8.2 J-ring test

The J-ring test was used to assess a strong index for the evaluation of passing ability of SCC mixture; it is possible to be used in conjunction with the slump flow test, these combined tests examined the flowing ability and the passing ability of the concrete through gaps in the obstacles, e.g. reinforcement.

- For this test, the slump test apparatus is used with an open steel rectangular section ring with 16 steel rods (ϕ16 mm) and 100 mm height.
- The gap between the bars is 42 mm.
- Wider gaps can be used when fibers are introduced to the mix which should be 1-3 times the maximum length of fibers used, See Fig. (5).

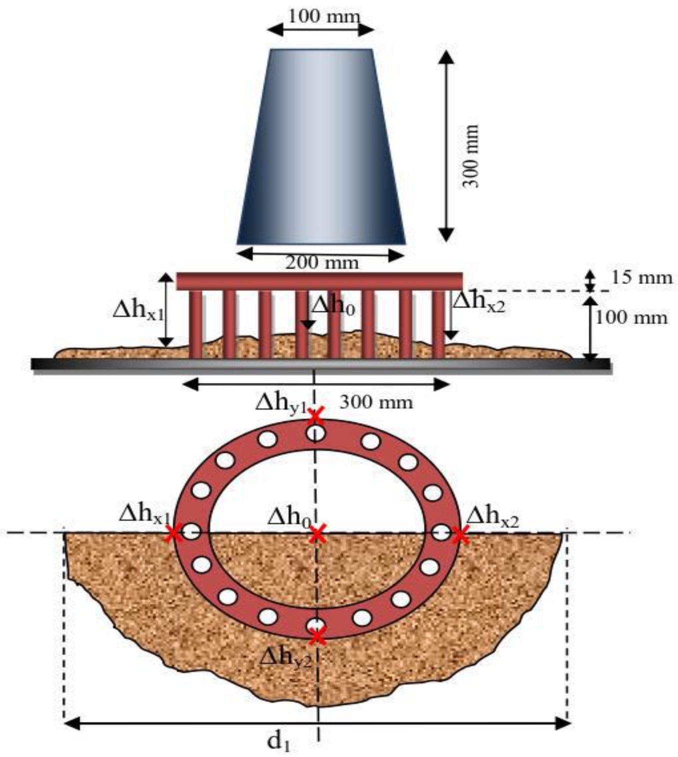

Fig. (5): J-Ring test instruments and procedure.

The procedures of this test are:-

- ✓ Measuring the difference in height between the concrete just inside the bars and just outside the bars
- ✓ Calculating the average of the difference in height at four locations in (mm), see Fig. (5).This test complies with **ASTM C1621**.

$$P_J = \frac{\Delta h_{x1} + \Delta h_{x2} + \Delta h_{y1} + \Delta h_{y2}}{4} - \Delta h_0$$

PJ **:** Blocking step

Δh0: is the height measurement at the center of flow.

Δhx1, Δhx2, Δhy1, Δhy2 are the four measurement heights at positions just outside the J-ring.

The blocking step PJ should be less than 10 mm

8.3 L-box test

The L-box test is used to assess the filling and passing ability of SCC, or in other words the ability of concrete to pass though reinforced bars without blocking or segregation.

• After filling the vertical section of the L-box with one minute left to rest, the gate is lifted to allow SCC to flow into the horizontal section, passing through the reinforcement bars.
• When the concrete has stopped, the height of concrete at the vertical and at the horizontal section (H1, H2), respectively is measured by using measuring tape
• The blocking ratio (H2/H1) represents the filling ability which is acceptable when it ranges from **(0.8 - 1.0)**, as shown in Fig. (6).

