# A Sustainable Future for Inevitable Urban Construction

Data Dictionary

## General Discussion of ConcreteDirect

Concrete Direct is an application that offers a seamless and transparent way of collaboration across the delivery supply chain and increases crew utilization. ConcreteDirect has an underlying idea of simplifying the concrete ordering and delivering process. From order to pour using its one centralized platform, one can get to place, change and confirm orders as well as track delivery progress. This tool caters to the three most important elements of any concrete delivery chain - partners/customers, drivers and dispatchers.

## General Discussion of Converge

ConcreteDNA is a construction intelligence platform that allows contractors to build more efficiently, safely, and sustainably. The system is powered by a fully wireless and embeddable sensor that measures and transmits the temperature and compressive strength of the pour in real-time to the platform. Paired with an artificial intelligence feature that is able to predict the curing time of a given mix, contractors are able to plan ahead and strike concrete formwork that lies on the critical path precisely when it is safe to, rather than waiting on slow test cube lab reports. By determining the compressive strength of concrete in real-time, contractors can choose a concrete mix that is only as performant as they need, allowing them to significantly reduce the cement content and be more responsive with design mixes

## Detailed Data Description

### ConcreteDirect Data:

**Note:** *All files in ConcreteDirect Data link to each other by the “order_id” or the “payload_id” columns. There might be repeats of the same payload id throughout the files, do* *not discard them, it could be due to the different product items and mix descriptions. ConcreteDirect Data and Converge Data DO NOT have a direct link.*

## a) Payload Level > HackZurich_Truck_PlantLevel

This table has Truck specific information such as which driver is linked to a specific truck, which payloads are they connected to, which plant they picked up the delivery from and which plant they actually are assigned to as well as the capacity of the truck.

| Column Name | Description |
|---|---|
| payload_id | Unique identifier generated for each payload. |
| vehicle_id | Unique identifier generated for each vehicle. |
| driver_id | Unique identifier generated for each driver. |
| source_plant_id | Unique identifier generated for each truck from there they are supposed to pick up the delivery. |
| source_plant_longitude | Longitude of the source plant |
| source_plant_latitude | Latitude of the source plant |
| home_plant_site_id | Unique identifier generated for the plant where the trucks originated from. |
| home_plant_longitude | Longitude of the home plant |
| home_plant_latitude | Latitude of the home plant |
| max_load_size_cubic_meters | The largest quantity the truck is able to deliver. Units in Cubic Meters. |

## b) Payload Level > HackZurich_PourLogistics

Pour logistics has all data from when a ticket is created in the system.
The process is that one order has multiple tickets or payloads; one payload is one delivery of concrete; and each payload or ticket is created on the day of delivery and

assigned to a truck which then is batch at a plant. A batch is a mixing of the concrete in the truck once the material has been loaded. This table contains all the logistical timestamps and locations of pours. It tells the story of a lifecycle of one ticket, starting from when the ticket was created till when it was poured out into the site and back to the plant.

| Column name | Description |
|---|---|
| site_id | Unique identifier of the site |
| order_id | Unique identifier of the order that customer places on Concrete Direct. |
| payload_id | Unique identifier generated for each **payload**. |
| ticket_created_ts | Time stamp signifying when the ticket was created. (**GMT**)<br>Format: YYYY-MM-DD HH:MM:SS+ss |
| payload_status | Status of the payload: There are 2 different types of Status in this database:<br>**1. Recalled:** Loads that were sent back/canceled either from the jobsite or right after being loaded.<br>**2. Delivered:** Loads that were delivered. |
| status_updated_at | Time stamp signifying when the ticket/payload status was last updated. (**GMT**)<br>Format: YYYY-MM-DD HH:MM:SS+ss |
| pour_quantity | Quantity poured per ticket/payload in Yards |
| cumulative_quantity | Sum of quantity poured per ticket in one particular order in Yards. |
| eta | Estimated time of arrival for each truck. Collected from Google. (**GMT**)<br>Format: YYYY-MM-DD HH:MM:SS+ss |
| product_item_id | Unique identifier of the type of product that went into the batching mix. |
| product_quantity | Quantity of the type of product that went into the batching mix. |

