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Calculated Brick Masonry for Speedier and Economic Construction

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SYNOPSIS

The use of brickwork dates back to prehistoric time and is the backbone of building industry. The wall thicknesses are decided based on tradition or so called empirical rules. Little attention is paid to the intrinsic strength and structural behaviour of masonry. The structural potentiality of masonry, therefore, remained unexploited. Work carried out at this Institute and abroad has revealed its potentiality. It is seen that besides speedier construction, great economy can be achieved if the masonry is designed on rationalised basis like any other structural component. The IS 1905-61 has been revised and gives the necessary data for the design of masonry walls. In this paper the factors which govern the design of brickwork are described and a few illustrative examples of calculated brick masonry are given. It is seen that where good bricks are available, single brick thick walls can be adopted for four storeyed construction thereby giving great savings.

1. INTRODUCTION

1.1 Brick masonry forms the backbone of building industry since prehistoric times, and even till today it is commonly used and forms a major part of any building. Somehow little attention is paid to the intrinsic strength and structural behaviour of masonry, and engineers and architects are not well aware of its strength potentialities. The wall thicknesses adopted are either based on traditional practices or calculated by empirical methods or thumb rules. This often results in bulky construction and is uncompetitive in comparison to other forms of construction. Therefore, it has been a normal practice to have load bearing masonry walls upto three storeys and to go in for concrete framed construction with infill walls for four storeys and above.

1.2 Extensive experiments and research carried out abroad and in India have proved beyond any doubt that masonry behaves just like any other structural element and has revealed its structural potentiality. The strength of masonry which is a function of brick strength, strength of mortar, workmanship, slenderness ratio, eccentricity of loading etc. can now be predicted. These latest developments in the performance of brick masonry under load have been considered in the revision of the Indian Standard IS : 1905-61(1) and the relevant data such as basic stress, reduction factors for slenderness and eccentricity of load, additional permissible stresses under concentrated load, tensile and shear stresses etc., required in the design of masonry have been furnished. Therefore, it is possible to design the masonry walls on rationalised basis like any other structural component and these may be referred to as calculated brickwork or sometimes engineered brickwork. The calculated brick masonry will reduce the cost of construction and will provide a speedier construction due to little variation in the thickness of wall for buildings upto 4 to 5 storeys where a single brick thick wall can be provided in all the floors depending on the conditions of loading as well as brick and mortar strength. The factors which govern the design of brickwork are briefly discussed in this paper followed by two illustrative examples (Appendices I and II).

2. PARAMETERS IN DESIGN OF BRICKWORK

2.1 The design for bearing walls is based on stress concept. Consideration is given for the actual loads to be carried by the wall in conjunction with certain specified permissible stresses related to the brick strength, mortar composition used, and its slenderness ratio.

2.2 The design load intensity on a wall is a function of the floor loads and the openings in the wall. Judicious positioning of the openings and reducing them where possible, results in reduced thicknesses for the bearing walls.

2.3 In the design of calculated brick masonry, the effective dimensions of the member for calculating the slenderness ratio and the point of application of load etc. are to be ascertained. The effective height or length of wall depends upon the degree of lateral restraint offered by slab, beam or truss etc. at top and bottom or by cross wall, buttresses etc. along the sides. Similarly when the wall is strengthened with pillars at intervals, its lateral stability is increased. In such cases the effective thickness is the product of its actual thickness and a factor greater than one. All these values are given in IS: 1905-66 (revised). Having arrived at these parameters, a section can be arrived at, such that the actual stresses do not exceed the permissible limits.

