TECHNICAL INFORMATION ON BUILDING MATERIALS

FOR USE IN THE DESIGN OF LOW-COST HOUSING

TIBM - 29

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THE NATIONAL BUREAU OF STANDARDS
UNITED STATES DEPARTMENT OF COMMERCE
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CORROSION OF FERROUS METALS UNDERGROUND

Corrosion of buried iron or steel differs in several important respects from the attack on similar material when exposed to air, (See TIBM Nos. 10 and 17), or when wholly or partly submerged in water (See TIBM No. 22). The main factor governing corrosion is the presence of oxygen and water together on the metal surface. Impurities in the air or the water are also important factors.

In soils, the atmosphere often differs from ordinary air. In addition to a difference in oxygen content, there may be gaseous impurities such as carbon dioxide, gases from decaying plants, hydrogen sulphide, etc., which affect the corrosion rate. Air in the soil is nearly always saturated with water vapor, but certain impurities which affect the corrosion rate under other conditions probably are not present. The access of soil air to the buried metal may vary considerably in different soils. In general the amount of oxygen available for corrosion at a given time or area is much less in soil corrosion than with atmospheric corrosion. Moreover, the amount of oxygen available varies on different parts of buried metal. Soil water always contains varying amounts of dissolved salts such as chlorides, sulphates, phosphates and bicarbonates. These affect the rate of corrosion directly and indirectly by their effect on the acid or alkaline character of the water. Since the pitting type of corrosion is frequently associated with these general conditions, it might be expected that soil corrosion of metals would oftentimes result in pitting. This has been found to be the case in extensive investigations by the National Bureau of Standards and also in inspections by public utility companies of oil or gas pipe lines that have failed by soil corrosion. An important feature of soil corrosion is the occasional formation on the surface of a more or less adherent coating of corrosion products which may exert some protective effect.

An investigation of soil corrosion was started at the National Bureau of Standards in 1922 and is still in progress. The ferrous metals used are chiefly plain and copper-bearing steels, wrought iron, open-hearth iron and cast iron. Recently a few special alloy steels have been included. Short lengths of pipe of different wall thickness and diameter were buried in trenches in such a manner that a few specimens of each material could be removed at intervals and examined. The pipe specimens were buried in 45 different types of soils in different parts of the United States (See attached map).

A later phase of the investigation was devoted to a study of bituminous and other coatings such as are frequently used or recommended for preserving buried pipes. Galvanized coatings and a few other metal coatings such as lead were also included. Although some conclusions have been reached with reference to the bituminous coatings, definite statements can not yet be made regarding the behavior of galvanized pipes in different types of soils.

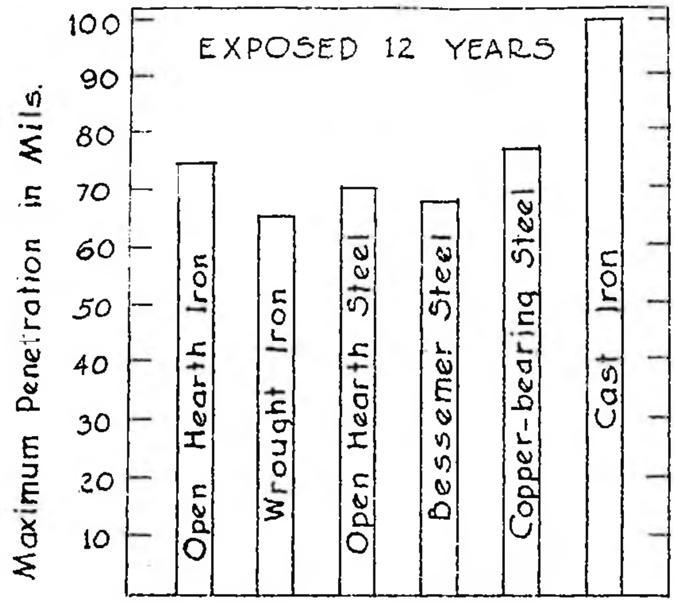
The National Bureau of Standards soil corrosion investigation has shown that soils differ radically in their corrosive action on iron or steel. The most corrosive soils are heavy, poorly drained soils which are either very acid or contain excessive quantities of soluble salts. A porous well-drained soil is generally only slightly corrosive, whereas a heavy, close-grained poorly drained soil usually gives trouble. Sandy soils are least corrosive because of their excellent drainage.

