International Journal of Social Science Archives

ISSN: 2707-8892

Available at www.ijssa.com

International Journal of Social Science Archives, June, 2023, 6(1), 58-68

Investigating the Causes of Masonry Failure and Effective Solutions in the Project

Shakir Iqbal*, Sadaqat Hussain
Department of Civil Engineering, Sarhad University Peshawar, Pakistan.

***Email:** shakiriqbal499@gmail.com

***Abstract*:** Brick masonry is a combination of brick and mortar. For temporary work, mud mortar may be used and for all permanent work, cement mortar is used. In this project, we focused on brick masonry failures, their causes, and remedies. This is a common issue now in the entire world, but mostly in urban areas. There are several causes that affect the failure of the masonry, i.e., the interaction effects between the clay brick units and the weaker cement mortar, earthquake settlement, temperature, etc. So in this research, first we find out the different causes that cause brick masonry failures and identified the factor with the highest severity through questionnaire surveys. The author also recommended the best solution for the factor with high severity to reduce brick masonry failure. The study considered a total of 227 responses. The information was gathered from employees of various construction industries in Pakistan. Due to time and resource constraints, the convenience sampling technique, a type of non-probability sampling, is used for data collection purposes. The findings suggested the most severe factor is an earthquake whose severity level is 8.2 and low severity factor is temperature whose severity level is 2.8.

Keywords: Brick, Mortar, Masonry, Brick masonry

1.Introduction

Brick masonry is a very old construction method, and masonry work composed a huge section of buildings all over the world (Ucer et al., 2017). Such masonry work is sometimes required to hold up special forceful loading resulting from chance impact or seismic movement. The brick masonry is appropriately useful only to that type of construction employing fairly small structure units prepared of burn clay (Ashour et al., 2015). Normal bricks are efficient in cost and one of the strongest building materials now commonly used. This research provides an outline of brick masonry building construction, which consist 62.38% of the total build background of Pakistan. Masonry construction limits from classic one-story buildings which are commonly in pastoral areas up to three-story buildings (common in town area). This type of building is commonly built without looking for any official engineering participation. In reality the archaeological excavator found support that brick masonry can be traced back more than six thousand years (Getachew, 2017). In the building brick is load bearing and gives high compression strength, but look is no issue. In difference bricks are used on uncovered areas where appearance is a key consideration. The brick masonry failure depends on the brick quality, ratio of mortar, temperature, earthquake, settlement, usage of poor quality of material etc.

The brick masonry failure is the most common issue nowadays and we are trying to address this problem in our project. The brick masonry is brittle and has been designed to fail prematurely through shearing along the bedding panels or diagonal splitting. Brick masonry's structural limitations, such as poor shear and tensile strength, brittle characteristics, potential debris damage, and weakness to out of plane loads, limit its role as an effective infill in resisting lateral loads. To overcome the limitations mentioned above, traditional brick infill has been modified by using hollow blocks and aerosol blocks masonry infill as well as reinforced masonry infill to determine the success of reinforced masonry in resisting lateral forces loads. The focus of the study is to assess the performance of brick masonry infill which is subjected to standing loading. The main objective of this research is to find causes and solution of brick masonry failure and reduce the different masonry failure with the better solution. The brick masonry failure is a common issue. The main challenge is to find a better and economical solution for brick masonry failure.

2. Literature Review

Brick was introduced in North America for the duration of the 17th century (Carran et al., 2012). According to confirmation, the first man-made brick was established in Virginia. As the explorer accepted the strength, stability and flexibility of manufacturing Brick masonry is one of the oldest manufactured construction materials in the globe. Bricks have been the building construction a lot of the world's huge resources, involve the, which has brick masonry lining the interior walled brick; they begin to make collection production center (Thomas& Ding, 2018). A brick is a construction material used in different construction site such like construct the walls, pavement and other structure parts in masonry building (Raut et al., 2011). The name brick composition of clay but it is nowadays use to represent some rectangular unit laid in mortar a brick can be composed of shale posture soil, lime and sand.

