
TECHNICAL UNIVERSITY
SOFIA


medis

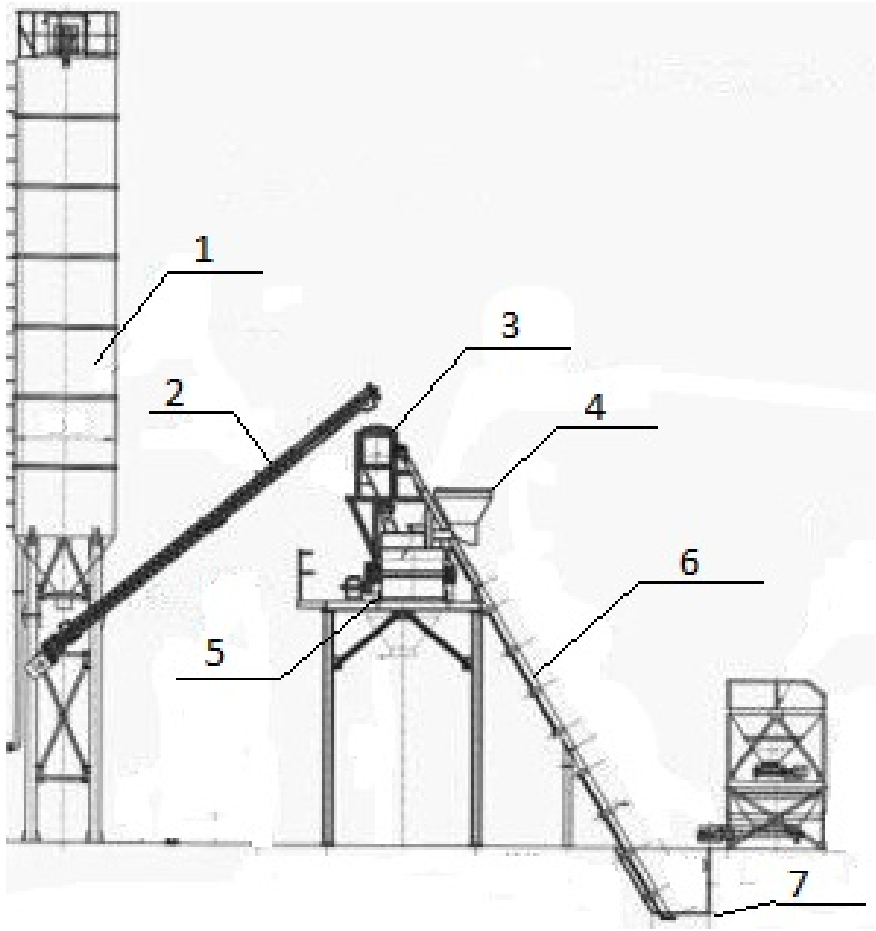
# Exercise - Concrete plant model and controller

- **Concrete plant model** – shows the students how to emulate a complex discrete and batching system.
- Workflow breakdown – five exercises
  - Exercise one – Design of the simulator behavior. Students helped by the tutor should identify all simulator subsystems, specify inputs and outputs and the simulator behavior.
  - Exercise 2 and 3 - Development and test of the different simulator subsystems.
  - Exercise 4 – Controller development – ready-for-use controller will be proposed for quick start-up
  - Exercise 5 – Integration of all the subsystems and test of the controller/simulator behavior.

# Exercise structure

- Simplified concrete plant simulator.
- Simulation of scale behavior for dosing gravel and sand using scale producing analog value. The scale is implemented as a MODBUS-connected weight sensor.
- Simulation of multiple scales behavior for dosing cement and water. The cement scale produces analog value and the water scale is implemented as a MODBUS weight sensor.
- Simulation of cart transporting the inert materials from the scale to the mixer
- Simulation of the mixer operation – adding the materials in correct order, mix time, emptying.

# Concrete plant schema




- 1. Cement silo
- 2. Cement auger
- 3. Cement and water scales
- 4. Skip cart
- 5. Mixer
- 6. Skip cart railway
- 7. Inert materials scale

# Concrete simulator signals

| Digital inputs | Digital outputs | Analog signals |
|---|---|---|
| Dose sand | Cement empty valve opened/closed | Inert materials scale value (MODBUS) |
| Dose gravel | Water empty valve opened/closed | Cement scale value (DAC) |
| Dose cement | Mixer opened/closed | Water scale value (MODBUS) |
| Dose water | Skip cart down | |
| Cement empty valve | Skip cart ready | |
| Water empty valve | Skip cart up | |
| Mixer open/close | Emergency stop button | |
| Skip cart up | Loose skip cart rope | |
| Skip cart down | | |

