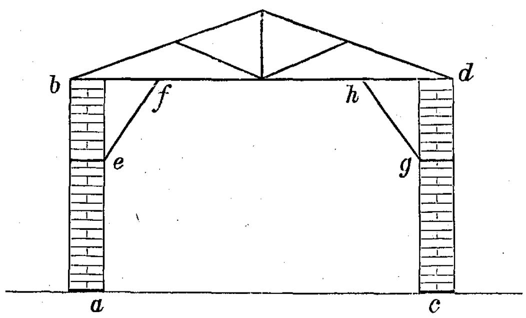
Example of a Simple Brick Structure damaged by Earthquake.

By

F. OMORI, Sc. D.,

Member of the Imperial Earthquake Investigation Committee.

As an example of a very simple brick building, whose seismic stability can roughly be calculated, I consider here the market-house at the town of Ensuiko, in the Prefecture of the same name, which was damaged on the occasion of the Kagi earthquake of Nov. 6, 1904. This structure consisted merely of a roof with wooden truss supported by 20 brick posts (*ab*, *cd* in the accompanying figure.) The building covered an area of 100 *tsubo*, and was 20 *ken* in length and 5 *ken* in width, the longer axis being parallel to the N–S direction.* The roof had a total area of 3,960 square *shaku*, and was covered by the tiles of the native style. As the weight per square *shaku* of the roof, truss, and the tiling, is about 15 lbs, the total weight of the roof system was about 60,000 lbs, distributed with the average amount of 3,000 lbs among the masonry posts, of which there were 10 on each side with a mutual distance of 2 *ken*. The posts consisted each of 38 layers of bricks, the height being 8.6 *shaku* (=103″), and the section



* 1 *ken* = 6 *shaku* = 1.82 metres. 1 *tsubo* = 1 *ken* square.

$1\frac{1}{2}$ bricks square, or 1.17 *shaku* (=14″) square. Assuming the weight per 1 cubic inch of the brick work to be 0.0603 lb, the weight of each of the columns will be 1,206 lbs. Thus the total pressure at the foot of each column was 4,206 lbs, giving an average amount of 21,5 lbs per square inch of the base area. This amount of compression, added to the tensile strength of the mortar joint of the brick work which is assumed to be about 20 lbs per sq. in., gives a value of 41.5 lbs per sq. in. for the effective tensile strength at base section of the columns. Again, the centre of gravity of the whole building is estimated to be at a height of 7.4 *shaku* (=2,230 mm), that is to say, only 1.2 *shaku* (=$36\frac{1}{2}$ cm) below the top of the supporting columns. This fact illustrates the importance of reducing the weight of the roof of a structure, in order to lessen the intensity of effects on the latter of the earthquake motion.

The seismic stability of the Ensuiko market-house, whose construction has been sketched above, is indicated by the acceleration ($=a$) of the earthquake motion, which is capable of fracturing the supporting columns at their weakest position, namely, the base. This can be calculated by the formula

$$a=\frac{4\,gx_0^3F}{3\,f\,W};$$

the value of the different constants being as follows:—

$x_0 = 177.5$ mm
$f = 2{,}230$ mm
$F = 41.5$ lbs per sq. in.
$W =$ Weight supported at the foot of the column $=4{,}206$ lbs.

The value of the acceleration a is found to be only 497 mm/sec^2. Such an intensity of motion is by no means that of what may be called a "great destructive shock," but is not much different from the maximum acceleration at Hongo on the occasion of the semi-destructive Tokyo earthquake of June 20, 1894. Thus the seismic stability of the market-house under consideration will be seen to be very low. In order to make a structure in Formosa practically earthquake proof, we must raise its seismic stability to an acceleration of about 2,000 mm/sec^2.

As is to be easily imagined, all the posts of the market-house were fractured by the earthquake of Kagi of 1904 at their bases, each being also broken at or near the foot of the timber diagonal support (*ef* and *gh* in the figure.) It is hereby to be remarked that great care must be taken in the use of trusses and ties. The existence of even an apparently insignificant discontinuity, in the form and dimension, the rigidity, or the material, invariably produces a fracture or mutual destruction at the joints.