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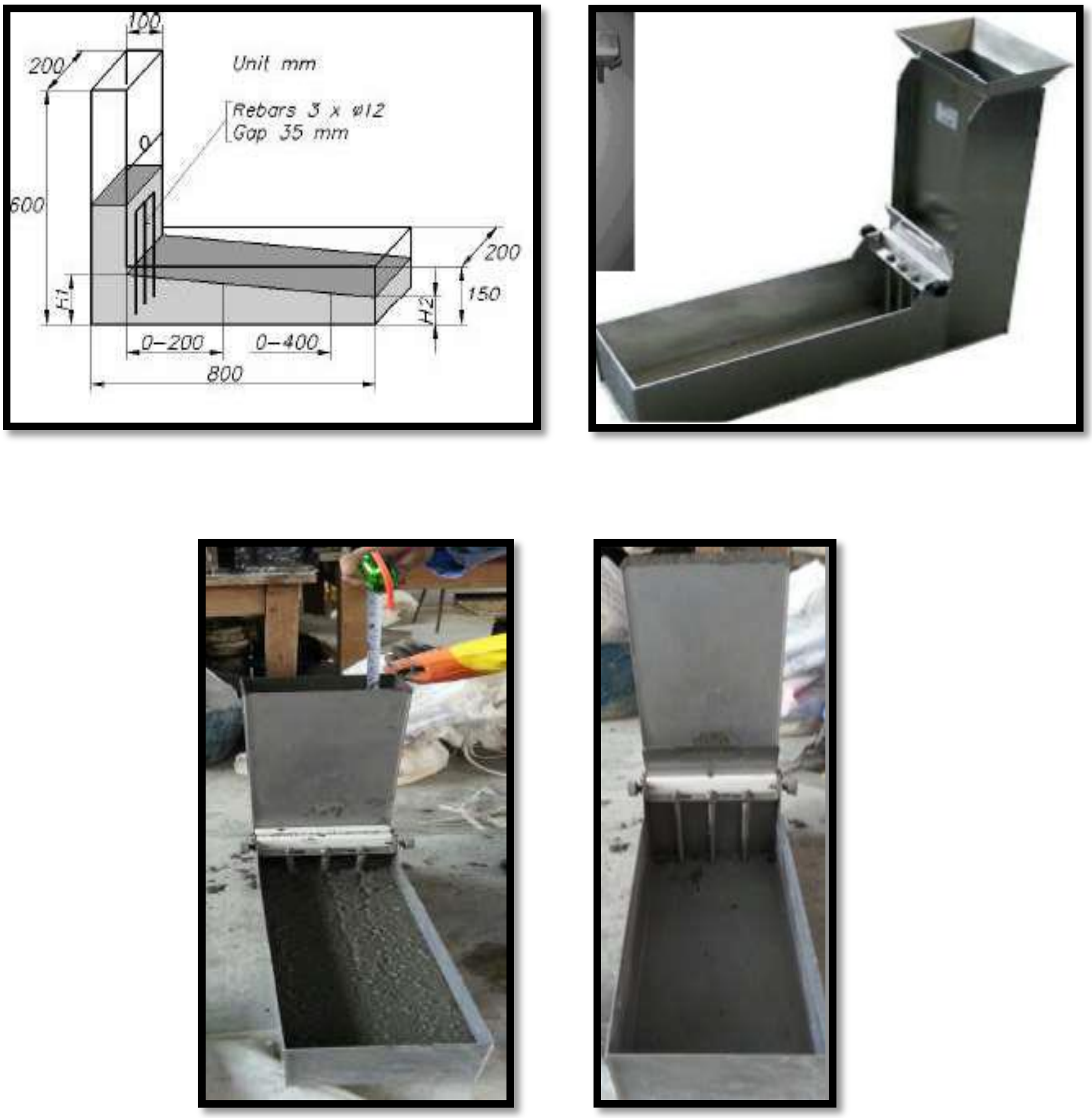


Fig. (6): L-Box test instrument and test procedure

$$PL = \frac{H_2}{H_1}$$

PL : The blocking ratio

H_1: is the mean depth of concrete in the vertical section of the box

H_2: is the mean depth of concrete at the end of the horizontal section of the box.

8.4 V-funnel and V-funnel at T_5 minutes tests: -

- The V-funnel flow test gives an indication of the filling ability of SCC provided that blocking and/or segregation do not take place
- ✓ The flow time of the V-funnel test is related to the plastic viscosity of SCC

The required amount of concrete that it is needed to carry out the test about 0.012 m^3. The procedures of this test are:-

- ✓ Placing the V-funnel on firm ground. Moisten the inside surfaces of the funnel. Then keep the trap door open to allow any surplus water to drain.
- ✓ Close the trap door and place a bucket underneath.
- ✓ Fill the apparatus completely with concrete without compacting; simply strike off the concrete level with the top with the trowel.
- ✓ After the funnel is fully filled within 10 sec, the trap door is opened and allows the concrete to flow out under gravity.
- ✓ The time for the discharge to complete is recorded (flow time) by stopwatch. The V-funnel flow time t_V is the period from releasing the gate until first light enters the opening, expressed to the nearest 0.1 second.

