YAPICHEM

Concrete Technician
Hand Book

Dear Customer,

The Manuel that you are reading at the moment is prepared by the expert team of Yapıchem for the use of laboratory technicians working at “Ready Mixed Concrete” sector by taking into account testing processes and application necessities.

In the Manual, detailed information is given both in written and visually about the tests, sampling techniques, determination methods, equipments and their uses; obtained results from the tests are explained in detail, and for the concrete tests to be carried out as explained and it is aimed at being a reference source for the personnel of the related departments.

Furthermore, recommended limiting values for composition and properties of concrete according to the exposure classes that concrete is going to be subjected to, concrete casting at hot and cold weather conditions that affects the ultimate compressive strength and durability, the reasons for cracks at fresh and hardened concrete and all the precautions to be taken related all of them are given in detail.

Concrete Classes and Strengths Table and Cement Classes Table are attached for information. This Manuel is prepared by taking into account the technical data of TS EN 2016 Standard, TSE and Turkish Ready Mixed Concrete Association. Yapıchem does not accept any legal responsibility for the results due to the wrong application or other reasons.

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General Manager

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SAMPLING OF AGGREGATES (TS 707)

The most important issue when sampling an aggregate pile is that the specimen must represent the aggregate pile. The opposite situations may cause wrong results; the specimen must be taken carefully from different sections in the middle of the pile, not from the top or bottom of the pile. The collected specimens must be homogeneously mixed and reduced down to sufficient amount for the test. This process is performed through splitting or quartering methods. Reducing process is performed by pouring 5 kg of specimen onto a clean surface, spreading the material in circular motion and by dividing the material into four equal sections with a tool, such as trowel, and by taking two opposing sections. The selected segments are mixed again and this process is performed until the material is sufficient for this test. Again, in splitting method, 5 kg of sample is poured into splitting device and preferred bucket is selected; this process is performed until the material is sufficient for this test. (Figure 1)

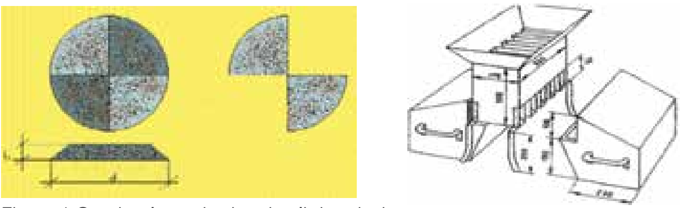


Figure 1 Quadruple method and splitting device

DETERMINATION OF SPECIFIC WEIGHT and WATER ABSORPTION METHODS (TS 3526)

In order to calculate concrete mix, the specific weights of the aggregate to be used in production must be known. The specific weight is the weight of absolute unit volume absorbed by aggregate grains.

Determination of specific weight and water absorption methods of fine aggregate

Equipment

- Scales: with 2 kg scales and 0.1 gr accuracy
- Paneled heater or air blast heater: A panel or air blast heater with gas or electrical heater, which has strength to increase the temperature to 105°C ± 5°C around the immediate surroundings of the test sample.
- Measuring tank: A glass measuring tank with 500 or 1000 ml capacity
- Glass plate: A glass plate, which is large enough to cover the measuring tank
- Metal mold: A metal mold, which is shaped as frustum and which is 38 mm in top inner diameter, 89 mm in bottom inner diameter and 73 cm in height.
- Jam rod: A rod made of brass, which is approximately 25 mm in diameter and 350 kg in weight, with non-rounded tip.
- Vacuum pump
- Towels or similar drying rags, pans, trowel, ventilator, desiccator, thermometer

Test Sample

The amount of test samples to be used in tests varies depending upon the size of the maximum size of grain.

Accordingly, the weight (kg) of each test sample is given in table 1.

Max. size of grain (mm)	**0,25**	**0,50**	**1**	**2**	**4**	**8**	**16**	**31,5**
Amount of test sample (kg)	**0,8**	**0,8**	**0,8**	**0,8**	**0,8**	**1,5**	**2**	**3**

Table 1 – Amounts of Test Samples Required for Determination of Specific Weight

Process

After the test sample, which has been created in accordance with (TS 707-1) and in the amounts specified in Table-1, is soaked for 24 hours, the water is drained by filtering without losing the fine grains and spread into a pan. The pan is placed on paneled heater and dried. If required, an air stream is created with a ventilator and the material is mixed continuously, thus, the material quickly turns into a saturated dry surface. Saturated dry surface state is acquired right after the fine aggregate turns from dark (wet) color into light (dry) color. Visual recognition of saturated dry surface depends upon the experience of the test list. The sample must not be dried excessively. If the saturated dry surface cannot be visually recognized, frustum or cutting methods are applied.

- Determination of saturated dry surface state with frustum method:

The sample, which is assumed to have reached its saturated dry surface state, is placed loosely on frusto-conical metal mold as the large surface facing downwards and the top of the material is slightly hammered 25 times with jam rod and removed by moving the mold vertically upwards. If the boniness of the sample continues when the mold is removed, it means there is free moisture; the material must be dried and frustum must be applied again after a while. If it is seen that the conic shape of the sample is easily tainted, it is assumed that the saturated dry surface is acquired. If the material is dried redundantly for any reason, a little water is sprayed on the sample, mixed and moisturized, and then frustum method is applied.

- Determination of saturated dry surface state with cutting method:

A hemisphere shaped pile is created with the sample, which is thought to reach saturated dry surface state.

If the pile can protects its surface planeness that comes up when the pile is divided into two pieces vertically with a trowel, the drying process is continued. If the vertical surface cannot hold itself and collapses, this is the saturated dry surface state.

The sample in saturated dry surface state is weighed and saturated dry surface weight is recorded (W1).

The sample is brought to oven-dry state. The sample is placed into a desiccator and cooled down to room temperature. The cooled sample is placed into glass measuring tank and weighed together.

Predetermined weight of the measuring tank is subtracted from this weight and 'dry weight' of the sample is determined (W2). The measuring tank is half-filled with approximately 20°C of water and the bubbles are removed by slightly hitting on flat surface (Figure 2) and by rotating at the same time. In order to accelerate the removal of the bubbles, vacuum pump may be used. After waiting for an hour, the measuring tank is filled with approximately 20°C of water up to 500 ml (or 1000 ml) tick mark and weighed (W3).