2.1.1 1st Class Bricks

The size of the first class brick is 19 x 9 x 9 cm. These bricks are made from high-quality earth, free from salt deposits. The first class brick should be carefully burnt and also have better color. These types of brick should be standard in shape with square edges and similar face and also free from cracks, chips, stones, etc. when two bricks are struck together they must give a ringing sound (Aubert et al.,2016). The compressive strength of first class brick should not be less than 140 kg/cm^2. And this type of brick immersed in water for 24 hours shall not absorb more than 20% of water. The first class brick is excellent for all kinds of construction in the external walls. They are also suitable for flooring.

2.1.2 2nd Class Bricks

This type of brick is completely burnt and produces a clear ringing sound. A minor difference in size, shape or color is acceptable. The compressive strength of 2nd class brick must be at least 70 kg/cm^2 (Benlalla et al., 2015). When immersed in water for 24 hours, the water absorption value should not exceed 22%. The second class brick is frequently used for exterior work when plastering is required. And they can also be used for internal workings, but not for flooring.

2.1.3 3rd Class Bricks

These brick are not totally burnt as in previous two cases but are normally of the same shining yellow color. The compressive strength of 3rd class brick between 35 – 70 kg/cm^2 and absorption value between 22 – 25 percent when immersed in water for 24 hours. They are used generally in the ordinary type of construction and in dry situations (Chowdhury et al., 2015).

2.1.4 4th Class Bricks

4th class bricks are mostly rough in shape but dark in color which is mostly over burning. The compressive strength of these brick more than all type of brick above 150 kg/cm^2 and also have low porosity and absorption. These types of brick are mostly used in foundation (Chowdhury et al., 2015).

2.1.5 Brick Masonry

Brick masonry is a mixture of brick and mortar. For short-term work mud mortar may be used for all permanent masonry work cement mortar are used (Martins et al., 2017). The most commonly used bond used in brick masonry is the following.

2.1.6 English Bond

English bond brickwork is made up of alternate courses of stretcher and header. This traditional pattern is considering to be one of the strongest bonds and is commonly used for bridges and engineering project.

2.1.7 Flemish Bond

The contraction of perpendicular joint in the successive way, closers are inserted in exchange courses after that to the quoin header. In walls having their depth equal to an odd quantity of half bricks, the bats are basically used to realize the bonding.

2.2 Small Masonry Buildings in Seismic Area

The small buildings are more affected by high-frequency waves small building in Bucharest, Romania. According to earthquake rules, it is one of the country's earthquake zones. Because the masonry design code requires it, improved wall density and a high concentration of masonry panels are used. It is worth noting that buildings and masonry structures are also included in the literature. This article will investigate a building's nonlinear behavior and demonstrate how to achieve a preferred ductile behavior. When the plastic state is reached, the pressure redistribution will be visible in the layout and structure of the plastic hinge. This analysis also includes information about the architect's personality, internal strengths, and endurance. As the output of the enforcer bars reaches, the limiting elements enter a plastic state, but this must be considered alongside masonry cracking and maximum deformation. This analysis begins with a 3D model to demonstrate the overall performance of the structure, and then separate models are used to examine the behavior of each wall. Flexible analysis of the wall thickness is also important and realistic, when the building enters the plastic state; the interconnected beams reach the threshold of failure for the first time.

2.3 Mechanical Properties of Brick Masonry Walls

The mechanical properties of masonry walls, while the main part of the planning investigation is to determine the properties of compressive strength, elastic modules, shears modules, and quality durability on masonry walls. The experimentally determined values for the modulus of elasticity of the test walls are higher than those provided in the policy. Based on the equations given at national and global standards, the values of standard compressor strength are better than the ethics of the compressive strength of the walls we examined.

