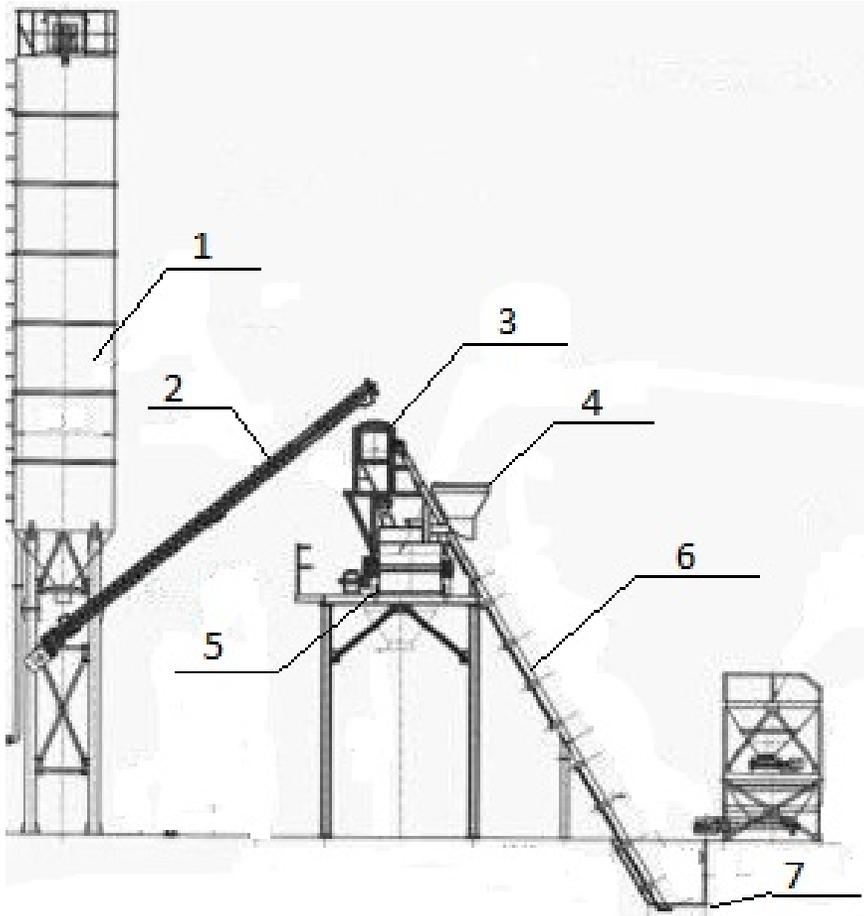




Exercise object - concrete plant - part 2

- ▶ 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

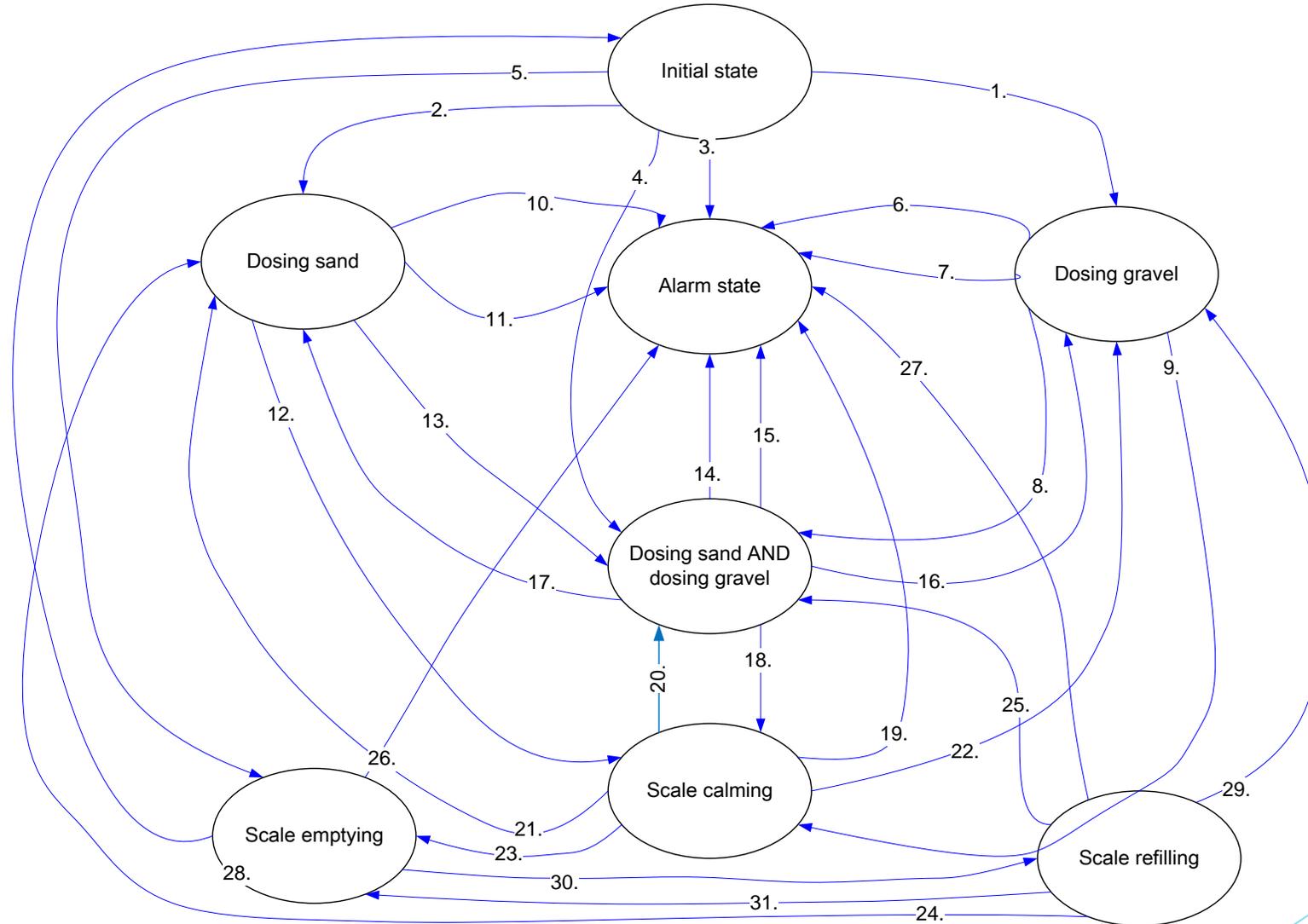


- ▶ 1. Cement silo
- ▶ 2. Cement auger
- ▶ 3. Cement and water scales
- ▶ 4. Skip cart
- ▶ 5. Mixer
- ▶ 6. Skip cart railway
- ▶ 7. Inert materials scale

Inert materials scale - detailed state machine

- ▶ 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 materials scale - detailed state machine