3. CONCLUSIONS

3.1 The various factors affecting the strength and stability of a brick wall are to be carefully considered while designing a brick masonry structure. For masonry walls, the ye-laws specify the minimum thickness for walls irrespective of the quality of masonry units. Thus, there has been no encouragement for producing better quality bricks. But now, as per the revised IS code, better the quality of bricks, lesser is the thickness of the wall. This will give an impetus to brick industry to produce high strength bricks. By the use of better quality bricks, plastering may be replaced by pointing, thus saving in scarce material, cement. From the illustrative examples, it may be seen that even with commonly available bricks of 100 kg/cm², single brick thick wall can be adopted for four storey construction. Bearing wall construction being simpler and easier will increase the pace of work, besides saving in cost. This being a familiar type of construction, will not impose any difficulties with the contracting firms. The only thing needed will be better quality of work; and this would be possible by providing proper training to the brick layers and also training the supervisors to keep to quality. When the thickness of the wall used in all the storeys is the same, the room sizes are identical and hence, identical shuttering can be used repetitively.

4. ACKNOWLEDGEMENT

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ILLUSTRATIVE EXAMPLE NO. 1

To calculate the thickness of the internal and external wall in G.F. in a four storey building for the following data:—

(i)	Crushing strength of bricks	— 105 kg/cm^2
(ii)	Mortar for Masonry	— 1:1:6 (cement: lime:sand)
(iii)	Room size	— 3m×4m on either side
(iv)	Door opening area	— 1m×2.135m
(v)	Storey height	— 3 metres
(vi)	D.L. on slab	— 415 kg/m^2
(vii)	L.L. on slab	— 200 kg/m^2
(viii)	Slab designed as one way along shorter span.	
(ix)	Bearing of slab on outer walls	½ thickness of wall.

Solution

Internal wall

Net length of wall (after deducting opening) = 4—1 = 3m.

Ratio of net length to gross length of wall = 3/4 = 0.75

Let the thickness of wall in all the storeys be equal to 22.6 cm.

Load on per metre net length of wall

(i) Load from four slabs (neglecting the effect of continuity of slab)

$$= \frac{4 \times 3}{0.75} \times (415 + 200) = 9840 \text{ kg/m.}$$

(ii) Self weight of wall from all the four storeys

$$= \frac{0.225 \times 1920 \times 4}{0.75} \left\{ 3 - 2.135\ (1 - 0.75) \right\}$$

= 5760 kg/m.

∴ total load = 9840+5760 = 15600 kg/m.

When the spans on each side of the wall are nearly equal, the load may be assumed as axial.

$$\therefore \text{Stress} = \frac{15600}{100 \times 22.5} = 7 \text{ kg/cm}^2.$$

External wall

Load on per metre net length of wall

(i) Load from four slabs

$$= \frac{4 \times 3}{2 \times 0.5}\ (415 + 200) = 4920 \text{ kg/m} \quad .. \text{ (i)}$$

acting at T/4 from the centre of wall where 'T' is thickness of wall.

(ii) Self weight of wall = 5760 kg/m (acting at the centre of wall) .. (ii)

∴ Total load (i) and (ii) = 10,680 kg/m

∴ Net eccentricity of load

$$= \frac{4920}{10680} \times T/4 = 0.11\ T$$

$$\therefore \text{Stresses} = \frac{10680}{100 \times 22.5} \pm \frac{10680 \times 0.11 \times 22.5 \times 6}{100 \times 22.5^2}$$

$$= 4.7 \mp 3.1 = 7.8 \text{ and } 1.6 \text{ kg/cm}^2$$

Permissible stress

Basic stress for 105 kg/cm^2 brick and 1:1:6 mortar = 10 kg/cm^2.

The wall is laterally restrained at top and bottom by slabs, the effective height = 0.75×3 = 2.25 metres.

∵ slenderness ratio = 225/22.5 = 10.

Reduction factor for slenderness ratio of 10

(i) Zero eccentricity = 0.84 (from IS-1095)

(ii) Eccentricity of 0.11 T = 0.83 (from IS-1905)

∴ Permissible stress in

case i) 0.84×10 = 8.4 kg/cm^2; and

case ii) 0.83×10 = 8.3 kg/cm^2.