Specific Weight = $\frac{W1}{(W1+W2)-W3}$

W1 = sample weight W2 = weight of the measuring tank filled with water
W3 = sample + water + jar

Water Absorption = $\frac{W1-W}{W}$

Dry material W1: saturated dry surface sample

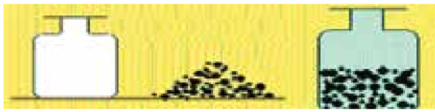


Figure 2 Specific weight measuring tank (Pyknometer)

SIEVE ANALYSIS TEST (TS 130)

Sieve analysis test means finding aggregate percentages in 1 m^3 of concrete with percentage by weight of various sizes of aggregate sections (Figure 3) in terms of diameter to all aggregate mixture passes through sieving an aggregate mixture with square-mesh Standard test sieves.

Figure 3 Aggregate piles with different grain diameters

Maximum Aggregate Size

Maximum aggregate size is the smallest sieve-mesh gap, where the entire aggregate mixture passes during the sieving process.

Coarse Aggregate

Coarse aggregate is the aggregate, which remains on the sieve with 4 mm sieve-mesh in accordance with TS 12271.

Fine Aggregate

Fine aggregate is the aggregate, which passes through the sieve with 4 mm sieve-mesh in accordance with TS 1227.

Mineral Fill Material

Mineral fill material is the material, which passes through the sieve with 0.063 mm sieve-mesh in accordance with TS 1227.

Equipment

- Scale : A scale, which can weigh the test samples with minimum 0.1% of accuracy.
- Sieves : Wire sieves in accordance with TS 1227.
- Drying oven : An oven, which can be adjusted to 110 ± 5°C and which is sufficient in size.
- Splitter : Sample separator splitter as seen in Figure 1.

Preparation of Test Sample

The sample aggregate is mixed thoroughly and homogenized, and sufficient amount of material for test with splitter is separated as test sample. Quartering method may also be used in this separation and test sample preparation process. In this method, the aggregate is turned into a smooth circular pile and divided into four equal parts with the sharp edge of the trowel.

Testing

The test sample is dried to constant weight in drying oven adjusted to 110 ± 5°C and weighed (W0). Test sieves (Figure 4) are stacked upside down from the sieve with largest mesh towards the smallest. Dried and weighed test sample is placed on the sieve on the top and sieved. This process can be performed manually or sieve jigging machine may also be used.

The sieving continues for sufficient time together with the materials in it. The sufficiency of sieving period is understood by the fact that the amount that goes through the sieve in 1-minute of sieving is less than 1% of the material remaining on the sieve.

In order to understand this, the sieve is held by hand and tightly closed with a cap over the top, the sieve is slightly inclined and sieving is continued by hitting the palm of the other hand with 150 hits per minute. Meanwhile, at the end of each 25 hits the sieve is rotated 1/6 around its own axis. With this speed, the rate of the material that passes through the sieve to the material remaining on the sieve in 1 minute shows the sufficiency of sieving duration.

For sieves with screen mesh larger than 4 mm, when the material remaining on the sieve forms a single grain layer, it means the sieving duration is sufficient. At the end of this sieving process, each material remaining on the sieve is weighed with 0.1 accuracy (Wn).

Calculation

At the end of sieve analysis test, the rate of each material remaining on the sieve is calculated as percentage of the entire test sample weight with the following formula and rounded off to a whole number:

$$Sn = \frac{Wn}{W0} \times 100(\%100)$$

In this formula :

Sn = The percentage (%) of the material remaining on the sieve in any screen-mesh (n) dimension

Wn = The weight of the material (gr) remaining on the sieve in any screen-mesh (n) dimension

W0 = The weight of test sample (gr)

Figure 4 Sieve analysis set

PREPARATION OF METHYLENE BLUE SOLUTION

Equipment

- 1000 gr distilled water
- Methylene blue powder
- Scale: With 2 kg scales and 0.1 gr of accuracy
- A mixer, which operates in 600 and 400 of speed
- 1000 ml glass beaker
- Chronometer

Process

750 gr of 1000 gr distilled water is poured into glass beaker, 10 gr of methylene blue dust is added to water and mixed for 45 minutes in 600 speed and discharged into a separate container. At the end of this process, remaining 250 gr of distilled water is used to clean the impeller and the beaker and added to 750 gr of mixture. You must wait for 24 hours before using this solution and make sure that the container is air-tight. Shelf life of this solution is 28 days and the solution must be renewed for better tests at the end of 28 days.

METHYLENE BLUE TEST (TS EN 933-9)

Equipment

- Scale: With 2 kg scales and 0.1 gr of accuracy
- Titrometer
- A mixer, which operates in 600 and 400 of speed
- Glass rod
- 1000 ml glass beaker
- Distilled water
- Filter paper
- Methylene blue solution
- Sieve no: 2
- Tray
- Chronometer

Process

Methylene blue test is performed with the set shown in figure 5. 200 gr of fine aggregate is sieved through sieve no: 2. The sieved aggregate is added to 500 gr of distilled water and mixed for 5 minutes in 600 speed. Titrometer is filled with 100 ml of blue liquid, 5 ml of methylene blue solution is added at the end of 5 minutes and mixed for 1 minute at 400 speed. When this process is over, the glass rod is dipped into the mixture and instilled on the filter paper and halo formation is checked. This process is continued until halo is formed on instilled liquid after adding 5 ml, and mixing for 1 minute at 400 speed. If the halo disappears in first 4 minutes, 5 ml more paint solution is added. If the halo disappears in fifth minute, only 2 ml more paint solution is added. In both cases, the mixture and stain test continue until the halo appears for 5 minutes.

Formula : MB=V1/M1x10

Here;
M1: Mass of test sample section, gr,
V1: Total volume of added paint solution, ml.
MB value, the paint amount used for per kilogram of (0-2) mm range is recorded with 0.1 gr modality.

Note : Number 10 in abovementioned equities is used for converting the volume of paint solution into paint mass adsorbed per kilogram of tested size range.

