GENERAL SUMMARY

Reference: EERI RECONNAISSANCE TEAM EFFORTS
Guatemala February 6, 1976 to February 12, 1976

By: Thomas D. Wosser

Guatemala City is located in a volcanic plain, approximately 5000 feet above sea level. Its skyline to the south is dominated by the volcanoes Peca, Agua and Fuego, some 20-25 km distant. The Pacific Ocean is approximately 75 km due south. Although the valley in which the city sits is bounded by hills, the terrain in Guatemala City is generally quite flat. Flat, that is except for the occasional very steep and very deep barrancas, which exist throughout the area. The barrancas and the steeply cut road beds were greatly affected by the earthquake, resulting in many slides, with loss of homes and the interruption of highways.

By far the most significant effect of the earthquake was the utter devastation to the very poorly built structures - the adobe dwellings of the poor. Damage in some of the outlying villages was observed. In Chemaltenango, for example, a rough approximation would indicate collapse of perhaps 70-80% of the adobe buildings, with commensurate loss of life. The latest count, as of February 15, indicated a loss of life of approximately 22,000 throughout the country. While we do not have the statistics, most of this loss must have occurred as a result of the failure of adobe dwellings. Such failures were not restricted to the villages, but occurred in Guatemala City as well, where dwellings were constructed in a similar manner.

Many of the older structures in downtown Guatemala City were constructed of adobe or other masonry materials. For the most part, these fared somewhat better, with very general parapet failures, some wall fall out and some roof collapse. Even the poorly built brick buildings performed significantly better than the adobe dwellings. These structures and other relatively low buildings have no diaphragm or other horizontal roof bracing, the roof construction often being of corrugated iron or transite.
Massive masonry churches suffered much damage throughout the city. The older concrete structures performed reasonably well. Twenty to thirty year old buildings of five and six stories were reviewed and found to have suffered little structural damage, although glass breakage and damage to the masonry partition work was extensive.

Modern buildings, constructed within the past five years, generally performed quite well. There is one steel framed high rise building approximately twenty stories, while all the others are of reinforced concrete, generally of reinforced concrete frames, without shear walls. Guatemala City does not have a large number of high rise buildings. My guess is somewhere in the range of about thirty over ten stories or so. There is a height limit established by aeronautical regulations, so many feet above sea level. I believe the steel frame building is the tallest in town. These buildings appeared to have benefited from the lessons learned in Caracas. Columns are substantial in size and are spirally reinforced with the spiral continuing through the joint. Beams are reinforced with continuous top and bottom steel and with what appears to be a good stirrup design. We were told that while there is a “planning code”, there is no “building code” as such, and the expertise of the project engineers is relied upon to provide the proper design. Apparently they use the ACI for concrete work and the California Code, assumed to be the SEAOCA Blue Book for seismic design. That would imply UBC, Zone 3.

Although the modern buildings performed very well structurally, there was substantial damage to the partitions which are generally constructed of plaster finish, partially reinforced brick. In some of the buildings, attempts were made to keep the architectural partitions relatively free from the structure and it is believed that this worked to some degree. This element of design in construction, hat is the performance of masonry partitions, was the most significant element observed in the results of the earthquake. It is not new, but the extent of architectural damage with little or no structural damage is worthy of note and of consideration in future designs.

A very brief review in Puerto Barrios indicated little or no damage in the town, where timber construction predominates. However, the concrete pier jetting out into the bay had failed and the warehouse building at the end of the pier had collapsed into the water.

Finally, it is the writer’s opinion that damage in Guatemala City might have been much worse. On the rather limited observations, I would assign a Modified Mercali Intensity of VII, possibly up to VIII in some areas. The thought that intensity may not have been as high as it was generally held to have been should be thoroughly reviewed and discussed. The Guatemala Architects, Engineers, Contractors, Developers and Government Officials should be aware of this possibility and should not become too comfortable, thinking that they have survived the “killer quake”.

