A CONSTRUCTION METHOD PROVIDING HIGH EARTHQUAKE RESISTANCE IN REINFORCED CONCRETE BUILDINGS

Orhan Pekin[I], Faruk Sirmali[II], Kemal Özden[III] and Pratima Rani[IV]

SYNOPSIS

A method of constructing a building having high resistance to earthquake, which method separates the structure into two parts, the foundation and the superstructure and isolates the said parts from each other; brings the 'Floating Foundation' concept instead of the attached foundation; and stiffens the superstructure by means of rigid cornered triangles and/or trusses with stable surfaces.

INTRODUCTION

It is known that for centuries earthquakes have caused great loss of life and property. Research into the field of earthquake is therefore of vital importance. The method presented herein brings solution to this problem and can be summarized in two steps as follows:

1. To isolate the superstructure from the foundation, and hence, not to transmit the earthquake to the superstructure.

2. To stiffen the superstructure.

A study of foundations is necessary in order to explain the first proposal.

STUDY OF FOUNDATION

In all foundation types, foundations are generally attached to the ground and integrated with the ground. Since the structure is erected as attached to the foundation, the foundation mass which, during the earthquake, moves together with the ground bearing the vibrations in itself, will tend to move the superstructure in the direction of the earthquake. The superstructure, on the other hand, will resist this motion on account of inertia, and, through the inertia forces generated in the opposite direction, will tend to remain stationary, i.e. it will move in the opposite direction. Therefore, stress between the foundation of the structure and the superstructure will be generated. Due to this reason, the construction of an earthquake resistant structure should be such that:

1. It can prevent the generation of these stresses, or if this is not possible,
2. The superstructure should be capable of resting these stresses.

I President, Tekno-Mesken Contracting Const. & Engg. Co., Istanbul.
II Professor, Dept. of Civil Engg., Technical University, Istanbul.
III Professor, State's Engg. & Architecture Academy, Istanbul.
IV School of Research and Training in Earthquake Engineering, University of Roorkee, Roorkee, INDIA

In order to prevent the stresses from being generated, it is essential to combine the superstructure itself with its foundation above the ground and to isolate this whole unit from the foundation in the ground. In the proposed method, if the ground is not firm, this surface will have to be strengthened by one of the foundation systems. Thus, a reliable surface upon which the structure may be safely located will be obtained. By placing materials such as roller clay, neoprene, teflon over the ground surface prepared in this way, a medium will be obtained which is resistant to vertical forces but which has a capacity of dynamic isolation and sliding. Upon this medium, the floating foundation (which is integral with the superstructure) shall be placed.

As the lateral forces which are generated during earthquakes are 2 to 10% of vertical loads and are vibratory in character, sliding supports which would dampen this motion should also be developed. The beds referred to above may be achieved by placing them directly underneath columns interconnected by beams over a reliable foundation which has been integrated with the ground. For example, under a column supporting a vertical load W, if a support, which would move at a lateral force αW (depending upon the seismic coefficient α say), could carry the load W without being collapsed, the problem will be solved. For this purpose, sliding supports to be placed under each column can be calculated beforehand.

Proceeding along these lines the proposed method can be applied to multistory buildings as well as to low story buildings. For this purpose, metal or plastic of open, closed, pipe section or other profiles may be employed. Also the lateral movement of the main structure, formed from the foundation built integrally with the superstructure, can be possible without collapse under the action of the lateral forces. To limit the motion of the structural mass, the said platform can be bounded at the boundaries thereof or a fonder band formed from the plastics and similar materials can be used for this purpose. Such absorbant elements which would be mounted on the enclosure wall will control unlimited movements of the structure during the earthquake. Figure 1 shows the method for isolating the foundation.

STUDY OF THE SUPERSTRUCTURE

Methods which will stiffen the structure are now investigated. Generally, reinforced concrete structures consist of columns, beams and floors. As such a system is often formed of rectangles, it is unstable, liable to angular deformation. When the angles are deformed, large moments will come into existance. Thus, the system will be subjected to large moments at joints and to lateral inertia forces during earthquakes. Upto the present, in earthquake computations, sections of columns and beams subjected to the said moments have been investigated, and when the dimensions proved inadequate, the sections of columns and beams, and the reinforcement content, were increased. When such measures were also insufficient (especially in multistorey buildings) shear walls were placed in various directions. In all these cases the problem has been tried to be solved by a lot of costly measure. Also, structures that are constructed without shear walls proved to be dangerous during long earthquakes even though they may be resistant to earthquakes. Because of their rectangular shape these are geometrically unstable structures. They are therefore non-rigid.

In practice, the earthquake investigation is usually carried out by considering the reinforced concrete structures as mere frames or continuous beams and columns, but the coefficient applied so far is insufficient. On the other hand, when the earthquake coefficient is increased, columns become insufficient in the conventional system. Shear walls can be considered only for tall and important buildings since they are a costly approach to the solution of the problem. In short, in conventional buildings, the structure is made heavier by increasing column and beam sections and by making shear walls. With a view to providing resistance to earthquakes. A heavier structure, in turn, creates larger inertia forces and larger stresses during the earthquake. Therefore, economical and lightweight measures which will ensure the resistance of the structure against horizontal effects have been realized in the proposed method.