Figure 5 Methylene blue set

MOISTURE DETERMINATION IN AGGREGATE

First, a certain amount of the sample taken with appropriate methods from the aggregate (TS 707) is weighed and noted. Then, the weighed aggregate is heated in drying oven or in a furnace until it becomes oven-dry. Oven dry means the dryness of all gaps within the aggregate grain. The aggregate pile, which became oven-dry, is weighed after it is cooled down. And then, the moisture rate in the aggregate pile is calculated after applying the following process.

$$\textbf{Aggregate moisture rate (\%)} = \frac{\text{initial weighing} - \text{oven dry weighing}}{\text{oven dry weighing}} * 100$$

GRANULOMETRY TEST (TS EN 933-1)

Granulometry

Sieve No (mm)	SIEVED MATERIAL %			REQUIRED LIMIT VALUES
	GRAVEL I	GRAVEL II	SAND	
32	100	100	100	100
16	10	85	100	89-62
8	4	35	100	77-38
4	0	5	100	66-23
2	0	0	80	53-14
1	0	0	52	42-8
0.5	0	0	28	28-6
0.25	0	0	8	15-2

Table-2 Required limit values for the material that goes through the sieve %

The curve, which shows the distribution of grains with certain sizes in an aggregate, is called Granulometry Curve. Granulometry curve of the aggregate is determined with sieve analysis. When TS EN 12620 is considered, the sieves from 3 different basic sieve sets are used in sieve analysis test. The method for performing sieve analysis test on an aggregate pile is specified in TS EN 933-1. An example of % material amounts that go through the sieve is given in Table 2.

MAXIMUM AGGREAGATE SIZE

According to the data, the maximum grain size of aggregate is 32 mm. Since gravel I, gravel II and sand will be used together, the mixture rates of the aggregates are determined at this stage.

As a result of the evaluations made with the information given in aggregate section, a mixture in the granulometry given in table 3 below is obtained with 25% of gravel I, 35% of gravel II and 40% of sand.

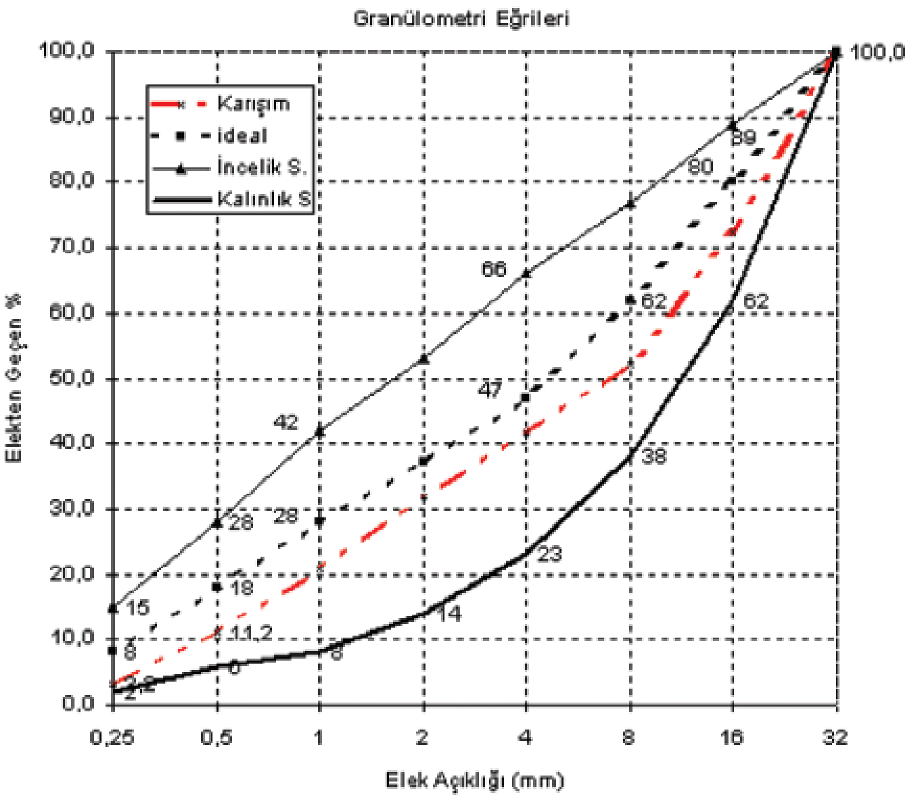


Table 3 Granulometry Curve

SLUMP TEST (TS EN 12350-2)

Fresh concrete is compressed and filled into frustum-shaped mold. After the mold is pulled up and removed, the slump distance of fresh concrete mass is used as consistency measure of the concrete. Step by step slump test is shown in pictures in Figure 6.

Figure 6 Slump test

Equipment

The mold is made of 1.5 mm or thicker metal, which is not negatively affected by cement paste in short time, in order to create a test sample. The inner surface of the mold should be free from any bulges, such as rivets, the inner surface must be smooth and should not contain any dents and notches. The mold should have the following inner dimensions, should be hollow and frustum-shaped.

- Base diameter : (200 ± 2) mm
- Top surface diameter : (100 ± 2) mm
- Height : (300 ± 2) mm

The bottom and top surface of the mold must be open, parallel to each other and must be perpendicular to the longitudinal axis of the mold. In order to fasten the mold during the test, there should be two gripping parts close to the top surface of the mold and lock clamps and stepping apparatus close to the bottom. Use of molds attached to the bottom with lock clamps is allowed on condition that the clamps should not move the form or should not affect the slump of concrete during release of the mold by loosening the clamps.

Tamping rod must be (600 ± 5) mm in length and (16 ± 1) mm in diameter, with non-rounded tip and must be made of plain steel with circular cross-section.

Funnel filling head (optional) must be made of metal, which is non-hydrophilic and which is not affected by cement paste in short time, and must have fitting clamps for placement on the mold.

Ruler with intervals less than 5 mm, segmented from 0 mm to 300 mm, and which has the zero point at the end of the ruler.

Base plate/surface is a flat plate or other surface, which will constitute a base for the mold and which is non-hydrophilic and rigid.

Re-mixing container is a rigid and flat tray that must be made of a material, which is non-hydrophilic and which is not affected by cement paste in short time. The dimensions of the tray must be suitable for re-mixing of concrete by using square shovel.

Class	Slump, mm
S1	10 - 40
S2	50 - 90
S3	100 - 150
S4	160 - 210
S5	> 220

Table – 4 Slump classes and mm intervals in accordance with the standards

Testing

The inner surface and base plate of the mold is moisturized without letting any free water on the surface and the mold is placed on its horizontal base plate/surface. While filling the mold with concrete, the mold must be firmly fastened on base plate/surface by clamping to the base or by stepping on two stepping sections.