Again, loss of life was related to the time of occurrence. In this case, people home asleep in their adobe dwellings had a small chance for survival. It is to be hoped that some educational program can be implemented, along with different materials, so that the people can discard their inherently dangerous method of construction and build homes which will provide a much higher degree of safety.
BUILDINGS REVIEWED BY TOM WOSER
GUATEMALA CITY - FEBRUARY 7, 1976 TO FEBRUARY 11, 1976

A. As part of Grupo 2 for Department of Obras Publicas
   1. Hospital Roosevelt - Between 5 ave. and 9 ave. Zone 11.
      This is a major hospital with 2000 beds. It is composed of several
wings which were not clearly identified. The main building, with
several wings was completed in 1954, the maternity building in 1939.
Maternity wing 4 stories, main building 5, counting basements. Appear
 to be R/C beam and slab, frames both directions, infill walls of brick
with occasional rebar in grouted hole. Minor glass breakage. Shear
cracks and joint cracks in infill panels, more serious in lower stories.
Cracking very minor in main building, more severe in maternity. Water
Tower had no seismic damage. Upper diagonal rods appeared slack. Later
reported that there was a pre-existing broken plate at top. Hospital
very well maintained.

Hospital Neuro-Psiquiatrico - Pinca La Verbesa Zone 7.
This hospital is composed of a number of different units of less than
first quality construction. Appearance shows lack of maintenance,
probably because of low funding. The major elements are:

   Connecting Canopies.
 supported by what appeared to be pipe columns at intervals of
perhaps 12'. Virtually all canopies had collapsed. Estimated
perhaps 500 linear feet. Column failures - columns actually composed
of 5" o.d. transite pipe, containing a "cage" of 4 vertical bars and
ties and concrete. In several cases, where the canopies collapsed,
they fell on adjacent structures, causing damage.

b. Administration Building
Two story building composed of R/C frames in transverse direction
only, with slab between. No damage to frames. Longitudinal
partition (one Wythe brick) at center of building suffered sub-
stantial damage in first story.
Damage to brick severe enough to where I could not judge the
building to be capable of surviving another earthquake equal to
that of February 4, 1976.

c. Pavilion Buildings (Ward Rooms)
There were five basically identical Pavilion Buildings, one story
in height of R/C beam and slab construction, two way frames, R/C
columns. Exterior walls pumice block up to high windows. No
structural damage. Non structural damage insignificant. Buildings
had been unoccupied.

d. Dining Room
The Dining Room had collapsed. Unreinforced pumice block walls,
trussed rafters, corrugated iron roof.

e. Kitchen Building
Two stories, R/C beam and slab; two way frames. Very poorly
maintained. One column failed because it was struck by canopy.
Two others had cracks. Pumice block infilled walls severely
cracked.

This is the tuberculosis hospital, approximately thirty years old.
It is composed of a number of different units.

Administration Building
Small building, adobe exterior walls, concrete roof, negligible

b. Administration-Service Building
One story, adobe walls, corrugated iron roof. Not much damage.
Parapet should be removed.

c. Ward Room
One story, with R/C frames, two way beam and slab, on both sides.
Center portion roofed with trussed rafters and corrugated iron.
No damage.

d. TB Division Building
Two three story concrete frame, two way beam and slab. Infill
pumice block walls, with plaster finish. Much glass damage, much
damage to block. Column failures at roof level over kitchen. For
standing wall at rear entrance should be removed.

Infected Building
Constructed as a temporary building twenty years ago. Still in use
Wood trusses, corrugated transite roof, plywood ceiling. Wood frame exterior walls, with tectum-like covering. Only damage was to ceiling - some falling panels.

f. Lung Sickness Building

4. Military Pavilion
Connected to end of Lung Sickness Building. Appeared to be
of same construction, but much worse condition. Parapets fell, in addition to bad wall cracks.

Chapel
Constructed with adobe walls about 3' thick, wood frame roof, Spanish tile. Walls badly cracked.