The procedure for measuring segregation resistance; without warping the concrete or moistening the inner surfaces of the funnel is:-

- ✓ The bottom gate is closed and immediately the V-funnel refilled. After 5 minutes from refilling, the bottom gate is opened and the concrete is allowed to flow out on its own weight.
- ✓ The stopwatch is started when the bottom gate is opened, and the time measured to complete the discharge (flow time at T_5 minutes) is recorded according to **EFNARC**, see Fig. (7).

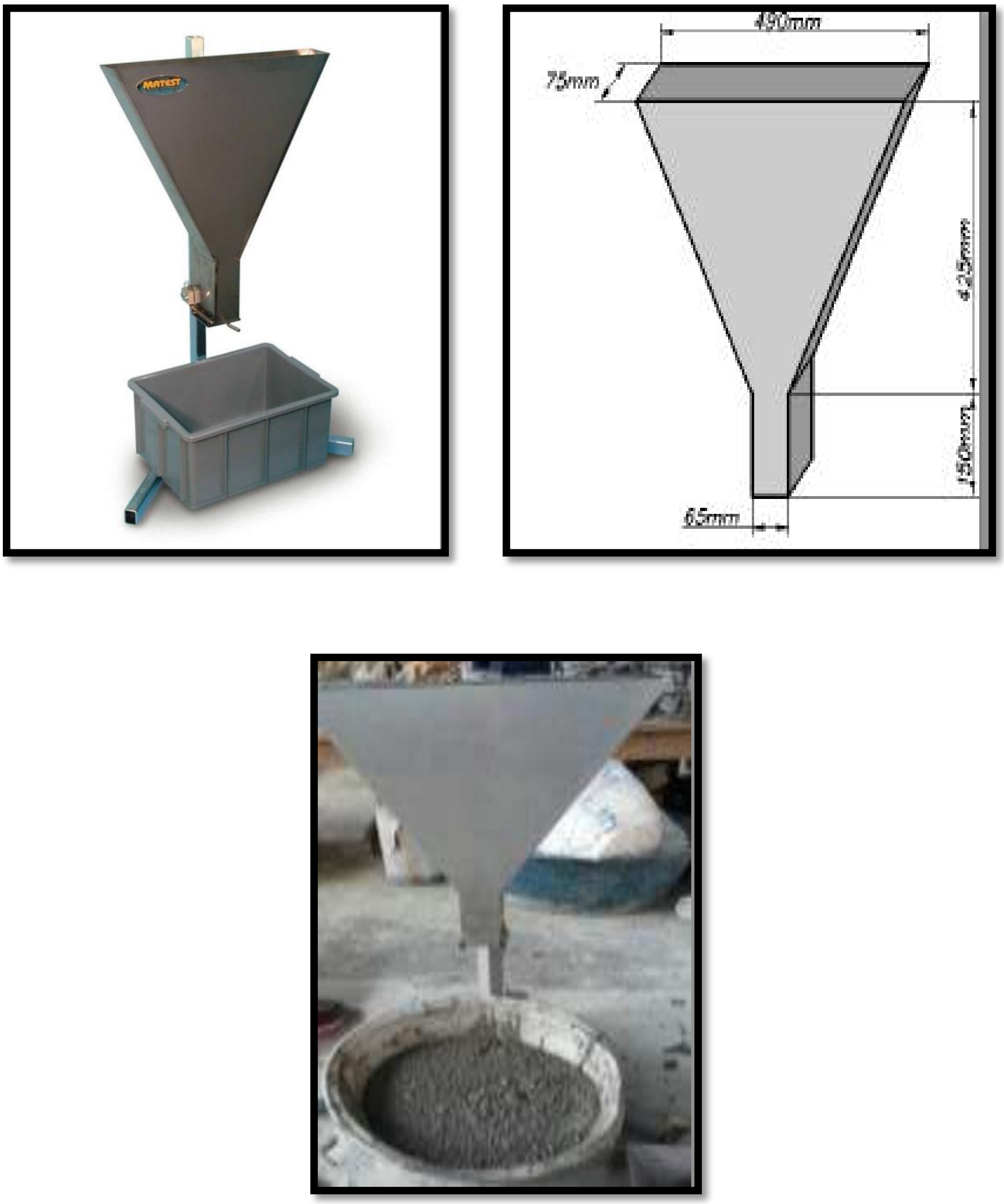


Fig. (7): V-funnel test instrument and procedure.