Fresh concrete is filled into the mold as three equal layers and as the compressed thickness of each layer is approximately 1/3 of mold height. During filling process, each layer is compressed by pricking 25 times with jamming rod. The impacts of jamming rod must be evenly distributed on surface area of each layer. In order to ensure even distribution of impacts onto the surface while compressing the bottom layer, the jamming rod must be slightly inclined towards vertical direction and at least half of the impacts must be made from edges towards the center on the points that would create spirals.

The second and last layers must be compressed by slightly sinking the jamming rod into the bottom layer all the way to the bottom. While filling and compressing the top layer, it must be ensured that the concrete level is higher than the top surface level of the mold before starting compressing process. If the fresh concrete level decreases below the top surface level of the mold while compressing the top layer, concrete must be added to make sure that the concrete level is higher than top surface level of the mold. The excessive concrete that spills over the top level of the mold after the completion the compressing process must be skimmed by cutting and rounding moves of jamming rod (similar to jigging move) and the surface must be leveled. The concrete that spilled on base plate/surface must be cleaned.

The mold is held by its handles, pulled vertically upwards and removed. The pulling of the mold must be completed between 5 to 10 seconds, the mold must be pulled with constant speed and the person must avoid applying lateral or twisting moves to the concrete mass.

The entire test must be completed within 150 seconds from filling the concrete into the mold to pulling and removal of the mold without any interruptions.

DETERMINATION OF UNIT WEIGHT AND AIR CONTENT IN FRESH CONCRETE BY WEIGHT METHOD

Unit weight of fresh concrete means the unit volume weight of fresh concrete, which is compressed and placed into a certain volume, in kg/m3.

Air content in concrete is the expression of the rate of current air volume in concrete, except for closed aggregate spaces, to volume of concrete.

Test Method

If the volume of measuring tank is less than 11 dm^3, the concrete must be compressed by pricking in order to prevent added air loss. The concrete in measuring tanks with dm^3 or more volume can be compressed by pricking or vibration method. If this has not been specified in specification regarding the work, the method is determined by considering the processability of the concrete. The concretes with less than 2.5 cm of slump value must be compressed with vibration method, concretes with more than 7.5 cm of slump value must be compressed with pricking method.

Both methods can be applied for concretes with slump value between 2.5 cm and 7.5 cm. compressed concrete surface must be at the top level of measuring tank or must be very close to that level.

If required, more sample concrete is added or excessive concrete is skimmed with a trowel. And then, the surface of concrete is leveled to fit the top level of the mold with skimming plate. If the thickness of skimmed concrete layer is more than 3 mm, the test is repeated. For skimming process, first, the skimming plate is pushed onto the concrete surface as to cover half of the surface and pulled back horizontally. Then, the plate is placed on the skimmed surface again and the remaining surface is skimmed by pushing the plate forward while pushing down on the top. And then, until the surface of concrete is completely leveled, the plate is moved all along the surface in inclined position.

After the surface of the concrete in measuring tank is completely leveled, the concrete smudged around and on the outer surface of the tank is cleaned. The filled tank is weighed in scale and the net weight (Wn) of the concrete in the tank is determined after subtracting the tare weight from the gross weight of the tank.

The unit weight (B) of fresh concrete is calculated with the following formula. The result is expressed in kg/m^3 and rounded off to the closest kg/m^3 value:

$$B = \frac{Wn}{Vk}$$

In this formula :

B = Unit weight of fresh concrete, kg/m^3

Wn = Net Weight of the concrete in measuring tank, kg

Vk = Calibrated volume of measuring tank, m^3

The air determination device (Figure 7) in accordance with TS EN 12350-7-02 and concrete sample must be taken in accordance with TS EN 12350-1:1999.

Flanges of tank and cap mechanism must be thoroughly cleaned. The cap mechanism must be placed and clamped to the tank. The user must ensure that there is no leak between the tank and the cap. Main air valve is closed and valves A and B are opened. The device is filled with water from A and B valves by using syringes until water is released from the other valve and the user hits the device slightly until the air bubbles within the water completely disappear. The air discharge valve connected to the closed air cell is closed and air is pumped into the closed air cell until the pressure indicator reaches the initial pressure (zero). After waiting for a few seconds to cool the pressure air down to ambient temperature, the pressure indicator is brought exactly on the initial pressure point through pumping more air or discharging a little pressure air. Meanwhile, the user slightly hits the pressure indicator by hand.

Valves A and B are both closed and the main air valve is opened. The user bashes on the sides of the aerometer tank. The value indicated by pressure indicator is seen after hitting on the indicator for a few times by hand and ensuring that the indicator is stable, the air percentage is read as A1.

After the test is completed, valves A and B are opened and pressure air is discharged and the cap mechanism is removed by loosening the clamps.

Figure 7 Air determination device

PREPARATION OF CONCRETE TEST SAMPLES (TS EN 12350-1)

Place of preparation

Concrete test samples must be prepared in place they will be preserved or as close to this place as possible. The samples must be transported to their storage place immediately after their preparation. Meanwhile, the samples must not be shaken and t umbled.

Placement of concrete into sample molds

The concrete is placed into sample molds as double layers. While pouring the concrete into the mold, the shovel, scoop or trowel must be trotted around the top surface of the mold and the user must make sure that the concrete is homogeneously distributed within the mold and separation of large aggregate must be prevented. In order to ensure that the concrete is thoroughly spread within the mold, pricking rod is used if necessary. The top layer of concrete must be sufficient to fill the mold completely after compression. In case the mold is not completely filled, the user must make sure that the additional concrete represents the concrete blend.

Compaction of concrete within the sample molds (TS 3351)

Compaction Methods

While preparing concrete test samples, compacting methods, such as pricking, inner or outer vibration, may be used.

In addition, if it is not specified, the compaction method is determined by considering the workability (slump) of concrete. The concretes with less than 2.5 cm of slump value must be compacted by vibration method, concretes with more than 7.5 cm of slump value must be compacted by pricking method. Both methods can be applied for concretes with slump value between 2.5 cm and 7.5 cm.

NOTE - The methods given in this standard may not be enough for compaction of concrete with very little water quantities and slump values. For this type of concrete, the compaction methods recommended in related standards or specifications may be used.

