SPECIAL STRUCTURES

In addition to standard types of buildings such as have been discussed in the preceding sections of this chapter, there was a number of special structures in Agadir which do not fit into any specific category. A few of these which were of particular interest with regard to their earthquake performance will be described here.

"La Reserve" Restaurant

The restaurant "La Reserve" had a very attractive location on the beach at Agadir, and the architect developed an unusual style of structure well adapted to its location (FIGS. 71 and 72). The plan form of the structure consisted of three intersecting circles, each about 35 feet in diameter, with their centers located at the apexes of an equilateral triangle about 30 feet on a side. The deck of the structure was supported at a height of about 12 feet by a tapered column under the center of each circular segment of the structure. The lateral strength of this structure was controlled by the bending and shear capacity of these columns with no other bracing being provided. The complete collapse of the structure, which could have been anticipated, is shown in FIGS. 73 and 74. Some indication of the mechanism of failure is provided by FIG. 75. At the left side of this photograph can be seen the upper part of one of the supporting columns which has punched through the base slab of the structure.

Fig. 71. "La Reserve" Restaurant From the East, Before the Earthquake

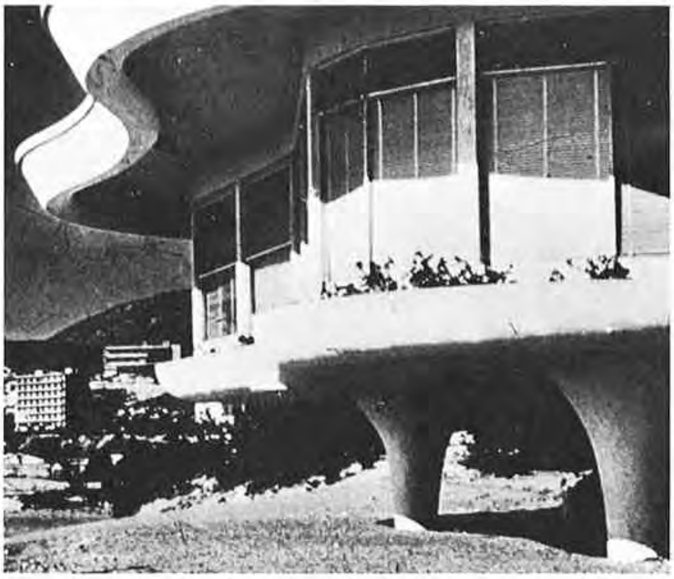

Fig. 72. "La Reserve" Restaurant From the South, Before the Earthquake

Fig. 73. "La Reserve" Restaurant From the East, After the Quake

Fig. 74. General View of the Collapsed "La Reserve" Restaurant

Fig. 75. Detail of the Collapse, Showing How Columns Have Punched Through the Floor System

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Fig. 76. The Customs House in the Port Area, After the Earthquake

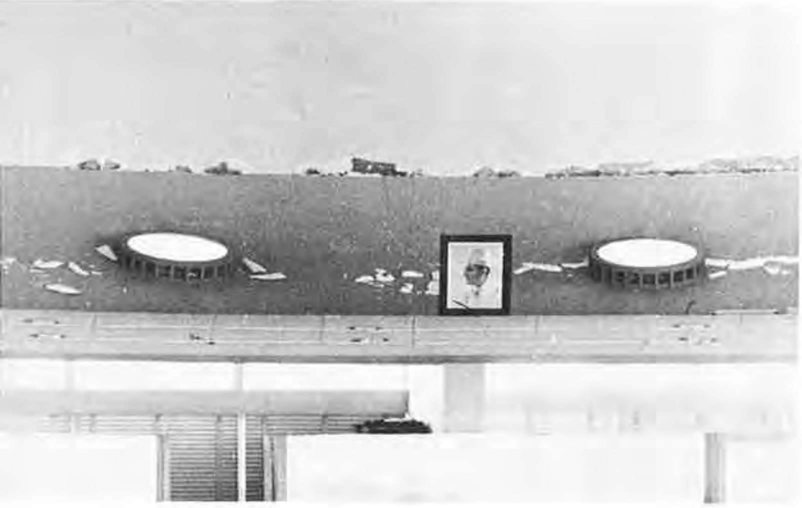

Fig. 77. Interior View of Customs House, Showing "Working" of Joint Between Walls and Dome Roof

