FPC CONTROL UP TO CUSTOMER'S GATE: A GLOBAL APPROACH TO PRODUCTION AND CUSTOMER SERVICE

MARCO BORRONI

Abstract

Measuring and recording slump from production to delivery at customer's job site was the first goal of a project that involved a major change in the way we produce and deliver concrete.
Usually, slump control is only related to production at the plant, and data is usually recorded for wet batching - but in general not for dry batching; in any case no information is collected at the jobsite.
To ensure complete satisfaction of customer's needs, a complete set of activities was set to change the way we design, produce and deliver concrete.
A slump measurement device was installed on all truck mixers in order to check slump both at the plant and at the jobsite; all data are recorded and reported together with production and driving data to perform a complete analysis of every delivery.
Every truck mixer has been tested to refine the measurement process based on oil pressure of drum's hydraulic engine.
Every truck mixer is provided with a leaflet showing the delivery procedure. The leaflet is placed on the truck mixer and available to the customer.
Managing the product workability depending on transportation time was the first consequence of adapting mixes and transportation procedures.
A complete new mix design tool was developed, in order to adapt mixes to the outside temperature, to driving and pouring time and to specific fresh state performances for concrete.
The full control of the slump at delivery makes it possible to add a seal to the drum's water pipe, in order to avoid unwanted water additions.
A customer technical assistance procedure was created in order to recommend best jobsite practice for concrete and to monitor the application of the delivery procedures.
An operation manager was appointed in every geographical area, to ensure the achievement of the goals in slump control and in the overall production quality; the operation managers interact with technologists, maintenance managers, plant managers and batchers.
Customers have been invited to conferences (more than 40 on across the country) where the company presented and debated this new approach; also specific pouring requirements are discussed for each delivery on a daily basis.
This new approach is acknowledged by customers as a more reliable and transparent process, we gained a reduction in disputes at the pouring stage, an increase in slump values and a dramatic reduction in unwanted water additions.

Keywords

Slump control, slump measurement, FPC, customer service

Biographical notes

Marco Borroni is Operations and Plant Design Director for Unical, part of Buzzi Unicem Group. Unical is the leading RMC producer in Italy, running more than 130 plants through the country; the company has been involved in the major infrastructure building sites in a several decades history. He joined the company in 1994, coming from mechanical industry, and played different roles as Area manager, Northern Italy manager and Production and Applications manager. He is member of Italian rmc association (ATECAP) board.

1. INTRODUCTION

There are various ways concrete can be produced - dry batch, wet batch from any kind of mixer - but information about slump is only available at the worksite. No reliable information is available at jobsite, unless a slump test is performed, however it's quite impossible for every single delivery. Moreover, especially in Italy, we used to face very often water addition requests before pouring, this leading to well-known harmful consequences.

Figure 1 asking for water

This bad habit would severely deplete concrete as a product, as transportation can change its properties and the producer cannot control the whole process up to customer's gate. . High quality concrete producers are more damaged as differences in the product could be hardly detected if customers are not properly equipped to check the product consistency - especially if water is added.
As an additional hint, dry batching in all our plants, a reliable and traceable slump control system in production was needed.

2. H2NO project

Considering the above scenario, we started a project having a clear unique goal: to deliver the right consistency for concrete in every jobsite. So no water addition would be requested, simply because it wouldn't be needed.
We named the project "H2NO", meaning "no (extra) water needed".

Figure 2 H2NO logo

All internal activities started in 2008, and the project was launched to the market in 2010.

During the development of the project, we realized how much it affected mix design, production, transport and delivery, marketing and sales, leading to significant changes in many activities of our company. The goal to control consistency led to a complete new way of thinking concrete production.

3. Slump control

The slump itself is not a physical quantity: it's a reference test (Abrams cone or vibrating table) where a linear dimension (millimeters) stands for consistency of concrete that is, in fact, it's ability to be deformed, i.e. put in place that is the final goal of pouring.