2.4 Brick Masonry Behavior for Different Mortar Ratios

Brick masonry plays an important role in the construction industry, highlighting the need to investigate the nature of masonry performance under various conditions and compositions. The operation of compressive and dark brick masonry with various mortar ratios is presented. The material properties are investigated through compression testing of brick units, mortar cubes, and cylinders. (Nagarajan et al., 2014), Bricks are tested in both dry and wet conditions to allow for a comparison of material performance along all three axes. Compression and share tests are performed on brick prism triplets with varying mortar ratios to evaluate and compare their compressive strength, bond strength, and range actions. The results of compression and share tests are compared, and vice versa. The research carried out will make it possible to evaluate the behavior of masonry used by statistical imitation under locked up and compression loading.

3. Methodology

This section describes the data collection procedure, the sampling technique, the data analysis procedure and techniques and the study limitations.

3.1 Population

The study's population consists of team members and project managers from project teams working on a construction project in the city of Pakistan. The construction project in Pakistan is the focus. The chosen samples are thought to be representative of a Pakistani construction project in which questionnaires were distributed to various project teams for analysis. Almost 500 questionnaires were distributed, and 227 responses (or 45.4 percent) were received.

3.2 Research Design and Method

Researchers will use two common research methodologies in quantitative research: survey research and experimental research. In this study, a survey research methodology was used because it provides standardized information to describe variables and examine relationships between items.

3.3 Sample and Sampling Technique

The current study's sample consists of construction project teams, which include team members and project managers. Due to time and resource constraints, the convenience sampling technique, a type of non-probability sampling, is used for data collection purposes. In this type of sampling, data is collected haphazardly from the available population. It is ideal for this type of research because the data was not collected in a sequential or organized manner. This sample will depict the original scenario of the entire population, expressing the causes and remedies of brick masonry failure.

3.4 Sample Size

The sample should be chosen to represent the population as accurately as feasible (Sekaran, 2011). The population is defined as a group of people, events, or things related to a topic of interest to the researcher. He believes that a sample size of 200 to 500 is adequate for perceptual studies.

3.5 Tools Used for Data Collection

The questionnaires were distributed to respondents who work in construction organizations. The responses were recorded on a 10-point Likert scale, likert scale 0-3 represents low severity, 3-6 is medium and 6-10 represents high severity." Demographic information is also included in the questionnaire. The proposed study will rely on primary data collected through questionnaires. Secondary data, on the other hand, will be gathered by reading relevant literature to complete the study. The responses will be gathered through the use of a Google form (online) and, where applicable, a personal visit.

3.6 Data Analysis

Data collection was done by questionnaires. Severity was marked by respondents on Likert scale in order to acquire a clearer view of the data and generalizing results. On Likert scale 0-3 represents low severity, 3-6 is medium and 6-10 represents high severity.