8.5 U-Box test

The test is used to measure the filing ability of SCC, as shown in Fig. (8), the procedure for this test is:-

- ✓ Fill the one compartment of the apparatus with the concrete sample. Leave it to stand for 1 minute.
- ✓ Lift the sliding gate and allow the concrete to flow out into the other compartment
- ✓ After the concrete has come to rest, measure the height of the concrete in the compartment that has been filled, in two places and calculate the mean (H1).
- ✓ Measure also the height in the other compartment (H2).
- ✓ Calculate H1-H2, the filling height.
- ✓ If the concrete flows as freely as water, it will be horizontal, so H1-H2=0.
- ✓ Therefore the nearest this test value, the ‘filling height’, is to zero, the better the flow and passing ability of the concrete.

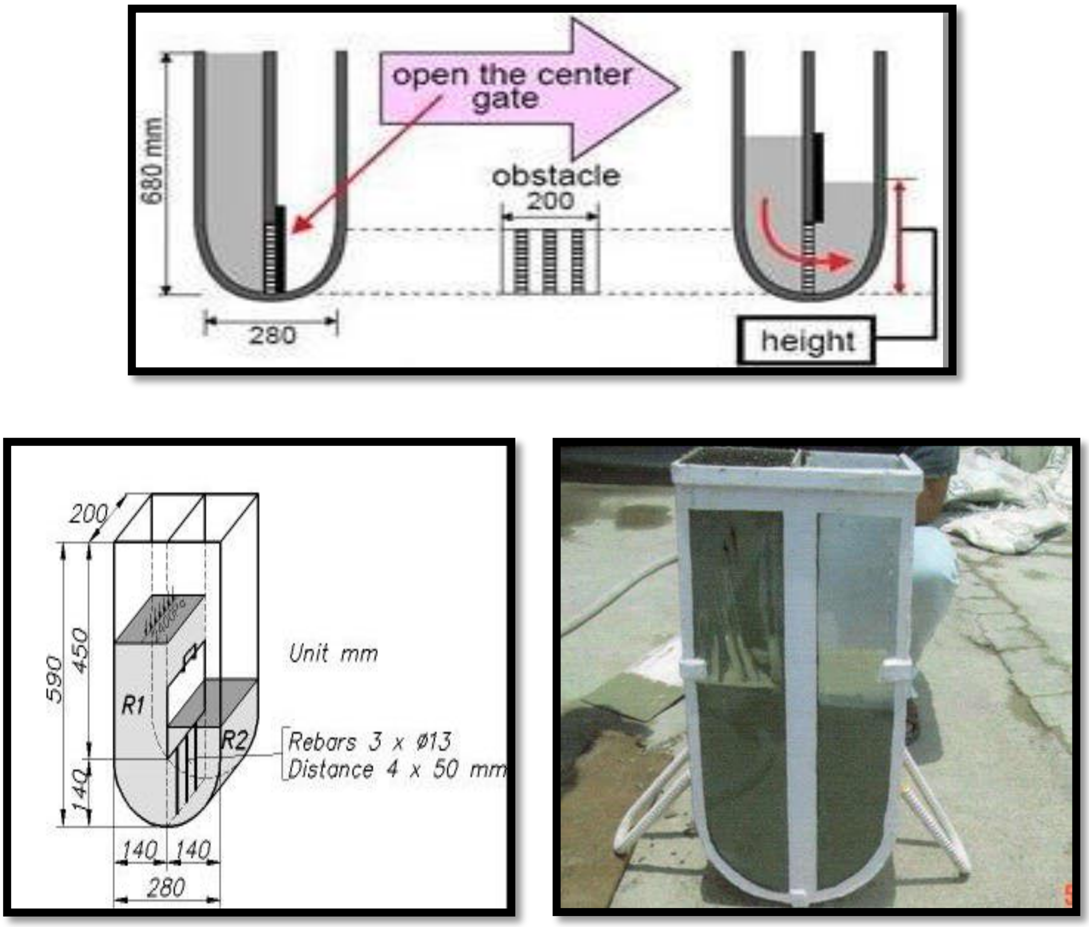


Fig. (8): U-Box test instrument and procedure.