5. Occupational Therapy, etc.
One story - no significant problems.

6. Children's Pavilion
Similar to Ward Room - no problems.

k. Annex
Series of one story buildings - open sides above wainscot height -
no bracing. Wood trusses, corrugated iron roof, tectum-like partitions. Concrete columns. No damage.

Exterior Fence
Masonry - collapse over considerable length.

Casa del Niño #3 Av. Elena 18-23 Zone 1.

The exterior walls (adobe masonry fence) of this children's home were built in 1930. The one story structures within the courtyard are almost new.

They are constructed of R/C frames with steel joist roof framing carrying corrugated transite roof. They had T-bar ceilings. The only damage observed on the site was a partial collapse of the adobe fence at one corner.
Casa del Niño #1 provides facilities for 500 children. Approximately 100 children live in, while the other 400 are given day care services. The site occupies the better part of a block which houses a number of different buildings.

a. Near the entrance is a one story building around a small quadrangle. It is built of masonry walls, with wood framing supporting a corrugated iron roof. No damage.

b. There is a hospital building and clinic building which are one story and appear to be of concrete frame construction. Some slight cracks in the hospital building and no damage in clinic. Generally good condition.

c. Old Building - high story height, adobe walls, reportedly came through the 1917 earthquake. The building houses the laundry and, I believe, the kitchen too. One end wall, near the laundry appears to have moved considerably and should be rebuit. There is also a high, free standing parapet which should be corrected.

d. The most interesting building is the Nursery School, constructed in 1968 and added to in 1975. It is three stories high, above a partial lower story. It has suffered major column damage at the first full floor level, as well as substantial damage to the masonry partitions at all levels. The construction is of R/C frames @ 15'-6" across the building, with a slab spanning between them. There do not appear to be any longitudinal frames. In the upper stories, the building cantilevers approximately 8'-0" beyond the columns of the frame. The building is rectangular, approximately 37'-0" x 95'-0" with a separate stair tower located near the center of the building on one side. This was built with a 1-1/2" expansion joint which suffered some pounding damage. The plan of the building is approximately as shown with damaged columns marked with an X.

The concrete spalled off the columns near the floor level and the reinforcing bars buckled. Columns are tied columns, with small ties at large spacing.

The partitions are constructed of a single wythe of brick with a weak plaster both sides. Bricks are shaped as shown below and were reinforced vertically at approximately 6' to 8' o.c.
Failure of the brick partition filled with debris the interior stair between the lower level and the first main level.
The building will require reinforcement of the columns and substantial rehabilitation (architectural) to the masonry partitions.

Casa del Niño #2  13 Ave, 1-01  Zone 1.
There are two separate structures at this children's home. The first, built in 1930, is a one story structure surrounding an open court. It has masonry walls, including interior cross walls, with a corrugated iron roof supported on wood framing. It has a wood finished ceiling approximately 14' high. It is in good condition, with no apparent damage.
The second building also surrounds a courtyard. This structure, built in 1960 is two stories in height, except for a high one story auditorium.
It is of reinforced concrete construction except for steel framing over the auditorium. The steel framing supports corrugated iron roofing and a tectum-like T-bar ceiling. Again, no damage was observed.

INFON Building  - Instituto Fomento Municipalitie  - .2 Ave. 8 Calle, Zone 9.
This beautiful, modern building of reinforced concrete, was completed in August of 1974. It is six stories in height above a basement, which is larger in area than the structure above. The additional basement area is separated from the main area by expansion joints. The structure is composed of a waffle floor system and concrete frames in both directions. All exterior concrete walls, were cast after completion of the frame. Special details were used to separate the walls from the frames as much as possible.
Design was based on the Uniform Building Code and the substantial columns are of spiral reinforcement with the spiral extending through the joint.

