MEASURING BRICK MASONRY MORTAR JOINT SOLIDITY

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ABSTRACT

Void mortar joints have been the bane of brick masonry for more than a hundred years. This paper proposes a method for determination by visual observation of the percent solidity of mortar head and bed joints in masonry built with solid units. Joint solidity is defined as the ratio expressed as a percentage of a surface area of a masonry unit that is or clearly was covered by mortar in contact with units on both sides of the joint, divided by the gross area of the same surface. The method determines the degree to which masonry joints are filled with mortar. It does not determine the density or porosity of mortar. Joint solidity is one of several aspects of materials, design, construction, and maintenance that affect masonry performance. Information concerning the percent solidity of mortar joints is indicative of masonry construction quality control which may relate to water permeance, air permeance, durability, corrosion of embedded metal, strength, sound transmission, and other properties of masonry.

Key words: Construction, joint, masonry, mortar, sampling, solidity, testing, workmanship.
INTRODUCTION

In the United States unfilled mortar joints in brick masonry are a violation of law and a breach of contract, both of which can get a contractor in serious trouble. Workmanship affects water permeance of masonry more than any other factor, and water causes most building problems. Walls that do not leak, do not stains due to efflorescence or spall due to freezing of entrapped water. More seriously water can result in the corrosion of anchors and ties, which with the loss of structural integrity can become life threatening. Water increases masonry volume, reduces insulation effectiveness, deteriorates interior finishes and building contents, and causes tenant inconvenience and litigation.

This paper provides a method for measuring mortar joint solidity as a basis for making such statements as; “One can be 90% confident that 42% of the mortar joints were less than 63% filled.”

In general people are very good at judging mortar joint solidity. In research conducted in 1989 at the University of Texas at Austin, 31 respondents each judged the solidity of 27 simulated mortar head joints, providing 837 solidity judgements. The average error was only 4.3%, and the most frequent error was less than 2%. Of course, some people are better than others at judging joint solidity. One of the 31 respondents had an average error of only 2.6%, and the highest

Figure 1. Partially Filled Mortar Joint.
average error was 7%. The conclusion of this research was that the unaided human eye is a satisfactory instrument for judging mortar joint solidity. No sophisticated expensive equipment is necessary for this purpose.

Try your own ability to judge mortar joint solidity. Observe Figure 1 and make a judgement. In Appendix I you will find the correct answer.

The following text if formatted as a formal test procedure.

TEST METHOD FOR DETERMINING MORTAR JOINT SOLIDITY IN BRICK MASONRY

1. Scope

1.1. This method covers the determination by visual observation of the percent solidity of mortar head and bed joints in masonry built with solid units. The method is applicable to masonry built with units having a net cross-sectional area greater than 75% of the gross cross-sectional area measured in the same plane. The method concerns the solidity of masonry joints, not the solidity of mortar. The method determines the degree to which masonry joints are filled with mortar. It does not determine the density or porosity of mortar. The method can be used in forensic investigations of masonry workmanship. Joint solidity is one of several aspects of materials, design, construction, and maintenance that affect masonry performance.

1.2. The values stated in SI units are to be regarded as standard. The values given in inch-pound units in parentheses are for information only.

1.3. This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2. Terminology

2.1. joint solidity, n. - ratio expressed as a percentage of a surface area of a masonry unit that is or clearly was covered by mortar in contact with units on both sides of the joint, divided by the gross area of the same surface.

3. Significance and Use

3.1. This method is intended to provide a direct means for determining solidity of mortar head and bed joints in masonry built with solid units.
4. Apparatus

4.1. This method involves the use of the following equipment:
- hammer of suitable weight
- 25 mm (1 in.) to 50 mm (2 in.) wide chisel
- marking pen
- camera and film
- pencil or pen
- paper for data recording

4.2. Optional equipment: transparent material graduated in 10 mm by 10 mm lines.

5. Sampling

5.1. Divide the masonry to be examined into a number of areas of 93 sq m (5000 sq ft.). Each such area should be composed of a single size of masonry unit. Within each such area randomly select the number of locations indicated in Table 1 corresponding to the course height of the masonry units in each area. Every location within each area should have an equal chance of being selected in every trial. (See Appendix II.)

5.2. If the masonry to be examined exceeds in area a multiple of 93 sq m (5000 sq ft), prorate the number of selected locations in the residual area.

5.3. If the masonry to be examined is less than 93 sq m (5000 sq ft), select not less than the number of locations indicated in Table 1 corresponding to the course height of the masonry units in that area.

5.4. At each selected location remove a prism of masonry from the structure using a power driven rotary saw in such a manner as to avoid cracking. Each prism should be one wythe thick and at least two stretchers wide. The height of each prism should be not less than that given in Table 1.

6. Procedure

6.1. Prior to removal from the structure mark on each prism an arrow and the word “UP” to indicate the vertical orientation of the prism.

Table 1. Number of Courses Per Prism.

