CONSTRUCTION PRACTICES FOR MULTISTORY BUILDINGS SUBJECTED TO EARTHQUAKES

By

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INTRODUCTION

The architect and engineer are challenged by nature, to control the earthquakes on the construction of buildings. At the same time man is building higher constructions on earthquake zones. Still there are many unknown forces which the engineer must investigate. The author means by this the earthquake responses, ground motions and limits of design in relation with these observations. In the aseismic design of tall buildings there are considerations in which the building will respond in a certain way, this will cause a deformation in the structure and movements between floors. Aseismic design indicates us to avoid torsions in the building and recommends the constructor to force the architectural project to a symmetrical structure. In this kind of a building, the architect should follow closely the advise of the aseismic design-engineer and numerical computations. Attention on the architectural project and finishings should be taken into consideration.

The Tower Latino Americana, 43 story office building.

Fig. 1

The aseismic design (x) gave the pattern for a symmetrical project of the building, and the possibility of having a maximum differential movement between floors of 1/2". This displacement was taken in consideration, in the finishings, (partition walls, windows and fire proofing).

(x) Aseismic design of 40 story building in Mexico City by Dr. N. M. Newmark and Dr. Leonardo Zervaert. World conference on Earthquake Engineering 1956 Berkely, Cal.

Partition Walls: The partition walls were designed in rows which did not run into the columns, Fig. 2; also these walls were tied to the floor and lost in the ceiling, Fig. 3, to take here the displacement between floors. In this case it was recommended, to prevent a movement of a 1/2", Fig. 4.

In this particular building: Siporex slabs were used 3" by 2' and 8' long. These slabs were fixed on the floor by a channel bolted to the concrete slab of the floor structure, Fig. 5, between siporex slabs, "U" wires tied them. On the ceiling a second channel fixed the slabs together and "U" shaped steel bar holds them to the next floor, Fig. 6.

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Windows

The windows of the building were designed to take the displacement of 1/2" between floors. This was possible, having every glass on a frame pivoting in the center; so that each frame was in the possibility to take the deformation. The setting of the glasses in the frames, gave a space large enough to take a displacement also, Fig. 7.

Fire Proofing

As an efficient fire-proof on a steel structure, there was specified by tests of a light concrete with carlita (peerlite) 2" thick. These concrete sheets were poured in place and to prevent any cracking. The fireproof was specified to be poured with a separation from the steel, Fig. 8, structure to allow and to take the movement or deformation of the structure.

Mexico City Earthquake - 28 July - 1957, 1,500 buildings Fig. 9, were reported to have damages. After an inspection of many of those, it was found that the structures were too flexible and these structures did not have serious damages, although the interiors, windows and glasses were destroyed. The loss, due to these effects, went very high, so as to have the authorities unknowing the complete estimate on this loss, Fig. 10. The author considers that many of these buildings would have suffered no damages, in the case of having a proper design of the partition walls, windows and so on following the recommendations of the aseismic design-engineer. The loss of a damaged building is higher on the architectural finishing and details than on the structure. Due to the fact that in Mexico City the foundations and super structures are about the 30% of the total cost of the building, Fig. 11.

One of the buildings, where this idea of paying attention in connection with the aseismic design engineer was taken in consideration, is the Tower Latino Americana, Fig. 12. This building suffered no monetary loss, by the owner during this earthquake. On a thorough inspection, two points were brought out to be considered in the future.

1o.) In two places, in an office area of 300,000 square ft. were the specifications of the partition walls were not followed by the tennant, these partition walls (siporex slabs) were installed on the column lines, a small crack was observed in connection between the plaster and the finishing of the column. This indicates us that the fireproof had not the right space to allow the structure free movements, Fig. 13.

2o.) In several places it was necessary to continue the partition walls (Concrete bricks) in the elevator shaft to the next floor, and no joint was left between that wall and the beams. The author observed some diagonal cracks due to the movement of the different floors, Fig. 14.

New Ideas on Partition Walls

In a tall building or in any other construction where we cannot have a structure so rigid as the partition walls, following the right aseismic design we must have a joint that may take displacement between floors so that the decoration and finishing of the building will not suffer any damage during an earthquake. With this procedure, the success will be inevitable and there will be no loss of money, Fig. 15. If the structural design is to be of beams and slabs, we cannot have a straight line to allow the displacement between floors and it will be troublesome as pointed before, in the Tower Latino Americana.