8.6 GTM screen stability test

GTM screen stability can be used to check the segregation resistance of SCC. Its test procedures are as follows:

- ✓ Put 10 ± 0.5 L concrete into the container which is shown in Fig.9, must be installed in a horizontal position, and stands for 15 ± 0.5 min.
- ✓ The sieve pan is placed on a weighing machine and its mass (Wp-g) recorded after ensuring the position is being stable. Then the sieve placed on the pan and again the mass was recorded
- ✓ Pour (4.8 ± 0.2) kg concrete onto the center of the sieve. Record the retained mass of concrete (W_C g) on the sieve
- ✓ The concrete is allowed to stand in the sieve for (120 ± 5) s then the sieve removed vertically. The passing mass of the concrete on the pan is recorded (W_{PS} g).
- ✓ Test segregated portion SR is calculated from the following equation and reported to the nearest 1 %.

$$SR = (Wps - Wp)\, 100 / Wc \,\%.$$

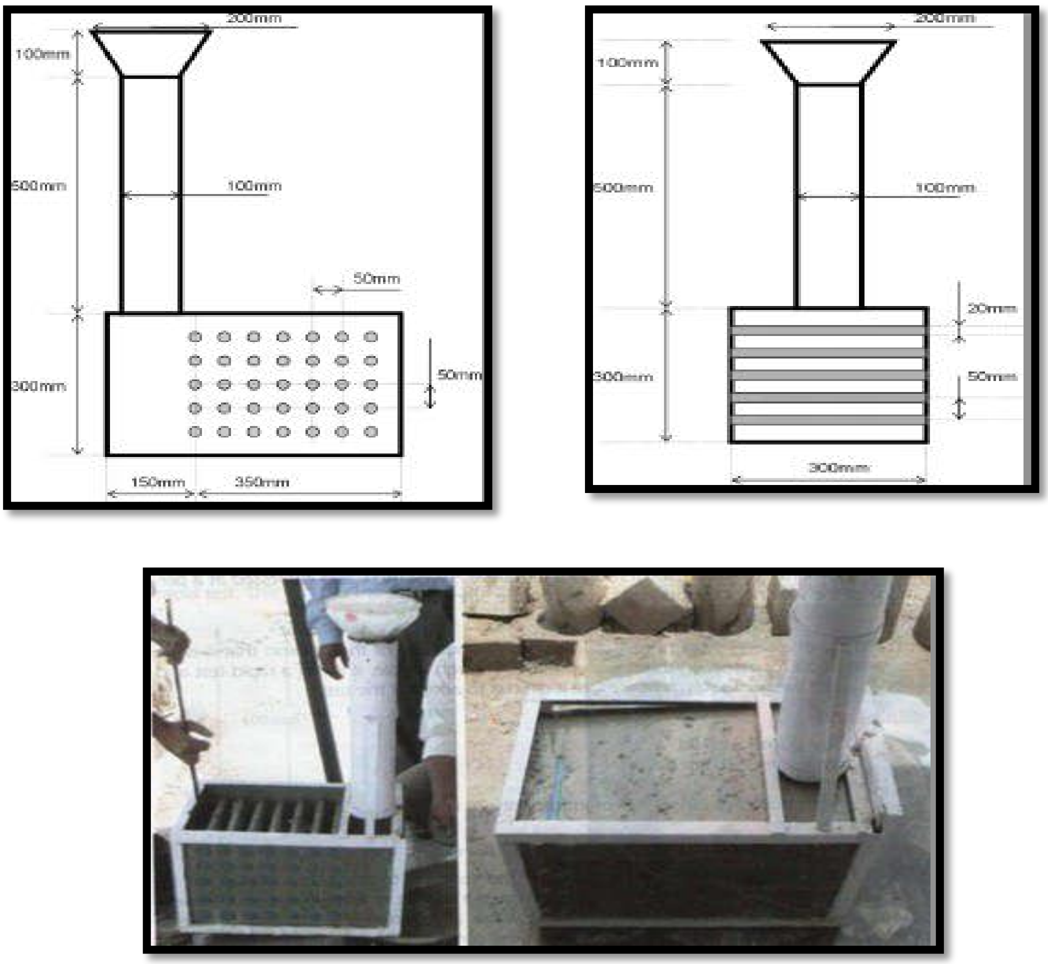
Fig (9): Sieve segregation resistance test using standard sieve (diameter of square hole: 5mm, diameter of the sieve: 350mm)

8.7 Fill box test

The test is used to measure the filling ability of self - compacting concrete with a maximum aggregate size of 20mm.