| | |
|---|---|
| payload_event_batch_start_time | Start-time of loading concrete mixture onto trucks. (**GMT**[1])<br>Format: YYYY-MM-DD HH:MM:SS+ss |
| payload_event_batch_end_time | End-time of loading concrete mixture onto trucks. (**GMT**)<br>Format: YYYY-MM-DD HH:MM:SS+ss |
| payload_event_departure_time | Departure-time of loaded trucks from the plant. (**GMT**)<br>Format: YYYY-MM-DD HH:MM:SS+ss |
| payload_event_arrival_time | Arrival-time of loaded trucks on the job-site. (**GMT**)<br>Format: YYYY-MM-DD HH:MM:SS+ss |
| payload_event_pouring_start_time | Start-time of concrete pouring on the job-site. (**GMT**)<br>Format: YYYY-MM-DD HH:MM:SS+ss |
| payload_event_pouring_finish_time | End-time of concrete pouring on the job-site. (GMT)<br>Format: YYYY-MM-DD HH:MM:SS+ss |
| payload_event_wash_time | Start-time of truck wash after payload delivery (GMT)<br>Format: YYYY-MM-DD HH:MM:SS+ss |
| payload_event_to_plant_time | Timestamp of when truck left the jobsite(GMT)<br>Format: YYYY-MM-DD HH:MM:SS+ss |
| payload_event_at_plant_time | Timestamp of when the truck reached the plant (GMT)<br>Format: YYYY-MM-DD HH:MM:SS+ss |
| delivered_at | Local time zone of the jobsite |
| pouring_longitude | Latitude of the pour |
| pouring_latitude | Longitude of the pour |

### c) Payload Level > HackZurich_Batch_MixDesigns

This file contains all the mix designs. AKA the components of what the type of concrete was made of as well as their ratios. These data fields are at an order as well as a payload level, so the mixtures for each payload/ticket can be seen in the table.

[1] **GMT:** Greenwich Mean Time, this might need to be manipulated and changed to the local time zone using the **local_time_zone** column when using external data.

| Column Name | Description |
|---|---|
| order_id | Unique identifier of the order |
| payload_id | Unique identifier for each payload. |
| product_mix_id | Unique identifier for the type of product in the batching mix |
| prodct_mix_item_type | Description of the item type of product in the batching mix |
| product_mix_description | Description of the type of product in the batching mix |
| order_item_description | Detailed description or the order item (first numeric value is the PSI of the mix) |
| material | Actual components that make the specific mix. Ex: Cement, Fly ash, aggregates, water… |
| design_qty | Quantity designed to be in mix per unit of Concrete |
| design_qty_uom | UOM of design qty |
| required_qty | design quantity x load quantity |
| required_qty_uom | UOM of required qty |
| batched_qty | Actual amount of the material batched |
| batched_qty_uom | UOM of batched qty |
| water | Amount of water in the load |
| water_uom | UOM of water |
| moisture | Variation percentage between required and batched |

## d) HackZurich_OrderLevel

This file has all Order level details. This table is populated before the order date and when the order was placed on the app. This table gives an understanding of what the plan was for that particular day and order. Data points like spacing_minutes, and description gives an indication of what was the wishlist for that order for that particular day.

| Column Name | Description |
|---|---|
| order_id | Unique identifier generated for each order that customer places on Concrete Direct. |
| product_item_id | Unique identifier for the type of product in the batching mix |
| start_time | Scheduled order start time |
| order_created_ts | Order creation timestamp |
| last_modified_ts | Order last modified timestamp |
| spacing_minutes | Specified truck arrival intervals, requested by the customers |
| rate_type | Specifying if the *spacing_mins* is supposed to be in intervals of minutes or in intervals of quantity. |
| order_item_id | Unique identifier generated for each order item |
| psi/description | Description of the *order_item_id* |
| pour_element | Description of the structure being built (ex: floor, column) |
| extended_pour_element | Detailed description of the structure being built |

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|---|---|
| pour_element_information | Comments on the structure being built |
| pour_method | Description of the method used to make the pour on site. (ex: bucket and crane, pump) |
| local_time_zone | Time Zone of the order/ticket/jobsite |
| location_latitude | Pin drop latitude of the jobsite |
| location_longitude | Pin drop longitude of the jobsite |

# Converge data:

## Background & context

The key data available from the Converge platform is 'maturity data'. This data provides insights on the temperature and strength development within specific concrete pours. A technique known as the maturity method allows the compressive strength of concrete to be calculated as a function of its temperature. Concrete strength development occurs as a result of a chemical reaction known as hydration. The warmer the concrete, the faster the rate of reaction and strength gain. Conversely, at cooler temperatures the rate of reaction and strength gain will be slower.

Typically concrete strength is determined by casting samples (either cube or cylinder samples) which are stored in standard conditions (in a water bath at a fixed temperature - often 20°C or 23°C depending on the country) and crushed after 7 & 28 days. Since the hydration reaction is exothermic, it is common for actual pours of the same concrete to reach much higher temperatures, and this allows contractors to take actions such as formwork removal sooner. Furthermore, strength calculations are performed every 20 minutes, so the information is available sooner than with traditional test methods.