The idea in this case is to have the joint on the floor and hang the partition walls from the ceiling. By hanging the partition walls, the author had the possibility to use prestressed slabs and precast concrete slabs (light and regular concrete) in a favorable way. The prestressed slabs are easier to handle and are stronger, Fig. 16. The floor is obliged to have a steel channel for the joint. As a side line, the author would like to mention that this has been used to solve also the problem of differential settlements, which Mexico City is suffering continuously, Fig. 17.

The earthquake in Mexico City has proved the author that it pays to study and solve these problems on tall buildings. The author has estimated that if those details of the Tower Latino Americana would not have been taken in consideration, the cracks on the partition walls would have been raised up to $ 300,000.00, the glasses on windows would be broken for an approximate value of $ 200,000.00 as well as the fireproof would be useless and it would have been in danger of fire and total collapse. The author estimates that the damages could easily have gone up to $ 1.000.000.00 on this building, of a total cost of $ 4.000,000.00. Another problem that the constructor had the necessity to take in consideration was, that when he constructed the highest building in that area in Mexico City, the people were uncertain and felt unsafe in the building. So that the tennants could easily incur into panic during an earthquake. This would cause in many cases, more casualties than the damages in the building. The panic of tennants could be started by a crack on the plaster of a partition wall, even though the structure is responding to the aseismic design perfectly. It is on our conscience to try with the architects and owners to talk them into paying attention on these finishing details.

Acknowledgment

The author expresses many thanks to Dr. Nathan Newmark and Dr. Leonardo Zeevaert for their ingenuity to solve the aseismic design problem of the Tower Latino Americana, as a contribution for progress.

References

Aseismic design of 40 - story building in Mexico City by Leonardo Zeevaert, Prof. N. M. Newmark. World Conference on Earthquake Engineering 1956. Berkely, Calif.