- ✓ Set the apparatus level on firm ground.
- ✓ Moisten the inside surfaces of the apparatus. Fill the apparatus with the concrete sample.
- ✓ Fill the container by adding each 5 seconds one scoop with (1.5 to 2) liter of fresh concrete into the funnel until the concrete has just covered the first top obstacle.
- ✓ Measure the height at the side at which the container is filled on two places and calculate the average (h1).
- ✓ Do this also on the opposite side (h2). Calculate the average filling percentage:

Average filling %: F= {(h1+h2)/ 2*h1} * 100%



Fig(10) :Fill box test instrument and procedure

8.8 Orimet test

• The Orimet flow time is the period that a defined volume of SCC needs to pass through a narrow opening (a narrowed tube).

• The flow time of the Orimet test is to some degree related to the plastic viscosity.

• The Orimet flow time t_O is the period from releasing the gate until first light enters the opening, expressed to the nearest 0.1 second

• Acceptance criteria for SCC are (0 – 5) sec.

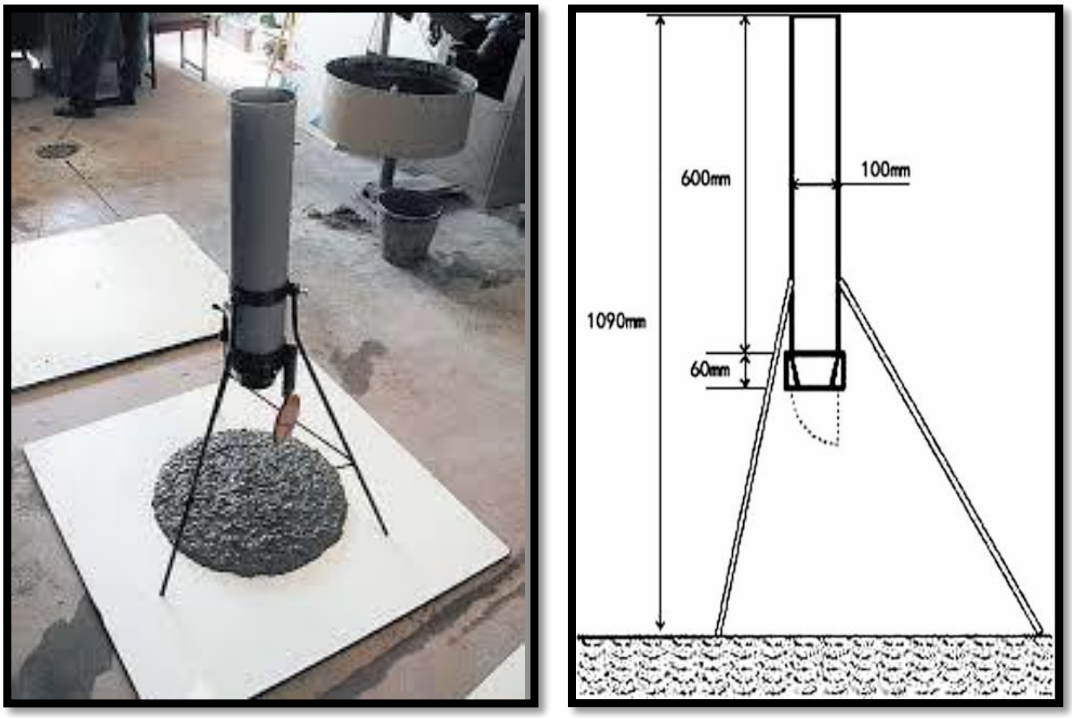


Fig. (11): The Orimet test instrument and procedure.

