

Methodical Recommendations

for virtual laboratory experiments on the study
of the self-compacting concrete properties

1. TESTING OF SELF-COMPACTING CONCRETE MIX FOR SPREADING WITH THE ABRAMS CONE (SLUMP-FLOW TEST)

Purpose: evaluation of the fluidity and spreading rate of self-compacting concrete according to EN 12350-1, «Testing of Concrete Mix Part 1: Sampling». The cone spreading diameter and the concrete spreading time are measured until a diameter of 500 mm is reached.

Equipment: Abrams stainless steel cone; base plate (see Fig. 1) with a smooth surface measuring 1000x1000 mm with a marking of 500 mm – circle and center (for positioning the cone). Plate thickness not less than 2 mm. The surface of the plate should be flat, non-absorbent, resistant to concrete and not rust. The design of the plate should not allow distortion during operation. Deviation from flatness should not exceed 3 mm at any point, if a calibration line is installed in the center of the opposite sides.

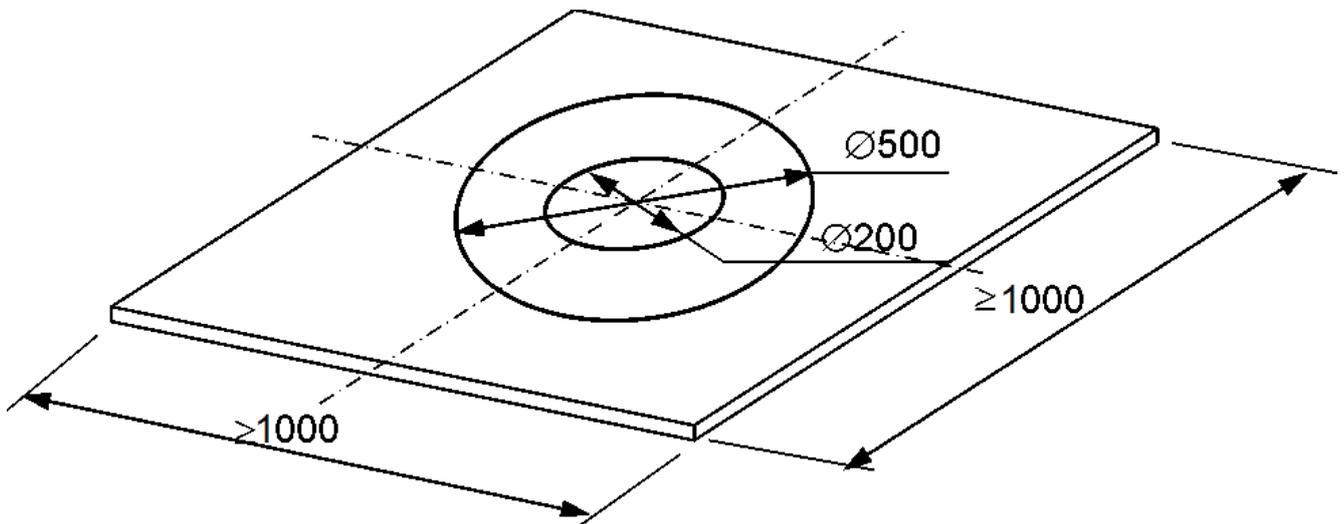


Figure 1. Base Plate with Marking

Operating procedure: the cone is filled with freshly prepared concrete mixture without compaction. Not later than 90 seconds after filling, the cone rises. The stopwatch starts immediately. As the mixture reaches a diameter of 500 mm, time is fixed. After completion of spreading, the spreading diameter of the concrete mixture in diametrically opposite directions is determined. The average value is an indicator of the spread of the cone.

Processing results: the result is an indicator of workability of self-compacting concrete in terms of the diameter of the cone spread. Time t_{500} is a measure of the spreading rate and viscosity (see table).

Table 1. Concrete Mixture Classes

Spreadability Class	Diameter, mm
SF1	550-650
SF2	660-750
SF3	760-850
Viscosity Class	Time, t_{500} , s
VS1	< 2
VS2	≥ 2

Instructions for Working with the Program



1. By left-clicking on the icon No.1, the composition of the concrete mixture is selected. In the virtual laboratory work, 6 experimentally tested compositions of self-compacting concrete are proposed, which differ in the dosages of the raw materials.



2. Left-clicking on the icon No.2, the laboratory installation will be assembled - the Abrams cone and the loading funnel, after which the concrete mixture will be poured into the cone.



