CONCEPT OF SINGLE BRICK THICK LOAD BEARING WALLS UPTO FOUR TO FIVE STOREYED RESIDENTIAL BUILDINGS IN SEISMIC ZONES

G.C.Mathur (1)

Introduction

In areas which are prone to seismic forces, it is necessary to design buildings and other structures which adequately resist the seismic impact. Many countries of the ESCAP Region notably Iran, India, Indonesia, Phillipines and Japan are subject to seismic forces of severe intensity. Disasters have frequently occured in these regions claiming heavy toll of life and property.

In the wake of rapid pace of urbanisation, the density of population in urban centres has been increasing and construction of multi-storeyed buildings for residential purposes has come in vogue. This has led to greater awareness regarding planning, design and construction of buildings and houses taking into account the seismic forces. In order to put up buildings and houses which not only offer adequate safety from damage and destruction caused by earthquakes but which can also be constructed at economical cost intensive research and development work has become necessary.

Low Cost Housing

In India as in other developing countries, there is an acute shortage of housing. As per the estimates made by the National Buildings Organisation (N.B.O.) at the beginning of 1980 there is a total shortage of 15.1 million dwelling units in the country. In urban areas alone the estimated backlog is of the order of 5 million dwelling units. In order to avoid heavy burden on national exchequer, new construction techniques/materials/concepts of housing have to be introduced for fulfilling the basic need of shelter, especially for the weaker sections of the society. Apart from the fact that the structure has necessarily to be low cost, it has also to be designed to resist earthquake forces adequately as two-third of the Indian Sub-Continent lies in seismic zone of moderate to severe intensity. The matter becomes all the more important in areas where land is scarce and costly and it is incumbent to build four to five storeyed buildings without the use of lifts.

In many parts of the country burnt clay bricks are the principal building material as suitable soil is locally available from which good quality bricks are made at

---

(1) Director, National Buildings Organisation & U.N. Regional Housing Centre, ESCAP

economical cost using simple techniques. Bricks are commonly used for construction as not only the techniques and skill of brick masonry construction are readily available, but at the same time the performance of brick masonry in tropical climatic conditions is very satisfactory. However, with large-scale programme of construction, the cost of bricks has considerably risen and in many places their scarcity is also being experienced. It has, therefore, become necessary to optimise the use of bricks by rationally designing the load bearing brick masonry, for 4 to 5 storeyed residential buildings. This would result in economical construction as besides saving in consumption of bricks and mortar the reduction in the thickness of walls would make available more floor area for a given plinth area.

Research Work Done

The Department of Earthquake Engineering, University of Roorkee, India (formerly the School of Research and Training in Earthquake Engineering) which was established in 1960, has undertaken pioneering research work in seismic design and construction of structures of varied types including low cost housing employing brick masonry construction. The Indian Standards Institution has classified the Indian Sub-Continent into five zones depending upon the intensity of earthquakes. Delhi and Calcutta regions, for example, fall in the seismic zone IV and III respectively where the magnitude of earthquake on the Ritcher's Scale correspond to 6.5 to 7 and 6 to 6.5 respectively. Based on the research and development work done in India and abroad, the Indian Standards Institution has formulated codes of practice for designing of earthquake resistance structures including brick masonry construction.

The National Buildings Organisation has been creating greater awareness in the country and in the ESCAP Region and for this purpose, in collaboration with the Department of Earthquake Engineering, University of Roorkee, the N.B.O. has produced a 16 mm film entitled "When the Earth Trembles". It explains the measures which should be taken in planning, design and construction of houses to withstand the earthquake forces adequately at economical cost. The film produced by the Films Division, Government of India, has been screened all over the country through cinema houses and T.V. circuit.

Developments in Load Bearing Brick Masonry Constructions

One of the important activities of the N.B.O. is also to promote adoption of appropriate technology for housing and building construction. Towards this end, the N.B.O. is operating an Experimental Housing Scheme under which buildings

and houses incorporating new construction techniques, materials, design concepts etc., are put up and the results of experimentation are evaluated and the proven new construction techniques and materials are recommended for adoption on wider scale.