4. Result and conclusion

4.1 Risk Factors in descending order

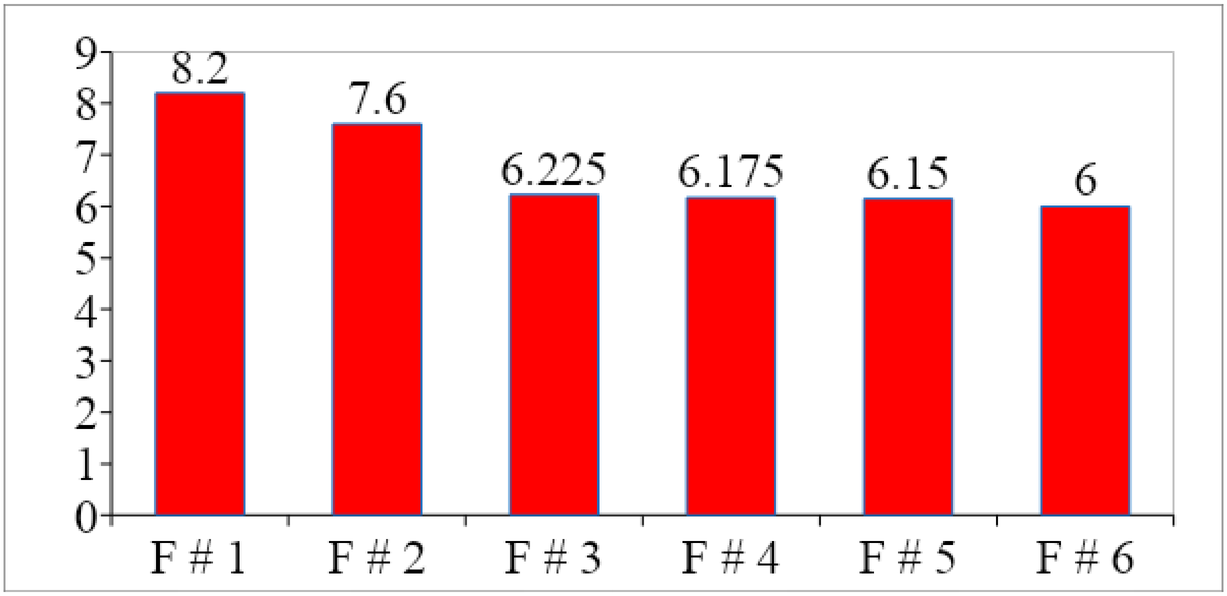
Table 4.1: Factors in Decanting Order

S .NO	Factors	Severity
1	Earthquake	8.2
2	Settlement	7.6
3	Usage of Poor quality of materials	6.225
4	Insufficient bonding and improper curing.	6.175
5	Building movement	6.15

6	Differential loading	6
7	Failure to fill bed joint	5.9
8	Poor quality of brick	5.875
9	Error due to saving in economy	5.8
10	Incorrect mixing and proportioning of mortar	5.55
11	Seepage of dampness from ground, roof and exterior faces	4.975
12	Plumb alignment	4.875
13	Moisture absorption	4.55
14	Exposure to rain	4.5
15	Continuous exposure to chemicals	4.45
16	Lack of strength at corner and junction of walls	4.025
17	Sulfate attack	3.95
18	Lime run off	3.95
19	Absence of grading in before the use of fine aggregate for motor	3.775
20	If percentage of clay and silt in fine aggregate exceed by 3%	3.575
21	Chemical alteration	3.375
22	Efflorescence	3.4
23	Atmospheric pollution	2.95
24	Temperature	2.875

4.2 Graphical Representation of the analyzed data

4.2.1 First Six High Severity Factor



Factors With the Maximum Severity

From the research study, we found there are so many factors whose severity level is very high, but the factor with the maximum severity is the earthquake, whose severity level is 8.2, which is a very high level that should be taken seriously Masonry buildings are broken structures, and under severe earthquakes casualties, the entire stock of the building is in high danger. During the past earthquake in Pakistan, such structures have lost a large number of human lives. As a result, it is critical to improve the seismic behavior of masonry buildings. To achieve this goal, various earthquake prevention features can be implemented. Ground tremors during earthquakes generate inertial forces in many areas of the building. These forces are transmitted to the foundation via the roof and walls. The main goal is to ensure that these forces reach the ground without causing significant damage or collapse. The masonry buildings have three components (roof, wall, and foundation). It plays a very significant role in the failure during the construction of brick masonry. There should be proper seismic design for the construction of brick masonry.

4.3 Some Other Sever Factors

The aim of the research was to identify those risk factor which cause in the failure of brick masonry. Settlement is the secondary high severity factor which affects the brick masonry failure. The severity level of settlement is 7.2. It is high level which also can be taken seriously because the most common reason for brickwork to crack is uneven settlement of the building. Many brick walls of historic structures show cracks throughout the depth of the wall. Such cracks are frequently due to the "historic" and recent heterogeneous settlement along the wall. In this way, wall restraint actions are born, which are a reaction to the wall's contact with the foundation and the earth. The contraction site should be maximum bearing capacity and also proper designing of foundation.