3. By clicking the left mouse button on the icon No.3, the cone rises and the concrete mix spreads over the base plate. In this mode, the three-dimensional view of laboratory work can be rotated and scaled. Rotation is done by pressing the left button and moving the mouse, if the mouse pointer is not on the dimension lines. Scaling a three-dimensional view is done by rotating the mouse wheel.

To measure the spread of concrete mix, move the mouse pointer over the dimension lines and move the pointer while holding the left mouse button in the direction of the measurement axis. Measurements are made in two perpendicular directions. The measurement accuracy is 1 mm.



4. The experiment parameters are reset by left-clicking on the icon No.4, after which the experiment can be repeated. The initial dosages of the concrete components, as well as the measurement results, are entered by the user in a special laboratory journal, the recommended form of which is attached to this laboratory course.



5. Left-clicking on the icon in the upper right corner of the screen will close the program.

2. TESTING OF SELF-COMPACTING CONCRETE MIX IN A V-SHAPED FUNNEL (V-FUNNEL TEST)

Purpose: determination of flow rate and viscosity of self-compacting concrete. The time the concrete flows out of the V-shaped funnel is measured.

Equipment: A V-shaped funnel on stainless steel legs with an opening valve (see Fig. 2) and a nozzle to facilitate filling the funnel with concrete.

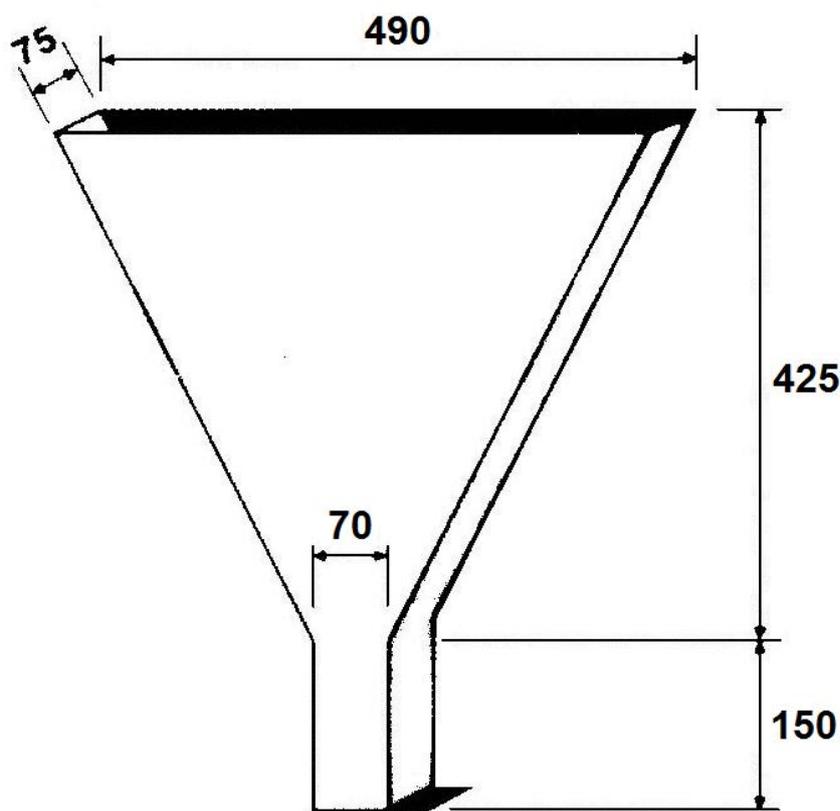


Figure 2. V-Shaped Funnel Design for Testing Self-Compacting Concrete for Viscosity

Operating procedure: using a nozzle, the funnel is filled with concrete in an amount of 12 liters. Simultaneously with the opening of the valve, a stopwatch is activated, with which the time of passage of concrete through the funnel is fixed.

Processing results: the result of the test is the time of expiration of the concrete mixture from the funnel, corresponding to the concrete grading class (see table).

Table 2. Concrete Mixture Classes

Viscosity Class	Time, s
VF1	< 9
VF2	9...25

Instructions for Working with the Program



1. By left-clicking on the icon No.1, the composition of the concrete mixture is selected. In the virtual laboratory work, 6 experimentally tested compositions of self-compacting concrete are proposed, which differ in the dosages of the raw materials.



2. Left-clicking on the icon No. 2, the auxiliary loading funnel will be installed, after which the concrete mixture will be poured into the V-shaped funnel.