FIG. 1 TOWER LATINO AMERICANA

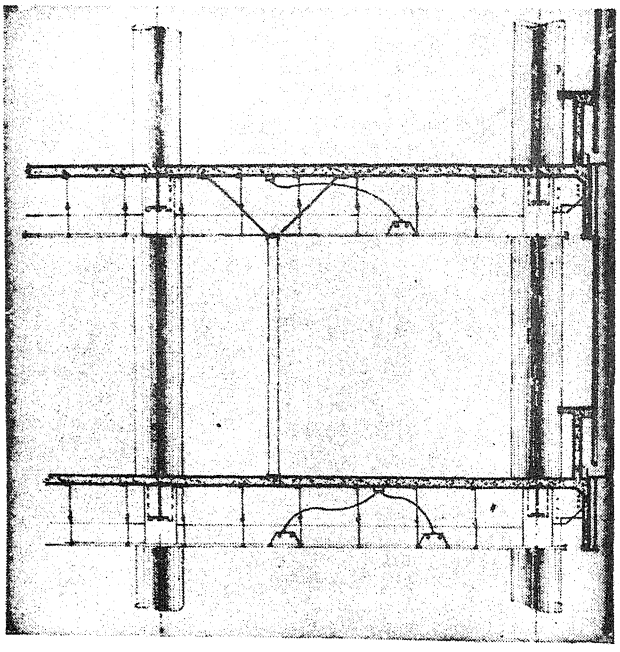

FIG. 2 DRAWING OF THE PARTITION WALLS

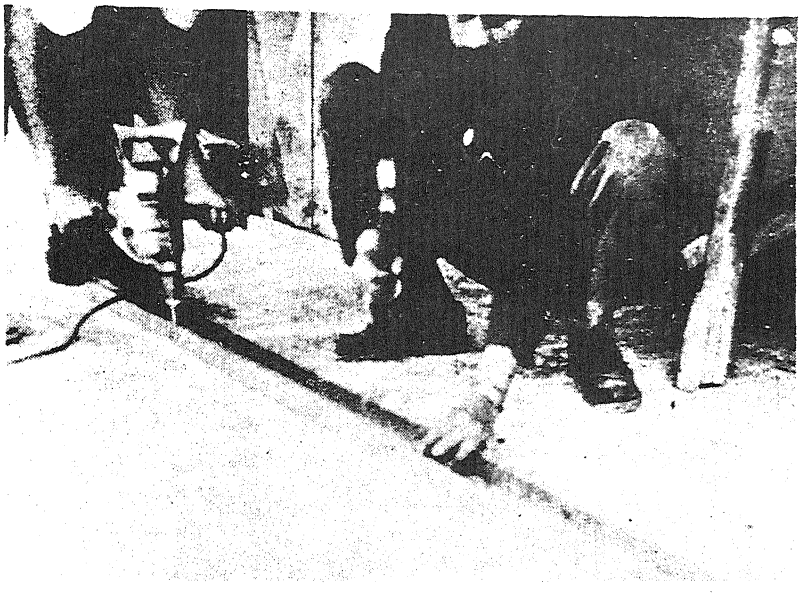

FIG. 3 CHANNEL TIED TO THE FLOOR.

FIG. 4 THE SIPOREX SLABS ARE TIED TO THE FLOOR WITH THE STEEL CHANNEL.

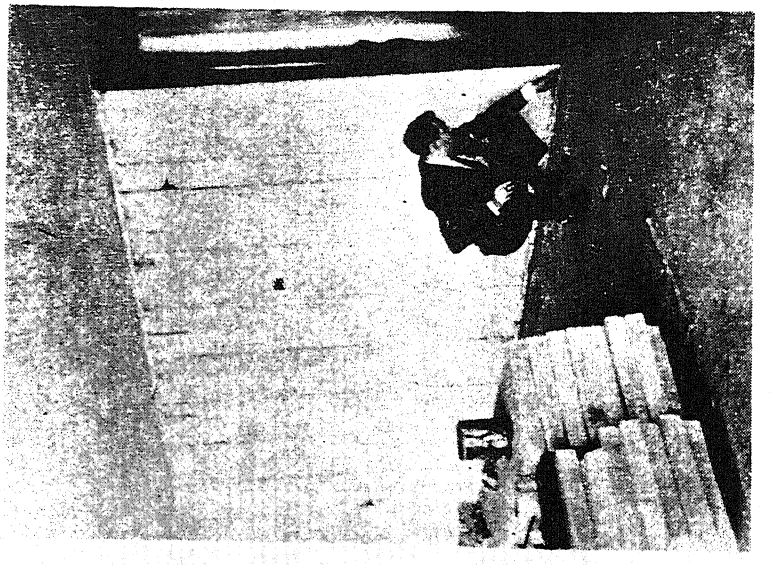

FIG. 5 A COMPLETED PARTITION WALL READY FOR FINISHING.

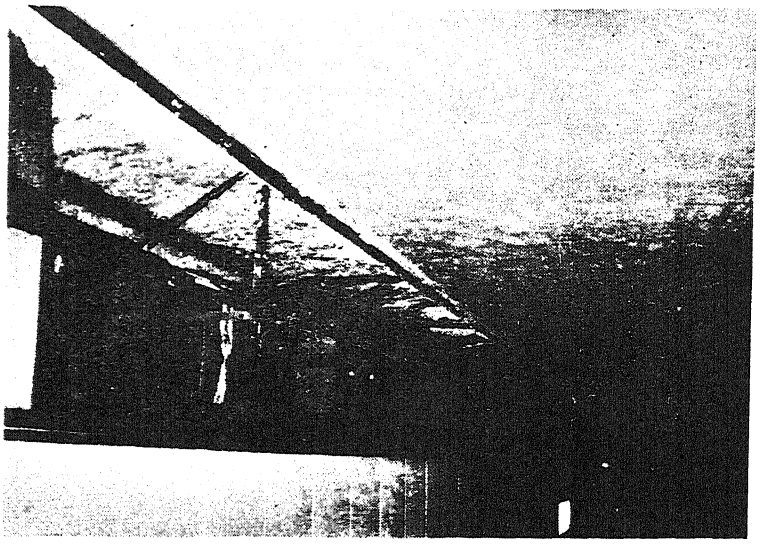

FIG. 6 CEILING AND PARTITION WALL.