There is no apparent damage to the structure, but substantial damage to the masonry partitions. Damage generally decreases toward the top of the structure. There was some damage to the exterior concrete walls, including "fall out" of the rubber expansion joint material. Also, the concrete stair railings were damaged at several floor levels. These were reportedly not designed as structural elements, although they acted as such.
Precast sun screens are connected to the structure at the top and by hand, but are not except for spalling. See attached plan and cross-section for outline.
Instituto Guatemalteco de Turismo. 7 Ave. Calle, Zone 5.

This sixteen story building is almost complete structurally, lacking only the roof and penthouse. The following is a typical floor plan of the upper stories. The 4th and 5th floors are somewhat larger and the 3rd floor forms a large plaza.

This building is entirely of reinforced concrete construction, with frames in both directions, supporting a two way waffle slab. The waffles, which are 34" x 34" inside with 6" thick stems, are formed with wood, covered with polyethylene film, which are good for four reuses. The slab is 2 inches thick. Three sizes of columns are used in the building; 1.20 meters square, 1.00 meters and 0.80 meters. They are constructed as spiral columns with spirals through the joint. Reinforcing steel is part Belgian, part local, Grade 60.

Again, all partitions are of brick, to be covered with plaster. The brick is partially reinforced, as described for the Nursery Building at Casa del Niño #1. In this building, there was virtually no apparent damage to the brick partitions, probably due to the fact that the top joint had not been mortared to the structure.

Exterior spandrels are finished in the following manner. After the forms are removed, the exterior surface is struck with a hammer to "pock mark" it at an estimated random 8" o.c. A brown coat of plaster is then troweled on, followed by a finish coat containing granite chips. Although it is a very craftsmanlike finish, it is subject to earthquake induced spalling. Spalling of veneers of various types was much in evidence throughout the City.

The only apparent damage to this building was to the support of an architectural panel at one end of the building. There was absolutely no damage observed to the structure. Performance was excellent.

This six story building, built in 1960, appears to have been constructed with two way R/C frames, with slabs between. Walls and partitions are of plaster finished-infill brick panels, which suffered some damage. The building is on a corner with two adjacent sides with a relatively large amount of glass, much of which broke. There was probably substantial torsion. On the main street frontage, the frame line and glass line is about 3 to 4 feet back from the face of the building, allowing for a small cantilever balcony at each floor. The outside face of the balcony has a treatment of solid brick "screens", perhaps 5' wide and 15' o.c. between floor levels. These "screens" were badly cracked, as they tried to act as shear walls. No damage to the frame was observed.


The buildings at this exposition ground have been taken over to serve as emergency hospital facilities to perform the function of the General Hospital, which has been closed. The following buildings were reviewed:

a. Salon de Casales

This two story concrete frame structure is serving as an administration building. A two way slab spans between the two way concrete frames. Building cantilevers somewhat beyond columns. Walls are masonry infill panel which suffered some cracking and some displacement from the frame – relatively minor. At the roof level, there is a horizontal crack at what is probably the horizontal construction joint between the top of the column and the horizontal framing. The crack occurs at most of the columns and is relatively minor. Two rather small transite water tanks on the roof were displaced from concrete block supports. The building is generally in good condition. Very little, if any, glass damage.

Light Tower

The concrete frame light tower, perhaps 8 to 10 feet square and 40 feet high, was undamaged.

c. Concrete shell over outdoor stage – undamaged.

d. Salon Guatemala

The Salon Guatemala is composed of two one story buildings separated by an expansion joint, where some minor pounding damage occurred.

The larger of the two buildings is constructed with tapered pre-stressed beams, estimated to be 6 feet deep at midspan. They are spaced approximately 25 feet o.c. and span 66 feet across the building. Deep corrugated transite sections span between the beams. The beams are supported by cast-in-place columns and the solid exterior walls are of precast prestressed panels which span from floor level to a bond beam above. The only damage observed was a crack in one of the transite roof units.

The smaller unit has a lower roof which appeared to be constructed with a two way concrete frame. No damage was observed.

Building No. 7.