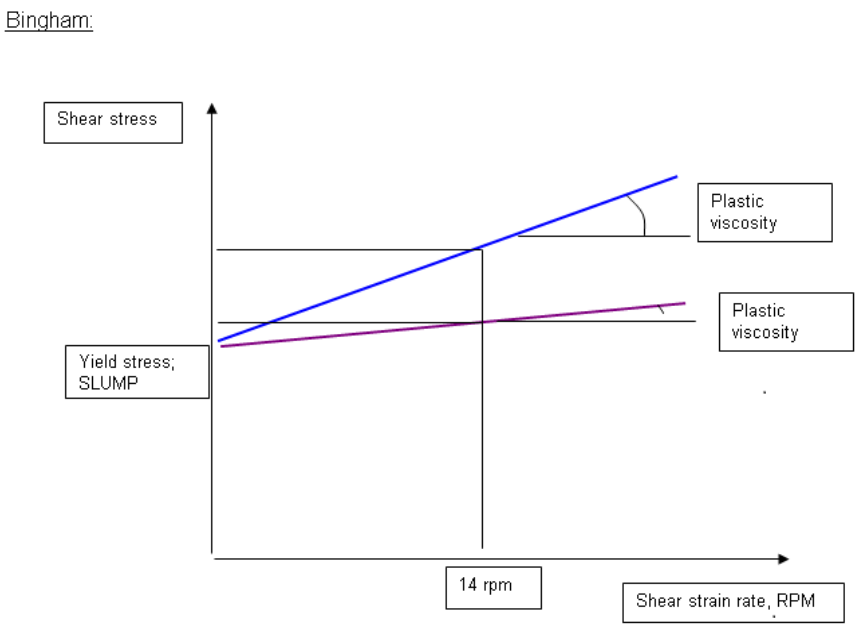

Figure 3 Bingham's law

As we know from Bingham's law, slump can be related to shear stress at low shear strain rate, i.e. conditions that occur during slump test and during pouring (although not really the same due to vibration). Those are not of course conditions during mixing at higher speed (both in a truckmixer or in a mixer): this will have to be taken into account.
Finally we can summarize that slump is related to the force needed to change material's shape: in Abrams' test that forced is fixed and represented by gravity and the measurement is the final effect (test cone height reduction): so slump test reports concrete deformation under a given force.

3.1 Slump detection

To set up an online slump detection system, it is obviously impossible to measure concrete deformation inside the mixer. All indirect measurement system will then be related to the force (or energy) needed for concrete deformation: this is already usually done in mixers by controlling electrical power input; similarly in dry batching via hydraulic engine oil pressure.
It's then all matter of correlations: both Slump test and force measurement are related to consistency, so next step is to create correlations between the formers.
One major point to be highlighted: in dry batching the truckmixer acts as a production mixer so, when equipped with any measuring device, information will be available also during transportation and at job site.

3.2 Device

We started from already previous experiences in correlations on hydraulic pressure and slump by the integration of the sensor in our computer batching system: the ISM (Infrared Slump Meter) is made of speed and pressure sensors, a central unit, an infrared transmission system to connect truckmixer and plant, and a display panel to show drum's rotating speed and hydraulic pressure.
During the development of the system, together with the supplier, we pursued the idea of a simple, reliable and low cost equipment, ease to install and maintain, not affected by an extremely harsh environment. Mainly the truck is carrying the sensors, leaving all the choices to plant's operator and to driver. So we can maintain the needed flexibility to face all the extremely variable conditions we meet, while having a traceability of all operations.
A deep investigation has been carried out to determine the factors affecting the pressure measurement: hydraulic circuit behavior (including drum speed regulation), drum geometry and blades shape, rotating speed, sensor signal noise. At the same time, also errors in slump test have been considered: being a manual operation there's a "human" factor that can alter measurements.