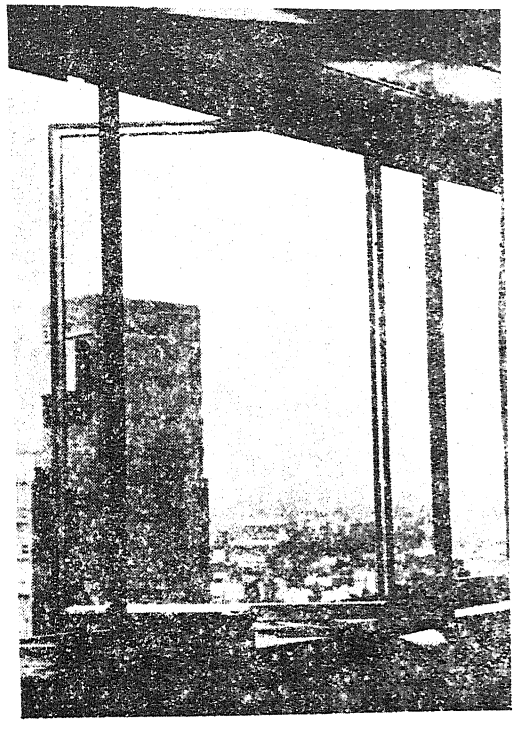

FIG. 7a WINDOWS, DESIGNED TO TAKE HORIZONTAL MOVEMENTS.

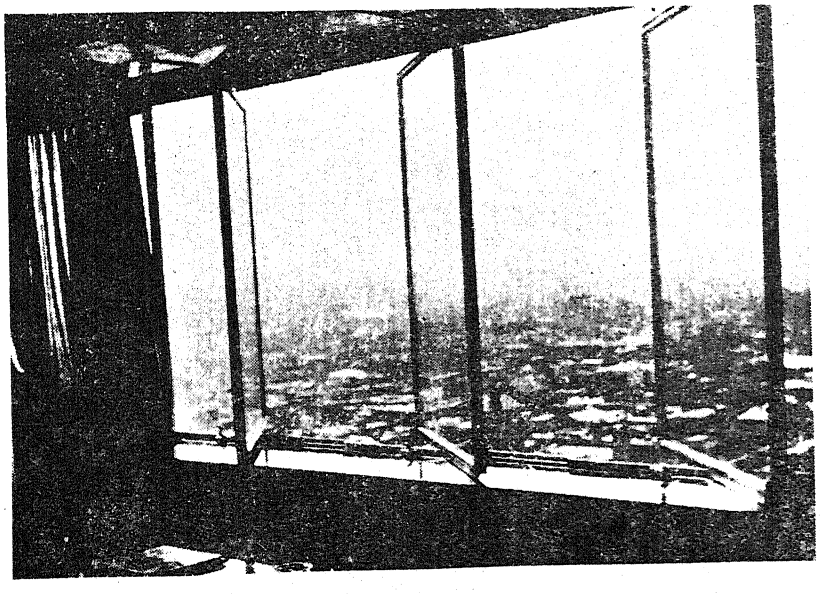

FIG. 7b WINDOWS, DESIGNED TO TAKE HORIZONTAL MOVEMENTS.

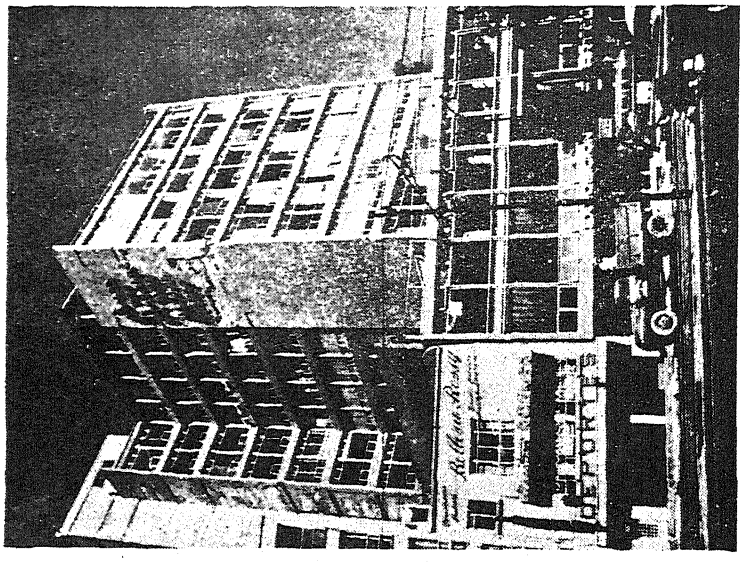

FIG. 9a A BUILDING WITH SERIOUS DAMAGES. SUCCEDED TO CEINFORCE THE STRUCTURE, AT PRESENT IT IS IN SERVICE AGAIN.