Rodding

The concrete is placed into the mold as layer with approximately equal volumes (depths) and pricked 25 times by a rounded tip of the rodding rod.

The number of rodding impact required for each layer in cylindrical molds is given in Table – 5.

Cylinder diameter < cm	Number of Impacts for Each Layer
15	25
20	50
25	75

Table 5 Number of pricking impact

Required number of profiling impact for cubic or girder molds is calculated as one impact for each 15 cm^2 of top surface of the mold. The impacts must be evenly distributed on the surface of the mold. While rodding the bottom layer, the rodding rod must sink into the layer, but the bottom of the mold must not be bashed hard. While pricking the other layers, the impacts must be adjusted to ensure 2.5 cm of penetration into the layer below. The spaces that may occur during rodding must be eliminated by slightly hitting on the edges of the mold. The edges and corners of pricked layer must be smoothed with trowel, if necessary.

Vibration

The concrete is placed into the mold as layer with approximately equal volumes (depths). Vibration for each layer must start after placing the entire layer. A suitable vibration time is applied for each layer in accordance with consistency of concrete, type of vibrator and sample mold.

Smooth and bright appearance of concrete layer generally indicates that sufficient vibration is applied. Excessive vibration must be avoided, since it may cause segregation of concrete. The quantity of the top layer must be adjusted to prevent overflow of concrete more than approximately 6 mm. In case the mold is not completely filled after vibration, the additional concrete must exceed the top surface of the mold maximum 3 mm.

Leveling sample surfaces

The concrete surface plane of the molds are polished after compression process. For this purpose, the excessive amount of concrete overflowing from the top surface of the mold is skimmed with a pricking rod or trowel, the leveled surface is polished with trowel or jig. These treatments must be completed as soon as possible and with the most practical method. Acquired sample surface must be at the same level with the edges of the mold, the dimensions of the dents and bulges on the surface must not exceed 3 mm.

Figure 8 Concrete sample molds

DETERMINATION OF COMPRESSIVE STRENGTH OF TEST SAMPLES (TS EN 12390)

The samples are loaded until they break in pressure test machine (Figure 9) in accordance with EN 12390-4. The maximum load that can be carried by the sample is determined and compressive strength of the concrete is calculated. Pressure test machine must be in accordance with EN 12390-4.

Preparation and placement of the sample

Before placing the sample into the test machine, the excessive amount of water on the surface is dried. The surfaces of loading heads of test machine is wiped and cleaned and any loose bulges or grains on the surface of the sample, which will contact with the heads, are removed.

No placement parts should be used between test sample and loading head of the test machine other than range adjustment blocks (EN 12390-4) and additional plates.

Cube samples must be placed as load application direction is perpendicular to concrete pouring direction.

The samples must be placed as centered on the bottom loading head of the machine.

Cube samples must be placed with ± 1% accuracy in the center of specified dimensions or cylinder samples must be placed ± 1% accuracy in the center of specified diameter. If additional loading plates are used, these must be adjusted in accordance with bottom and top surfaces of the sample.

If the test machine has two columns, the cube samples must be placed as the finished surface facing the column.

Loading

A stable loading speed between 0.2 MPa/s ($N/mm^2.s$) and 1.0 MPa/s ($N/mm^2.s$) must be chosen. The load must be applied with stable speed until it reaches the maximum load as the deviation from selected speed shall not exceed ± 10%, without the impact effect.

Presentation of Results

Compressive strength is calculated by using the following equation:

fc = F /Ac

Here;
fc Compressive strength, MPa (N/mm^2),
F The maximum load reached at the time of breaking, N,
Ac Cross section area, where the pressure load is applied on the load, mm^2. This area is calculated by using actual dimensions measured on the sample by using specified dimensions of the sample (EN 12390-1).

Compressive strength must be presented by rounding off the closest 0.5 MPa (N/mm^2).

Figure 9 Concrete Press

The table of exposure classes, which must be considered in determination of mixture and selection of appropriate concrete class, that the concrete will be exposed concrete casting under hot and cold weather conditions that affect the ultimate strength and resistance of the concrete and the precautions to be taken, and the reasons for potential cracks on fresh and hardened concrete and the precautions to be taken are explained below. For information purposes, the concrete classes and strengths table and cement classes table are attached.

- Recommended limit values for concrete mixture and properties
- Concrete casting in hot weather
- Concrete casting in cold weather
- Concrete cracks
- Cement Classes Table
- Concrete Classes and Strengths Table

RECOMMENDED LIMITING VALUES FOR COMPOSITION AND PROPERTIES OF CONCRETE / TURKISH STANDARD

ICS 91.100.30 TÜRK STANDARDI TS EN 206-1/Nisan 2002

Table F.1 – Recommended limiting values for composition and properties of concrete

	Exposure classes																	
	No risk of corrosion or attcak	Carbonation – induced corrosion				Chloride – induced corrosion						Freeze / thaw attack				Aggressive chemical environments		
						Sea water			Chloride other than from sea water									
	X0	XC1	XC2	XC3	XC4	XS1	XS2	XS3	XD1	XD2	XD3	XF1	XF2	XF3	XF4	XA1	XA2	XA3
Maximum w/c	-	0,65	0,6	0,55	0,5	0,5	0,45	0,45	0,55	0,55	0,45	0,55	0,55	0,5	0,45	0,55	0,5	0,45
Minimum strength class	C12/25	C20/25	C25/30	C30/37	C30/37	C30/37	C35/45	C35/45	C30/37	C30/37	C35/45	C30/37	C25/30	C30/37	C30/37	C30/37	C30/37	C35/45
Minimum cement content (kg/m^3)	-	260	280	280	300	300	320	340	300	300	320	300	300	320	340	300	320	360
Minimum air content (%)	-	-	-	-	-	-	-	-	-	-	-	-	4,0 [a]	4,0 [a]	4,0 [a]	-	-	-
Other requirements											Aggregate in accordance with EN 12620 with sufficient freeze/thaw resistance					Sulfate – resisting cement[a)]		

a) Where the concrete is not air entrained, the performance of concrete should be tested according to an appropriate test method in comparison with a concrete for which freze/thaw resistance fort he relevant exposure class is proven.

b) When SO_4^2 leads to exposure Classes XA2 and XA3 essential to use sulfate-resisting cement. Where cement is classifed with respect to sulfate resistance, moderate or high sulfate-resisting cement should be used in exposure Class XA2 (and in exposure Class XA1 when applicable) and high sulfate-resisting cement should be used in exposure Class XA3

CONCRETE CASTING IN HOT WEATHER

TS 1248 defines the temperatures over 30°C in 3 consecutive days as “”very hot weather”.