4.4 Use of Poor Quality Material

Poor quality material is another high severity factor. The severity level is 6.225. It also causes the failure of brick masonry. The quality of building materials affects the largely quality of the building as a whole. There is an infinite amount of materials and products which go into one building. The options of each are infinite and can be purchased nearby or abroad. The safety and long permanence of the building is affected if the quality is not applied. To reduce this factor to maintain the good quality of material such as use the first class brick and specific ratio of the mortar.

4.5 Insufficient Bonding and Improper Curing

The most affected and curable factor of brick masonry is an insufficient bonding and improper curing. The severity level is 6.175. Brick Masonry is a compound material consisting of masonry unit bricks and mortar joints. This fact accounts for its natural petition but can also be its natural weakness. The achievement of an effective bond between mortar and unit is the most important feature of masonry construction. If sufficient bond is not achieved, the mortar joints will operate as planes of weakness and cracking will occur due to wind, soil movement or negligible earthquake tremor. Long term deprivation and unacceptable entrance of water through the wall are also likely. We always focus on suitable bonding and proper curing during the construction of brick masonry.

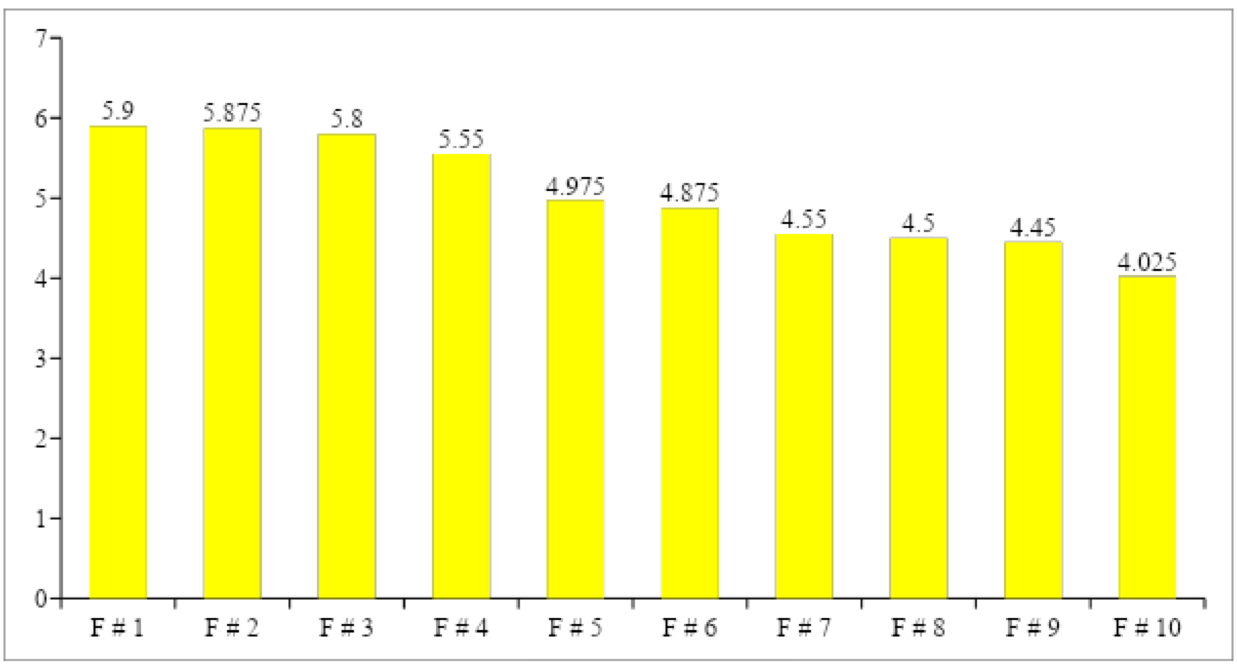
4.6 Building Movement

For example, there are different factors, such as temperature changes and humidity changes, which can cause defects in the masonry structure. These movements should be considered in order to prevent their destructive power on the buildings of the architect. Usually, foundation-drive motions are the most common cause of cracking in masonry walls. Due to the common reduction and rise in moisture content under the masonry structure, by the masonry buildings that are built on clay soil, it is most likely to be subject to the movement of the foundation. In calculation, to decrease corrosion and prevent foundation problems in weak soil, it is more suitable and involved to solve these problems and stop future structural damage.