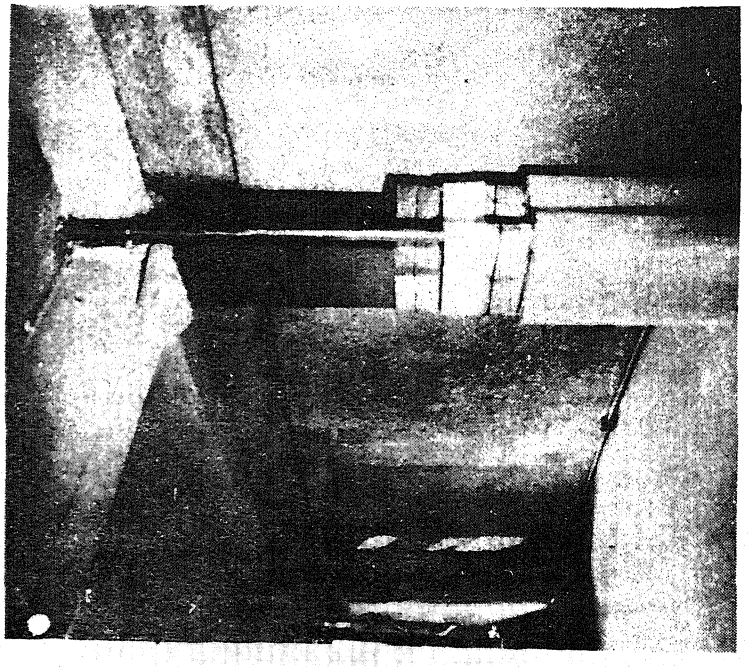

FIG. 8 TYPICAL FIRE-PROOFING OF A COLUMN.

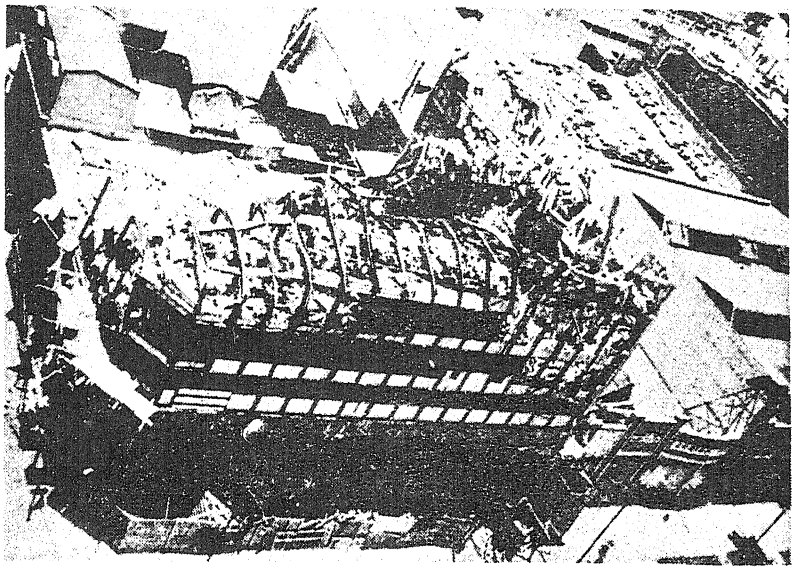

FIG. 9b A 8 STORY BUILDING UNDER CONSTRUCTION WHICH FAILED.

FIG. 9c A 7 STORY BUILDING WHICH COLAPSED.