3. By clicking the left mouse button on the icon No. 3, the shutter of the V-shaped funnel opens, time is measured and the concrete mix expires from the funnel. In this mode, the three-dimensional view of the laboratory work can be rotated and scaled. Rotation is done by pressing the left button and moving the mouse. Changing the scale of the three-dimensional view is done by rotating the mouse wheel. The dimensions of the laboratory setup are displayed on the screen.



4. The experiment parameters are reset by left-clicking on the icon No.4, after which the experiment can be repeated. The initial dosages of the concrete components, as well as the measurement results, are entered by the user in a special laboratory journal, the recommended form of which is attached to this laboratory course.



5. Left-clicking on the icon in the upper right corner of the screen will close the program.

3. TESTING OF SELF-COMPACTING CONCRETE MIX IN L-SHAPED BOX (L-BOX TEST)

Purpose: evaluation of the formability of self-compacting concrete by determining the spreadability and ability to overcome obstacles from rods with a concrete mix.

Formability characterizes the behavior of the concrete mixture during the passage of bottlenecks, for example, between reinforcement bars without delamination and agglomeration of coarse aggregate. There are two types of tests: with 2 rods and with 3 rods. The 3-bar test simulates denser reinforcement.

Equipment: L-образный ящик с длиной основания 800 мм, в котором для имитации арматуры установлены стержни (см. рис. 3). В конструкции ящика имеются задвижка и воронка для его заполнения.

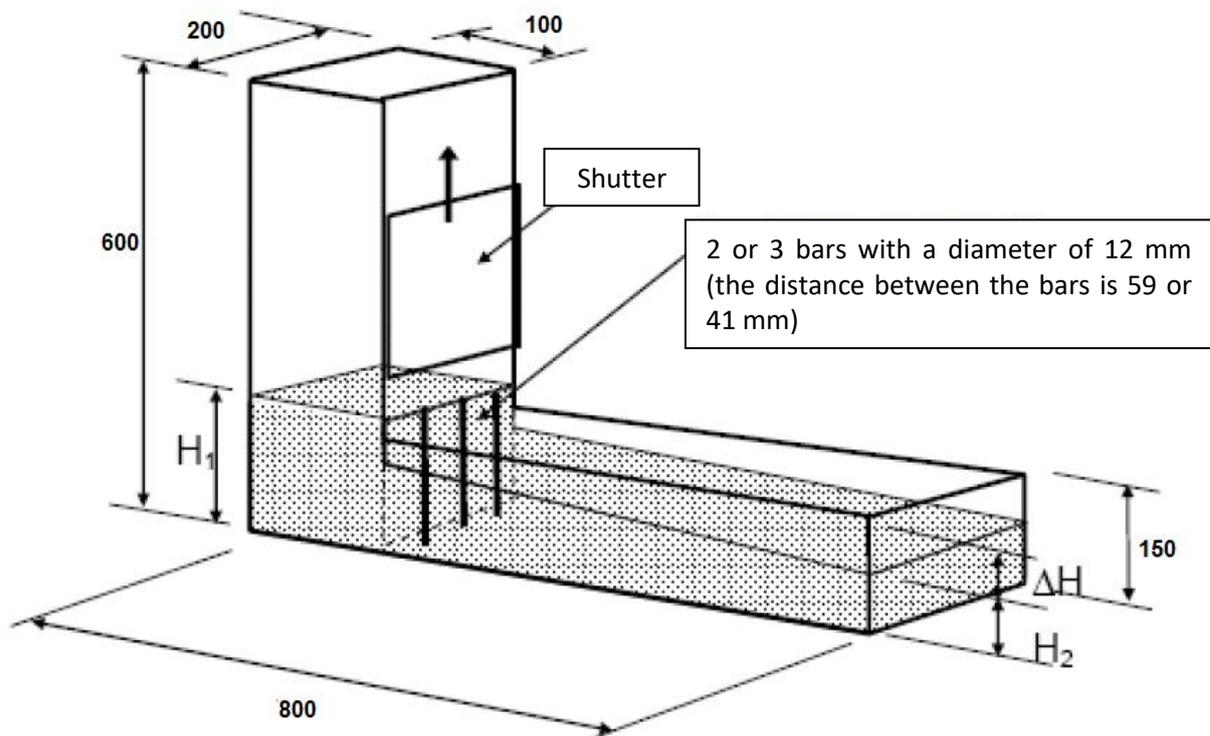


Figure 3. L-Shaped Box Design for Testing Self-Compacting Concrete for Formability

Operating procedure: with the help of a funnel, the vertical part of the box is completely filled with concrete. Not earlier than 60 seconds, the shutter rises, and concrete passes through a series of vertical rods imitating reinforcement and spreads along the horizontal part of the box. After the spreading process is completed, concrete levels are measured at the fill point (H_1) and at the point of reaching the end position (H_2). Additionally, the time to reach concrete from the 200 and 400 mm mark in the horizontal part of the box can be measured, which allows us to talk about the filling ability of self-compacting concrete.