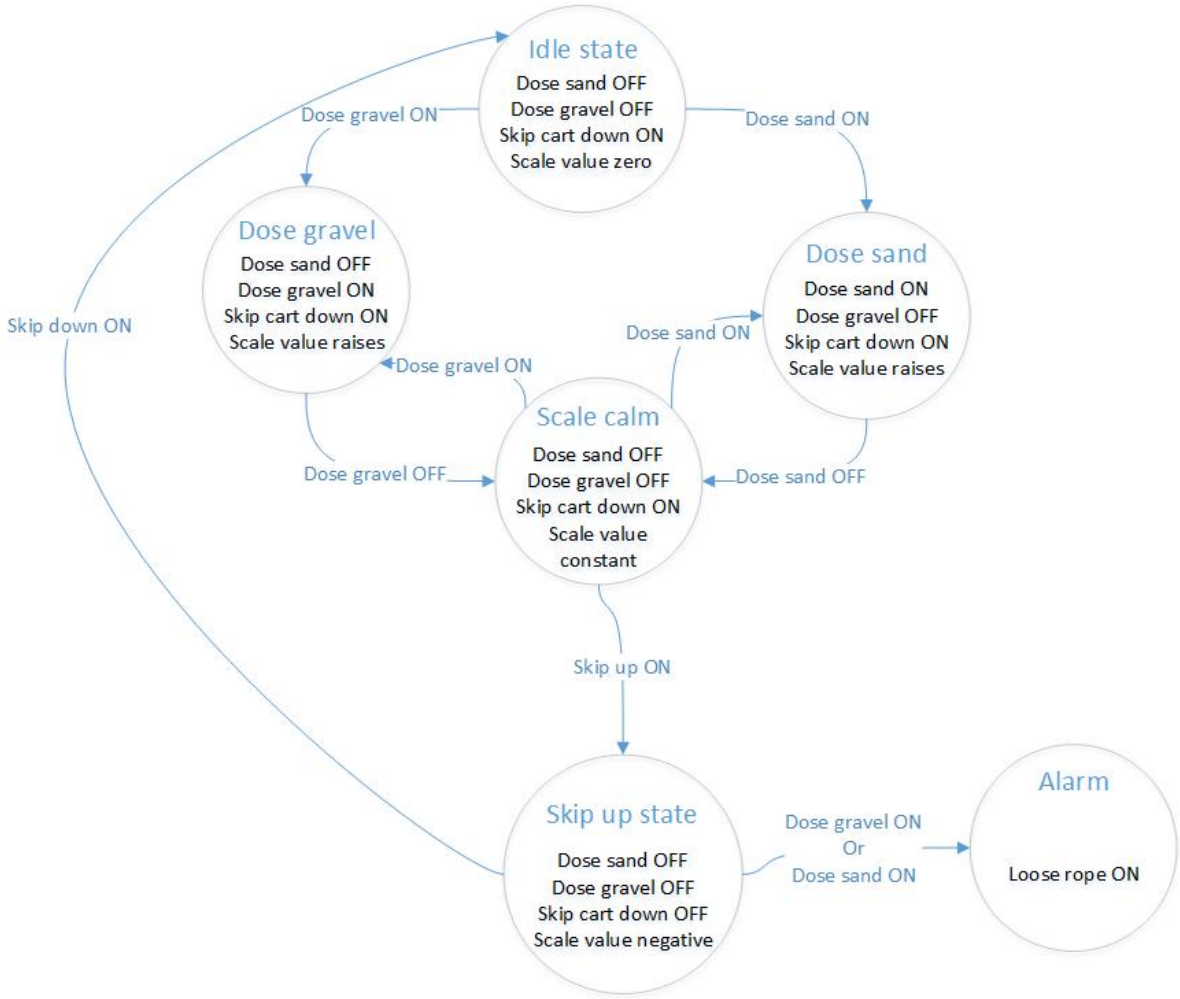
# Concrete controller signals

| Buttons | LEDSs | Analog signals |
|---|---|---|
| Button dose sand | Inert scale ready | Trimmer sand moisture for recipe corrections (this signal is not implemented in this simulation) |
| Button dose gravel | Cement scale ready | |
| Button dose cement | Water scale ready | |
| Button dose water | Skip cart is down | |
| Button cement empty | Skip cart is ready | |
| Button skip cart up | Skip cart is up | |
| Button skip cart down | Mixer is closed | |
| Button mixer open/close | Automatic mode | |
| Switch manual/auto mode | | |
| Switch water empty | | |

# Inert materials scale

- Inert materials scale needs the skip cart to be in down position in order to dose materials in it. If the skip cart is not down the material will be spilled around the skip cart path, eventually causing it to derail when it goes down. In that case simulator will raise the Loose rope signal.
- While gravel dosing speed is more or less linear, sand dosing speed can vary. The speed can be different for wet or dry sand, also for fine dry and sand on chunks. Simulation can be done with linear sand dosing, or can be extended with different parameters to make the simulation closer to the real-world.
- Since the cart weight is not zero, its weight should be considered during simulator design. Scale should be tared to operate normally.
- Scale value is reset when the skip cart goes up, and next batching can be started once we receive skip down signal.

