TECHNICAL NOTES on Brick Construction
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Technical Notes 15 - Salvaged Brick
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Abstract: The use of salvaged brick in new building construction is discussed. Factors affecting the selection include altered physical properties (durability), esthetics, economics, building code requirements and experimental testing.

Key Words: brick, masonry, **mortar bond**, **salmon brick**, **salvaged brick**.

INTRODUCTION

Selecting building material requires the consideration of four factors: esthetics, design properties, economics and required level of performance. Salvaged brick are occasionally selected for their "rugged appearance" and sometimes for their low initial cost. Rare is the case when salvaged brick are chosen for their design properties. In general, walls using salvaged brick are weaker and less durable than walls constructed of new brick masonry units. Most salvaged brick are obtained from demolished buildings which stood 40 to 50 yr, or more. In fact, it may be next to impossible to salvage brick from modern structures which use brick set in portland cement mortars. When brick are initially placed in contact with mortar, they absorb some particles of the cementitious materials. It is virtually impossible to completely clean these absorbed particles from the surfaces of the brick units. This may greatly affect the bond between brick and mortar when reused.

MANUFACTURING METHODS

In the early 1900's, manufacturing methods were markedly different from those of today. De-aired brick were unknown; coal- and wood-fired periodic and scove kilns were commonplace. The modern solid, liquid or gas-fired tunnel kilns with accurate temperature controls throughout were also unknown. Manufacturing conditions years ago were generally such that large volumes of brick were fired under greater kiln-temperature variations than could be tolerated today. These conditions resulted in a wide variance in finished products. Brick from the high-temperature zones were hard-burned, high-strength, durable products; those from low-temperature zones were under-burned, low-strength products of low durability. These temperature variations also resulted in a wide range in absorption properties and color. The under-burned brick were more porous, slightly larger, and lighter colored than the harder-burned brick. (It is the nature of ceramic products to shrink during firing. Generally, for a given raw clay, the greater the firing temperature, the greater the shrinkage and the darker the color.) Their usual pinkish-orange color resulted in the name *salmon brick*.

During these bygone years, prevalent methods of construction made production of both hard-burned and salmon brick economically feasible. Most masonry buildings had loadbearing brick walls which were a minimum of 12 in. in thickness. The hardest, most durable units were used in exterior wythes; the salmons (and others) were used for the interior wythes and were not exposed to the exterior elements. Much sorting and grading of brick was performed at the construction site by the mason, although the brick manufacturers eventually assumed this responsibility.

The advent of skeleton frames marked the beginning of high-rise construction and the gradual demise of thick loadbearing masonry wall construction. (Despite the reduction in its use, loadbearing remains a very economical method for constructing low- and mid-rise buildings). Architects and engineers began to design non-loadbearing walls, and gradually decreased wall thicknesses. This evolution in design and construction techniques necessitated a change in brick manufacturing procedures. Slowly but surely, the demand for salmon brick dwindled. After the use of hollow backup units became prevalent, the need for salmon brick became practically non-existent. At the same time, having invented the thinner, lighter weight panel wall, designers focused their attention on wall strength which they equated to compressive strength of the individual brick.

Because the principal demand was for high compressive strength and durability, manufacturers had to produce a high proportion of well-burned brick. This demand necessitated a change in manufacturing methods. Thus, an evolution in design and construction techniques brought on a significant and beneficial evolution in the production of brick. (For a synopsis of present day manufacturing methods, see *Technical Notes* 9 Revised, "Manufacturing, Classification and Selection of Brick; Manufacturing - Part 1").

MATERIAL SELECTION

Physical Properties. Several arguments are often advanced in favor of the use of salvaged brick. Among these are:

1. Because brick are extremely durable, they can be salvaged and used again.

2. If the brick were satisfactory at the time they were first used, they are satisfactory at present.

Both arguments are fallacious.