In seismic regions, so far it has been the practice to construct thick load bearing brick masonry walls restricted to three stories. However, based on experiments and analytical observations, taking into consideration seismic forces, the Indian Standard Code now permits construction of structures upto 4 stories with load bearing walls restricting the total height to 15 metres only provided seismic considerations are taken into account in planning, design and construction.

Under the Experimental Housing Scheme of National Buildings Organisation, construction of single brick thick load bearing brick walls for upto 5 storied residential buildings with a total height of 15 metres has been taken up at Calcutta and Delhi with adequate measurements to account for earthquake forces. Diagramatic representation of the development in construction of brick masonry structures is given in the Figure 1.

Four Storied Single Brick Wall Construction

In the first instance construction of 16 four storied blocks having 96 dwelling units were taken up for construction at Delhi in 1968. The project was undertaken by Central Public Works Department under Experimental Housing Scheme of N.B.O. The main features of construction are: (Fig. No. 4)

a) Adoption of 23 cm (9") thick load bearing brick masonry wall in all the floors with conventional R.C.C. slab roofing and floors.

b) Planning of structures on concept of cross wall construction.

c) Ceiling height has been reduced to 2.75 metres.

d) Using 23 cm (9") N.B.C.C. bricks of strength 300 kg/cm^2 in cement mortar 1:6, 9" (23 cm) bricks of strength 70 kg/cm^2 in cement mortar 1:3 in first floor and in cement mortar 1:6 in second and third floors. (Subsequently, construction with 9" load bearing walls is being done in bricks of strength 105 kg/cm^2 and 70 kg/cm^2 depending on the load).

e) Strengthening the structure against seismic forces which include provision of R.C.C. lintel bands, corner reinforcement in masonry, reinforcement at junction of walls, openings of doors and windows, etc.

As compared to the conventional type of load bearing brick masonry wall employing 34.5 cm (13½") walls in ground and first floor and 23 cm (9") in the remaining two floors, single brick load bearing walls resulted in a saving of 4½%.

The confidence of the engineers and builders about its behaviour and safety is apparent from the fact that it has almost become a universal practice that wherever good quality bricks are available in different parts of the country, 23 cm (9") thick brick walls upto four stories are adopted.

Five Storied Single Brick Thick Load-Bearing Residential Buildings With Precast Roofing(Without Lifts)

In order to provide more built-up accommodations in a given piece of land, construction of five storied residential buildings employing single brick thick walls in all the five floors has also been taken up by the National Buildings Organisation on an experimental basis. A five storied residential building, having 24 dwelling units was completed by Calcutta Metropolitan Planning Organisation in Calcutta in 1974. The main characteristic features of the building are:

a) Adoption of 25 cm (10") thick load bearing brick walls in all the five floors (Calcutta bricks are 10" size, whereas bricks in Delhi are of 9")

b) Planning of structure on concept of cross wall construction.

c) Precast R.C. channel type roofing and flooring evolved by Central Building Research Institute, Roorkee.

d) Strengthening the structure against seismic forces (which include provision of R.C.C. lintel bands, corner reinforcement in masonry).

e) Ceiling height has been reduced to 2.75 metres in all the floors.

The total height of the building does not exceed 15 metres. The performance of the structure is being observed. Meanwhile, construction of some 500 dwelling units on the basis of five storied residential blocks have also been completed employing above techniques of construction by the Calcutta Metropolitan Planning Organisation.

Five Storied Single Brick Thick Wall Construction with RCC Roofing

In Delhi, which in terms of seismic intensity is more severe than Calcutta, the construction of five storied residential buildings has been taken up by the C.P.W.D. under

the N.B.C. Experimental Housing Scheme. The construction work of the building was completed in 1978. The main features of this experimental project are: (Fig. No. 5)

a) Adoption of 23 cm load bearing brick wall construction in all the floors.

b) Planning of structures on concept of cross wall construction.

c) The ceiling height reduced to 2.75 metres. The total height of the building being 15 metres.

d) Strengthening measures to resist the earthquake have been incorporated which include provision of sil R.C.C. bands, corner reinforcement.