Where concrete is being used in time-critical applications, the contractor will sometimes specifically request a mix which gains strength faster. This reduces the risk of delays when relying on the concrete to hit certain key strength milestones. Typically, formwork can be removed at strengths of 10-25MPa. To satisfy such requests, the concrete supplier may have to increase the cement content of the mix, or use a cement type which has higher initial strength gain. In both cases, this 'overspecification' of the mix will typically result in a concrete with a higher embodied carbon overall. Portland cement, the key ingredient driving strength gain in concrete, has a high embodied carbon (often >700 kg $CO_2$ per tonne) in relation to other ingredients. Reducing cement contents enables a reduction in the embodied carbon for the concrete. Since maturity monitoring provides a potential for contractors to take action sooner, it might be possible to use mixes with lower cement contents and lower embodied carbon.

Mix designs have also been provided, along with estimates of the embodied carbon for each mix. 5 different mixes were selected with a range of embodied carbon values. Each mix belongs to a different construction site (jobsite). The sites can be identified from their IDs, given below:

- site_189
- site_190
- site_232
- site_246
- site_247

Each sensor is generally given a name referencing where it has been placed in the structure. This information is entered by the contractor at point of use, and they will typically follow a naming convention depending on the use case. Some information has been provided below to help understand the naming conventions used:

- Site 189
    - For this project, each sensor has been cast into a slab pour during the construction of a large office black. Floor numbers (or level numbers) are included at the start of each sensor name as with the prefix “L” or “MGY-Level”. Each floor (or level) consists of up to 6 individual slab pours. Again, the pour number is included in the sensor name.
    - The key strength requirement for this project was 25MPa.
- Site 190
    - Two towers were constructed on this project (Tower 1 and Tower 2). Each sensor has been cast into a slab pour (or in some cases a beam pour). The tower number is included at the start of each sensor name with the prefix “T1”, “T2”, or “Tower-1”, “Tower-2”. Floor numbers are included at the start of each sensor name as with the prefix “L” or “Level”. Each floor (or level) consists of up to 2 individual slab pours. Again, the pour number is included in the sensor name.
    - The key strength requirement for this project was 25MPa.
- Site 232
    - For this project (a university research campus), each sensor has been cast into a core. These are a set of walls at the centre of the building, containing lift shafts or staircases. In total, 4 cores were constructed between the atrium (on level 0) and level 10. The core number and the level are contained within the sensor name.
    - The key strength requirement for this project was 40MPa.
- Site 246

    - This project is a large commercial shopping centre. Each sensor has been cast into a slab pour. The contractor has named each sensor with the prefix “SLA” followed by a two-letter location code (eg. “-AS”) followed by the floor number (eg. “-00”) and finally the pour number (eg. “-04”). There are up to 15 pours on each floor.
    - The key strength requirement for this project was 25MPa.
- Site 247
    - For this project, a series of 3 tall towers, sensors have been cast into slab pours. The towers were designated “A1”, “A3” and “A4” which is the prefix of each sensor name. Construction went up to floor 30 and pours were situated on the North and South sides of each tower. This information should be clear from the sensor name.
    - The key strength requirement for this project was 20MPa.

Each site is based in Europe, and units are given in metric.
Some common conversions are provided below:

- 1 $kg/m^3$ = 1.68555 $lb/yd^3$
- 1 litre = 33.814 fluid oz
- °F = (°C × 9/5) + 32

### a. <site_id>/<site_id>_mix_design.csv

This file contains information relating to the concrete mix composition. Each row represents a material, and contains information regarding that material and the quantity (mass per cubic metre) contained within each batch.

| **Column Name** | **Description** |
|---|---|
| `material_description` | String containing a description for this material. |
| `quantity` | Number representing the mass of material batched in every cubic metre. |
| `units_of_measure` | String containing the units of measure, associated to the quantity column. Values are either “kg/m3” or “l/m3” |
| `manufacturer` | String containing the name of the supplier for that material. |
| `source` | String containing the geographical source of |

| | |
|---|---|
| | the material. |
| `material_type` | String containing the type of material (eg. \`Aggregate\`, \`Binder (cement)\`, \`Binder (slag\`), \`Water\`) |

### b. <site_id>/<site_id>_schedule.csv

This file contains information regarding the pour time associated with each sensor. This is the time at which the sensor was cast into a concrete element.