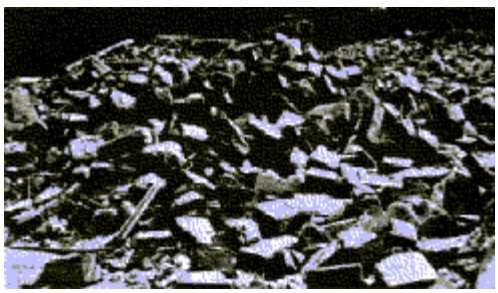
When brick are initially placed in contact with mortar, they absorb some water and some particles of cementitious materials. The initial rate of absorption (suction) is an important factor which greatly affects the bond between brick and mortar. Brick with extremely high or extremely low suctions do not develop good bond. (For discussion of bond strength between mortar and new clay masonry units, see *Technical Notes* 8 Revised, "Mortars for Brick Masonry").

With salvaged brick, more factors influence bond. Pores in brick are filled with particles of lime, dirt and other deleterious matter. Many bedding surfaces of salvaged brick will not be thoroughly clean, but will instead be covered with mortar. The bond between new mortar and old mortar is not very strong. If the original mortar bond was weak, the new bond will be adversely affected. The bond to salvaged brick is considerably less than to similar new brick and has been demonstrated many times by comparative tests (see Experimental Tests Section in this *Technical Notes*).

Most authorities agree that water penetration through masonry results from incompletely filled joints and incomplete bond between brick and mortar. That is, water penetrates through flaws at joints rather than directly through the brick and mortar. Thus, masonry walls of salvaged brick, with their inferior mortar bond, are likely to be more susceptible to water penetration and weaker under lateral loading than similar masonry of walls constructed of new units. The ultimate compressive strength of the walls will also be lower if salmon brick are present.

The durability of masonry depends upon the quality of materials and mortar bond. Generally, salmon brick do not provide the same durability as new brick when exposed to weathering. With the thinner masonry walls of today, brick are used primarily as a facing material to provide a weather resistant barrier of protection. Thus, many salmon brick are eventually placed in exposed faces of walls constructed of salvaged brick. Even where solid brick walls are used, many salmons are likely to be exposed to weathering, because it is impossible to accurately sort and grade salvaged brick. With soft, highly absorptive salmon brick exposed to the weather, and with poor mortar bond permitting excessive water penetration, it is quite likely that masonry of salvaged brick will spall, flake, pit, and crack due to freezing and thawing in the presence of excessive moisture.

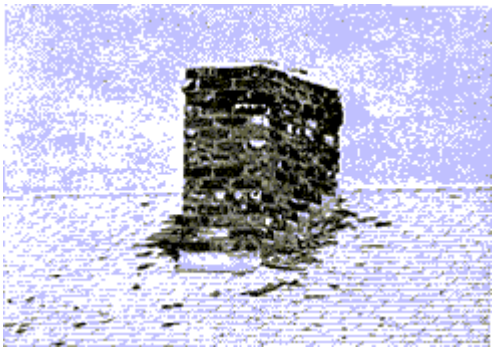
One common characteristic of most manufactured building materials is a reasonable degree of uniformity within a particular grade or within a given manufactured lot. Salvaged brick lack this distinction. Hard-burned and soft-burned brick, hopelessly mixed during wrecking operations, effectively create a material stockpile of two widely differing grades of materials (see Figure 1). A sample of the material will contain specimens of each grade. If tested for absorption or compression strength properties, the sample will show widely diversified characteristics. The average absorption or strength will not approximate the true values for either grade, but will lie somewhere between. In effect, it is difficult to determine whether salvaged brick will meet present day material specifications or building code requirements.



When existing walls are demolished, hard-burned brick and salmons are hopelessly mixed. It is virtually impossible to distinguish between durable and non-durable units.

FIG. 1

Esthetics. Salvaged brick may satisfy the desire for a rugged, colorful masonry surface. Architects often desire the extreme range of colors from dark-red to the whites and grays of units still partially covered with mortar. But most frequently the light pink color of the salmon creates the desired effect. Unfortunately, the pink in salmons results from under-burning which produces units that must not be exposed to weathering. Excessive disintegration due to weathering can soon drastically alter the appearance originally desired (See Figs. 2 - 4).