The Customs House

Another unusual structure was the customs house (Fig. 76) which was located adjacent to the port. This 80-foot diameter reinforced concrete shell structure supported by many large tapered columns, performed very well during the earthquake. An interior view of the joint between the outward sloping wall of the structure and the dome roof is shown in Fig. 77. Considerable working of this joint is evident, and there is some indication of cracking in the outward sloping wall, but the system remains structurally intact. This structure was constructed in an area of filled ground, and was supported on concrete piles driven to solid rock at a depth of 25 to 30 feet. Evidence of settlement of the fill with respect to the pile-supported structure is shown in Fig. 78. Also shown is some cracking at the base of one of the columns supporting the roof system. Several columns showed such cracking, but it was not considered indicative of significant structural damage.

Fig. 78. Cracking at Base of Column of Customs House; Note Settlement of Soil With Respect to Structure

PORT FACILITIES

Earthquake damages occurring in the harbor area generally were of a different nature than those observed in other parts of the city, and therefore will be discussed separately in this section. The chief distinctive characteristic of the port was that it was the only area in the city in which structures were supported on filled ground, and only in this area did foundation and soil conditions play a part in the damage picture. Much of the information presented in this section has been adapted from the excellent report prepared by Lcdr. A. S. Waters, CEC-USN, Public Works Officer, of the U. S. Naval Air Station, Port Lyautey, Morocco (9).

The harbor consists of a shore line pier enclosed on the south and west sides by two breakwaters. A general view of the port area is shown in Fig. 79, a photograph which was taken from near the crest of the Kasbah hill. The inner harbor area is shown in Fig. 80, and a sketch of the harbor facility is presented in Fig. 81. The general form of construction consists of a rubble breakwater to the seaward side and a concrete quay wall on the docking side. The zone between the breakwater and quay wall has been filled to provide the level areas for warehouse and staging facilities.

Fig. 79. View of Agadir Harbor from the Kasbah Hill *(U.S. Navy)*

Fig. 80. View of Inner Harbor

(U.S. Navy)

(U.S. Navy)

Fig. 82. Subsidence of Fill Adjacent to North Quay Wall

(U.S. Navy)

Fig. 83. Subsidence of Fill Adjacent to North Quay Wall

The primary cause of earthquake damage on the port area was a general subsidence of this fill material. According to the Port Engineer, Mr. Bouayad, the fill was placed by dumping large rocks first and then filling over these with successive layers of smaller rocks, finishing with a layer of earth. Apparently the fill material was not compacted thoroughly during construction. Consequently, the heavy earthquake vibrations caused the finer material to sift down into the voids in the coarse material, resulting in very large settlements over the entire fill zone. Fig. 82 shows the extent of the settlement in an area where it approached the maximum. The subsidence was quite uniform over a large area, so that the surface of the filled area remained flat; however, the concrete quay wall which was supported on a solid foundation did not settle, and the vertical extent of the fracture line between the concrete wall and the fill is quite impressive.

Similar relative settlements between quay wall and fill were noted all around the periphery of the harbor basin. Relatively little harm resulted in most locations as shown by Figs. 83 and 84. However, rails for the operation of 6-ton portal cranes were located along the dock sides in front of the warehouses. With one crane

Fig. 85. Effects of Fill Subsidence, Along Crane Rail System, North Quay Wall

(U.S. Navy)

Fig. 84. Effects of Fill Subsidence, Along West Breakwater

Fig. 88. Crane Upset Along West Quay Wall

(U.S. Navy)