Stiffening the superstructures: As is known, in space systems three non-planer bars are required to fix a point. Forces coming from any direction to this point are resisted by tension or compression force. Let us now built our construction system in space from this basic principle. First, the foundation pertaining to the superstructure is prepared as a rigid unit. Then the first storey floor is rigidly connected to this foundation at every joint.

A point in the first storey is connected to the foundation by means of two diagonal beams which are in two separate planes, in addition to the column. Thus, this point is rigidly attached to the foundation by means of three points, that is, it is made rigid. Another point, is made rigid by attaching it to a diagonal beam, and to the rigid point through the floor. All points in the same storey are then attached to the foundation and to the previous rigid points by means of three bars, one being their own column and the other two being the two beams passing through the floor (that is by the floor itself). Thus, all joints on the first storey floor slab are rigidly attached to the foundation. After this operation, the second storey is attached, and the method is applied in the same way upto the top floor.

When this method is applied in buildings with many stories, vertical trusses will appear beside these rigidly held points (Figure 2). This method is employed on the periphery if the periphery of the structure permits it. It it is not inconvenient to form the periphery of the structure with truss, by using the method in this way a high earthquake resistance will be provided, and the trusses will provide many solutions for the windows. The diagonals in the trusses in the proposed method are subjected to either all tension or all compression forces from a one-directional earthquake. In order to prevent this we can frame the trusses in two directions rather than in the same direction, by the use of horizontal 'V' shapes (Figure 3). In this case, half of the diagonal beams will be subjected, during the earthquake, to compression forces, and half of them to tension forces. In this regard, the reinforced concrete structures which has a high resistance to compression, is appropriate.

Apart from the proposals outlined above, the resistance of the structure to the earthquake can also be attained by forming space truss cores without rigidly attaching all the points of the structure. By using trusses instead of shear walls which are generally used in tall buildings, bulky and expensive structures, as well as the foundation problems brought about by heavy walls in the buildings, are avoided. In this proposal, the building is supplied with vertical rigid & isostatic trusses from both directions. One of the novelties of this proposal is the provision of safety against horizontal forces (especially earthquakes) in buildings by means of plane, horizontal or vertical trusses. The rigid surface which proposed herein may be constructed along the entire facade in the form of compartments equipped with trusses (in various directions). An allegation to the effect that the diagonal beams of our proposal would spoil the window openings, would be absurd. The architect can place the openings in the faces containing the trusses without spoiling the facets, according to the architectural configuration of the building.

CONCLUSIONS

1. The method presented in the paper isolates the foundation and superstructure from each other by means of special teflons, balls and/or rollers i.e. sliding supports. This isolates superstructure from the generation of stresses due to earthquake forces.

2. The enclosure wall provided in the foundation avoids the overturning of the structure.

3. To make the superstructure earthquake resistant, it is stiffened by means of simple trusses, plane trusses, compound trusses or space trusses in various directions. This stiffened structure acts as an integral unit against earthquake forces.

4. The lateral displacements of superstructure in all the directions are checked by bounding it by a wall inclosure upto ground level and packing the gap by plastics or similar material.