A chimney of salvaged brick which has spalled considerably

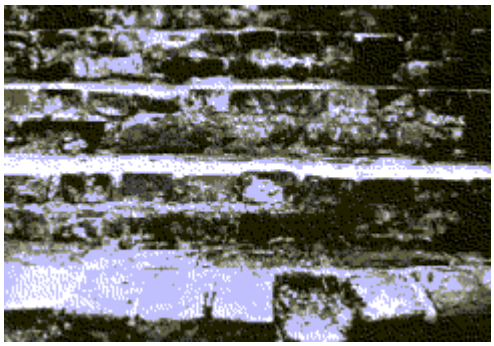
within a relatively short time after construction (Knoxville, Tennessee).

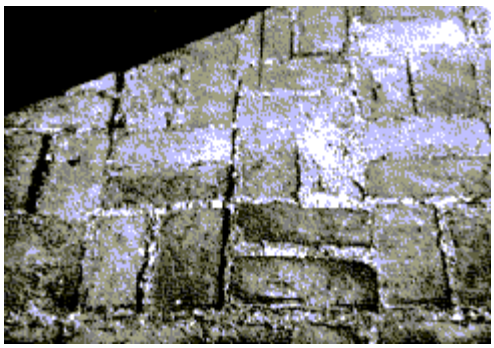
FIG. 2

A close-up of a wall indicating the excessive spalling that is likely to occur

where salvaged brick are exposed to weathering.

FIG. 3





Because of the greater likelihood that moisture will be present,

salvaged brick should not be used for exterior patios, walks, pavements, etc.

FIG. 4

All pink brick are not necessarily under-burned. During recent years the architectural demand for a variety in colors has led to the extensive use of raw clays which burn other than dark red when fired to maturity. Today, among other colors, many hard-burned, pink brick are available. These units may conform to the requirements for highest quality under applicable ASTM specifications. (Many pink brick conform to Grades SW or MW (severe or moderate weathering) under ASTM C 216 or C 62.

Many manufacturers blend different colored brick to provide a rustic appearance similar to salvaged brick. There are advantages to using new brick: the architect may specify any desired color blending and may specify the desired grade under ASTM specifications. Thus, he can obtain the desired esthetic effect without sacrificing durability or strength, a feat which is nearly impossible to accomplish when using salvaged brick.

Economics. Although in many instances salvaged brick have sold for more money than new brick, a principal reason for their use is their low prevailing initial cost. But initial economy often proves to be false economy. For example, labor costs are usually higher for salvaged brick due to the required sorting and cleaning of the units. Maintenance costs for salvaged-brick masonry are very likely to exceed this initial cost considering: 1) cutting out and replacing disintegrated units; 2) tuck pointing mortar joints to reduce leaks and repair cracks; and 3) repeated attempts at waterproofing. (The dangers of coating masonry of under-burned units are discussed in *Technical Notes* 6A, "Colorless Coatings For Brick Masonry". Under-burned units may undergo accelerated disintegration if impermeable coatings are applied to the exterior wall face). In many cases, the initial economics of salvaged brick prove false and result in higher total expenditures.

BUILDING CODE REQUIREMENTS (See references)

American Standard Building Code Requirements for Masonry, ANSI A41.1, Section 2.1.1 (appendix commentary):

"Irrespective of the original grading of masonry units, compliance with code requirements of material which has been exposed to weather for a term of years cannot be assumed in the absence of test. Much salvaged brick comes from the demolition of old buildings constructed of solid brick masonry in which hard-burned bricks were used on the exterior and salmon brick as back-up, and, since the color differences which guided the original brick masons in their sorting and selecting of bricks become obscured with exposure and contact with mortar, there is a definite danger that these salmon bricks may be used for exterior exposure with consequent rapid and excessive disintegration. Before permitting their use, the building official should satisfy himself that second-hand materials are suitable for the proposed location and conditions of use. The use of masonry units salvaged from chimneys is not recommended, since such units may be impregnated with oils or tarry material."

National Building Code**,** Section 1401.2:

"Second-hand units: Brick and other second-hand masonry units which are to be reused, shall be approved as to quality, condition and compliance with the requirements for new masonry units. The unit shall be of whole, sound material, free from cracks and other defects that would interfere with its proper laying or use, and shall be cleaned free from old mortar before reuse."