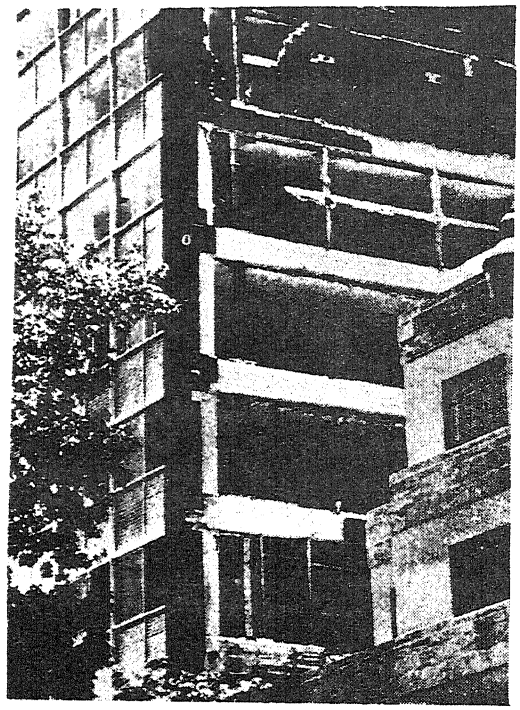

FIG. 10a A BUILDING SERIOUSLY DAMAGED ON THE CONCRETE STRUCTURE. IT SUCCEDED IN THE REINFORCEMENT IT IS IN SERVICE NOW.

FIG. 10b A BUILDING WITH STEEL STRUCTURE SERIOUSLY DAMAGED; 12 COLUMN BUCKLE. THIS BUILDING IS NO LONGER IN SERVICE.

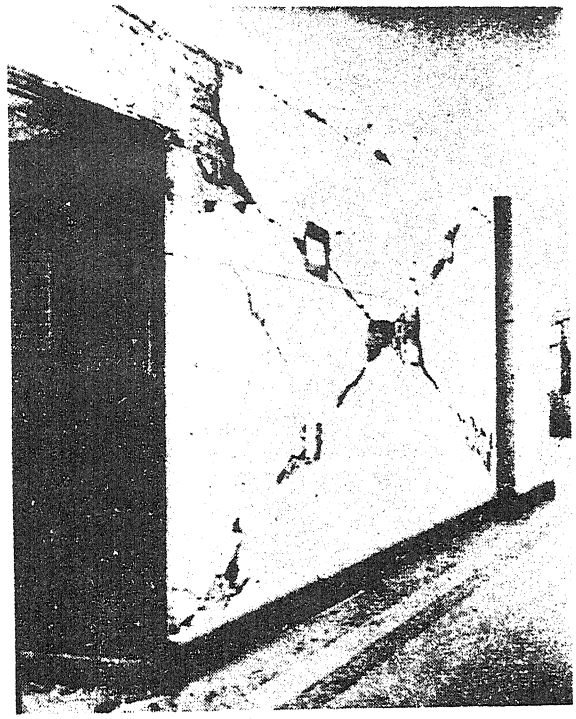

FIG. 10c TIPICAL FAILURE OF A PARTITION WALL TIED TO THE STRUCTURE.

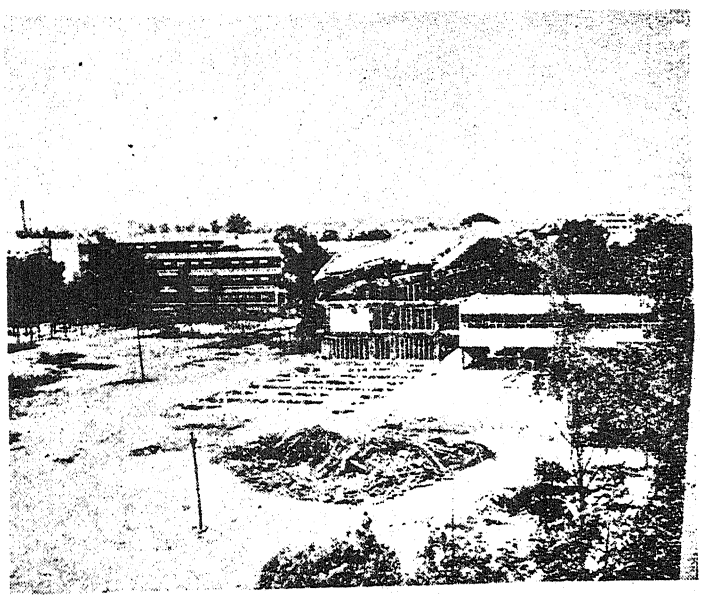

FIG. 10d THE POLYTECHNIC UNIVERSITY FAILED ON THE CONCRETE STRUCTURE.

FIG. 11 A BUILDING WITH STEEL STRUCTURE, UNDAMAGED. ARCHITECT. AGUSTO H. ALVAREZ CONSULTING ENGINEER: CARLOS EACALANTE M. S.