Building No. 7 is a one story prefabricated steel frame building approximately 72 feet wide by 240 feet long. The frames appear to be of three hinged arch form and they support a metal deck roof. Exterior walls are of pumice block up to clerestory windows. The west side of the building has no ceiling, while the east side has a rather fancy suspended fabric ceiling. No damage could be observed.
f. Building #6 - Building #5 - Building #4

These structures are all very similar and are also similar in size and shape to Building #7. Again, they are about 72 feet wide and have a length of about 240 feet, comprised of 20 bays at 12 feet o.c. The corrugated iron roof is supported by wood purlings and bowstring shaped wood trusses. The trusses have solid chords, double wood diagonals bolted to the chords and steel rod verticallas. Walls are solid on the ends and essentially solid up to the clerestory windows between columns. For Buildings 4 and 5, the walls are of pumice block and for Building 6, the walls are brick.

In all three buildings, the ceiling was formed in a series of V shaped sections across the building, with styrofoam panels as the finish materials. A number of the styrofoam panels were loose. That was the only damage observed in any of the three buildings.

Building #3

Building #3 is similar to Buildings #4 and #5, but roof framing is a wood lamella with steel rod ties at the column lines. Again, no damage was observed.

h. Building #8

Building #8 is a relatively small prefabricated steel frame building with metal deck roof and walls. The frames appear to be simple spans and there is rod bracing in the walls. No damage was observed.

i. Building #9

Building #9 is similar to Building #7. There is no apparent damage, but a high wood frame partition is in great need of bracing.

j. Bank Building

The Bank Building is serving as a center for volunteer workers and receipt of some goods. It is a small building, with what appears to be a concrete frame and spanning concrete roof. It has infilled masonry walls, which are cracked. Cracks also show in the spanning concrete ceiling.

k. Shelter

The shelter is composed of a number of interconnected umbrella shaped reinforced concrete elements. There was no apparent damage.

Guatemala City

This is the main telephone building in Guatemala City. It is seven stories in height above the basement and it is composed of two separate units, the stair and elevator tower being located behind the building and separated therefrom by an expansion joint. The main portion of the building is 9 bays long by 3 bays wide, of flat slab construction, with deep drop panels and very large columns. Partitions are of brick covered both sides with plaster. Both the mortar and the plaster are weak. There was substantial partition damage and glass damage. The stairs, which are open and relatively large exhibited some damage at intersections in the lower stories. The roof over the main portion of the building is composed of a series of concrete barrels which suffered some minor pounding damage adjacent to the stair-elevator tower. There was some overturning damage at the base of a column at the rear of the stair-elevator tower.

Equipment was bolted to the floor and braced with struts at the top. The struts were connected into the edge of the drop panels or into end walls. One connection into an end wall (masonry) had suffered some damage.
The building operated on emergency power for twenty-four hours after
the initial earthquake, using Diesel operated generators. Small storage
batteries in the basement were unbraced and exhibited some shifting.
The elevator was not being used, but we were informed that counterweights,
guide rails, etc., appeared to be okay.

Buildings Investigated on Individual Basis
1. Edificio Reforma Oblesico - Ave. La Reforma 15-54 Zone 9
   This fifteen story plus basement building was constructed by Grupo INSA,
   with Arq. Enrique Saravia and Ing. J.J. Hermonilla. It was designed in
   1970. In plan it is shaped approximately as shown in the following sketch:

   ![Floor Plan Diagram]

   Below the third floor, the building expands to a larger base, but
   expansion joints are provided to separate the tower portion from the
   remainder of the base. The basement is for parking, the first and
   second floors are commercial, the third and fourth floors are offices
   (temporarily) and the upper floors are condominium apartments. The
   construction is of reinforced concrete frame with beams in one direction
   and joists in the other direction. Beams are 65 cms. wide x 60 cms.
   (24"t) deep and joists are typically 20 cms. wide (35 cms. on column lines)
   x 60 cms. deep. The drawings indicate all joists and beams to have
   continuous top and bottom steel with extra bars, top and bottom at the
   column lines. Stirrups are provided in all members #3 bars in joists and
   #4 bars in beams, with minimum spacing generally 5 cms. (2"t) and maximum
   spacing 25 cms. (10"t).
   Columns are spirally reinforced, generally #5 spiral at 5 cms. pitch, with
   the spiral continuing through the joint at an increased pitch. Column
   sizes vary as follows:

<table>
<thead>
<tr>
<th>Floor</th>
<th>Size in Meters (square)</th>
<th>% Steel (t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-2</td>
<td>1.10</td>
<td>3.0 - 4.3</td>
</tr>
<tr>
<td>2-5</td>
<td>1.00</td>
<td>2.8 - 5.2</td>
</tr>
<tr>
<td>5-8</td>
<td>0.90</td>
<td>3.0 - 5.6</td>
</tr>
<tr>
<td>8-11</td>
<td>0.80</td>
<td>3.2 - 4.5</td>
</tr>
<tr>
<td>11-14</td>
<td>0.70</td>
<td>2.7 - 3.4</td>
</tr>
<tr>
<td>14-17</td>
<td>0.60</td>
<td>2.2 - 2.5</td>
</tr>
</tbody>
</table>

   Foundations are spread footings immediately below the basement level. All
   partitions are of brick, finished with plaster both sides, as are the railings
   on the exterior balconies.
   The partitions are rather severely damaged, particularly in the lower stories
   and exhibiting definitely decreasing damage from the seventh floor on up. There
   was not much glass damage but there was some spalling of veneer in the lower stor
Except in the basement, the beams and joists are coated with a plaster finish. The framing was inspected in quite some detail in the basement, 1st, 2nd, 3rd, 4th, 5th, 6th, 7th, 8th, 9th, 10th and 15th floors. In general, it appears to be in very good condition. Absolutely no cracks were observed in the columns or in the joints. Some minor hairline cracks were observed in joists and beams, but none above the 5th floor. Some of the cracks are vertical, some diagonal, within about 3 feet of the column, limited to not more than two cracks spaced perhaps 12" - 18" apart. Again, these cracks were noted as hairline cracks in the plaster finish (which was not removed) and there was no spalling of the plaster.

The building is judged to have performed very well structurally, but it will require a substantial amount of repair to the partitions. The architect is considering the possibility of removing the brick construction and replacing it with honeycomb or some other material.

Puerto Barrios

The only significant damage reported to have occurred in Puerto Barrios was to the pier at the mouth of the bay. The pier projects out into the bay an estimated 1/4 mile where it terminates in a warehouse type structure. The warehouse itself must extend another 500 to 600 feet beyond.

It was reported that this pier was used for small ships in the 6,000 to 10,000 ton category, with other ships being served, docking parallel to shore at Santo Tomas DeCastilla, at the "inboard" end of the bay. The pier and the warehouse suffered extensive damage. The pier appeared to have lunched out from shore, showing a break several feet wide, buckling railroad tracks and indicated other effects of compression. At the end, the warehouse collapsed into the water as the end of the pier failed.

The pier is of reinforced concrete construction, with earth fill and ballast for two sets of railroad tracks, plus a walkway. It is supported on concrete piles. On the inboard side of the pier is a supplemental loading dock type of structure composed of pre-cast concrete slabs supported by the pier and an outboard concrete beam carried by timber piles which had been jacketed. There was substantial damage to this element as numerous portions collapsed into the water.

While the cause of the failure was not determined, it would appear to have been the result of some form of ground failure.

Hotel Del Norte

The Hotel Del Norte is a two story wood frame structure, originally part of the United Fruit Company operations. The building was not examined in great detail, but it was clear that considerable differential settlement had occurred. It appeared that the timber piles in the north and east sides (water sides) of the building had settled or moved laterally, or both.
GENERAL SUMMARY

REFERENCE: Second Trip to Guatemala
February 18 through February 22, 1976
BY: Thomas D. Nosser

My second visit to Guatemala included a detailed review of two high-rise buildings, the Reforma Obelisco and the El Cortijo and a third, Torre de Santa Clara, under construction to the first floor. In addition, a relatively large number of other buildings were reviewed in a rather brief manner. Before describing the buildings, I would like to note some general information of interest.