4.7 Differential Loading

Differential load is a basic and high severity factor with the severity level is 6. Building events are forces, deformations, or accelerations applied to an arrangement mechanism. Loading reason of stresses, deformation, and displacement in structures. This is because measurement is conceded out by the method of structural analysis. Differential loading is basic element of structure design which is directly affected on a building at the time of design the different load should be reserved in mind and also know about the all type of load

4.2.2 Next Ten Medium Severity Factor



Factor 1: Failure to fill bed joint

Factor 2: Poor quality of brick

Factor 3: Error due to saving in economy

Factor 4: Incorrect mixing and proportioning of mortar

Factor 5: Seepage of dampness from ground and roof

Factor 6: Plumb alignment

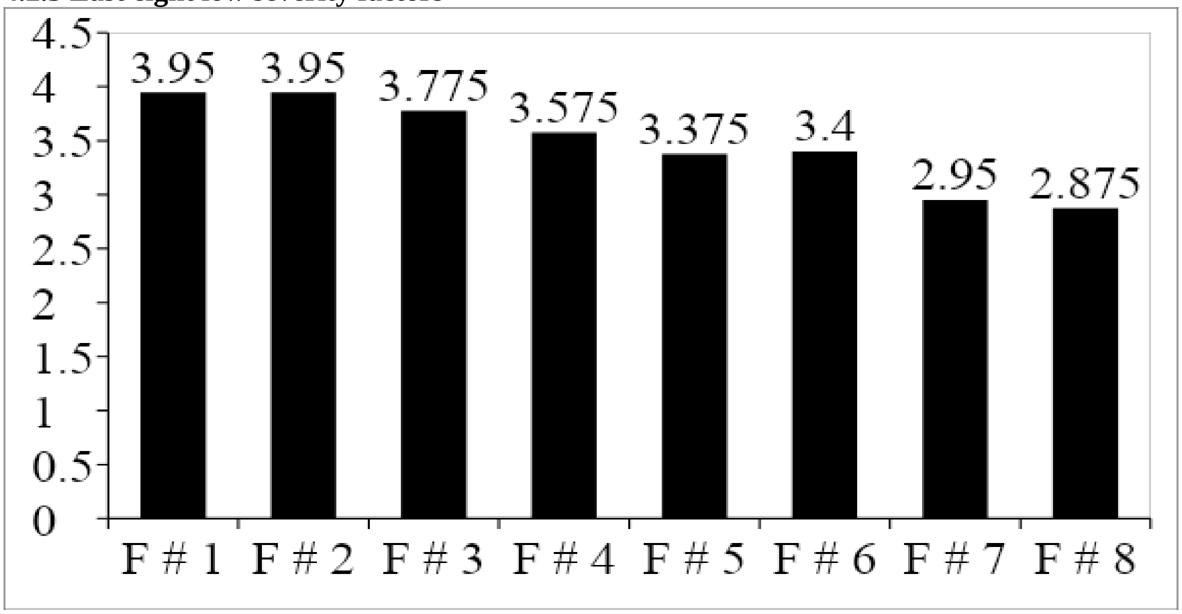
Factor 7: Moisture absorption

Factor 8: Exposure to rain

Factor 9: Continuous exposure to chemicals

Factor 10: Lack of strength at corner and junction of walls

4.2.3 Last eight low severity factors



Factor 1: Sulfate attack

Factor 2: Lime run off

Factor 3: Absence of grading in before the usage of fine aggregate in mortar

Factor 4: If percentage of clay and silt in sand increase by 3%

Factor 5: Chemical alteration

Factor 6: Efflorescence

Factor 7: Atmospheric pollution

Factor 8: Temperature

5. Recommendations

5.1 Seismic Design for Brick Masonry

Structural engineers should incorporate earthquake prevention features in the design, focusing on the roof, walls, and foundation. The primary goal is to ensure that inertial forces during earthquakes reach the ground without causing significant damage or collapse. Strengthening masonry buildings against seismic forces is essential for minimizing casualties and protecting structures during earthquakes.