The strengthening measures which have been adopted in the design and construction of the building have been recommended by the Department of Earthquake Engineering, who carried out a detailed analysis of the structure. For this analysis first and top stories have been checked which are the critical parts of the structure. Advantage is also taken of the symmetry of the structure while carrying out the analysis. The analysis leads to the following observations.

Shear stress is within safe limits for brick masonry if it is done in a cement sand mortar not leaner than 1:6. However, in several building's elements, the compressive and tensile stresses exceed the safe limit of stresses permissible in the walls. Since maximum stresses are computed at the ends of wall piers, no reduction in permissible stress is allowed due to buckling effects which are present only in the center of such walls. Hence, strengthening measures are required. Based on above, following measures are adopted:

a) For all brick work bricks used shall have a crushing strength of more than 70 kg/cm^2

b) All 4½" walls of all the stories shall be constructed in cement sand mortar 1:3 or equivalent.

c) The brick work in the first story shall be in cement sand mortar not leaner than 1:3 or its equivalent. In the rest of the stories it shall be not leaner than 1:6, or its equivalent.

d) Since all doors and windows, except in bath and W.C., have their top flushed with bottom of the slab, lintel bend cannot be provided. However, suitable horizontal dowel reinforcements at corners and junctions may be provided, at one course below window sill level and at about mid height above this level to the roof to ensure integral action as per details in Figure 3. The windows in bath and W.C. should be encased.

e) Vertical steel at corners and junctions of walls and also around the openings shall be provided as follows:

Stories	Top	Fourth	Third	Second	Bottom
Dia of single bar in mm.	12	12	12	16	16

Provision of vertical reinforcements and its encasement at the corners, junctions and jambs or openings shall be indicated in Figure 2.

f) Slabs shall be given full bearing on the wall to act as roof bands.

A similar block has been put up by C.P.W.D. in which instrumentation has been undertaken to check for stress distribution at various floor levels during the execution of work as well as the final stress distribution. Data is being collected regularly which would subsequently be available in a tabulated form.

Department of Earthquake Engineering has recommended that in case precast channel units developed by CBRI or similar precast elements are used for roofing and intermediate floors, following additional strengthening measures may be adopted against earthquake forces:

a) 4 cm (1½") cement concrete 1:2:4 topping with reinforcement consisting of 6 mm dia bars 23 cm, c/c., both ways may be provided.

b) Ends or sides of channel units, which are resting on all the walls, should have reinforcement (12 mm bars) projecting out in the form of loops or hooks. These projecting loops or hooks should be tied together with a runner bar of 12 mm dia passed through them and the gap concreted with 1:2:4 cement concrete.

Appropriate Technology

It would thus be observed that the main objective of undertaking experimental construction under the N.B.O. Experimental Housing Scheme is to promote evolution and adoption of appropriate technology of construction suited to local conditions. This would be obvious from the fact that in India particularly in Indo-Gangetic plains burnt clay brick is one of the predominently used basic construction material. In Delhi very good bricks are being manufactured which should be used to optimum advantage by constructing multi-storied residential buildings. The adoption of single brick thick load bearing walls upto 5 storied residential buildings avoids the necessity for putting up R.C.C. frame structure and thus saves scarce material like cement and steel. In hot and arid climatic conditions brick walls having 23 cm thickness provides adequate thermal comforts as compared to other types of walling material like concrete construction.

Both the manufacture and use of bricks is labour-intensive and provides employment to large numbers of skilled and unskilled workers who are available at cheap rates. Saving upto 15% in the cost of construction can be achieved by using brick load bearing walls upto five stories high, as compared to other forms of construction.