Except for one building of structural steel frame, all of the "high-rise" structures are of reinforced concrete. They are generally very symmetrical, more so than we normally see. Vertical load systems are of beams and joists, beams and waffles, flat plate waffles and beams and slab. With beam and slab, the spans are relatively short, in the 20 foot range, or less, but the other systems utilize spans up to 10 meters. In many cases the lateral load resisting system is a pure concrete frame, but there are a number of buildings with shear wall systems, although the walls are generally slender. Many of the high-rise structures were designed by Ing. Juan José Hermosilla. His columns are large, generally spirally reinforced, with 2%4% steel and spirals running through the joint. Horizontal framing members have continuous top and bottom steel.

Waffle slabs are formed in two ways. Wood forms were observed on several projects. They are wrapped with polyethylene and are good for about four reuses. The second method utilizes "casatones", two sections of precast pumice block, placed toe to toe. These elements remain in place and create a flat surface for the ceiling which is simply plastered. They come in three basic sizes 85x85 cm., 85x75 cm. and 75x75 cm. Total depths are 20, 17-1/2 and 12-1/2 cm. They usually cast a 2" thick slab on top. The casatones will weigh about 35 pounds per square foot, depending on size. It was also noted that they sometimes entrap water during construction which may not appear until much later, after plastering and occupancy. To obviate this problem, small holes can be made in the bottom of each unit for drainage. Clearly, the casatones add a significant amount to the weight of the building.

Also adding to the building weight are the masonry partitions, which are generally of brick, but sometimes of pumice block, almost always plastered on both sides. Exterior walls are of the same construction. Ing. Hermosilla designs for 30 pounds per square foot for partition loading. There are two general types of bricks. Type I is perforated with small holes, while Type II contains open cells large enough to accept reinforcing steel and grout. In general, these walls are reinforced; horizontally with 2 to 3/16 wire (Similar o-wall) in the mortar every sixth course, vertically with reinforced ribs spaced a minimum of 90 cm. and a maximum of 2 meters. With the Type I brick, the ribs are placed in a gap in the brick work perhaps 6" wide and they are reinforced with 4 to 8 vertical bars tied together with #2 ties @ 15" o.c. Dowels are supposed to be provided between the floor construction and the ribs, but they were observed to be missing in a number of instances. A connection to the structures was only through the rib dowels and the mortared joint. In some cases, efforts were made to isolate the walls from the frame by using styrofoam at the joint, although I think the ribs were still connected.

Comments

1. In many cases, the rather severe X cracking in the plaster and brick work did not extend through the nominal ribs.
2. Cracks in the plaster almost always occurred at the joint between the masonry and the concrete.

Where attempts were made to isolate the walls from the frame, there was less damage to the walls. These details and results should be studied further.
The plaster finish applied to the walls and exposed framing members is generally applied 1" thick and applied in two coats.

First coat called "Repello"
4 parts white and yellow sand (some clay in yellow sand)
1 part lime

Ten parts of this mixture is then mixed with one part of cement.

Finish coat called "Cernido"
about 5 mm thick
2 parts white sand
1 part lime

The mortar for the brick work is generally the same "Repello", except for the joints that are reinforced where "Sabieta" is used, composed of 3 parts river sand to 1 part cement.

Foundations are normally spread footings (some mat foundations) with allowable soil pressure in the 4000 pound square foot range. Most excavations are made as vertical cuts without lagging or shoring. Sandy, on site materials are often used for "Repello". All of the exterior basement walls that I observed were composed of sections of "Spancrete" like units perhaps 6" thick and 4 feet wide. These are normally just set in place on top of a lip at the foundation level and with a cap cast across the top with the first floor framing. There are no dowels, no bolts and no apparent connection. There were also no problems observed - absolutely none; not even working of the construction joints.