5.2 Settlement

To address this issue, construction practices should prioritize maximum bearing capacity and employ proper foundation design. Implementing foundation designs that mitigate settlement risks can significantly contribute to preventing brick masonry failures.

5.3 Use of Poor Quality Material

To mitigate this risk, it is crucial to prioritize the use of high-quality materials, such as first-class bricks and specific mortar ratios. Adhering to quality standards ensures the safety and long-term durability of the building, preventing failures attributed to substandard materials.

5.4 Insufficient Bonding and Improper Curing

Achieving an effective bond between mortar and units is crucial. Construction practices should emphasize suitable bonding and proper curing methods to prevent weaknesses in mortar joints, which can lead to cracking and water ingress.

5.5 Building Movement

To prevent destructive forces, architects and engineers should consider these movements in their designs. Foundation-driven motions, often caused by changes in moisture content, must be addressed to prevent damage. Solutions should include measures to reduce corrosion and prevent foundation issues in weak soil.

5.6 Differential Loading

During the design phase, engineers must account for various loads, understanding their impact on the structure. Proper structural analysis and design should consider all types of loads to ensure the building can withstand differential loading without compromising its integrity.

5.7 Failure to Fill Bed Joint

Implement comprehensive training programs for masons to emphasize the importance of proper bed joint filling. Conduct regular site inspections to ensure adherence to filling standards. Utilize advanced construction technologies, such as mortar sensors, to monitor joint filling in real-time.

5.8 Poor Quality of Brick

Establish stringent quality control checks for incoming brick materials. Collaborate with reputable brick suppliers and promote the use of certified bricks. Conduct periodic on-site brick quality tests to identify and replace substandard materials.

5.9 Error Due to Saving in Economy

Educate project stakeholders about the long-term costs associated with compromising on construction quality. Encourage a holistic view of project economics, considering maintenance and repair expenses over the life cycle. Incorporate financial incentives for projects that prioritize structural integrity over short-term savings.

5.10 Incorrect Mixing and Proportioning of Mortar

Conduct regular training sessions for construction personnel on proper mortar mixing techniques. Utilize pre-mixed mortars to ensure consistency and accuracy in proportions. Implement quality assurance checks at various stages of construction to identify and rectify mixing errors.

5.11 Seepage of Dampness from Ground and Roof

Integrate effective waterproofing measures in the construction design. Regularly inspect and maintain drainage systems to prevent water accumulation. Utilize moisture-resistant materials and coatings to mitigate the impact of dampness.

5.12 Plumb Alignment

Provide advanced tools and equipment to ensure precise plumb alignment during construction. Train masons on the importance of maintaining accurate alignment throughout the building process. Conduct regular site checks to identify and correct deviations from plumb alignment standards.

5.13 Moisture Absorption

Choose bricks with lower moisture absorption rates for construction. Apply moisture-resistant sealants to exterior surfaces. Implement proper ventilation systems to reduce humidity within structures.

5.14 Exposure to Rain

Erect temporary shelters or use protective coverings during inclement weather. Plan construction schedules to minimize exposure to rainy seasons. Employ water-repellent coatings on external surfaces to mitigate rain-related damage.

5.15 Continuous Exposure to Chemicals

Identify potential chemical hazards in the construction environment. Implement safety protocols to minimize exposure to harmful chemicals. Choose building materials that are resistant to chemical degradation.

5.16 Lack of Strength at Corner and Junction of Walls

Reinforce corners and junctions with additional structural support. - Ensure that engineering designs account for increased load-bearing requirements at these critical points. Regularly inspect and reinforce these areas during construction to prevent weak points.