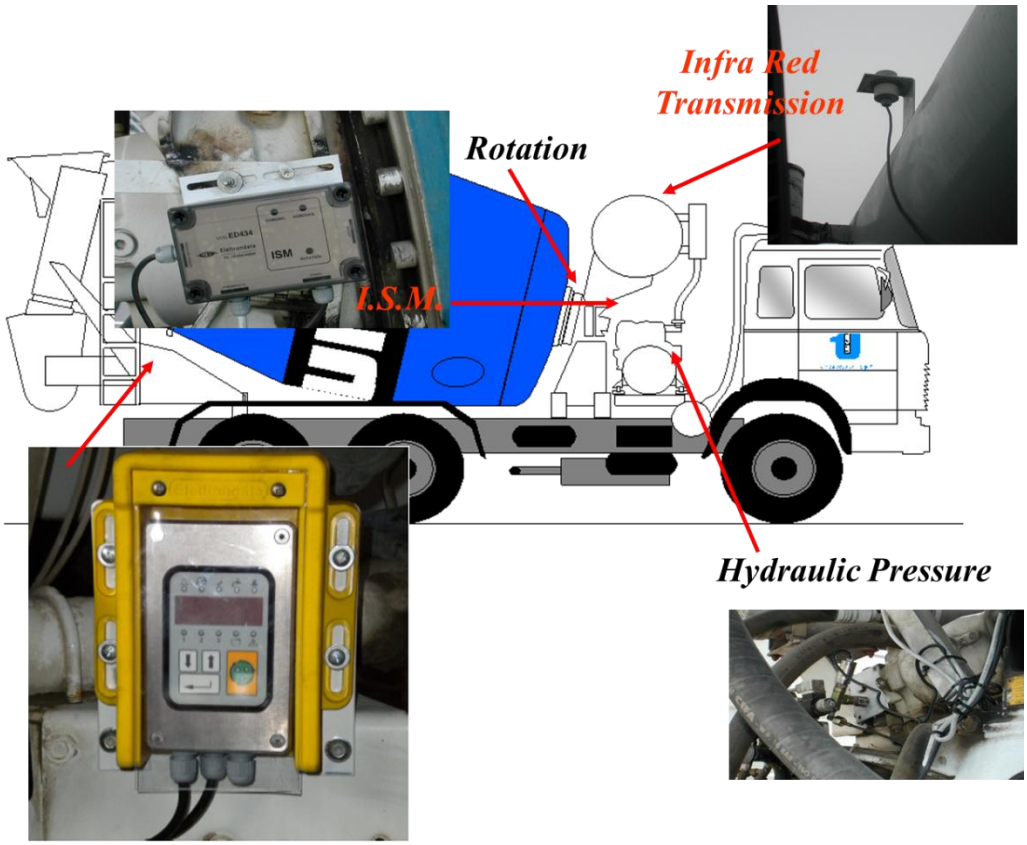

Figure 4 Infrared Slump Meter

3.3 Setup and tuning

To setup every truck in our fleet (about 800) a simple method was needed: we designed a correlation curve that takes approximately one hour to be determined, performing a limited number of slump tests. This can facilitate the re-building of the curve if variation in the truckmixer occurs, such as oil change, buildup removal, blades refurbishment and so on.
A quantity variation curve, that can be customized for every truck, accounts non complete loads; all the parameters related to concrete have instead been included in coefficients to be provided from laboratories. This allows to take into account all properties, such as viscosity, that will be crucial for the response of fresh concrete.
Pressure data is always available on the truck display and in plant operator's computer during loading; pressure data at delivery time are recorded in the central unit and transmitted to plant's computer via an infrared device when the truck is back to the plant.

The operator ìs immediately informed regarding driving and pouring times, pressure variations and driver's activities, thus allowing problem solving.
Moreover, the pressure display warns the driver if pressure is out of range so that appropriate actions can be taken before pouring.

4. Production control

4.1 Batching

The batching software has been modified to take advantage from instant pressure measurement: values are reported on the operator's computer screen to check slump stability and to adjust the quantity of water quantity in the mix.
Drum's speed is also reported, so rotation is adjusted by the driver to be in the optimal range for mixing.
For every single mix a specific range of pressure at the plant is calculated taking into account truck reference curve, quantity, mix type, ambient temperature, expected driving time and pouring mode.
The operator con examine slump evolution during batching in the same way as for a mixer, and detect any problem that may arise in reaching the correct slump. The system helps in detecting variations of raw materials, tolerances in plant's process or mixers wear.