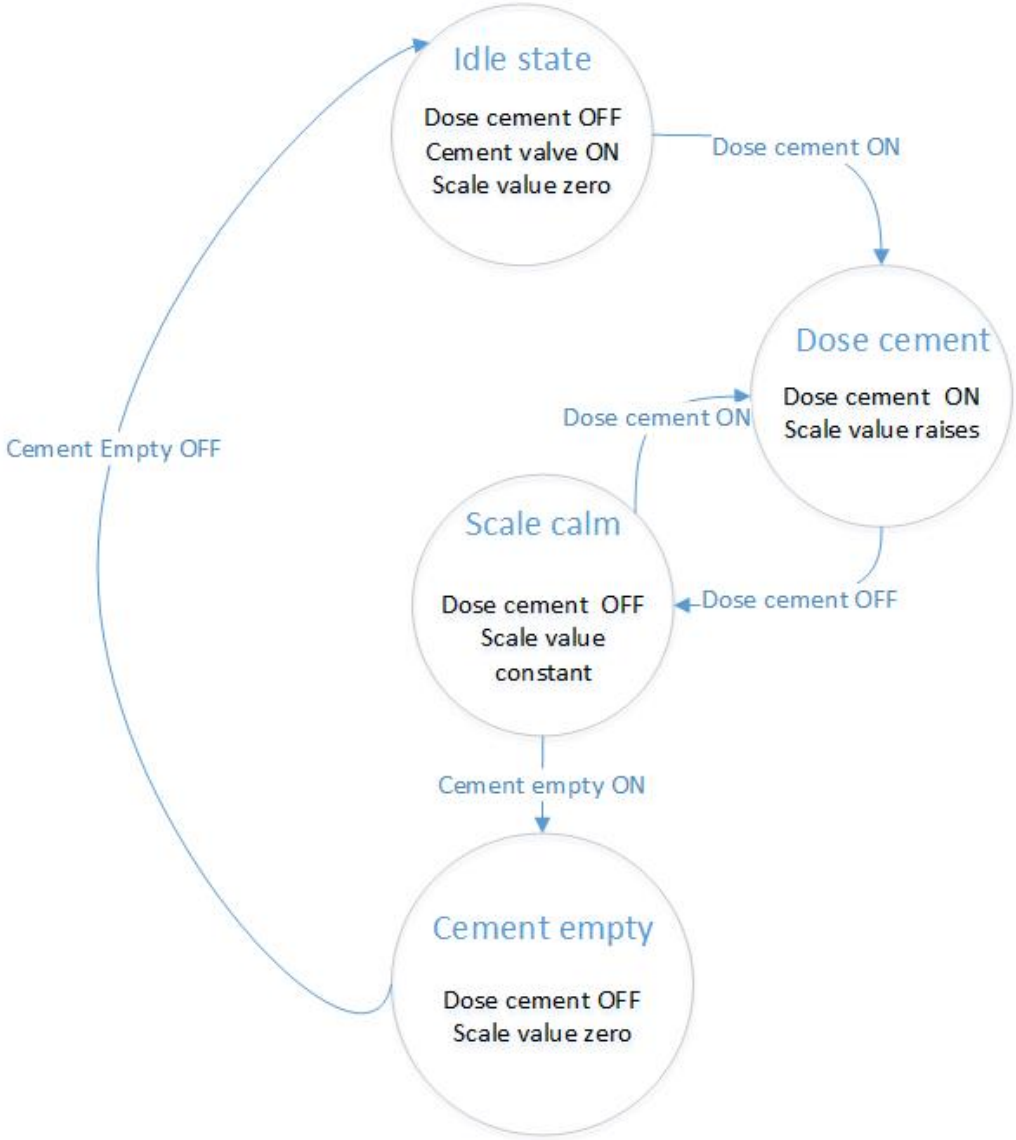
# Inert material scale state machine



# Cement and water scales

- Cement and water sales will be simulated as intelligent tensometric indicators with MODBUS communication. The simulator will simulate them separately in parallel, responding to queries both for Modbus slave 1 and 2.
- Dosing should proceed only when cement and water valves are closed. Otherwise the material will fall through the scale directly into mixer.
- Cement and water dosing speed is linear, but tails due to communication delay should be considered. Students should test different communication speeds, and different Modbus packet delays to see the effect of using smart sensors via bus, instead of analog inputs.

