

## SECTION 2

### WATER SYSTEM DAMAGE DUE TO PRIOR EARTHQUAKES

In this section, damage to water systems in Mexico caused by earthquakes prior to the September 1985 event is discussed. The recorded evidence suggests that, as in contemporary systems, the lack of flexibility (ductility) at pipeline joints was a major cause of pipeline damage in past earthquakes.

Damage to water supply and distribution systems in Mexico caused by destructive earthquakes has been documented to a greater or lesser extent since 1818. Information on water system damage before 1818 is not available although there is a 500 year record of earthquakes in Mexico. Table 2-I contains a summary of available information on earthquake damage to water systems for the period 1818 through 1985. It should be noted that the amount of damage in Mexico City has generally increased with the increasing size of the city which is in figure 2-1. Note historically that the northern portions of the Federal District have been the most heavily populated.

Of engineering importance is the fact that during the 1973 Orizaba earthquake, the main aqueduct (buried transmission line) supplying water to the city of Cordoba was severely damaged at a minimum of 20 points along its length. The aqueduct was a 36"φ reinforced concrete pipeline with 'lock joint' type joints. During this earthquake, all of the pipeline failures occurred at the joints.

The 1979 Guerrero earthquake damaged a 72"φ buried reinforced concrete aqueduct at 10 locations along its 6 kilometer length in southeast Mexico City. Figures 2-2 and 2-3 show typical damage. Pipeline failures were mainly the result of tension and/or compression at joints. In order of incidence, the failures were due to compressional crushing at the bells, pull out accompanied in some instances by rotation at the joints. An evaluation of the damage indicates that the failures were due to a lack of flexibility in the system as opposed to a lack of strength, [1] and [2]. The repair method used consisted of either replacing the broken pipes or repairing the joints with a bolted steel collar. Unfortunately neither of these procedures improve the deformation characteristic (ie, flexibility) of the pipeline joints. Replacing the broken pipes theoretically returns the system to its pre-earthquake

condition, hence leaving it vulnerable to future seismic damage. Repairing with a bolted steel collar has the effect of marginally reducing the overall flexibility of the system as a whole, and does not prevent damage at adjacent joints during future earthquakes.

The above discussion is not meant to question the engineering judgement of Mexican officials after the 1979 Guerrero earthquake, but to highlight the difficulty of increasing seismic resistance (flexibility) for an existing linear system with thousands of 'weak link' joints.

TABLE 2-I Historic Earthquake Damage To Water Systems In Mexico, [3]

Date	Earthquake Magnitude	Water System Damage
May 31, 1818	*	Broken arches in aqueducts in Mexico City.
May 4, 1820	*	Damage to above ground aqueducts in Mexico City.
January 6, 1835	*	Damage to above ground aqueducts in Mexico City.
October 3, 1864	*	Damage to buried clay pipes in Mexico City.
July 19, 1882	*	Damage to buried clay pipes in Mexico City.
April 14, 1907	8.2	Damage to buried clay pipes in Mexico City.
June 3, 1932	8.4	Extensive damage to buried pipelines in Mexico City.
June 30, 1973	7.5	Damage to buried aqueducts in the cities of Orizaba and Cordoba.
March 14, 1979	7.6	Damage to a main buried aqueduct in Mexico City.
September 19, 1985	8.1	Extensive damage to buried pipelines and buried aqueducts in Mexico City.

