# Summary

This STP is a compilation of papers dealing with the performance of masonry. Generally, the first papers in the volume deal with mortar materials and properties. The remaining papers deal with masonry units, assemblages, and applications.

The first paper presents a discussion by Isberner of methods available to determine the composition of hardened masonry mortar. Data gathered from petrographic examination of mortar can be combined with computer manipulation of quantitative chemical analytical data to yield approximate original composition of hardened mortars. Careful sampling of the mortar is important, and more accurate results can be attained if samples of the component materials of the mortar are also analyzed.

Gazzola et al describes the results of flexural bond strength testing using the bond wrench. The effects of different units, mortars, and sands on the bond strength between mortars and units are presented as is a comparison of different bond wrench arm lengths and testing conditions.

Isberner's second paper presents a method of testing mortars for efflorescence. Some other methods are discussed. The author's method allows a comparison of efflorescing tendencies of different mortar materials. It is possible to collect and analyze the efflorescing salts at different depths in the mortar. The author points out that even materials showing little or no efflorescence in the test could effloresce in actual service.

The paper by Matthys and Chanprichar discusses the ultimate strength flexural theory for reinforced brick masonry. The authors tested 20 beam column specimens and corresponding prisms with high-strength and low-strength brick masonry and with compressive loading parellel to and perpendicular to the bed joints. Flexural compressive stress distribution was determined.

Grimm, in his paper on Corrosion of Steel in Brick Masonry, explains that water and other substances corrode metal connectors, reinforcement, and structural supports. Corrosive conditions vary widely from place to place, depending on humidity, pressure of water in the wall, pollutants, and contaminants. Water can come in contact with metal through penetration and condensation. Corrosion can be very severe in a relatively short period of time. Recommendations for slowing down corrosion are presented by the author.

Harris presents a method of efflorescence testing similar in principle to the one presented on p. 29 by Isberner except that both water permeance and efflorescence are measured by this method. The amount of water penetrating a small mortar specimen is measured at desired increments of time (in days).

When permeability testing is finished, efflorescence is measured by quantitative chemical analysis of the salts deposited on the surface of the mortar specimens.

Yi and Carrasquillo report the results of a research project on the development of a method of test to determine the coefficient of thermal expansion of brick that have been placed in service. The research deals with the effect, on the thermal behavior of brick, of factors such as the moisture content of the brick, the temperature range, the number of temperature cycles, and the location on the brick of the measuring instrumentation. Both new brick, that is, brick that had not been placed in service, and brick that had been in service for at least ten years, were studied. Based on the test results, a proposed method of test using electrical resistance strain gages was developed.

Carr et al investigated the common method of providing temporary support for masonry walls during construction that consists of inclined braces restrained at the ground with stakes. Research was conducted on the stakes capacity to resist horizontal loads. Two sizes of wooden stakes and one size of steel stakes, each at two embedments and three inclinations were tested. Three different soils at three consistencies were used. The authors concluded that for most soils the stake capacity was found to be insufficient to support tall masonry walls in modest wind with the bracing at a reasonable spacing. An alternate method of bracing, using a wooden truss to deliver vertical loads to the soil rather than horizontal loads is suggested.

Naish reports on an effort to analyze the durability performance of glazed brick by conducting a historical review of the properties of glazed brick produced by his company and the characteristics of buildings constructed with glazed brick produced by his company. Mr. Naish concludes that the wall failures that he has observed are not the results of too generous ASTM specifications or inconsistant brick quality but rather wall design, construction, or maintenance. The author suggests two approaches to future research to develop wall design, workmanship, and maintenance criteria to improve the performance of masonry walls.

Huizer and Ward have previously reported on the development of a clay unit to compete the metal chimney. This clay unit has been shown to pass the requirements for "zero clearance" application at hearth temperatures of approximately 700°C (1292°F). Anticipating the probability that this clay unit would be required to meet the more severe requirements of the metal units, the authors investigated four of the tests that were considered most relevant to clay chimneys from the standards for metal chimneys. These tests included thermal shock, 650°C flue gases, 925°C flue gases, and creosote burnout. The test results showed that at present the clay unit would not pass the new standard for metal chimneys. The authors suggest that further research with regard to the unit geometry and the clay mixtures is needed.

Hamid et al report the results of their study to evaluate the use of direct modeling of ungrouted and grouted concrete block masonry under axial compres-

sion. The study includes the effects of mortar and grout strength along with various high to thickness ratios, number of courses, and bonding pattern. The degree of correlation with the prototype properties varied; however, the authors conclude that direct modeling is feasible for predicting the behavior of block masonry.

The paper by Wong and Drysdale, like the previous paper, deals with the compression characteristics of concrete block masonry assemblages. Concrete block prisms of various heights, including hollow, solid and grout-filled, were tested for compression normal to the bed joint and parallel to the bed joint. Test results with regard to failure modes, compressive strengths, and stress-strain relationships are discussed. Conclusions and recommendations include comments regarding unit testing, prism construction, wall construction, and design standards.

Johnson points out that there are many differing opinions regarding the appropriate method for the cleaning of masonry. He suggests that there has been a continual search for a universal technique despite the fact that masonry is highly variable. To address this problem, the author presents a strategy for the selection of a cleaning method that utilizes a decision chart to consider these variables. He requests constructive criticism of the decision chart.

Rath's paper addresses the nonperformance of exterior nonload bearing walls, curtain walls, built of brick masonry. He notes that these walls can be constructed in a number of ways, but regardless of the wall type, their function is to provide a permanent barrier to protect the building interior from the outside elements. The categories of nonperformance discussed by the author are water penetration, durability, efflorescence and structural behavior (cracking). He suggests the primary factors effecting nonperformance are design, construction, materials, and ASTM specifications. The author reviews the methods for evaluating and suggests ways of preventing nonperformance.

Grimm's review of the literature on the durability of brick masonry summarizes the engineering literature on this subject published in English since 1900. Bibliographies with a total of 228 entries are provided. It is noted that durability is a function of materials, design, construction environment, and maintenance. It may also be defined as the ability of a material to remain serviceable with prudent maintenance during a normal life span in the intended environment. Agents and mechanics of destruction, porosity, freeze-thaw resistance, mortar properties, florescence, environment architectural engineering, brick specifications, construction, and maintenance are discussed. The conclusions suggest that keeping the masonry as dry as possible is the single most important variable in masonry durability.

As was reported in the introduction to this publication, the effort to encourage the submission of papers dealing with field application and end use problems was successful. The papers addressing these areas range from guidelines for temporary masonry wall support systems and a stratgey for masonry clean-

ing through corrosion of steel in masonry and end use performance of masonry and masonry materials. The other papers contained herein report on research and test methods that address field application and field problems. Hopefully, in addition to providing a better understanding of the performance of masonry, these papers will generate further research.

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