Another general conclusion is that in any given soil all the ferrous materials are attacked at about the same rate. The pipe material supplied commercially in the greatest wall thickness might therefore be indicated in those cases where the greater cost of added wall thickness seems justified It has been noted that cast iron pipe frequently retains much of its usefulness even after severe corrosive attack, because the network of uncorroded constitutents of the cast iron is often reinforced by a heavy coating formed during corrosion which fills the pits and often plugs perforations.

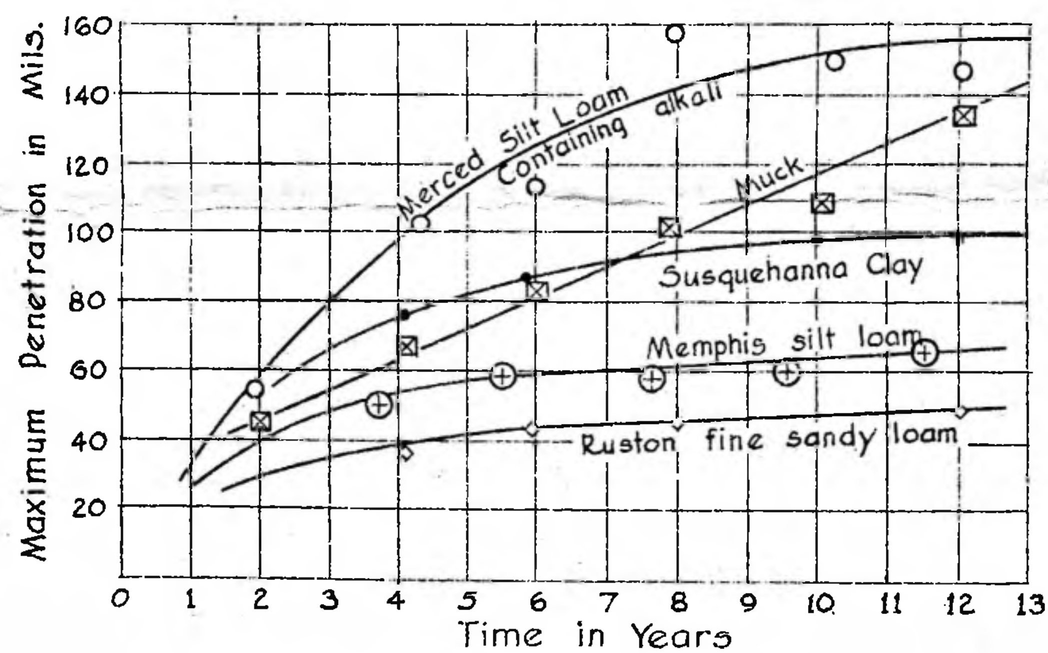
In very corrosive soils recourse must be had to protective coatings. Cement coatings have been found satisfactory except in alkali soils. Bituminous coatings should preferably be reinforced or covered with one of the approved commercially used wrapping materials, in order to minimize the chance of puncturing the coating when covering the pipe with earth or because of soil movements adjacent to the pipe when in service.

The National Bureau of Standards and others have devised useful electrical tests of simple nature for ascertaining the relative freedom of bituminous coatings from holes or porosity, and details of these tests may be obtained from the Bureau. Details may also be obtained from the same source as to procedure of test or names of laboratories testing the corrosive effect of soils on metals, which information may often prove helpful.