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\* Not available

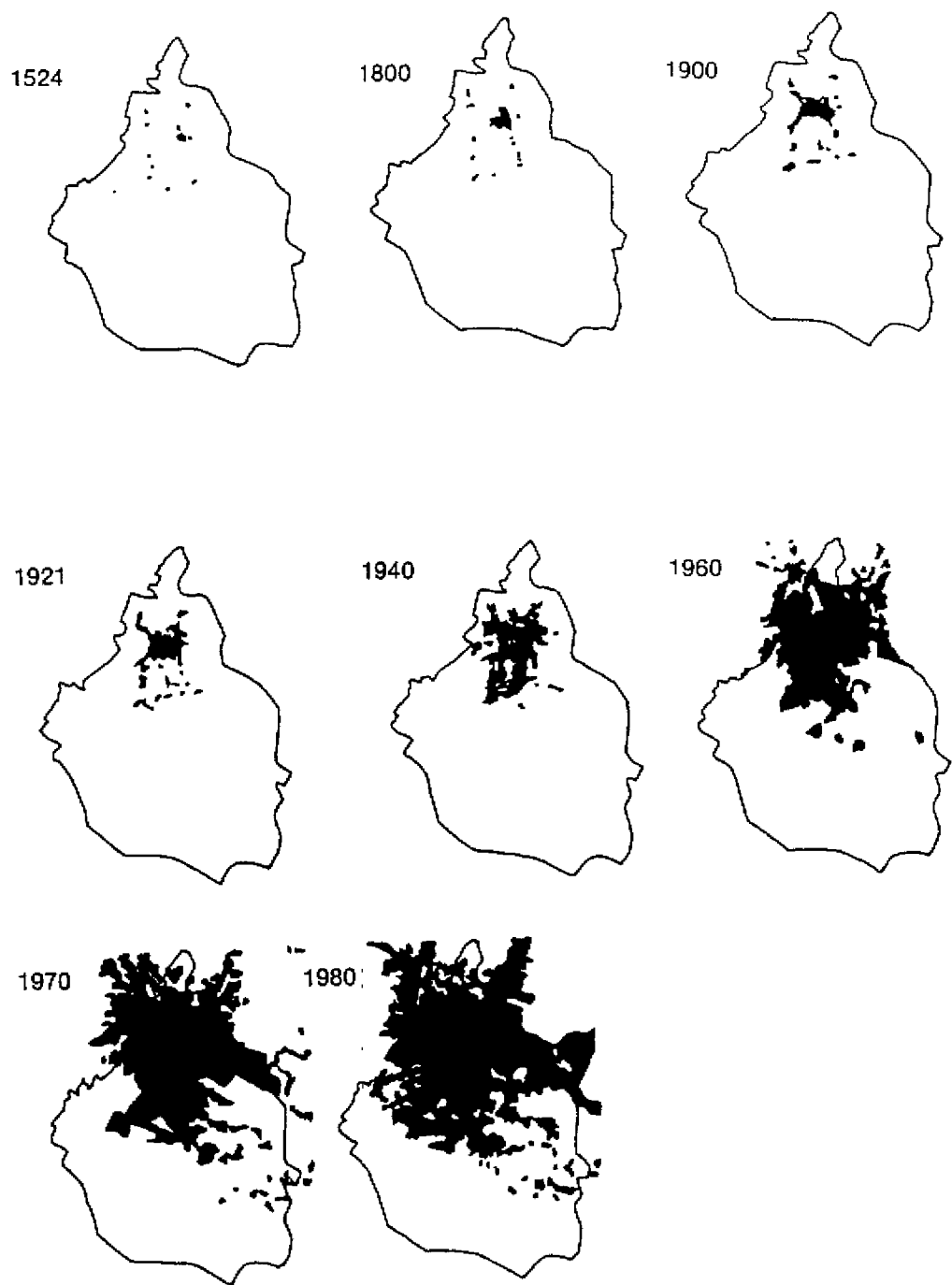


FIGURE 2-1 Growth Of Metropolitan Mexico City 1524-1980

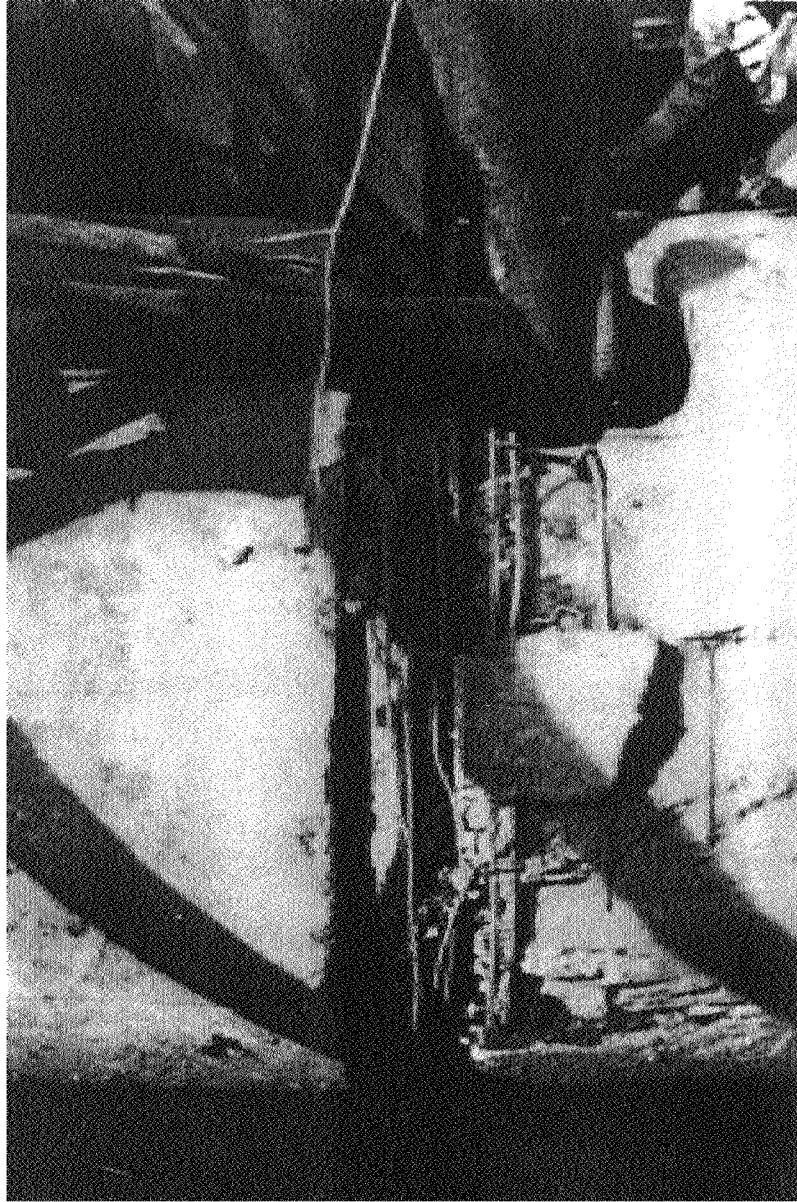


FIGURE 2-2 Aqueduct Damage During 1979 Guerrero Earthquake