C4 FRESH CONCRETE

1. Slump Test

The slump test is a common method used to evaluate the consistency and workability of fresh concrete. It measures the vertical displacement or "slump" of the concrete when a standard cone-shaped mould is filled with concrete, compacted, and then lifted vertically. The difference in height between the concrete before and after the mould is removed indicates the workability of the concrete. A higher slump value signifies better workability, while a lower value suggests poor workability. The slump test is widely used for its simplicity and ability to provide quick feedback on concrete consistency, making it a standard procedure on construction sites. This test particularly applies to conventional concrete mixes with medium to high workability.

The result is rounded to the nearest 10 mm. The consistency class is determined according to Table 1.

Table 1: Consistency classification based on slump test.

Degree	Slump according to EN 12350-2 [mm]
S1	10 to 40
S2	50 to 90
S3	100 to 150
S4	160 to 210
S5	≥ 220

2. Flow table test

The flow table test is a method used to assess the consistency and flowability of fresh concrete, particularly for highly workable or self-compacting concrete. In this test, fresh concrete is placed in a cone mould on a flat, smooth table, which is then lifted and jolted several times to allow the concrete to spread. The diameters of the spread concrete are measured, and the average is taken as the flow value. The test provides insight into the ability of concrete to flow under its weight, making it useful for evaluating concrete mixes designed to be placed without vibration. The flow table test is particularly suitable for concrete with high workability.

The formula gives the calculation of the flow value f:

$$f = \frac{d_1 + d_2}{2} \tag{1}$$

Where:

- d_1 is the maximum diameter of the spread concrete, measured parallel to one side of the table in mm;
- d_2 is the maximum diameter of the spread concrete, measured parallel to the other side of the table in mm.

The result is rounded to the nearest 10 mm. Based on the calculated flow value, the consistency class is determined according to Table 2.

Table 2: Consistency classification based on flow.

Degree	Flow according to EN 12350-5 [mm]
F1	≤ 340
F2	350 to 410
F3	420 to 480
F4	490 to 550
F5	560 to 620
F6	≥ 630

3. Density of fresh concrete

Density *D* of fresh concrete:

$$D = \frac{m_2 - m_1}{V} \quad (2)$$

Where:

- *D* is the density of fresh concrete in kg/m³,
- m_1 is the mass of the empty container in kg,
- m_2 is the mass of the container filled with compacted concrete in kg,
- *V* is the volume of the container in m³.

The density of fresh concrete is rounded to the nearest 10 kg/m³.

4. Measurement of concrete shrinkage

Concrete shrinkage is a volume change caused by chemical and physical processes during concrete maturing without mechanical loading. It changes the absolute volume of the solid phase and the external dimensions of test specimens or structural elements. Several types of shrinkage are distinguished, with their significance varying based on the maturing phase. Two standards are used in the Czech Republic: ČSN 73 1320 (1987) and EN 12390-16 (2024), focusing on free shrinkage due to drying. The test measures relative length deformations of prisms, with results plotted over time along with temperature and humidity changes. Mass loss due to drying is also tracked. The data helps determine concrete volume changes for structural design and evaluation. Three test prisms (40 × 40 × 160 mm) will be prepared for shrinkage measurement in the exercise.

The protocol records the date and time of mixing the dry concrete components with water. The concrete sample must be thoroughly mixed before casting the test specimens. The inner surface of the moulds is coated with a release agent, and measuring pins are placed in the prepared holes without shifting during filling. The moulds are filled in two layers, each compacted on a vibrating table or with a tamper. After levelling, the surface is covered with polyethene foil to prevent water evaporation. The specimens are de-moulded 24 hours after mixing, and the position of the contacts is checked. Initial measurements of mass and length are recorded, with repeated length measurements taken at 1-day, 7-day, and subsequent 7-day intervals. The specimens are stored on perforated racks in a laboratory with varying temperature and humidity, with these conditions recorded during each measurement.

The length changes recorded on the calibration rod are calculated using the following equation:

$$\Delta l_e(t_i) = \frac{(l_{e1}(t_i) + l_{e2}(t_i) - l_{e1}(t_0) - l_{e2}(t_0))}{2} \quad (3)$$

Where:

- $\Delta l_e(t_i)$ is the average length change of the calibration rod at time $t_i = 1,7,14,\ldots$ days in mm;
- $l_{e1}(t_0)$ is the initial reading on the measuring device at the time t_0 before the series measurement in mm;
- $l_{e2}(t_0)$ is the initial reading on the measuring device at the time t_0 after completing the series measurement in mm;
- $l_{e1}(t_i)$ is the reading on the measuring device at the time $t_i = 1,7,14,\ldots$ days before starting the series measurement in mm;
- $l_{e2}(t_i)$ is the reading on the measuring device at the time $t_i = 1,7,14,\ldots$days after completing the series measurement in mm.