Standard Building Code**,** Section 1401.2:

"1401.2.1 Masonry units may be reused when clean, whole and conforming to the other requirements of this chapter, except that the allowable working stresses shall be 50% of those permitted for new masonry units.

1401.2.2 Masonry units to be reused as structural units in areas subject to the action of the weather or soil shall not be permitted unless representative samples are tested for compliance with the applicable requirements of 1402."

Uniform Building Code**,** Section 2406 (k):

"Reuse of Masonry Units. Masonry units may be reused when clean, whole and conforming to the other requirements of this section. All structural properties of masonry of reclaimed units, especially adhesion bond, shall be determined by approved test. The allowable working stresses shall not exceed 50 percent of that permitted for new masonry units of the same properties."

EXPERIMENTAL TESTS

At various times interested parties have conducted tests to compare salvaged-brick masonry to masonry of similar new brick. One of the more comprehensive series of tests was conducted many years ago by the Engineering Experiment Station, University of New Hampshire. The following statements are from this test report: (Project No. 98, "Relative Adhesion of Mortars to New and Used Brick", for Star Brick Yard, Epping, NY (1934-1935)).

"The object of this study was to determine by laboratory methods the relative adhesion of different standard mortars to new and used or reclaimed brick . . . (using only) those materials . . . that would generally be employed . . .

". . . as far as materials are concerned . . . a wall laid up with used or reclaimed bricks . . . differ(s) from one laid up with new bricks . . . (only) in the adhesion of the mortar to the brick surfaces. It is this quality with which this study is concerned."

Four types of used brick were tested and compared to the same four types of new brick (a total of eight types). (The report describes the eight brick types tested as including hard and soft, water-struck and sand-struck, new and old brick). Seven different standard mortars were employed. In describing the testing procedures, the report states, in part:

"The brick to be tested were selected and were cleaned of all loose particles of mortar which could be removed by means of a hammer and wire brush. No attempt, however, was made to remove any particle of mortar, etc. which adhered so firmly to the brick surface that pounding and wire brushing would not release it."

The bulk of the report is too large to reproduce in its entirety. However, the following excerpts from the conclusions to the tests are of interest:

" . . . The adhesion of mortar to new (hard) bricks was materially greater than to second hand bricks."

"With but few exceptions the adhesion of mortar to hard bricks was far greater than . . . to soft bricks of the same type."

"Without exception . . . failure of the mortar to adhere to the surface of used brick far exceeded the failures of the joint between mortars and new brick. In other words, it appears that the capillary pores of the second hand brick were so plugged . . . that the new mortar could not gain any appreciable hold on the surface of the brick."

" . . . (The tests indicate) that the adhesive strength of mortar to the hard brick exceeded its cohesive strength..."

"With (all) used brick . . . cohesive strength of the mortars exceeded many times the adhesive strength of the same mortars to the surfaces of the brick."

" . . . within the limits of the test . . . relative adhesion of mortars to . . . reclaimed brick . . . (is) less than half what can be expected if the same mortars are used with new brick of the same type and degree of hardness."

SUMMARY

This *Technical Notes* has discussed the use of salvaged brick in new brick masonry wall construction. The considerations are based on existing knowledge and experience. No effort is made or implied that this is a total discussion of the subject matter, since conditions vary widely throughout the country. However, it is a basis from which the designer can decide on the use of salvaged brick in new masonry structures.

Final decisions on the use of the information and suggestions discussed in this *Technical Notes* are not within the purview of the Brick Institute of America and must rest with the project designer, owner or both.

REFERENCES (Building codes undergo continual revision. The editions listed are those current as the publication date of this *Technical Notes*).

1. American Standard Building Code Requirements for Masonry; ANSI A41.1; National Bureau of Standards (Miscellaneous Publications 211); Washington, D.C.; July 15, 1954 (Reaffirmed 1970).

2. National Building Code, 1987 Edition; Building Officials and Code Administrators International; 4051 W. Flossmoor Road, Country Club Hills, Illinois.

3. Standard Building Code, 1985 Edition; Southern Building Code Congress International; 900 Montclair Road, Birmingham, Alabama.

4. Uniform Building Code, 1985 Edition; International Conference of Building Officials; 5360 South Workman Mill Road, Wittier, California.