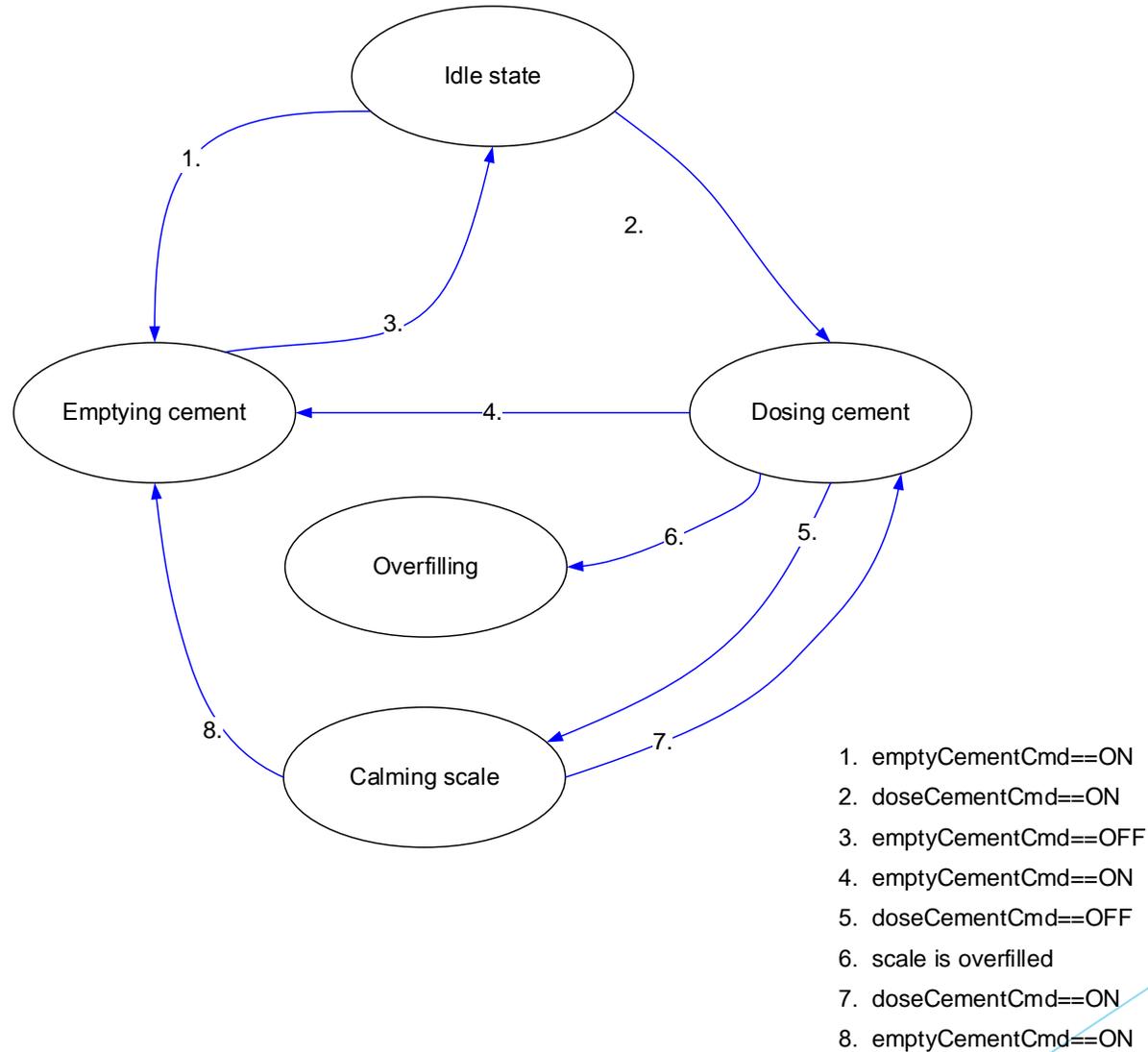


1. doseGravelCmd == ON: true
2. doseSandCmd == ON
3. cartIsDownFbk==OFF AND (doseSand OR doseGravel)
4. doseSandCmd==ON OR doseGravelCmd==ON
5. cartIsDownFbk == OFF
6. cartIsDown==OFF
7. Scale is overfilled
8. doseSandCmd==ON AND doseGravel==ON
9. doseGravelCmd==OFF
10. cartIsDown==OFF
11. Scale is overfilled
12. doseSandCmd==OFF
13. doseSandCmd==ON AND doseGravelCmd==ON
14. cartIsDown==OFF
15. Scale is overfilled
16. doseGravelCmd==ON AND doseSandCmd==OFF
17. doseGravelCmd==OFF AND doseSandCmd==ON
18. doseGravelCmd==OFF AND doseSandCmd==OFF
19. cartIsDownFbk==OFF AND (doseSand==ON OR doseGravel==ON)
20. doseSandCmd==ON AND doseGravel==ON
21. doseSandCmd==ON
22. doseGravelCmd==ON
23. cartIsDownFbk==OFF
24. doseSandCmd==ON
25. doseSandCmd==ON AND doseGravelCmd==ON
26. doseSandCmd==ON OR doseGravelCmd==ON
27. cartIsDownFbk==OFF AND (doseSandCmd==ON OR doseGravelCmd==ON)
28. cartIsDownFbk==ON AND cartIsEmpty==TRUE
29. doseGravelCmd==ON
30. cartIsDownFbk==ON AND cartIsEmpty==FALSE
31. cartIsDownFbk==OFF