The following equation determines the shrinkage development of individual test specimens:

$$\varepsilon(t_i) = \frac{\Delta l(t_i)}{z} = \frac{l(t_i) - l(t_0) - \Delta l_e(t_i)}{z} \quad (4)$$

Where:

- $\varepsilon(t_i)$ is the shrinkage of the test specimen at the time $t_i = 1,7,14,\ldots$ days in mm/m;
- $\Delta l(t_i)$ is the length change of the test specimen at the time $t_i = 1,7,14,\ldots$ days in mm;
- $l(t_0)$ is the initial reading on the measuring device at time t_0 in mm;
- $l(t_i)$ is the reading on the measuring device at the time $t_i = 1,7,14,\ldots$ days in mm;
- $\Delta l_e(t_i)$ is the average length change of the calibration rod at the time $t_i = 1,7,14,\ldots$ days in mm;
- z is the length of the measuring base, which in this case equals the length of the test specimen L in meters.

The following equation determines the mass loss development of individual test specimens:

$$\Delta m(t_i) = \frac{m(t_0) - m(t_i)}{m_0} \times 100 \quad (5)$$

Where:

- $\Delta m(t_i)$ is the mass loss at the time $t_i = 1,7,14,\ldots$ days in %;
- $m(t_0)$ is the mass of the test specimen at the time t_0 in grams;
- $m(t_i)$ is the mass of the test specimen at the time $t_i = 1,7,14,\ldots$ in grams;
- m_0 is the initial mass of the test specimen after removal from the mould in grams. For the purposes of the exercise, it is assumed that $m(t_0) = m_0$ (though this may not always be the case)

The shrinkage and mass loss over time are calculated separately for each test specimen. The final shrinkage and mass loss of the concrete over time are then determined as the arithmetic mean of the measurements taken for the individual test specimens. The measurement results are a graphical output showing the dependence of shrinkage and mass loss development over time, along with the evolution of the surrounding environment's temperature and relative humidity (RH) over time.

REPORT **FRESH CONCRETE**	**C4**
Instructor:	

Date and time of mixing dry components with water:

Concrete identification:

Maximum aggregate grain size:

Water consumption data:

Ambient temperature and humidity on the day of production:

WORKABILITY AND DENSITY

Measurement record

<table>
<tr><td>Test Type</td><td colspan="3">Measured Value</td><td>Consistency Classification according to EN 206+A2</td></tr>
<tr><td rowspan="2">Slump test
[EN 12350-2]</td><td colspan="3">h</td><td rowspan="2"></td></tr>
<tr><td colspan="3"></td></tr>
<tr><td rowspan="2">Flow table test [EN 12350-5]</td><td>d_1</td><td>d_2</td><td>f</td><td rowspan="2"></td></tr>
<tr><td></td><td></td><td></td></tr>
</table>

Measurement record

Test Type	Empty container mass	Container volume	Mass of the filled container	Density of fresh concrete
Density [EN 12350-6]				

PRODUCTION OF TEST SPECIMENS

Production record

Specimen Shape	Nominal Dimensions	Number of Specimens	Test Type

DETERMINATION OF CONCRETE SHRINKAGE DEVELOPMENT

Measurement record

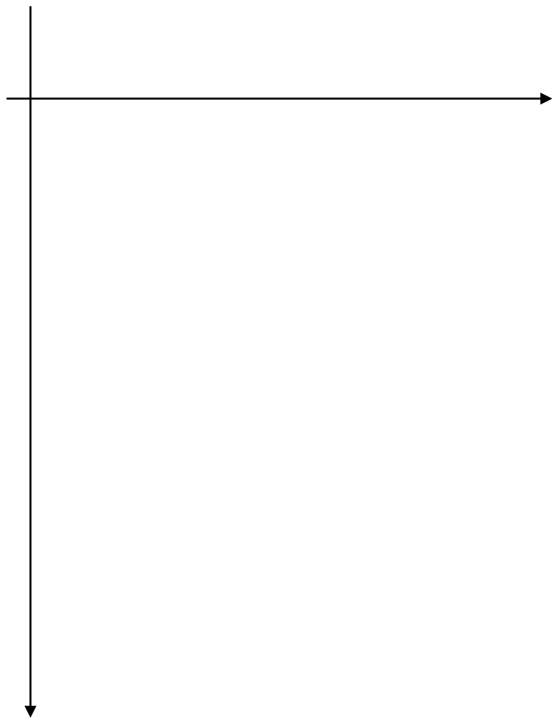
Measurement Number	Date and Time	T [°C]	RH [%]	$l_1(t_i)$ [mm]	$l_2(t_i)$ [mm]	$l_3(t_i)$ [mm]	Standard [mm]		$m_1(t_i)$ [g]	$m_2(t_i)$ [g]	$m_3(t_i)$ [g]
							$l_{e1}(t_i)$	$l_{e2}(t_i)$			