9- Initial mix composition of SCC

In designing the mix it is most useful to consider the relative proportions of the key components by *volume* rather than by mass. Indicative typical ranges of proportions and quantities in order to obtain SCC are given below. Further modifications will be necessary to meet strength and other performance requirements

Water: Powder by volume	0.8 to 1.0
Total powder content	(400 – 600) kg/m^3
Coarse aggregate content	28-35% by volume of the mix
Sand Content	>40% of mortar
Water content	<200 liter/m^3

Viscosity-modifying admixtures are a useful tool for compensating for the fluctuations due to any variations of the sand grading and the moisture content of the aggregates.

Mix Design Procedure

1. Determine the desired water content
2. Determine the coarse aggregate volume
3. Determine the sand content
4. Determine the paste content
5. Determine the optimum water to powder ratio and super plasticizer dosage in mortar
6. Finally the concrete properties are assessed by the standard tests.

10- Advantages of SCC

- Reduced Permeability
- Improves Quality, durability, and reliability of concrete structure due to better compaction and homogeneity of concrete.
- Ease of placement results in cost savings through reduced equipment and labor requirement.
- Less noise from vibrators and reduced danger from hand arm vibration syndrome
- Greater freedom in design

- Improves working condition and productivity in construction industry
- Faster construction
- Elimination of problems associated with vibration

11- Dis-Advantages of SCC

- More stringent requirement on the selection of materials.
- Costlier than conventional concrete based on concrete material cost (exception to placement cost)
- Requires more trial batches at lab as well as at ready mix concrete (RMC) plants
- More accurate measurement and control of constituent materials.

12-How economical is SCC

- It is seen that the materials cost of SCC is about 10-15% higher than NC. Therefore the cost of SCC is much higher than that of corresponding normal or high strength concrete.
- If one takes the other components of costs such as cost of compaction, finishing, etc. then one would realize that SCC is certainly not a costly concrete for comparable strength.

13-Uses of SCC

- Complicated reinforcement
- Raft foundation
- Retaining walls
- Pile foundation
- Repairs, restoration and renewal

14- Major constructions using SCC

- *Burj Khalifa in Dubai (2010)*
- Over 828 meters high and 166 stories

- Self-compacting concrete is playing a greater role in high rise construction to overcome the problem of congested reinforcement and ease of placement.

Burj Khalifa in Dubai

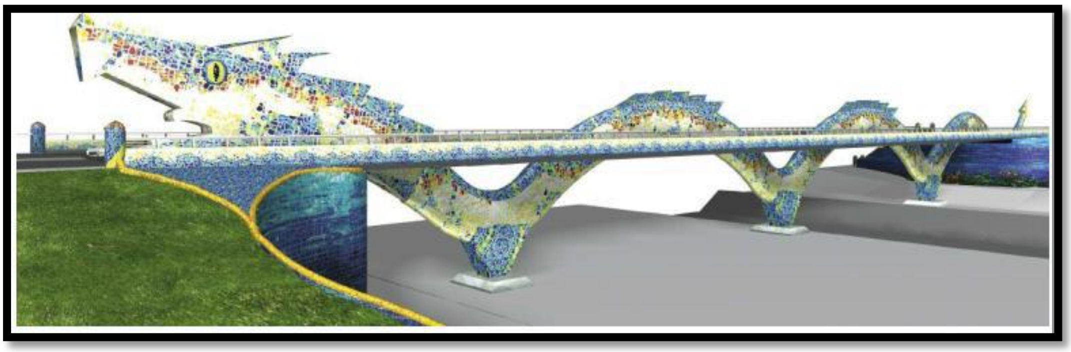
Sodra Lanken – Sweden

- It was one of the largest infrastructure projects that used SCC. About 6 km long four-lane highway in Stockholm
- Incorporating SCC was ideal to cope with the density of reinforcement required and the highly uneven rock surfaces.

Sodra Lanken – Sweden

Dragon Bridge (2012), Spain

- 124 m long bridge, distributed in four spans, stands out due to its unique shape
- The dragon's body is made up of 4 meters high and 2 meters wide, of self-compacting reinforced concrete



Dragon Bridge

Delhi metro project

Delhi metro project

Shin-Kiba Ohasi Bridge

Tarpur nuclear Power plant

Heavily Reinforced section

Seating Benches Constructed Using SCC