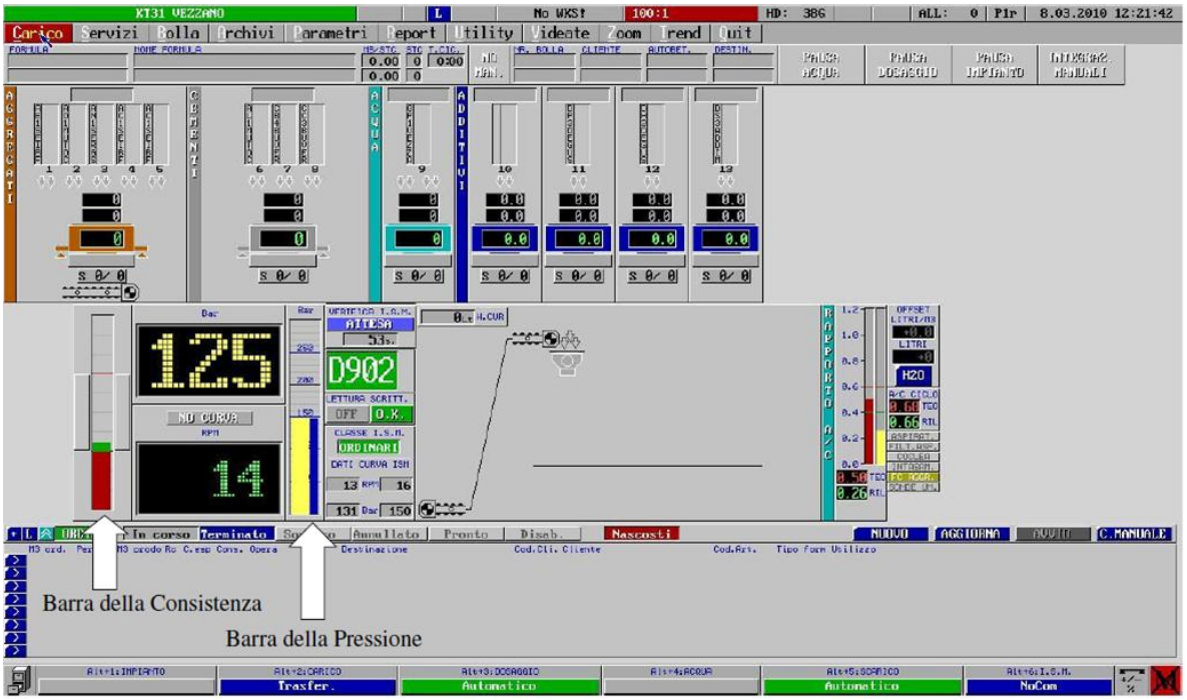

Figure 5 Batching

4.2 Delivery

The control is repeated at the jobsite: the driver follows a specific written procedure mixing again at high speed and checking pressure; small final adjustments can occur within fixed limits. Procedures are available on the truckmixer for the customer as well as the final pressure range printed on the delivery ticket, to be compared with values appearing on system display on the truck.
Pressure values at the end of this control procedure are saved and added to all other batching data: we gain a complete traceability of production and delivery, including driving time, pressure variation from plant to jobsite, final water or admixture integration and slump value at delivery.
The unique measuring system ensures the homogeneity of data.

4.3 Reporting

A full set of reports is then available, tracing every single delivery and summarizing main parameters over set time periods.
Some indexes are created to report overall indication on plant performance, to drive control and recalculation of parameters and maintenance activities on the plant or on the truckmixers.
For a system validation, all real slump tests values are cross-checked with collected data.

