Ref: Masonry Design and Detailing - C. Beall

3.4.2 Transverse Strength

The transverse strength of a brick acting as a beam supported at both ends is called the *modulus of rupture*. Tests at the National Bureau of Standards (NBS) indicate minimum values for well-burned brick to be in excess of 500 psi, with a maximum average of 2,890 psi. There is no general rule, however, for converting values of compressive strength to transverse strength, or vice versa. Tensile and shearing properties of burned brick have not been widely tested, but data from NBS indicate that *tensile strength* normally falls between 30 and 40% of the modulus of rupture and *shear values* from 30 to 45% of the net compressive strength. Tensile strength of structural clay tile is quite low and usually will not exceed 10% of the compressive strength. The *modulus of elasticity* for brick ranges from 1,400,000 to 5,000,000.

3.4.3 Absorption

The weight of burned clay products ranges from 100 to 500 lb/cu ft. Variations may generally be attributed to the process used in manufacturing and burning. Increased density and weight result from fine grinding of raw materials, uniform mixing, pressure exerted on the clay as it is extruded, deairing, and hard or complete burning. (Manufacturers are now placing organic materials such as sawdust in the clay body. These materials burn in the firing process, reducing fuel requirements. The resultant brick is lighter in weight, with little effect on strength or absorption.) The extrusion process produces very dense brick and tile characterized by high strength and a small percentage of voids. Since properties of absorption are also affected by the method of manufacture and degree of burning, these factors indicate fairly close relationships among total absorption, weight, density, and compressive strengths. With few exceptions, hard-burned units are highest in strength and density and lowest in absorption.

The absorption of a brick or clay tile is defined as the weight of water taken up by the unit under given test conditions, and is expressed as a percentage of the dry weight of the unit. Since highly absorptive brick exposed to weathering can cause a buildup of moisture in the wall, and since efflorescence is fostered by water in the wall, ASTM standards limit absorption to 17% for Grade SW and 22% for Grade MW units. Most brick produced in the United States have absorptions of only 4 to 10% (*see Fig. 3-21*).

An important property of brick that critically affects bond strength is the *initial rate of absorption, or suction*. High-suction brick absorb water from the mortar too quickly, impairing bond, proper hydration, and curing. Laboratory tests and field experience indicate that maximum strength and minimum water penetration occur with units having initial rates of absorption of less than 20 g/min at the time they are laid. Suction for commercially produced brick and tile may be as low as 1 or 2 g/min or as high as 60 g/min. Brick with high suction rates should be thoroughly wetted prior to installation, then allowed to "surface dry." Since suction can be controlled by this means, it is not covered in ASTM requirements. It should however, be included in project specifications.

Saturation coefficient, or C/B ratio, is a measure of the relationship of two aspects of water absorption: the amount freely or easily absorbed and the amount absorbed under pressure. The former (C) is determined by the 24-hour cold water absorption test, and the latter (B) by the 5-hour boil absorption test. The ratio must be 0.78 or less to meet ASTM standards. The

Designation	Absorption by total immersion: 24-hr cold, C (%)	Absorption by total immersion: 5-hr boil, B (%)	Saturation coefficient, C/B (%)	Saturation by partial immersion, flat, 1 min (g)
A	1.9	3.5	0.53	10
B	9.4	13.4	0.70	33
C	14.6	16.9	0.86	112
D	11.3	15.1	0.74	25
E	10.2	14.7	0.69	38
F	13.8	18.7	0.74	42
G	5.4	7.8	0.69	12
H	3.3	6.0	0.54	6
J	9.3	13.5	0.68	31
K	6.8	13.4	0.54	27
L	3.5	7.6	0.44	9
M	1.6	1.9	0.73	3
N	7.4	8.5	0.87	16
O	3.6	6.6	0.55	20
P	1.5	2.8	0.51	6
R1	4.2	6.5	0.64	7
R2	2.1	4.7	0.45	3
R3	4.9	6.6	0.73	5
U	5.3	9.3	0.56	30
V	8.98	15.07	0.59	32
W	4.02	9.82	0.38	4
X	9.11	15.83	0.57	35

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Absorption properties of various U.S. manufactured bricks. (*From Brick Institute of America*, Pocket Guide to Brick Construction, *BIA, McLean, Va.*)

C/B ratio determines the volume of open pore space remaining after free absorption has taken place. This is important under severe weathering conditions when a unit has taken in water that must have room to expand if frozen in order to avoid damage to the clay body. The theory does not apply to hollow masonry units or to certain types of deaired products. In those cases, strength and absorption alone are used as measures of resistance to frost action.

3.4.4 Durability

The durability of clay masonry usually refers to its ability to withstand freezing in the presence of moisture, since this is the most severe test to which it is subjected. Compressive strength, absorption, and saturation coefficient are evaluated together as an indication of freeze-thaw resistance since values cannot be assigned specifically for this characteristic.

Resistance to wear and abrasion are important aspects of durability for brick and tile paving, and for the lining of structures which will carry sewage, industrial waste, and so on. Abrasion resistance is also closely associated with the degree of burning, and ranges from underfired salmon brick at the low end to vitrified shale and fire clay at the opposite extreme.