**NOTE**: There may be multiple sensors cast into a single pour, in which case their times may differ by a few hours.

| **Column Name** | **Description** |
|---|---|
| `device_id` | Unique identifier for each sensor. |
| `pour_time` | Timestamp for when the sensor was cast into the concrete.<br>Format: YYYY-MM-DD HH:MM:SS+ss <timezone> |

### c. <site_id>/<site_id>_data/<pour_name>_<device_id>.csv

This folder contains CSV files representing each sensor used on a site. Each sensor has a unique device_id (numeric or alphanumeric) contained at the end of the filename, as well as the name of the pour it has been cast into. Each pour may contain 1 or more sensors.

Within these files, each row represents a single data point, and contains the temperature and strength of the concrete along with a timestamp. The strength at any given time is calculated based on the temperature measured by the sensor, using a technique known as the maturity method.

Sensors will be positioned prior to the pour commencing. In some cases, temperature data is recorded for some time before the concrete is poured. Each file may contain some rows at the beginning before the strength calculation begins. The strength calculations (shown in the column \`strength\`) will begin for a given sensor after the \`pour_time\`. The pour time can be found for each sensor in the site's \`schedule\` file. This can be used to calculate the elapsed time for each datapoint (by taking the difference between the pour time and the timestamp at any given row).

Data collection will typically stop after the mix reaches the key strengths required by the contractor (in the case of slabs or core walls this generally means the strength at which they can remove the formwork, supporting the hardening concrete). As such, the amount of data collected for each sensor varies.

| **Column Name** | **Description** |
|---|---|
| `time` | Timestamp for the data point.<br>Format: YYYY-MM-DD HH:MM:SS+ss <timezone> |
| ~~`timezone`~~ | ~~Timezone~~<br>~~Format: GMT+HH~~<br>Please ignore this field. The correct timezone is found in the time column. |
| `temperature` | Number representing the temperature of the concrete at that time<br>Units: °C |
| `strength` | Number representing the strength of the concrete at that time<br>Units: MPa |

## Bonus Data:

## Hack Swiss Data(LAB)_AGR:

This file has some sample data from the Quality data collected from a RMX lab in Switzerland. The process of collecting this data starts when a truck is batched. A little sample from that batch is collected and brought to the lab to understand the quality of the material.

### a) Production Data

| **Column Name** | **Description** |
|---|---|
| `Delivery Note Number` | one identical delivery note number equals to a truck load of concrete with its individual raw materials |
| `Mix Design` | Commercial description can contain several mix designs, e.g. mix design for summer vs. Winter, mix design with admix supplier A vs. supplier B, etc. |

| | |
|---|---|
| Material No. | raw materials of the concrete, cement (Z/), water (W/), fine and coarse aggregates (K/), as well as chemical admixtures (C/) |
| Material Descr. | material description of material number |
| Target Value | target quantity of material to be put into batch, in kg |
| Target Value (m3) | target quantity of material to be put into batch, per m3 of concrete |
| Actual Value | actual quantity of material batched, in kg |
| Actual Value (m3) | actual quantity of material batched, per m3 |
| Variance (ABS) | difference between actual and target quantity batched, in kg |
| Variance (%) | relative difference between actual and target quantity, in % |

## b) Concrete Technical

| Column Name | Description |
|---|---|
| Delivery Note Number | one identical delivery note number equals to a truck load of concrete with its individual raw materials |
| Mix Design | Commercial description can contain several mix designs, e.g. mix design for summer vs. Winter, mix design with admix supplier A vs. supplier B, etc. |
| Classification 1 | Reference to the respective concrete norm |

| | |
|---|---|
| Compr. Strength | strength class acc SN EN 206. Example C30/37: C=concrete, 30=minimum compressive strength at 5% fractile for cylinder specimens, 37=maximum compressive strength at 5% fractile for cubic specimens |
| Dmax | maximum size of aggregates in the concrete |
| Exposure Class | exposure of concrete against the environment, e.g. exposure against carbonation, chloride ingress, freeze-thaw attack. In this case (XC4, XF1) the concrete is suitable for exterior horizontal walls without attack of deicing salts |
| Customer | Customer ID |
| Plant | Plant ID |
| Delivery Date | Date where concrete was delivered to job site |
| Delivery Time | Time when concrete has arrived at job site (hh:mm:ss) |
| Air Temperature | measured air temperature during concrete testing (at RMX plant) - Units: °C |
| Concrete Temperature | measured fresh concrete temperature during concrete testing (at RMX plant) - Units: °C |
| Compressive Strength 28d (N/mm2) | compressive strength at 28 days of cubic specimens, cubic samples taken at rmx plant. |
| w/c-Value (m3) | water to cement ratio (=main factor which is driving compressive strength) |

Holcim

MAQER