TS 1247 defines concrete casting temperature in normal weather as between +5°C and +30°C.

In TS EN 206-1, temperature of fresh concrete (by giving deviation limits) can be determined by the user and the producer. Standard lowest concrete temperature is prescribed as +5°C. The ideal concrete temperature for concrete casting can be accepted as between 15-20°C.

Effects of hot weather on fresh concrete:

- Mixing water would increase.
- Slump loss would be more.
- The heat of concrete (hydration) would increase. The concrete would set in a shorter time.
- Plastic shrinkage cracks would increase.
- Control of air quantity in air entrained concretes would be hard.

Effects of hot weather on hardened concrete:

- The strength increases quickly at early ages, but 28-day strength would be lower.
- Since more water is added, a porous concrete with high permeability would be acquired.
- Since there would be temperature difference after the concrete is cooled down, the concrete would be more tendency to crack.
- There would be more shrinkage.

Precautions to be taken:

- Cements with low hydration temperature must be used
- The materials that constitute the concrete must be cooled down
- Additives must be used
- Precautions, which would prevent evaporation and loss of water, must be taken
- Contact with direct sunlight must be prevented
- The mold and reinforcement bars must be cooled down
- The columns must be wrapped with wet sacks
- Curing must be initiated as soon as possible
- The effect of wind must be reduced
- Retarder chemical admixtures must be used

CONCRETE CASTING IN COLD WEATHER

DEFINITION OF COLD WEATHER

According to TS 1248 Standard, cold weather is defined as follows:

- When average temperature <5°C for 3 consecutive days
- When the temperature in these 3 days is not >10°C more than half a day

CONCRETE CASTING IN COLD WEATHER

TS 1248 defines the temperatures under +5°C in 3 consecutive days as "cold weather". Freezing during hardening of fresh concrete is dangerous. Effects of freezing before setting and after hardening are relatively low. Temperature decrease in the environment, where the fresh concrete is casted, increases the hardening period, mold intake period extends, and strength of concrete decreases and aggregate splits may be observed. In order to protect concrete in cold weather, the initial concrete temperature must be prevented from decreasing below a certain value. If the temperature of the environment, where the fresh concrete is casted, decreases under +5°C in one day, the concrete must be protected from frost effect for 48 hours, if the temperature decreases below +5°C for more than one day, the concrete must be protected from frost effect for 72 hours. Turkish standards assume that concrete will not be damaged by frost effect after the pressure resistance of the concrete reaches 50 kgf/cm^2. This period is 3 days for a good concrete in +10°C of temperature.

Prerequisite temperatures for concretes manufactured and placed in cold weather

Thickness of concrete section, cm	Minimum prerequisite temperature for concrete during placement °C
<30cm	13 °C
30-90cm	10 °C
90-180cm	7 °C
>180cm	5 °C

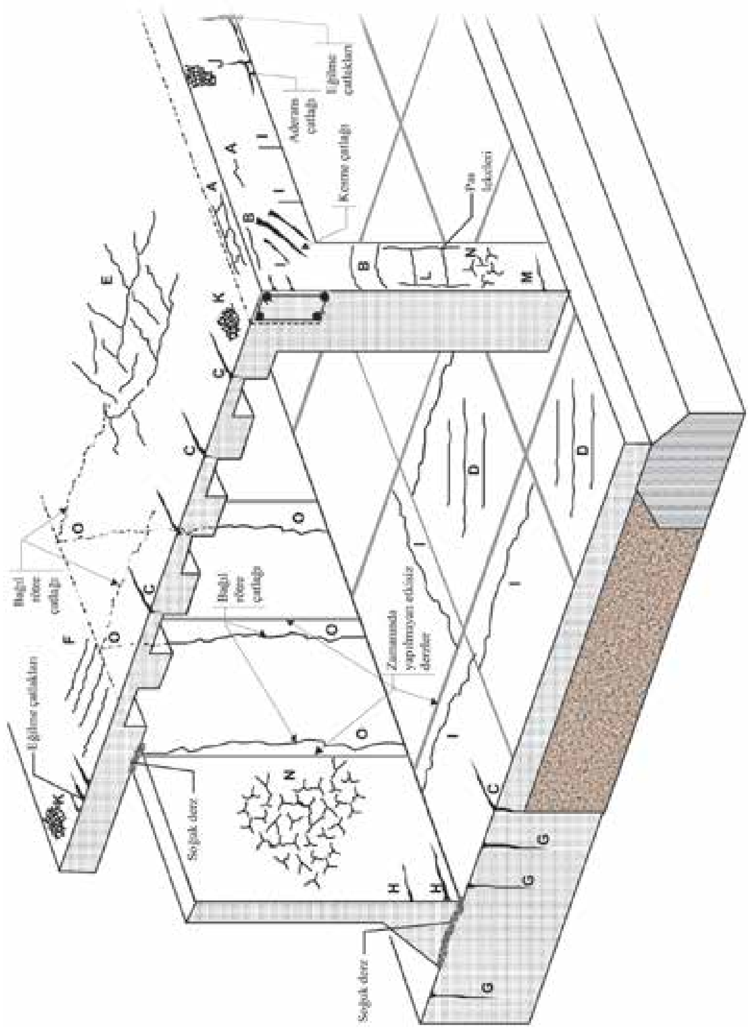
Minimum temperatures recommended for concretes by the end of mixture process

Thickness of concrete section, cm	Prerequisite temperature for concrete mixture manufactured under the following temperatures during manufacture °C		
	-18 °C' den düşük	-18 °C' ile -1°C arası	-1 °C' den yüksek
<30cm	21 °C	18 °C	16 °C
30-90cm	18 °C	16 °C	13 °C
90-180cm	16 °C	13 °C	10 °C
>180cm	13 °C	10 °C	7 °C

Precautions to be taken under Cold Weather Conditions

- In order to increase the temperature of concrete mixture, the materials composing the concrete must be heated before use,
- Cement, additives and concrete antifreeze, which will increase the resistance of concrete, must be used,
- Appropriate mold and insulation materials and/or curing methods must be used to protect concrete fall out in cold weather,
- The work must be planned beforehand, and the required preparations must be made before the concrete casting,
- Sufficient curing of concrete that cast in cold weather.

