LYMAN

2651

Centre Expérimental de Recherches et d'études du bâtiment et des travaux publics.
12 Rue Brancion
Paris 15e.

Corrosion of iron and/or copper embedded in concrete or plaster.

5 February 1965.

1.SUMMARY.

On request and at the expense of C I C L A, corrosion tests have been carried out in the Corrosion Section of the Laboratory for testing materials.

The results may be summarised as follows:

1.) When embedded in conventional concrete, copper is never corroded even in the most severe conditions(dry-wet cycles).

2.) When iron and copper are put in direct contact in the concrete the electro-chemical voltage difference is never high enough to cause galvanic corrosion of one of the two metals.

3.) Copper does not corrode in concrete containing calcium chloride, while iron is badly attacked; this corrosion is still enhanced when copper comes in contact with iron.

4.) Copper does not corrode in plaster. On the contrary, iron is strongly attacked, this corrosion is not markedly modified by a direct electric contact copper/iron.

2. EXPERIMENTAL METHOD.

2.1. Potential measurements.

Each system metal/concrete or metal/plaster undergoes an electrical-chemical voltage difference which depends on:

-the composition and the surface conditions of the metal.

-the composition and the physical structure of the surrounding material.

-the storage conditions.

By causing variations of one or several of the above mentioned para
meters and by recording the corresponding voltage differences, the
likelihood of corrosion may be ascertained. The voltage difference
were measured by comparison with a calomel electrode, using an
electronic voltmeter with a very high internal resistance. The re-
sults were plotted in graphs with the potential (mV) in ordinates
and the time(days) in abcissas. The potential records were made
during 40 days after the preparation of the samples. For each
metal/material combination, three samples have been prepared and
2 measurements carried out for each sample.

The figures indicated are thus average values of 6 different
measurements.

2.2.Samples.

2.2.1.Surrounding materials.

The samples are blocks of 7 x 7 x 30 cm and may be classified in
three groups as follows:

a) Conventional concrete.

River sand 5 - 10 mm: 4037g.
River sand 2 - 5 mm: 3498g.
River sand0,5- 2 mm: 2585g.
Cement   : 1925g.
Water   : 990g.

b) Concrete with additive.

Same composition + 38,5g. of calcium chloride.

c) Plaster.

Fine plaster with 80% water.

2.2.2.Metals.

Annealed copper tube 10/12 mm and iron rods 10mm.

2.2.3.Types of samples.

In each case the following conditions were provided for:

-copper tube alone.

-copper tube + iron rod without connection.

-copper tube + iron rod connected by an iron wire.

2.3. Storage conditions.

During the first 28 days, the samples were kept at room temperature in usual conditions. After this time, they were moistened and dried according to repeated cycles, in the following way:

1) water saturated atmosphere.
2) Infra-red heating.
3) Water absorption by capillarity,from an underlying layer of wet sand.

3. RESULTS.

The following values of the potential differences are either absolute differences (upper line) or differences between the highest potential (dry conditions)and the lowest one (wet conditions).
The figures are relating to potential differences between the underlined metal and the surrounding material. When both metals are underlined, this means a potential difference between the two metals.

3.1. In Concrete.

Curve A:- copper   Wet   : —80mV.
                   max.diff.: 220mV.

Curve B:- copper and iron without connection   Wet   :—80mV.
                                               max.diff.:220mV.

Curve C:- copper and iron without connection   Wet   :—240mV.
                                               max.diff.:320mV.

Curve D:- copper and iron without connection   Wet   :—120mV.
                                               max.diff.:140mV.

Visual examination of the samples.

The copper is covered with a uniform adhering oxide layer.-No corrosion.

The iron has a grey appearance, characterizing the passivated state.

-Sometimes some fine rust powder.

<u>Curve E:-</u> <u>copper</u> and <u>iron</u> with connection   Wet   :-140mV.

                         max.diff.:260mV.

<u>Visual examination of the sample.</u>

Same aspect of copper as above.

Rust slightly more abundant on the connection points.

<u>General Conclusion:</u> No corrosion problem.

  <u>3.2.In concrete with additive.</u>

<u>Curve F:-</u><u>copper</u>   Wet   :-90mV.

               max.diff.:110mV.

<u>Curve G:-</u><u>copper</u> and iron without connection   Wet   :-100mV.

                         max.diff.:160mV.

<u>Curve H:-</u>copper and <u>iron</u> without connection   Wet   :-380mV.

                         max.diff.:200mV.

<u>Curve I:-</u><u>copper</u> and <u>iron</u> without connection   Wet   :-280mV.

                         max.diff.: 80mV.

<u>Visual examination of the samples.</u>

Copper not corroded.

Several corrosion pits on the iron surfaces.

<u>Conclusion:</u> No corrosion danger for copper, but possibility of corrosion for iron.

<u>Curve J:-</u><u>copper</u> and <u>iron</u> with connection Wet   :-380mV.

                         max.diff.:240mV.

<u>Visual examination of the sample.</u>

Copper not corroded.

Very severe corrosion of the iron.

<u>Conclusion:</u> Severe danger of corrosion for the iron reinforcemen in contact with copper.

3.3. In plaster.

Curve K:- copper Wet   :+30mV.

max.diff.:50mV.

Curve L:- copper and iron without connection Wet   +30mV.

max.diff.:50mV.

Curve M:- copper and iron without connection Wet   :—630mV.

max.diff.:650mV.

Curve N:- copper and iron without connection Wet   :—670mV.

max.diff.:600mV.

Visual examination of the samples.

Copper not corroded.

Iron undergoes a general corrosion attack.

Conclusion: No danger of corrosion for copper but serious
corrosion problem for iron.

Curve O:- copper and iron with connection   Wet   :—580mV.

max.diff.:580mV.

Visual examination of the sample.

Copper not corroded.

Iron very badly attacked, still more strongly than in the previous
cases.

A
E1
E2
A1
A2
K1
K2
BCD1
BCD2