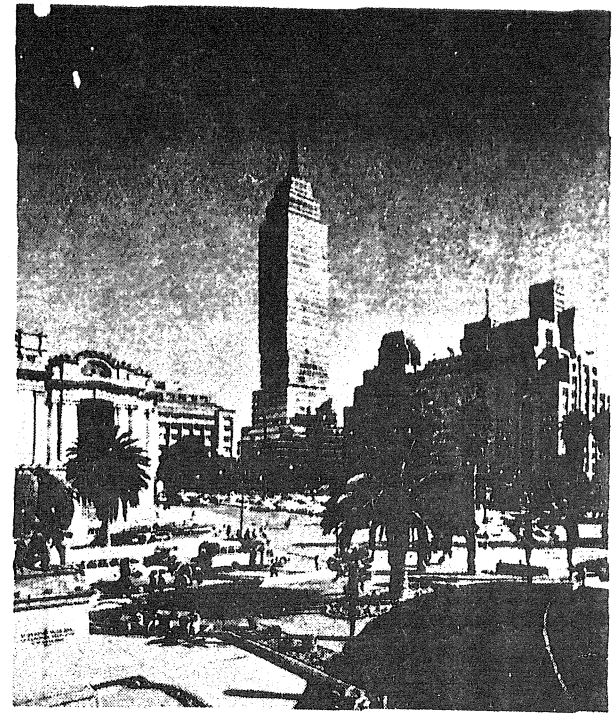

FIG. 12 TOWER LATINO AMERICANA, 43 STORIES, 182.00 METER (600 FEET). AWARD OF MERIT A. I. SC AFTER THE EARTHQUAKE 28 JULY 1957(7 DEGREE MERCALI SCALE)
CONSTRUCTED BY:
RESPONSIBLE: ADOLFO ZEEVAERT, C. E.
ARCHITECT. AGUSTO H. ALVAREZ
CONSULTING ENGINEERS:
LEONARDO ZEEVAERT Ph. D.
NATHAN M. NEWMARK Ph. D.

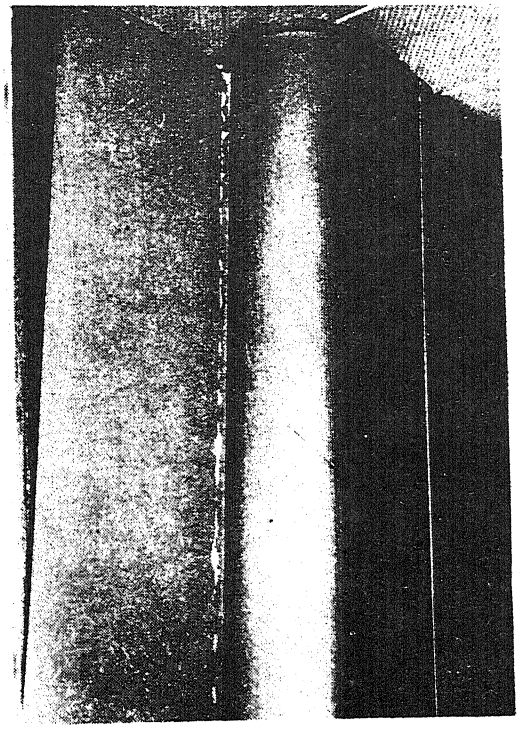

FIG. 13 A SMALL CRACK BETWEEN THE COLUMN AND A PARTITION WALL OBSERVED IN THE TOWER LATINO AMERICANA IN A PLACE WHERE SPECIFICATIONS WERE NOT OBSERVED.

FIG. 14 SMALL CRACKS IN THE ELEVATOR SHAFTS WHERE THE JOINTS BETWEEN FLOORS WERE NOT DONE PROPERLY.