References

Ashour, T., Korjenic, A., Korjenic, S., & Wu, W. (2015). Thermal conductivity of unfired earth bricks reinforced by agricultural wastes with cement and gypsum. *Energy and Buildings*, *104*, 139-146.

Aubert, J. E., Maillard, P., Morel, J. C., & Al Rafii, M. (2016). Towards a simple compressive strength test for earth bricks? *Materials and Structures*, *49*, 1641-1654.

Benlalla, A., Elmoussaouiti, M., Dahhou, M., & Assafi, M. (2015). Utilization of water treatment plant sludge instructural ceramics bricks. *Applied Clay Science*, *118*, 171-177.

Carran, D., Hughes, J., Leslie, A., & Kennedy, C. (2012). A short history of the use of lime as a building material beyond Europe and North America. *International Journal of Architectural Heritage*, *6*(2), 117-146.

Chowdhury, S., Ahmed, K. S., & Hamada, Y. (2015). Thermal performance of building envelope of ready-made garments (RMG) factories in Dhaka, Bangladesh. *Energy and Buildings*, *107*, 144-154.

Constantinescu, S. (2017). Study of confined masonry buildings in seismic areas. *Energy Procedia*, *112*, 545-554.

Getachew, K. (2017). Laboratory Investigation of Locally Produced Clay Brick Quality and Suitability for Load Bearing Element in Jimma Area, Ethiopia Alemu Mosisa. *Int. J. Eng. Res. Technol*, *6*(5), 809-817.

Krejcie, R. V., & Morgan, D. W. (1970). Determining sample size for research activities. *Educational and Sychological Measurement*, *30*(3), 607-610.

Martins, A., Vasconcelos, G., & Costa, A. C. (2017). Brick masonry veneer walls: An overview. *Journal of Building Engineering*, *9*, 29-41.

Nagarajan, T., Viswanathan, S., Ravi, S., Srinivas, V., & Narayanan, P. (2014, March). Experimental approach to investigate the behavior of brick masonry for different mortar ratios. In *Proceedings of the International Conference on Advances in Engineering and Technology, Singapore* (pp. 586-592).

Okail, H., Abdelrahman, A., Abdelkhalik, A., & Metwaly, M. (2016). Experimental and analytical investigation of the lateral load response of confined masonry walls. *HBRC journal*, *12*(1), 33-46.

Radovanović, Ž., Grebović, R. S., Dimovska, S., Serdar, N., Vatin, N., & Murgul, V. (2015). The mechanical properties of masonry Walls-Analysis of the test results. *Procedia engineering*, *117*, 865-873.

Raut, S. P., Ralegaonkar, R. V., & Mandavgane, S. A. (2011). Development of sustainable construction material using industrial and agricultural solid waste: A review of waste-create bricks. *Construction and building materials*, *25*(10), 4037-4042.

Sarangapani, G., Venkatarama Reddy, B. V., & Jagadish, K. S. (2005). Brick-mortar bond and masonry compressive strength. *Journal of materials in civil engineering*, *17*(2), 229-237

Sathiparan, N., & Rumeshkumar, U. (2018). Effect of moisture condition on mechanical behavior of low strength brick masonry. *Journal of Building Engineering*, *17*, 23-31.

Selvakumar Viswanathan1, and Premavathi Narayanan3 2014, Experimental Approach to Investigate the Behavior of Brick Masonry for Different Mortar Ratios *International Conference on Advances in Engineering and Technology (ICAET'2014) March 29-30, 2014 Singapore*

Thomas, D., & Ding, G. (2018). Comparing the performance of brick and timber in residential buildings–The case of Australia. *Energy and buildings*, *159*, 136-147.

Ucer, D., Ulybin, A., Zubkov, S., & Elias-Ozkan, S. T. (2018). Analysis on the mechanical properties of historical brick masonry after machinery demolition. *Construction and Building Materials*, *161*, 186-195.