# Cement and water scales state machine



# Skip cart operation

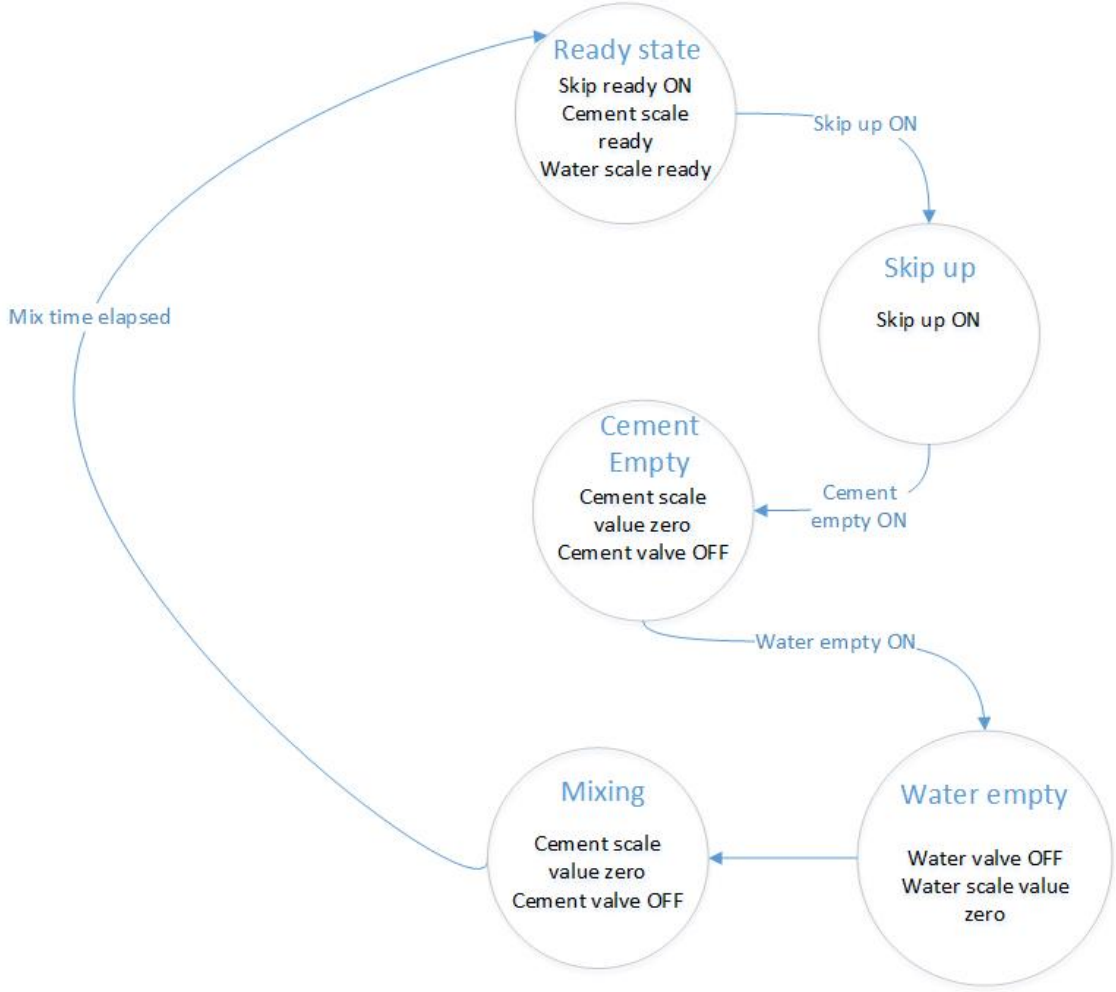
- Skip cart has three main positions
  - Skip down – when down skip cart can be loaded with materials
  - Skip ready – cart stops right before being emptied in the mixer in order to wait cement and water dosage to become ready.
  - Skip up – cart reaches the highest point of the railway and empties its contents into the mixer.
- Skip cart rope is monitored by additional tactile sensor (modelled in the simulator) to signal cart jam on the railway.

# Skip cart state machine

# Mixer operation

- Materials should be added in the mixer in specific order
  - Inert materials
  - Cement
  - Water
- Mixer emptying is implemented with toggle button behavior. Once pressed the mixer valve opens, second press of the button closes the mixer. When the mixer is closed there is a signal that the mixer valve is closed.

# Mixer operation state machine



# Mini-project

- Students will be asked to implement signals' flow as a value-controlled stream.
- Students will be asked to implement additional control line between the controller and the simulator to enable the step-by-step execution for the pair-controller-simulator
- Students will be asked to modify the upper-level state machines for both the controller and the simulator to implement step-by-step execution process

# The END