5. The method can be adopted without spoiling the architectural configuration of the building.

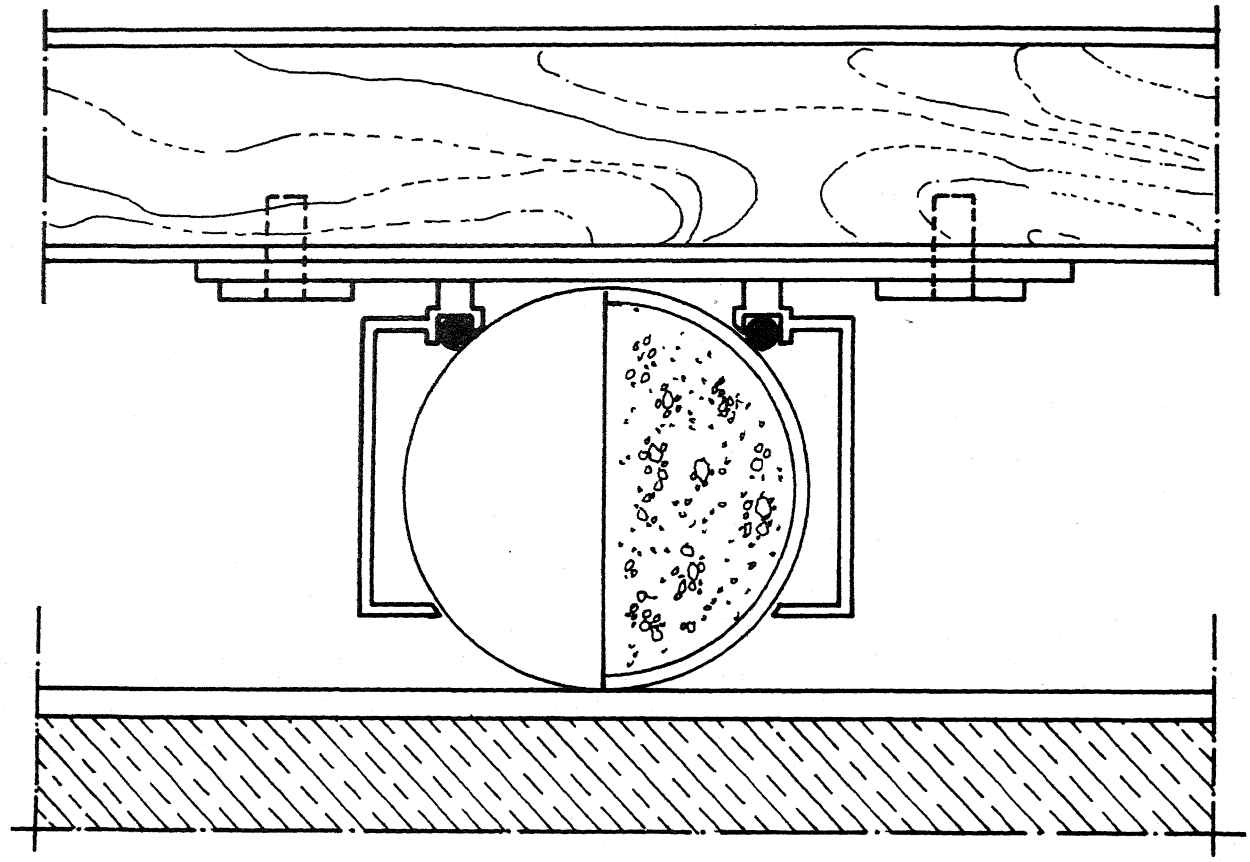

FIG. 1 _ METHOD OF ISOLATING FOUNDATION

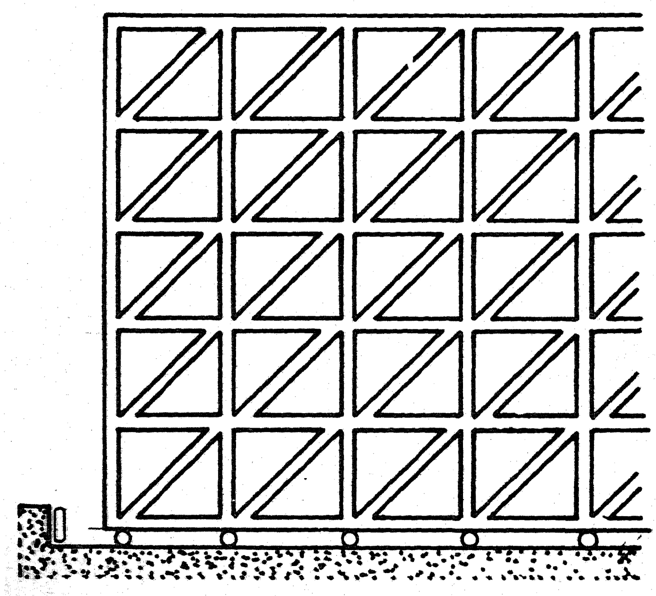

FIG. 2 _ STIFFENING WITH TENSION DIAGONALS

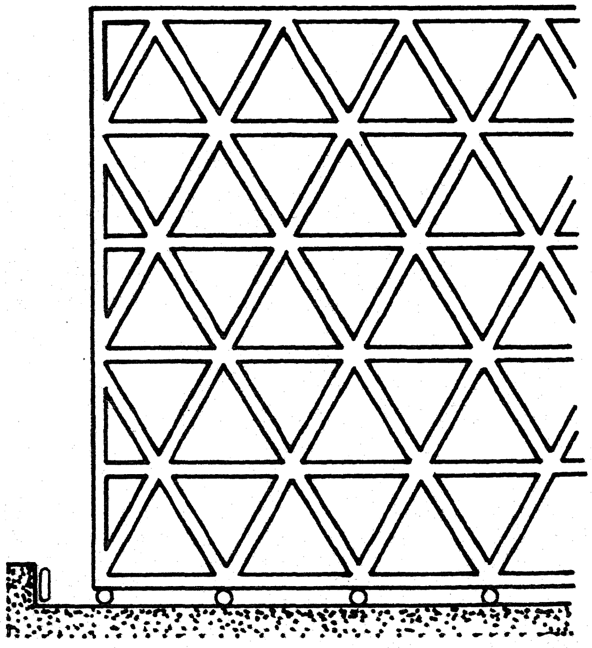

FIG. 3 _ STIFFENING WITH COMPRESSION DIAGONALS