Since the actual stresses both in internal and external walls are within the permissible values the assumed thickness is adequate.

ILLUSTRATIVE EXAMPLE NO. 2

To design a brick masonry column supporting a two-hinged arch for the following data:—

(i) Vertical reaction from arch 5000 kg.
(ii) Horizontal reaction from arch 150 kgm.
(iii) Height of column from base 300 kg.
(iv) Crushing strength of bricks 105 kg/cm².

Suitable mortar may be used.

Assume the column size as 40 cm×30 cm. Weight of masonry = $0.4 \times 0.3\ H \times G$.

$= 0.4 \times 0.3 \times 3 \times 1920$

$= 700$ kg.

Total vertical load

$W = 500 + 700 = 5700$ kg.

Horizontal force = 150 kg.

Moment at base due to horizontal force

$M = 150 \times 300 = 45000$ kg. cm.

Eccentricity at base $= e = M/W = 45000/5700$

$= 7.9$ cm.

$$\frac{e}{T} = \frac{7.9}{40} = \frac{1}{5.06}$$

$$= 0.197 < \tfrac{1}{6}$$

Therefore, the section is subjected to tension as shown in Fig. 1.

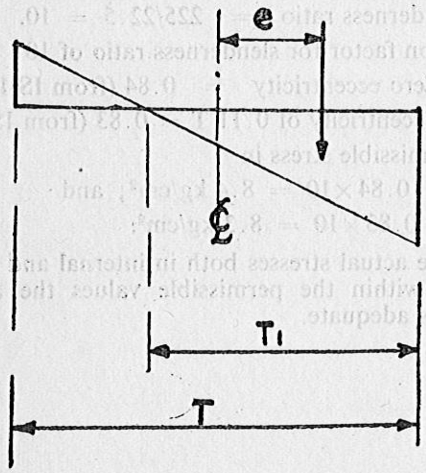

Fig. — 1

The effective thickness under compression:—

$T_1 = 3\,(T/2 - e) = 3\,(20 - 7.9)$

$= 36.3$ cm.

Max. stress at the edge $= \dfrac{2 \times W}{\text{effective area}}$

$$= \frac{2 \times 5700}{30 \times 36.3}$$

$= 10.5$ kg./cm²

Permissible stress

The column has adequate lateral support of arch, the effective height may be taken as 0.85 H.

(i) Slenderness ratio $= \dfrac{0.85 \times 300}{40} = 6.4$

(40 cm. side of the column shall be along the span of the arch).

(ii) $\dfrac{e}{T} = 0.197$

(iii) Stress factor due to slenderness ratio and ecentricity = 0.975 (from Table 5, IS: 1905 Draft Revision).

(iv) As the area of the column 40×30 or 1200 sq. cm. is less than 3000 sq. cm., the permissible stress shall be reduced by a factor equal to $\left(0.75 + \dfrac{1200}{12000}\right)$ *i.e.* 0.85.

If f_m is the required basic stress, the max. stress occurring in the column *i.e.*, 10.5 kg/cm² is equal to

$f_m \times 0.975 \times 0.85 \times 1.25$

(Allowing 25% extra, due to non-axial load) *i.e.*,

$10.5 = f_m \times 0.975 \times 0.85 \times 1.25$

$f_m = 10$ kg/cm².

Basic stress for 105 kg/cm² brick in 1:1:6 (cement:lime:sand) mortar is 10 kg/cm² and, therefore, it can be adopted for the construction.

It may be noted here that though the max. stress is 10.5 kg/cm², the average stress is only half of this value *i.e.*, 5.25 kg/cm².

Notations

G	=	Density of masonry.
T	=	Thickness of wall or column in the direction of span.
T_1	=	Effective thickness under compression.
e	=	eccentricity of load from centre.
W	=	Total weight.
M	=	Bending moment.
f_m	=	Basic stress in masonry.
H	=	Height of wall or column.