Processing results: the result of the work are the measured surface marks of the concrete mixture H_1 and H_2 . The consistency class of the concrete mix is determined by the ratio H_2/H_1 (see table 3). The ratio of heights H_2/H_1 must be at least 0.8.

Table 3. Concrete Mixture Classes

Class	Passability
PL1 ¹⁾	≥ 0.8 for 2 reinforcing bars
PL2 ²⁾	≥ 0.8 for 3 reinforcing bars

¹⁾ for the reinforcement pitch in the structure 80...100 mm

²⁾ for the reinforcement pitch in the structure 60...80 mm

Instructions for Working with the Program



1. By left-clicking on the icon No. 1, the composition of the concrete mixture is selected. In the virtual laboratory work, 6 experimentally tested compositions of self-compacting concrete are proposed, which differ in the dosages of the raw materials.



2. Left-clicking on icon No. 2, the auxiliary loading funnel will be installed, after which the concrete mixture will be poured into an L-shaped box.



3. By left-clicking on the icon No. 3, the shutter opens, the horizontal part of the box is filled with concrete mix. In this mode, the three-dimensional view of the laboratory work can be rotated and scaled. Rotation is done by pressing the left button and moving the mouse. Scaling a three-dimensional view is done by rotating the mouse wheel. The dimensions of the laboratory setup are displayed on the screen.

To measure the surface marks of the concrete mixture, hover over the red markers on the upper ends of the vertical and horizontal parts of the L-shaped box. The measurement accuracy is 1 mm.



4. The experiment parameters are reset by left-clicking on the icon No.4, after which the experiment can be repeated. The initial dosages of the concrete components, as well as the measurement results, are entered by the user in a special laboratory journal, the recommended form of which is attached to this laboratory course.



5. Left-clicking on the icon in the upper right corner of the screen will close the program.

4. TESTING OF A SELF-COMPACTING CONCRETE MIX IN A J-RING (J-RING TEST)

Purpose: determination of the passability of self-compacting concrete through the locking ring, as well as changes in the diameter of the spreading cone. The heights of the concrete mix H_0 inside the ring and at 4 points outside H_1 are measured, as well as the diameter of the spreading cone.

Equipment: locking ring (Fig. 4) with a diameter of 300 mm with fixed smooth metal rods with a diameter of 18 mm, Abrams cone made of stainless steel; base plate with a smooth surface with dimensions of 1000x1000 mm with a marking of 500 mm - circle and center (for positioning the cone). Plate thickness not less than 2 mm. The surface of the plate should be flat, non-absorbent, resistant to concrete and not rust. The design of the plate should not allow distortion during operation. Deviation from flatness should not exceed 3 mm at any point, if a straightedge is installed in the center of the opposite sides.

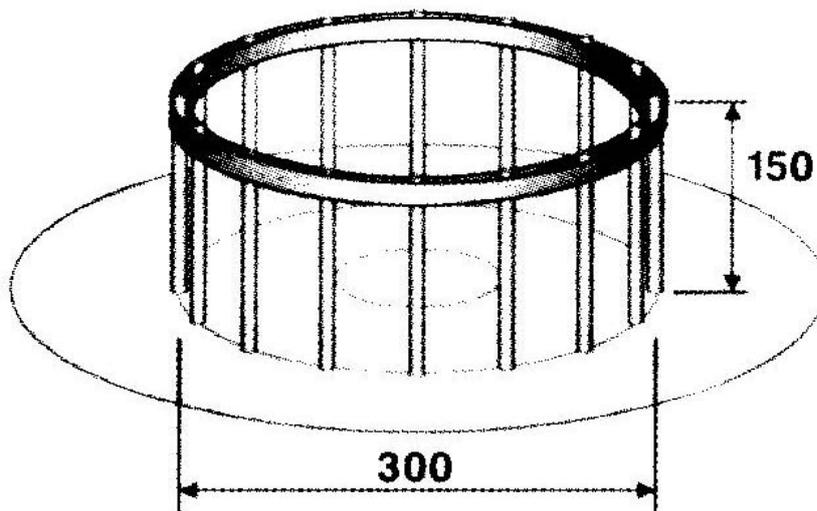


Figure 4. J-Ring Design for Self-Compacting Concrete Penetration Test

Operating procedure: the cone is filled with freshly prepared concrete mixture without compaction. Not later than 90 seconds after filling, the cone rises. After completion of spreading, the spreading diameter of the concrete mixture in diametrically opposite directions is determined. The average value is an indicator of the spread of the cone. The measured cone spreading diameter is compared with the spreading diameter without a locking ring (see Lab. Work. No. 1). Measured: the height of the concrete mixture in the center inside the ring (H_0), as well as the height at 4 points outside (H_1).