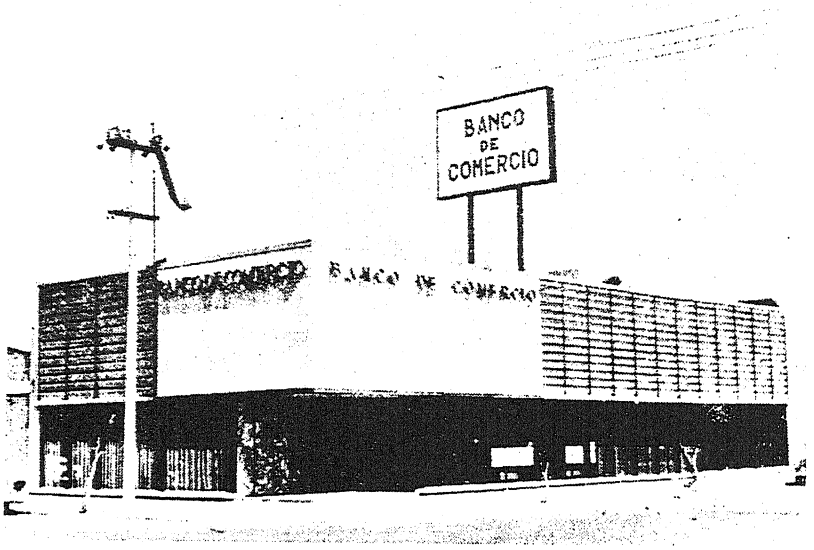

FIG. 15 A NEW IDEA TO HANG THE WALLS AND FACADE TO THE CEILING THESE WALLS DO NOT HAVE A FOUNDATION, IT IS ONLY A CENTER FOOTING.

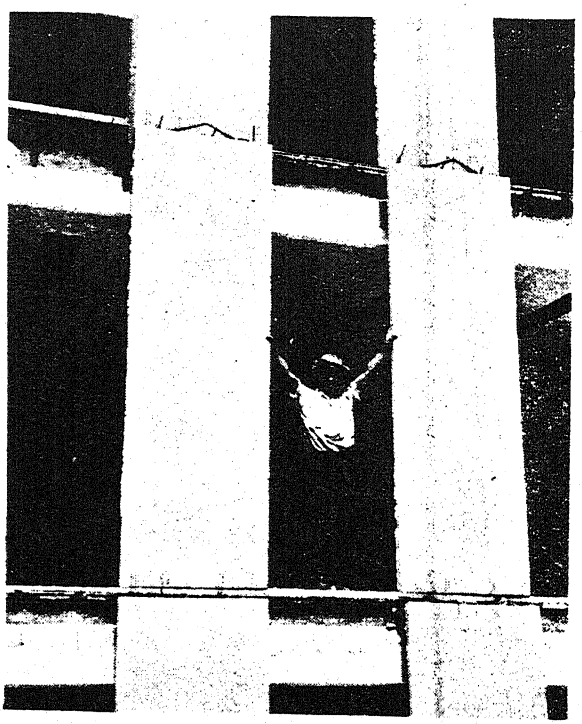

FIG. 16 PRESTRESSED SLABS FOR A FOSCADE WALL HANGING FROM THE UPPER FLOOR.

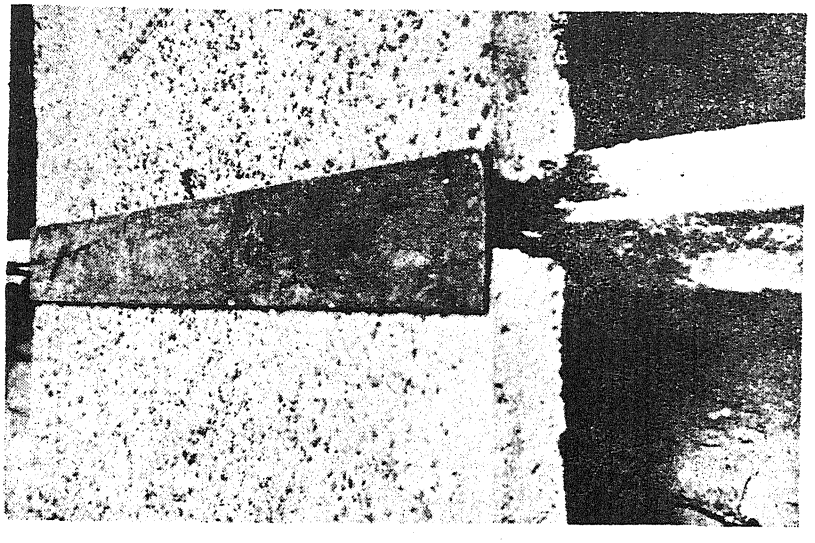

FIG. 17 JOINT BETWEEN FLOORS AND HANGING SLABS TO PREVENT DISPLACEMENTS.