Measurement record

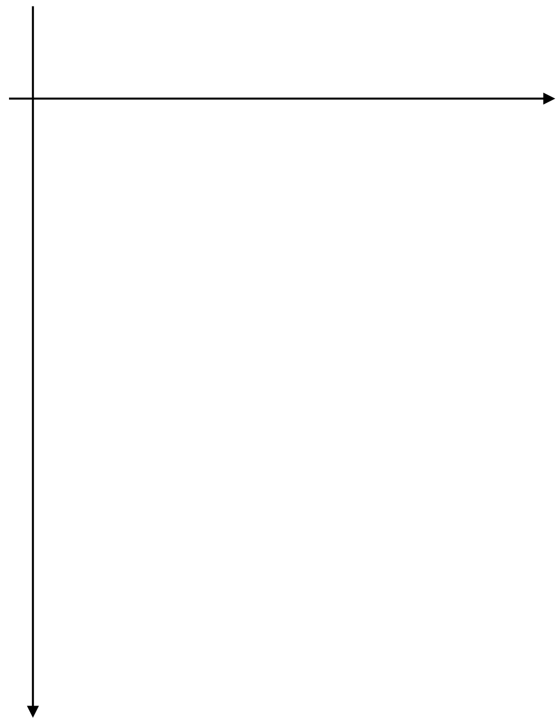
Age [days]	T [°C]	RH [%]	ε_1 [mm/m]	ε_2 [mm/m]	ε_3 [mm/m]	ε [mm/m]	Δm_1 [%]	Δm_2 [%]	Δm_3 [%]	Δm [%]

Graphical representations of the measurement results can be manually entered into the prepared images on the next page, or graphs prepared in an appropriate program (e.g., MS Excel, Python script, ...) can be pasted into the report.

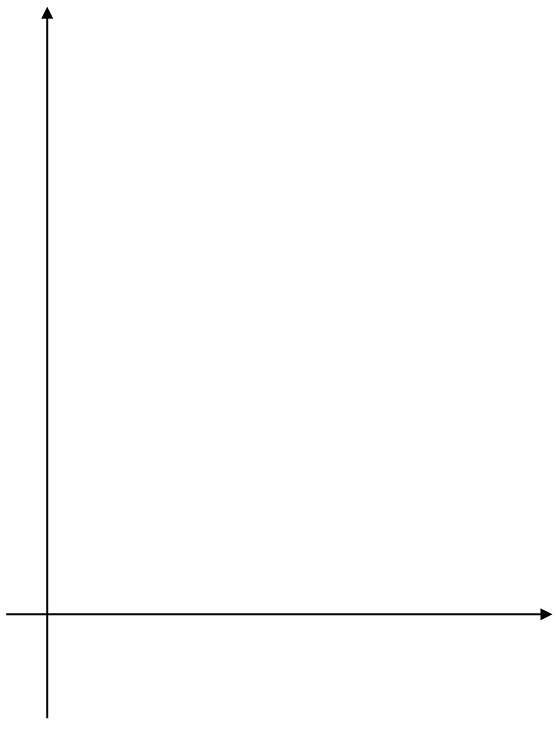
Graph 1: Shrinkage development over time



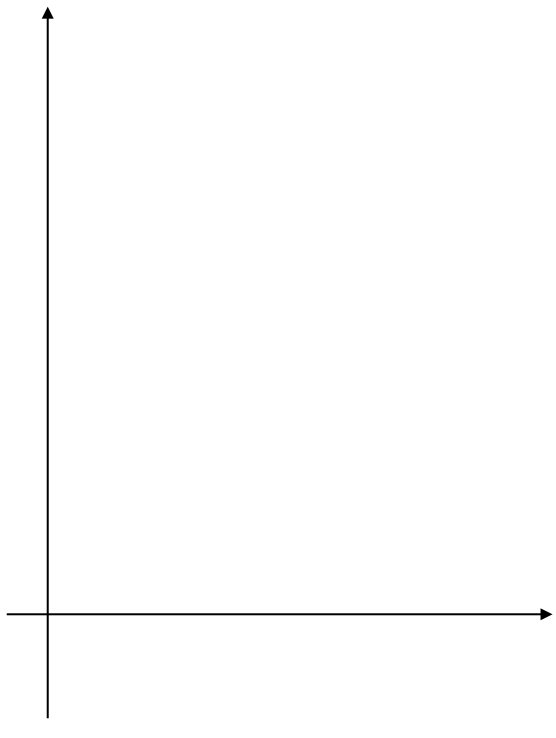
Graph 2: Mass loss development over time



Graph 3: Ambient temperature development over time



Graph 4: Relative air humidity development over time



Tests conducted and report prepared by: ______________________________