Chapter 4.12
Prediction of the Consistency of Concrete by Means of the Use of Artificial Neural Networks

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ABSTRACT

This chapter displays an example of application of the ANN in civil engineering. Concretely, it is applied to the prediction of the consistency of the fresh concrete through the results that slump test provides, a simple approach to the rheological behaviour of the mixtures. From the previously done tests, an artificial neural network trained by means of genetic algorithms adjusts to the situation, and has the variable value of the cone as an output, and as an input, diverse variables related to the composition of each type of concrete. The final discussion is based on the quality of the results and its possible application.

INTRODUCTION

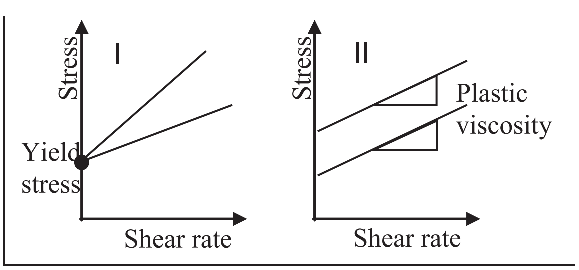
Concrete is one of the construction materials that is currently most used, since it provides a high compressive strength (similar to a rock) and can to be adapted into different shapes during its production. It is made of a mixture of water, cement, fine aggregate (sand, 0 to 4 mm), and coarse aggregates (6 to 12 mm and 12 to 25 mm), and, in some cases, other mineral admixtures (additions) or chemical admixtures (additives) with different functions.

CONCRETE RHEOLOGY AND WORKABILITY

The main properties of the concrete are determined in two different stages, the first one being manufactured, in which the material is in a fresh state, and the second stage corresponding to its hard state. In the first stage, the concrete appears like a fluid material and can be adapted to any shape. This property is associated to its workability. Its measurement is necessary because the capacity of the concrete to be adapted into another shape will depend on it. A suitable workability also allows for the possibility to compact the concrete that is required to evacuate the air content that is incorporated in the processes of production and placement.

The workability (also the facility of placing, docility, or consistency) depends on the rheological properties of the fluid, which are usually associated to a Bingham model (Tattersall, 1991) and must be determined to ensure that the concrete will be able to be placed. According to this theory, the fresh concrete can be described by two fundamental parameters: its plastic viscosity (the excess of the shear stress over the yield stress divided by the shear rate) and its yield stress (a critical shear stress to a point that once the yield stress is exceeded a viscoplastic material flows like a liquid). Most of the widely used tests are unsatisfactory in that they measure only one parameter, which does not fully characterize the concrete rheology. Figure 1 shows how two concretes could have one identical parameter and a very different second parameter. These concretes may be very different in their flow behaviours. Therefore, it is important to use a test that will describe the concrete behaviour, by measuring at least both factors.

Figure 1. Bingham model for two concrete mixtures of different behaviour



MEASUREMENT OF THE WORKABILITY OF THE CONCRETE

The methods to determinate the workability are usually indirect methods. The common methods are the rate of flow, the compacting factor, and the slump (being the oldest) (Abrams, 1922). This oldest method is the most used because of its simplicity. Other viscometers and rheometers have been developed to adjust to the parameters of the Bingham model, although their use in construction is very limited.

The test is very simple, inexpensive, and is used in construction to determine if a concrete can be accepted before its positioning. The test method is widely standardized throughout the world, including in ASTM C143 in the United States and EN 12350-2 in Europe (Koehler & Fowler, 2003).

The apparatus consists of a metallic mould in the form of a truncated cone whose larger base has a diameter of 20 cm, its smaller base of 10 cm, and a total height of 30 cm. The mould is stuffed with concrete in three layers of equal volume. Each layer is compacted with 25 strokes of a tamping rod. When finalizing the filling, the cone is extracted and the final height of the mass of concrete is measured. Figure 2 shows the test process.

In this test, the stress is composed of the weight of the concrete per unit area. The slump is influenced by both yield stress and plastic viscosity; however, in most cases, the effect of plastic viscosity on the slump is negligible. The concrete will slump or move only if the yield stress is exceeded and will stop when the stress (or weight of the

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