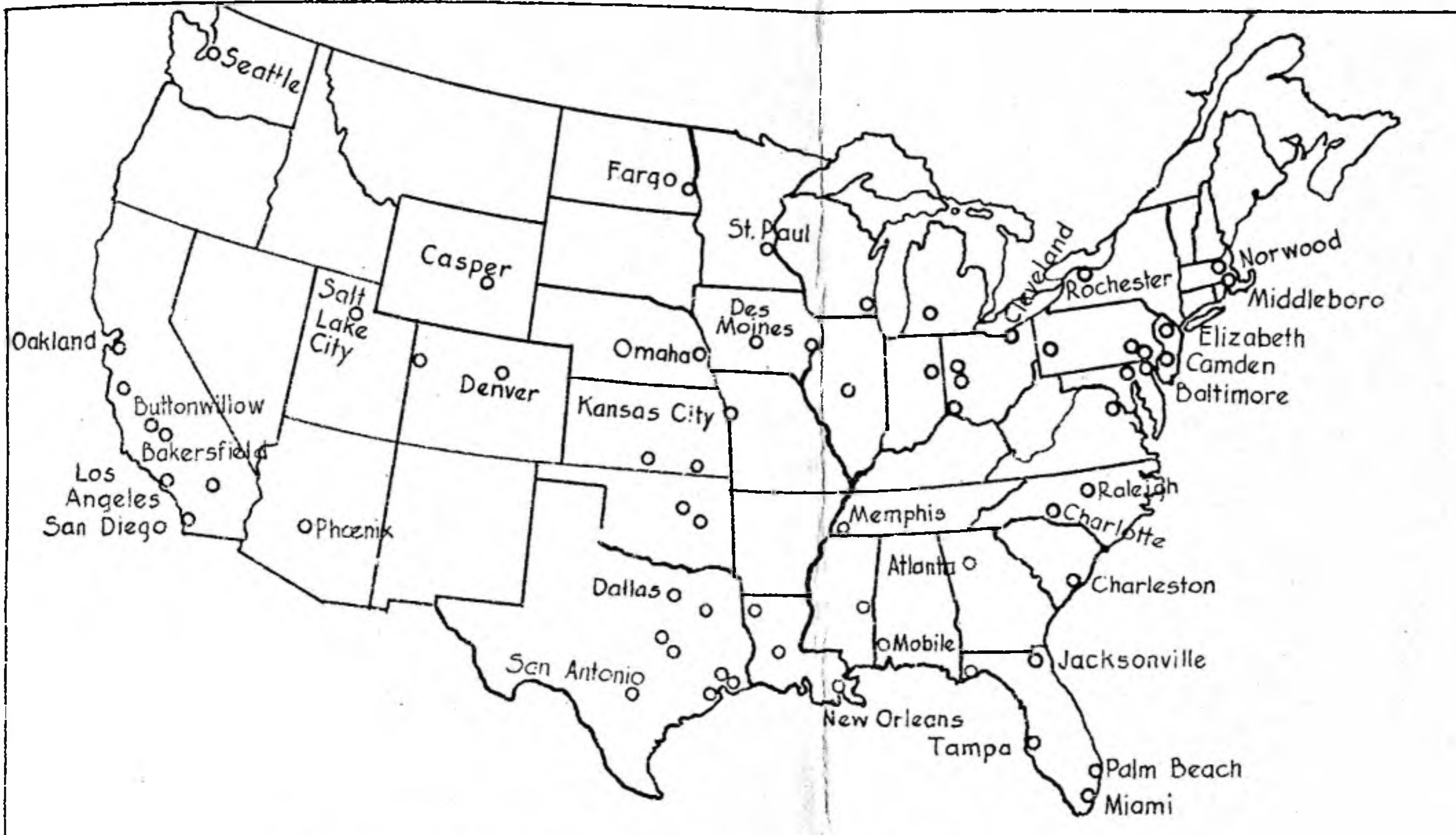
The attached charts show locations of tests on the corrosive effect of soils on various ferrous pipe materials, as well as the effect of soil drainage on the corrosion of these materials.



Similarity of various types of ferrous piping materials with respect to corrosion underground



The above illustrates the important effect of soil drainage. In poorly drained soils (designated as "Merced Silt Loam" and "Muck") the corrosion proceeds at a nearly constant increase. In well drained soils, represented by the other curves on the graph, the corrosion almost ceased after the first 7 or 8 years because of protective coatings which had formed on the pipe surface or at the bottom of the pits.



LOCATION OF FIELD TESTS IN THE NATIONAL BUREAU OF STANDARDS' INVESTIGATION OF THE CORROSIVE EFFECT OF SOILS ON PIPE AND PROTECTIVE COATINGS