<table>
<thead>
<tr>
<th>Course Height, mm (in.)</th>
<th>N.º of Locations</th>
<th>Prism Height, mm (in.)</th>
<th>N.º of Courses Per Prism</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 (1.97)</td>
<td>2</td>
<td>400 (15.75)</td>
<td>8</td>
</tr>
<tr>
<td>68 (2.68)</td>
<td>3</td>
<td>400 (15.75)</td>
<td>6</td>
</tr>
<tr>
<td>100 (3.94)</td>
<td>4</td>
<td>500 (19.69)</td>
<td>5</td>
</tr>
<tr>
<td>135 (5.32)</td>
<td>5</td>
<td>541 (21.3)</td>
<td>4</td>
</tr>
<tr>
<td>200 (7.87)</td>
<td>8</td>
<td>600 (23.62)</td>
<td>3</td>
</tr>
</tbody>
</table>
6.2. Saw cut the perimeter of each prism and remove them from the wall. Clearly identify, mark, and photograph the back of each masonry prism when it is removed from the structure. During handling and shipping of prisms, assure that specimens do not incur noticeable cracks.

6.3. Perform the following operations on each prism in the sample. Gently break open the mortar-masonry unit interface on one side of all undisturbed mortar joints, using hammer and chisel in such a manner as to avoid breaking the masonry unit or crumbling the mortar.

6.4. Disregard crumbled joints and those suspected of having been lost or disturbed during removal, handling, or shipment of a prism. Examine only those mortar joints that are on an unbroken surface area of the masonry unit.

6.5. Place the mortared face of each opened joint to be examined in a well-lighted position. If the edges of the mortar joint extend past the edges of the unit, draw a line (as in Fig. 1) indicating the edges of the unit. Perform joint solidity tests on the area bounded by the edges of the unit or the lines. By visual inspection or by using a transparent grid estimate and record joint solidity.

6.6. At a right angle to the plane of the joint take a well lighted, close-up photograph of each mortar joint examined. For example see Figure 1.

6.7. It may be desirable for forensic purposes to measure and record the thickness (width), height and length of three whole masonry units selected at random from each prism; to measure to the nearest 1.6 mm (1/16, 0.0625 in.) the thickness of three bed and three head joints in each prism; and to determine the solidity of the masonry units.

7. Report

7.1. Include in the report a description of each prism examined. Include identification number, dimensions, condition as received for examination, date of removal from the structure, date of examination, name of examiner, location on the structure from which specimen was taken, and name and address of the structure from which the sample was taken.

7.2. Report the degree (%) solidity (fullness) of each bed joint and each head joint examined. Report the mean and standard deviation of the degree (%) of solidity for all head joints and for all bed joints examined. Report the number of head joints and of bed joints examined.

7.3. For bed joints report whether the mortar-masonry unit interface examined was the top or bottom of the joint. Report whether the mortar joint was over a unit surface having a core, cell, or frog.
7.4. Include with the report a print of the photograph of each joint examined and identify the prism from which it was taken.

8. Precision and Accuracy

8.1. Thirty-one subjects each judged by visual observation and without instrumentation the solidity of 27 simulated mortar head joints, providing a total of 837 judgments. Joint solidity ranged from 22.2% to 95.7% with a mean of 61.2%. The error for each judgment was recorded as the absolute difference (plus or minus) between the actual percent solid and the perceived percent solid. The mean error for all subjects was 4.3% with a standard deviation of 1.08%. The mean most likely error for all subjects was 3.9%. There is about one chance in 20 that a subject’s mean error will exceed 6%. The probability is 0.92 that a subject’s mean error will not exceed 10%.

CONCLUSIONS

The method presented here for measuring mortar joint solidity in brick masonry is reasonably accurate and inexpensive. However, the method does require some destructive testing which could create a problem in matching replaced masonry to the original. The author would be pleased to hear from those who may wish to try the method.

REFERENCES


APPENDIX I - JOINT SOLIDITY JUDGEMENT

The joint in Fig. 1 is 34% void (66% solid) determined very scientifically by Keuffel & Esser Co. planimeter No. F4236, Serial No. 598G4.

APPENDIX II - SAMPLING MASONRY

The purpose of materials testing is to formulate generalizations about the characteristics of those materials. To determine absolutely the mean mortar joint solidity of a large quantity of material, it would be necessary to test all of the material, which may be impractical, virtually impossible, or even self-defeating. Accordingly, some of the material may be tested from which results inferences
may be drawn about all the material. Valid tests of a sample give results that are
certain only for the sample, but those results permit conclusions of varying certi-
tude about the material from which the sample was taken.

The material from which a sample is taken is called a lot, that is, a quantity of ma-
terial which, insofar as is practical, consists of a single type, grade, class, size, fi-
nish (texture), and composition produced by a single source by the same process
and under practically the same conditions. A specimen is an individual piece of
material from a lot. A sample is a number of specimens.

Valid conclusions about a lot can be drawn by testing a sample only if the sam-
ple is representative of the lot. For that reason the method of selecting specimens
must be unbiased. Bias is avoided by selecting a random sample, i. e. every spe-
cimen of the sample has an equal chance of being selected in every trial. A sam-
ple selected haphazardly, without a conscious plan, is not a random sample. It is
a haphazard sample. It is virtually impossible to draw a sample at random by exer-
cise of human judgment alone. The proper use of an artificial, electronic, or me-
chanical device of selecting a random sample is necessary. Specimens may be se-
lected by assigning a number to each unit or small group of units in the lot and
using a table of random numbers or an electronic random number generator to
select a number of specimens. For any given set of conditions there are usually
several possible sampling plans, all valid, but differing in speed, simplicity, and
cost.

The degree of certitude with which conclusions are drawn from the results in-
creases with the number of randomly selected specimens in the sample. The re-
quired number of specimens depends on: (1) the variability in the characteristic to
be tested; (2) the permissible difference between the tested mean value and the
mean value of the lot; and (3) the degree of confidence with which one wishes
to state what that difference may be.