TYPES OF CRACKS IN REINFORCED CONCRETE STRUCTURES



Type of crack	Symbol	Generation Time	Generation frequency	The most frequent location	Main reason	Secondary reasons Factors	Precautions	Comment
Plastic settlement	A B C	Between ten minutes and three hours	Very frequent	Deep segments Tops of columns Toothed and waffle slabs	Excessive sweating Sedimentation of heavier parts in mixture	Slow setting due to fast early drying conditions Sun and wind exposure Retarder additives and cement properties	If the concrete is still plastic, expose to vibrator again, protect from dry air conditions, reduce bleeding, use air entrained concrete.	The cracks are usually seen in the direction of strain, they change in depths of section
Plastic shrinkage	D	Between thirty minutes and six hours	Very frequent	Roads and slabs	Shrinkage on the surface of concrete due to more evaporated water than concrete bleeding because of fast factor drying conditions such as sun and wind.	Low bleeding rate	In addition to the statements above, develop early curing (provide high levels of moisture). Add polypropylene fibers to the concrete. Apply early curing	The cracks rarely advance to the end of the element or are rarely longer than $1m^2$. They do not advance towards aggregate grains.
	E			Reinforced slabs				
	F			Reinforced slabs	Same as above, in addition, reinforcement bars very close to surface			
Early Thermal Shrinkage	G H	Between one day and two or three weeks	Very frequent	Thick walls Thick slabs	Generation of excessive heat with cement hydration, Excessive heat changes.	Fast cooling. Insufficient reinforcement distribution. Excessive joint space	Decrease temperature by using low-heat cement or insulate. Increase reinforcement distribution. Add steel fiber reinforcement.	The designer must consider thermal properties of the concrete for crack control and especially for determination of joint spaces in coating, flooring and walls.
Long-term drying shrinkage	I	Several weeks or months	Rare	Thin flooring (and walls)	Insufficient joints and wrong design.	Excessive shrinkage (contractible aggregate). Insufficient curing. Insufficient fixture distribution.	Decrease water content. Apply curing. Increase reinforcement distribution. Use low-contracted aggregate.	This generally results from a basic design or construction mistake.
Superficial Thin Crack	J K	Between one day and seven days, sometimes more	Frequently, widely	Fine concrete Slabs	Impermeable mold, Excessive polishing	Rich surface in terms of cement. Insufficient curing. Excessive vibration application close to mold	Change contact surface of the mold with concrete. Improve curing application and polishing.	Appears as map crack. Generally looks better in time. Rarely goes beyond being an aesthetic problem.
Corrosion of reinforcement	L	Longer than two years	Widely in old concrete	Columns and beams	Insufficient Concrete Cover	Inappropriate concrete class (permeable). Insufficient curing. Insufficient compaction.	Increase concrete cover. High concrete class. Good compaction. Good curing. Use chloride–free accelerator. Repair by experts is possible	The reinforcement corrodes, expands and cracks the concrete. Rust is generally seen on cracks.
	M			Precast concrete. Concretes that are exposed to freezing-thawing or sea salts	Excessive calcium chloride. Chloride conduits.			
Alkali silica reaction	N	More than five years	Very rare	Wet areas	Alkalis in cement react with reactive components in aggregate in existence of water and create a gel, which is hydrophilic and which expands.		Impossible to repair. However, it is not as important as it seems. Contact with concrete producer for precautions.	The cracks are map-shaped. Sometimes, a white gel leaks from the cracks.
Early Freezing Damage	P	1-24 hours	Very frequent	Thin sections and slabs	Water in fresh concrete freezes and expands.	Breach of curing and insulation conditions.	Keep the concrete over +5°C until the end of curing process. Apply insulation	There is NO structural strength in freeze-damaged concrete. It must be replaced.
Freezing-Thawing Damage	Q	Any time after hardening of concrete	Very frequent	Coatings	The water leaks through the surface of hardened concrete and freezes. It expands, cracks and crumbles the surface.	Inappropriate concrete class and type. Insufficient curing.	Use high-quality air entraining concrete. Apply sufficient amount of curing.	Defroster salts exacerbate the problem.

Structural Cracks

These types of cracks result from tensions that must be borne by the structure due to its function. They occur in structures, which does not have a project and which has soil problems, and they are very dangerous; they are not related to concrete casting and casting conditions. In these cases, authorized institutions (chamber of civil engineers, university, etc.) must be applied. This problem is not encountered when the structure is correctly planned and when there are no excessive loading. This type of cracks occur perpendicular to tensile stress within the reinforced concrete element. The cracks, which occur in mid-span of a girder, or which may be seen on console support, are this type of cracks.

Application-based Cracks

These types of cracks are seen in fresh or aged concretes.

Fresh Concrete Cracks

Fresh concrete cracks are generally seen on concretes applied on large surfaces, such as floorings, between the first 30 minutes and 5 hours following the placement of concrete into the mold. These cracks may be 10 cm in depth and starting from a few cm and reaching 2 m in length. Deep and long cracks may be very harmful in terms of strength and resistance of concrete. The two most important reasons of fresh concrete cracks are differences in settlement and plastic shrinkage.

Settlement Cracks

These cracks are formed in recently poured concretes with no concrete cover and no curing, which have been mixed with excessive amount of water, in porous reinforced concrete elements, in areas, where the reinforcing bars are too much, and when the concrete is not properly placed, and they are formed close to the surface right above the reinforcement. While large aggregate grains sink to the bottom, the water that contains cement particles rise to the surface. Beam and slab reinforcement that are close to the surface resist this replacement and fresh concrete does not completely settle in these areas. Unsettled concrete cracks all along the steel. Since the slabs are thin, there is less settlement and cracks are rarely seen. Since the beams are deeper, more settlement may occur and the map of reinforcing bars rise to the surface of the concrete, the cracks reveal the location of the reinforcement. As the water in concrete increases, the settlement increases too. If the concrete is not settled and compressed well, and vibration is not applied, settlement increases again. And so does the cracks. One way to prevent these cracks is to use concrete in normal consistency (-12 cm slump) and to avoid high-consistency concretes with excessive amount of water and to apply good vibration to concrete.