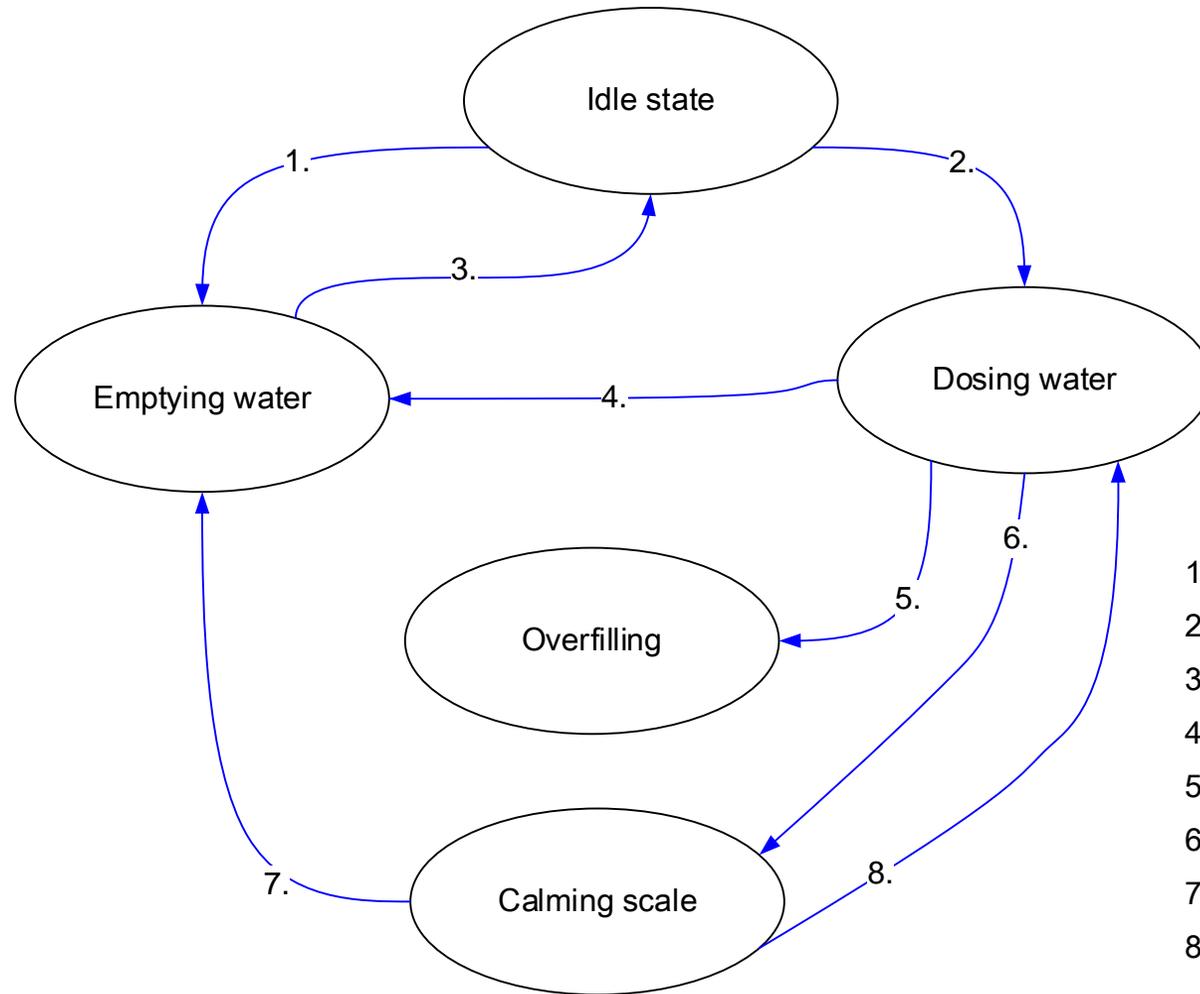
Cement and water scales - detailed representation