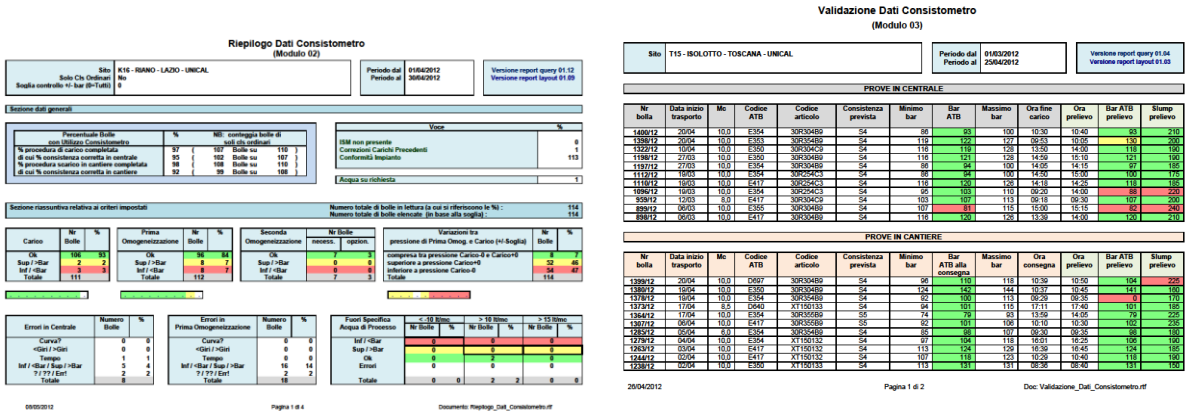

Figure 6 Reports

5. Mix Design

The possibility of gathering slump information at the plant and after transportation, allows new possibilities in mix design, such as considering workability losses in hot weather or long driving distances. This, in addition to the need of parameters to relate concrete fresh properties to slump behavior has led to the development of a completely new mix design tool.
Mixes are specifically designed based on fresh state performances, in addition to strength.
A specific set of tests has been created to characterize mixes, working on components and performing lab tests that are more reliable and less time consuming than field tests.

6. Organization

To master the new possibilities of process control, a new company function has been created: the operations manager; in every geographical area he has the direct responsibility for the slump control system and coordinates the activity of technical plant maintenance, mix design and laboratory control and batching systems control. Last but not least he takes care of all the training needs for plant managers, operators and drivers.
To support our customers in taking maximum benefit of the full control of slump, a field technical support team has been created: while visiting jobsites they suggest best pouring practices, the choice of the correct slump and additional fresh concrete performances. Meanwhile they also control drivers behavior and concrete quality preparing specimens if required by the customer.

7. Customers

More than 40 meetings with customers were organized to explain the whole project, discussing customer's needs and explaining all the possibilities offered by slump control extended at jobsite. Customers were given the possibility to enquire on additional performances of fresh concrete, such as longer lasting consistency or specific pouring conditions. The main advantages in having the right consistency were highlighted: reduced

handwork in pouring and increased quality avoiding water additions and achieving the best compaction.
The symbol of the project was introduced too: a seal on drums' water pipe. Every truck is equipped with, it has become a symbol of concrete that must not be modified to fit pouring requirements.

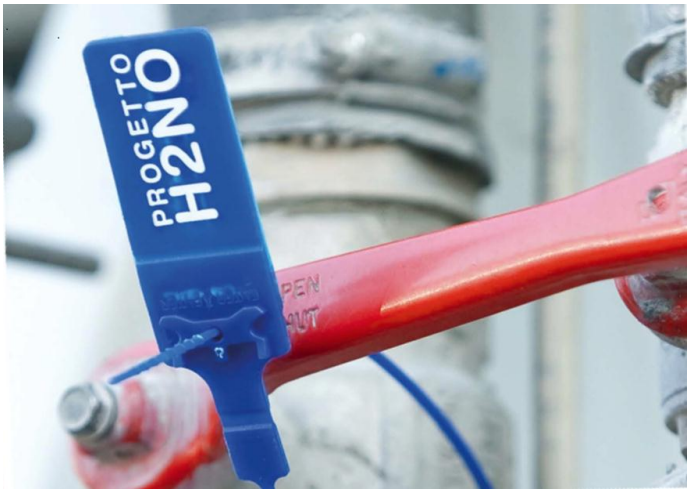

Figure 6 Seal

To underline the importance of the delivery and acceptance phase, for every jobsite customer's deputies are required to accept the product delivery and sign the delivery ticket; their name is printed on every ticket.
In case of requirements of extra water, only if subscribed by the customer's deputy and breaking the seal, a letter is then sent to customer's address as a remainder of the occurrence.
Relationship with customer become more transparent, working together and sharing more in information for best results.

8. Results

We gained an increased knowledge over the whole production process, leading to several improvements in plant facilities, in batching software, in mix design and improving our knowledge in components behavior (specially admixtures). Particularly in producing high performance concretes (high strength or SCC) we gained higher confidence and reduced variations in results.
Unwanted water additions were dramatically reduced close to zero; field assistance for specimens has increased, as a sign of customer's awareness about concrete control.
Disputes about concrete quality have significantly reduced too, as a sign that unsuitable pouring conditions are avoided and overall best results are reached with benefits for the supplier and the customer.
An increase in consistency has been recorded in the past years, leading to higher value products.
Customers are recognizing our company more and more as a leader and as reliable and transparent partner.