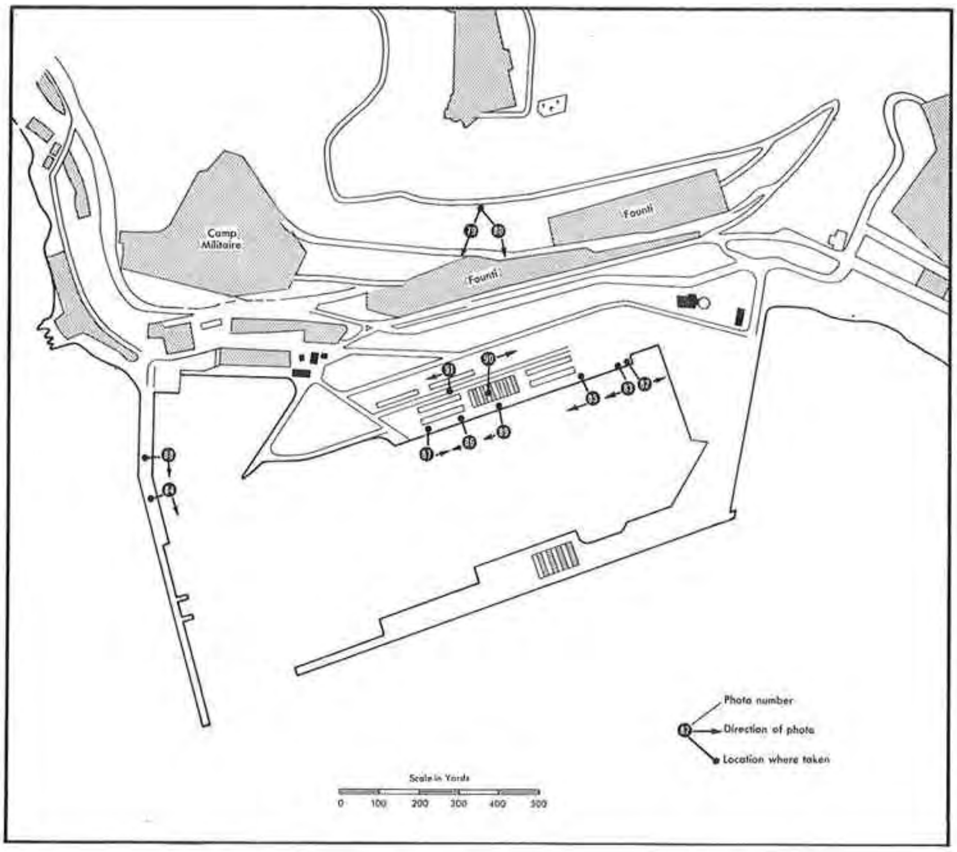

Fig. 81. Sketch of Agadir Harbor

(U.S. Navy)

Fig. 87. Tilting of Crane, North Quay Wall

(U.S. Navy)

Fig. 86. Cranes Overturned by Fill Subsidence, North Quay Wall

(U.S. Navy)

(U.S. Navy)

Fig. 89. Warehouse Building Crushed by Overturning of Crane

rail placed on the concrete quay wall and the other on the fill (Fig. 85) the settlement of the fill material caused a tilting of the cranes. Of the seven cranes operating on these tracks (4 on the north dock, 3 on the south) five toppled over as a result of the fill subsidence (Fig. 86) and the two which remained standing were tilted too far to be used with safety (Fig. 87). The smaller cranes on the west dock areas were affected similarly (Fig. 88).

The principal structural damage in the port area was a secondary result of the soil subsidence. Two of the cranes which toppled over dropped on the steel frame warehouse buildings, causing complete local collapse (Figs. 89 and 90). Except for these local effects, however, these lightweight, well-braced structures were practically unaffected by the earthquake. An adjacent open, steel-frame shed settled slightly on the subsiding fill material (Fig. 91), but showed no vibrational damage.

Although the magnitude of the earthquake forces acting upon the dock area structures is not precisely known, they were undoubtedly as substantial as those occurring in other shore areas in that vicinity of the city. The importance of frame action in buildings, in conjunction with construction materials having a high degree of resilience, toughness and strength, was probably well evidenced by the lack of significant primary damage to the dock area structures. There is no reason to believe that structures of the same construction as those demolished in the adjacent Founti section by the earthquake would have fared better in the port area.

As was stated in Chapter 1, there was no evidence of heavy tidal waves sweeping into the harbor. However, a Dutch intercoastal freighter which was moored along the side of the quay at the time of the earthquake reported that large swells raised the level of water in the harbor sufficiently to cause parting of its mooring lines.

(U.S. Navy)

Fig. 90. Interior of Warehouse Crushed by Crane

Fig. 91. Settlement of Steel Frame Shed Structure

(U.S. Navy)