- ▶ 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 scale - detailed state machine



Water scales - detailed state machine

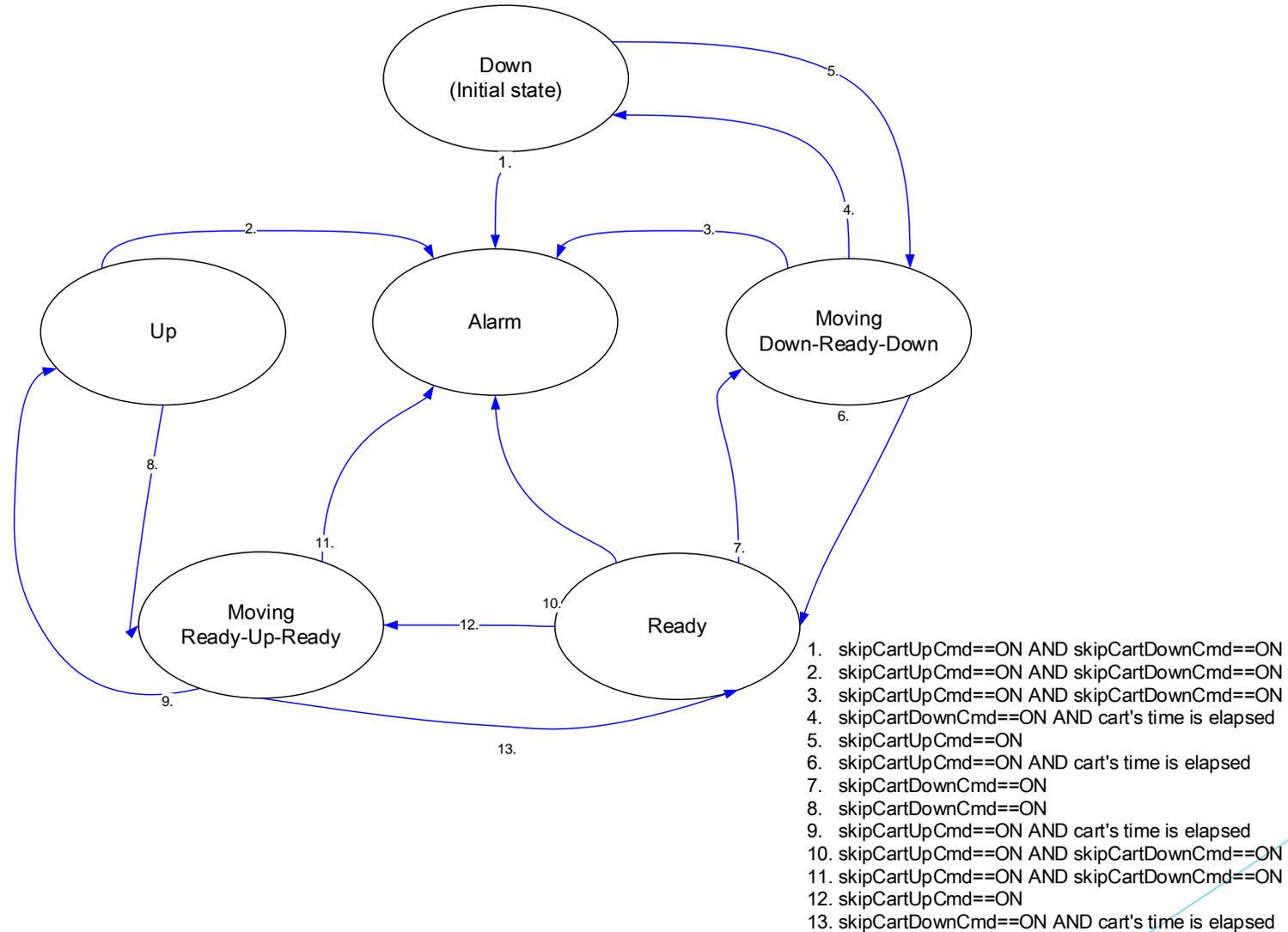


1. emptyWaterCmd==ON
2. doseWaterCmd==ON
3. emptyWaterCmd==OFF
4. emptyWaterCmd==ON
5. scale is overfilled
6. doseWaterCmd==OFF
7. emptyWaterCmd==ON
8. doseWaterCmd==ON

Cart operation - extended version

- ▶ 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.