In several buildings observed, the concrete was specified to be 4000 psi except for 5000 psi for columns. Reinforcing steel was required to have a yield strength of 55,000 psi, except 33,000 psi for stirrups. The concrete appears to be of excellent quality and the climate is very beneficial. Very few shrinkage cracks were observed. See Bob Freece's notes for more details.

Most of the high-rise apartments and hotels have balconies of some sort. In general, these appear to be constructed with a rather thin cantilever slab and with solid masonry railings. I feel that the railings are considered to be architectural items and do not receive any structural attention. There is normally damage at the juncture with the building wall line, but I did not observe any serious failures to the balcony railings. I think they were lucky. Balcony railing construction should be modified in order to adequately tie it all together. They should receive structural consideration, which they do not appear to be getting now.

In briefly reviewing a few drawings and in some discussions, I feel that very little attention has been paid to the need for collector bars where shear wall structures are used. Further, and along similar lines, many of the smaller buildings have roofs of corrugated iron or transite with absolutely no diaphragm or other bracing. The local concepts of bracing are incomplete by our standards.

The buildings generally have one stairway, which is not enclosed, and wraps around in a U shape. In most cases, the walls are masonry, although a few buildings have concrete walls at the stairs and elevators. In general, there are no handrails for the stairs. While many of the elevators were not in service, it was usually because of spalled masonry and plaster in the shaft, which required repairs. I am not aware of any counterweights out of the guide rails. Plastic piping was common in the plumbing systems.

-3-
I have been told that "normal" construction costs are in the order of $10 per square foot. Construction labor is very cheap, on the order of $2 to $5 per man day. I was told that reinforcing steel crews are paid on the basis of piece work and that wages average out in the order of $4 per man day.

There seems to be a general opinion that the predominant motion of the February 4 shock was in the east-west direction. This tends to be substantiated in Zone 10, where there is more damage to adobe fences oriented north-south than to those oriented east-west.

Guatemala City does not encompass a very large area, being approximately 10 km. from the north end of the airport to the north end of the city, which is somewhat narrower in the east-west direction. This is comparable to the distance from the center of San Mateo to the center of Redwood City.

One more item of note: I did not notice any evidence of any significant movement at construction joints. The local practice does not use any special effort at construction joints; no keys and no roughening, just nominal cleaning.

I do not have time to summarize my comments in detail for this printing, but my review on this visit included the following buildings in varying degrees very complete

<table>
<thead>
<tr>
<th>Building</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guatemala Fiesta Hotel</td>
<td>Zone 10</td>
</tr>
<tr>
<td>Hotel Camino Real</td>
<td>Zone 10</td>
</tr>
<tr>
<td>Apartamentos Reforma</td>
<td>Zone 10</td>
</tr>
<tr>
<td>Ciudad Viria</td>
<td>Zone 10</td>
</tr>
<tr>
<td>American Embassy</td>
<td>Zone 10 (?)</td>
</tr>
<tr>
<td>Camara de Industria</td>
<td>Zone 4</td>
</tr>
<tr>
<td>Liceo Guatemala</td>
<td>Zone 4-5 (?)</td>
</tr>
<tr>
<td>American School</td>
<td>Zone 15</td>
</tr>
<tr>
<td>Con Vista Condominio</td>
<td>Zone 15</td>
</tr>
<tr>
<td>Agencia Bandessa</td>
<td>Zone 9</td>
</tr>
<tr>
<td>Hotel Terminal</td>
<td></td>
</tr>
</tbody>
</table>

Somewhat detailed descriptions of these buildings will follow. I have complete drawings for Reforma Obelisco, El Cortijo and Santa Clara. The other buildings I viewed in the company of Ing. Juan José Hermosilla and Ing. Robert Figueroa, a recent graduates of UC Berkeley.