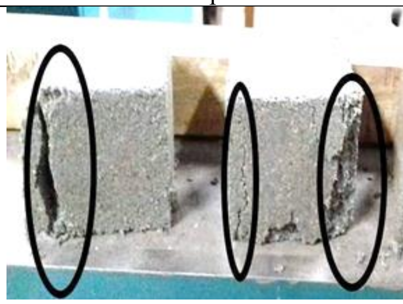


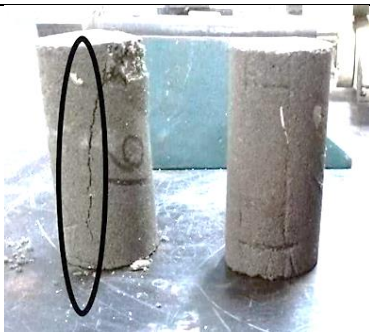
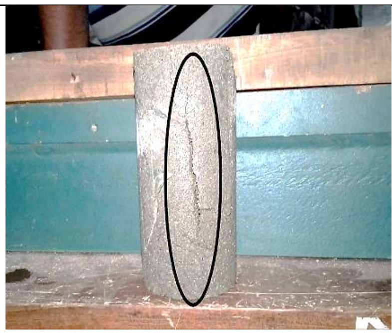
Fig. 27. (a) cylinder fracture kinds in sketches (ASTM C 39) and (b) According to the standard test specimen cube failure mode (BS EN 12390-3, 2002, Neville and Brooks, 2010) [23].

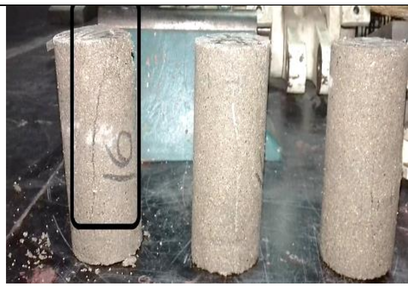
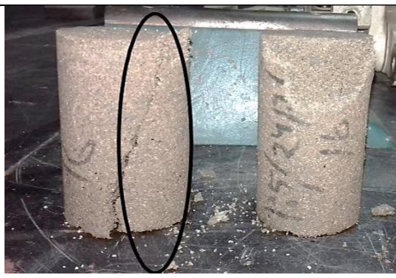
Table 4. Failure Mode for Mortar Cube and Cylinder.

Failure Mode for Mortar Cube at their different ages and cement/sand (c/s) ratios

c/s ratio	**3 Days**	**7 Days**	**28 Days**
1:3	 **Failure Mode:** Non- explosive	 **Failure Mode:** Non- explosive	 **Failure Mode:** Non- explosive
1:4	 **Failure Mode:** Semi-Explosive	 **Failure Mode:** Semi- explosive	 **Failure Mode:** Non- explosive
1:5	 **Failure Mode:** Semi- explosive	 **Failure Mode:** Non- explosive	 **Failure Mode:** Semi- explosive

Failure pattern for Mortar Cylinders at their different ages and cement/sand (c/s) ratios

c/s ratio	**3 Days**	**7 Days**	**28 Days**
1:3	 **Failure Mode:** Columnar vertical cracks	 **Failure Mode:** Columnar vertical cracks	 **Failure Mode:** Columnar vertical cracks

1:4	 **Failure Mode:** Cone and shear crack	 **Failure Mode:** Columnar vertical cracks	 **Failure Mode:** Columnar vertical cracks
1:5	 **Failure Mode:** No failure pattern was found, because the cylinder was fully demolished.	 **Failure Mode:** Cone and shear crack	 **Failure Mode:** Shear crack

4.5.2. Failure pattern of masonry prism

Failure patterns for Masonry Prism at different cement/sand (c/s) ratios are shown in Table 6.

It may be inferred from the figures that the failure of the masonry prism in the case of a c/s ratio of 1:5 is more pronounced than in the case of a c/s ratio of 1:3.

Table 6. Failure pattern for Masonry Prism.

Failure pattern for Masonry Prism at 28 Days		
 Failure pattern for Masonry Prism; c/s=1:3	 Failure pattern for Masonry Prism; c/s=1:4	 Failure pattern for Masonry Prism; c/s=1:5

5. Conclusion

To comprehend the strength and stress-day properties of mortar blocks and masonry prisms with various components, uniaxial compressive tests were carried out. The influence of the cement/sand(c/s) ratio of mortar on compressive strength behavior and Failure patterns was investigated. The following conclusions are drawn from the test results and observations:

- In most cases, side edge fracture, non-explosive, and semi-explosive fracture are observed as the failure mode for mortar cubes.
- Most prism failure patterns have exhibited columnar vertical failure.
- The compressive force of the masonry prism increases by approximately 76.48% when the cement-to-sand ratio is changed from 1:5 to 1:3.
- The most dangerous failure of the masonry prism occurs at the cement-to-sand (c/s) ratio of 1:5 compared to other c/s ratios incorporated in this research. This indicates that mortar strength has a significant influence on the masonry prism.
- At 28 days, the compressive strength of cubes and cylinders increases by approximately 68.19% and 64.61%, respectively, when the cement-to-sand ratio is changed from 1:5 to 1:3.
- Due to the higher cement content in a high cement-to-sand (c/s) ratio, the compressive strength increases with the increase of the cement-to-sand (c/s) ratio. This observation is evident from the compressive strength tests conducted on mortar cubes, mortar cylinders, and masonry prisms.
- The cement/sand (c/s) ratio of 1:3, along with a specific water/cement ratio of 0.45, in both cube and cylinder mortar specimens, as well as the masonry prism, yielded the best results among all the comparisons.
- In the majority of cases, vertical columnar failure is observed as the failure mode for mortar cylinders.

Some limitations of the study are discussed briefly:

- Strain values were not measured.
- In the compressive strength testing of mortar cylinders, deviations in results may occur due to manual shaping of the cylinders.

Recommendations

The following recommendation is stated to study more on Masonry Prism:

- Using the same test setup, a larger range of water-to-cement (W/C) ratios can be utilized instead of focusing solely on Cement-to-Sand ratios.
- To ensure the proper vertical alignment of the masonry prism and achieve perfect straightness, a frame setup may be introduced.
- A certain percentage of cementitious materials and various types of fibers within a specified range may be incorporated into mortar specimens.

Acknowledgments

The authors gratefully acknowledge the financial support provided by Ahsanullah University of Science and Technology, Dhaka, Bangladesh, for this work. The results presented in this study are based on their undergraduate thesis. The authors are thankful to everyone who contributed to the success of this research. They extend their sincere appreciation to their esteemed supervisor, Dr. Sharmin Reza Chowdhury, Professor in the Department of Civil Engineering at Ahsanullah University of Science and Technology, for his invaluable assistance, guidance, and support.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Authors contribution statement

Raisul Shuvo : Writing - Review & Editing.

Sharmin Chowdhury : Conceptualization, Supervision.

Rukshana Ripa : Project administration, Writing - Original Draft, Investigation, Visualization, Data Curation.

Sadia Sabrin : Data Curation, Formal analysis.

Foysal Shohag : Methodology.

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