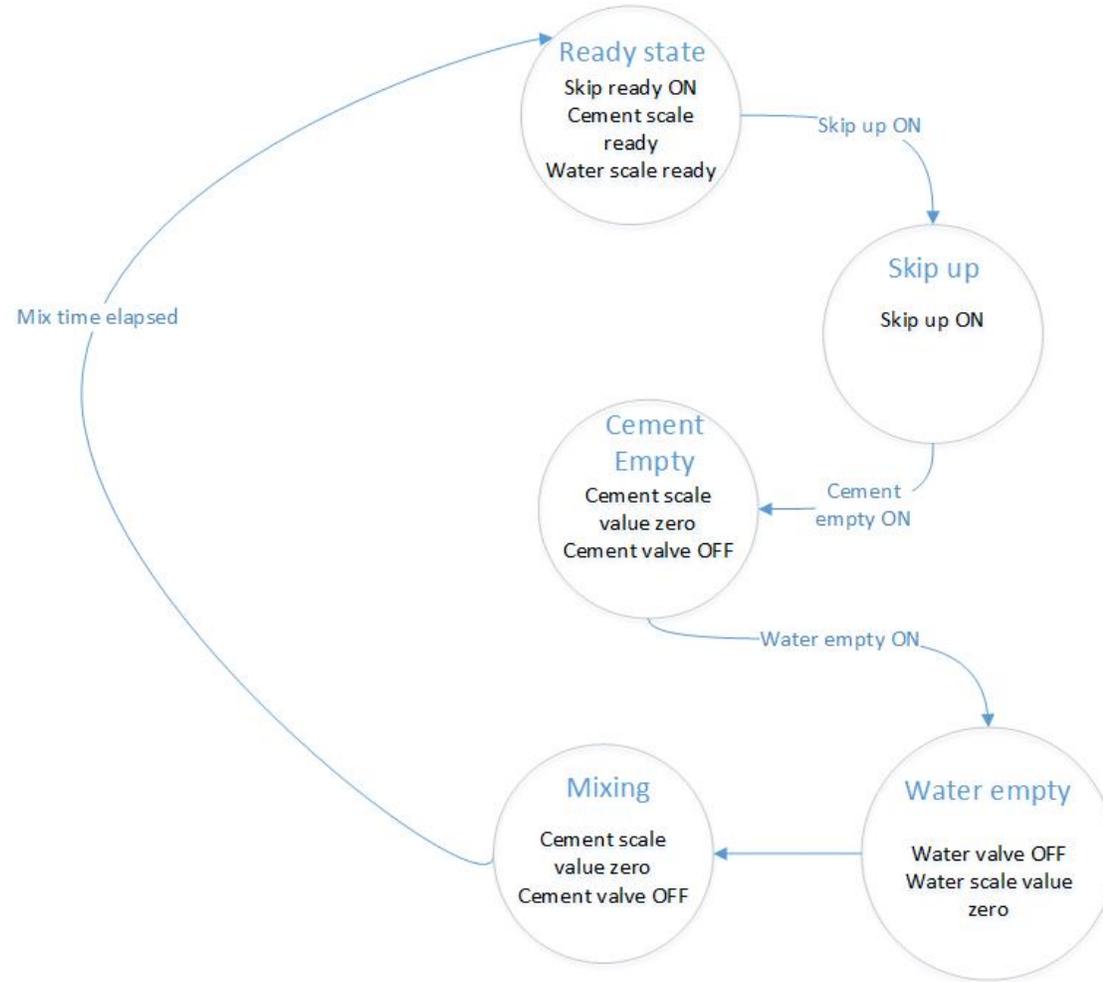
Cart operation - detailed state machine



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



The END