Processing results: the result of the work are the values of the heights of the concrete mixture H_0 and H_1 . The consistency class of the concrete mix is defined as the difference $H_0 - H_1$ (see table 4).

Table 4. Concrete Mixture Classes

Class	Passability, mm
PJ1	≤ 10 for 12 bars
PJ2	≤ 10 for 16 bars

* The decrease in spreading of the concrete mixture is also measured, which should be ≤ 100 mm.

Instructions for Working with the Program



1. By left-clicking on the icon No.1, the composition of the concrete mixture is selected. In the virtual laboratory work, 6 experimentally tested compositions of self-compacting concrete are proposed, which differ in the dosages of the raw materials.



2. Left-clicking on icon No.2, the laboratory installation will be assembled - an inverted cone, a loading funnel and a locking ring with 12 rods, after which the concrete mixture will be poured into the cone.



3. By clicking the left mouse button on the icon No. 3, the concrete mixture spreads through the blocking ring on the base plate. In this mode, the three-dimensional view of the laboratory work can be rotated and scaled. Rotation is done by pressing the left button and moving the mouse. Scaling a three-dimensional view is done by rotating the mouse wheel.

To measure the surface marks of the concrete mix, hover over the red markers. To measure the spread of concrete mix, move the mouse pointer over the dimension lines and move the pointer while holding the left mouse button in the direction of the measurement axis. Measurements are made in two perpendicular directions. The measurement accuracy is 1 mm.



4. The experiment parameters are reset by left-clicking on the icon No.4, after which the experiment can be repeated. The initial dosages of the concrete components, as well as the measurement results, are entered by the user in a special laboratory journal, the recommended form of which is attached to this laboratory course.



5. Left-clicking on the icon in the upper right corner of the screen will close the program.

5. TESTING OF SAMPLES OF SELF-COMPACTING CONCRETE FOR COMPRESSIVE STRENGTH (COMPRESSIVE STRENGTH TEST)

Purpose: determination of the class of self-compacting concrete by compressive strength. The failure load is measured.

Equipment: hydraulic press.

Operating procedure: samples are subjected to visual inspection (defective samples are not subject to testing), weighed, determine the average density. The test sample is mounted on the bottom plate of the hydraulic press so that the direction of the breaking force is parallel to the concrete mixture layers when it is being compacted. The increase in load on the sample should be gradual. The rate of rise of the load should be within (0.6 ± 0.4) MPa per second.

Processing results: the strength of concrete in MPa (kgf/cm^2) is calculated by the formula: $R = \alpha(P/F)$, where P is the breaking force, N (kgf); F is the cross-sectional area of the sample, mm^2 (cm^2); α is the scale factor. In virtual laboratory work, test cubes $10 \times 10 \times 10$ cm in size are tested (scale factor $\alpha = 0.95$).

Instructions for Working with the Program



1. By left-clicking on the icon No. 1, the composition of self-compacting concrete is selected. In the virtual laboratory work, 6 experimentally tested compositions of self-compacting concrete are proposed, which differ in the dosages of the raw materials. After choosing the composition of concrete, the user is invited to choose the age of the samples for testing - 3, 7 and 28 days



2. Left-clicking on the icon No. 2, the sample-cube $10 \times 10 \times 10$ cm will be installed on the bottom plate of the hydraulic press.



3. By clicking the left mouse button on the icon No. 3, the loading of the sample is switched on until complete destruction. In this case, the value of compressive force in kN is recorded, which is displayed on the electronic press board. The three-dimensional view of laboratory work can be rotated and scaled. Rotation is done by pressing the left button and moving the mouse. Scaling a three-dimensional view is done by rotating the mouse wheel.



4. The experiment parameters are reset by left-clicking on the icon No.4, after which the experiment can be repeated. The initial dosages of the concrete components, as well as the measurement results, are entered by the user in a special laboratory journal, the recommended form of which is attached to this laboratory course.



5. Left-clicking on the icon in the upper right corner of the screen will close the program.