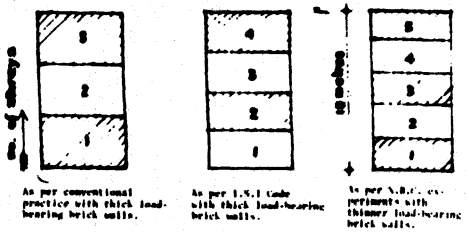
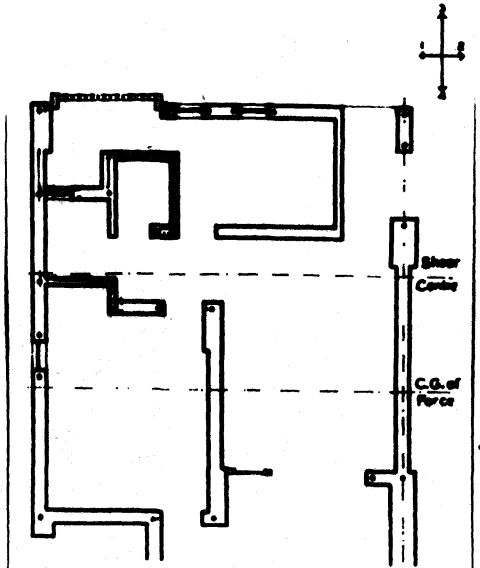
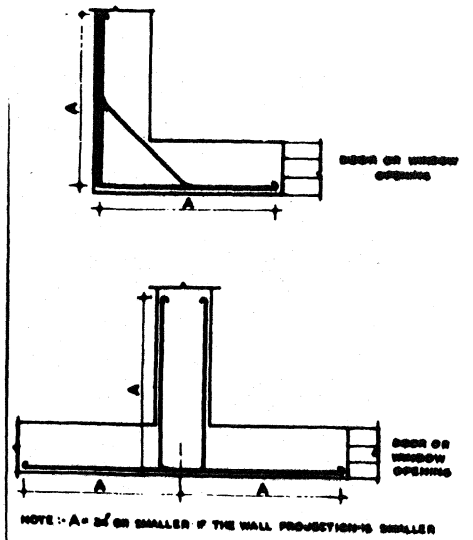


Fig. 1



TYPICAL FLOOR PLAN SHOWING VERTICAL REINFORCEMENT IN MASONRY

Fig -



NOTE :- A= or SMALLER IF THE WALL PROJECTION IS SMALLER

HORIZONTAL DOWEL REINFORCEMENT DETAILS AT CORNER AND JUNCTION OF WALLS.

Fig. -

Fig.4

Four storeyed single brick thick load-bearing residential building constructed by Central Public Works Department under NBO Experimental Housing Scheme in 1968 at New Delhi which is in Seismic Zone IV

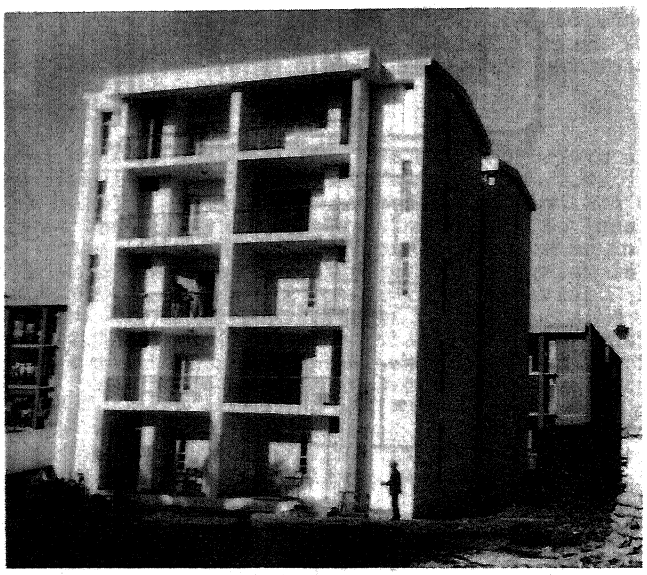


Fig.5

Five storeyed single brick thick load-bearing residential buildings with R.C.C. roofing constructed by Central Public Works Department under NBO Experimental Housing Scheme in 1978 at New Delhi which is in Seismic Zone IV.