Plastic Shrinkage Cracks

These types of cracks are especially seen in concretes, which are casted in hot, dry and windy days (slabs, floor, road, runway… concretes), and which are the cracks that are randomly distributed in various sizes and widths. Crack width is usually less than 1 mm and its superficial, they do not go deep and do not constitute a danger for the safety of the structure.

When the slab concrete is poured, the water on the surface starts to evaporate, it leaves the concrete and mixes with air; instead of this water, the water within the concrete starts to go up towards the surface (bled water). If the speed of evaporation is higher than the speed of water bleed, the surface of concrete starts to get dry and thus to shrink and crack. The same cracks may also occur when the old and unsaturated concrete under the fresh concrete or the other materials such as briquette in hollow-tile floor slab soak up the concrete water.

The factors that increase the speed of evaporation are apparent:

Temperature: As the temperature increases, the evaporation increases, as well. 10°C of increase in temperature increases evaporation approximately 2 times. If the concrete is hotter than the weather, evaporation accelerates.

Humidity: As the humidity decreases (dry air), evaporation accelerates and gets easier. When the relative humidity decreases from 90% to 5%, evaporation increases 5 times.

Wind Speed: As the wind increases, the speed of evaporation increases, as well. When the speed of wind increases from zero to 20 km per hour, evaporation increases 4 times.

Sunlight: If the surface of concrete is exposed to sunlight, surface temperature of the concrete increases and evaporation accelerates.

Two main factors that affect the water bleeding rate of concrete are the Compactness of Concrete and Aggregate Granulometry. The less porous the aggregate granulometry, the higher the strength of the concrete; however, since there are no pores, the ascendance of bleeding water gets harder, delays and water bleeding rate decreases. When bleeding water does not take the place of evaporated water, the surface of the concrete dries up and cracks. Since granulometry in ready-mixed concrete is well-adjusted, water bleeding gets harder and plastic shrinkage cracks increase.

The precautions to be taken for decreasing plastic shrinkage and dependent cracks are as follows:

- Prevent mold components from soaking up the water in concrete and from accelerating desiccation by moisturizing the mold and the fixture irons.
- Protect the concrete from sun (cast under a shade or at night), hot weather (cast at night) and wind (provide wind breakers).
- Prevent evaporation of water (by covering with wet sacks or nylon or by applying or spraying curing material).
- Cast, jig and immediately start curing concrete quickly by employing sufficient number of workers with required skills, maintain curing for at least 3 days. Plastic shrinkage cracks may start within half an hour – forty five minutes, i.e., way before the completion of concreting process. Therefore, protection measures may be required in completed sections, while the concreting process still continues. By covering the jigged sections with nylon, wet sacks and by applying curing material, these precautions would be taken gradually. If these precautions are not taken, the concrete cracks less or more depending upon the temperature, humidity and wind. It depends on you to minimize these cracks.

Aged Concrete Cracks

This type of cracks may be seen on concretes in various age groups (from a couple of weeks to 30 years). Cracks are physical or chemical-based. First, these cracks would have capillary appearance, then they grow and combine. Following these cracks, stripping, falling out and pots are seen on the surface of concrete. If the required measures are not taken, reinforced concrete elements may completely ruin in time.

The reasons for these cracks are freezing - thawing, alkali-active silica reaction, carbonation, corrosion/rusting of reinforcing bars, and reactions caused by substances such as sulphate-acid-salt, which are harmful for concrete.

Table 1: 27 no.s of cements that belong to General Cements Class

Cement Type	Name	Notation	Main constituents of cement (as % of mass)										Minor compounds
			Clinker K	Blast Furnace Slag S	Silica fume D	Natural Pozzolana P	Industrial Pozzolana Q	Fly ash with silica V	Fly ash with lime stone W	Baked schist T	Lime stone L	Lime stone LL	
CEM I	Portland Cement	CEM I	95-100	-	-	-	-	-	-	-	-	-	0-5
CEM II	Portland Cement with slag	CEM II/A-S	80-94	6-20	-	-	-	-	-	-	-	-	0-5
		CEM II/B-S	65-79	21-35	-	-	-	-	-	-	-	-	0-5
	Portland Cement with silica fume	CEM II/A-D	90-94	-	6-10	-	-	-	-	-	-	-	0-5
	Portland Cement with pozzolana	CEM II/A-P	80-94	-	-	6-20	-	-	-	-	-	-	0-5
		CEM II/B-P	65-79	-	-	21-35	-	-	-	-	-	-	0-5
		CEM II/A-Q	80-94	-	-	-	6-20	-	-	-	-	-	0-5
		CEM II/B-Q	65-79	-	-	-	21-35	-	-	-	-	-	0-5
	Portland Cement with fly ash	CEM II/A-V	80-94	-	-	-	-	6-20	-	-	-	-	0-5
		CEM II/B-V	65-79	-	-	-	-	21-35	-	-	-	-	0-5
		CEM II/A-W	80-94	-	-	-	-	-	6-20	-	-	-	0-5
		CEM II/B-W	65-79	-	-	-	-	-	21-35	-	-	-	0-5
	Portland Cement with baked schist	CEM II/A-T	80-94	-	-	-	-	-	-	6-20	-	-	0-5
		CEM II/B-T	65-79	-	-	-	-	-	-	21-35	-	-	0-5
	Portland Cement with lime stone	CEM II/A-L	80-94	-	-	-	-	-	-	-	6-20	-	0-5
		CEM II/B-L	65-79	-	-	-	-	-	-	-	21-35	-	0-5
		CEM II/A-LL	80-94	-	-	-	-	-	-	-	-	6-20	0-5
		CEM II/B-LL	65-79	-	-	-	-	-	-	-	-	21-35	0-5
	Portland Blended Cement	CEM II/A-M	80-94	12-20									0-5
		CEM II/B-M	65-79	21-35									0-5
CEM III	Portland Cement with blast furnace slag	CEM III/A	35-64	36-65	-	-	-	-	-	-	-	-	0-5
		CEM III/B	20-34	66-80	-	-	-	-	-	-	-	-	0-5
		CEM III/C	5-19	81-95	-	-	-	-	-	-	-	-	0-5
CEM IV	Pozzolanic cement	CEM IV/A	65-89	-	11-35					-	-	-	0-5
		CEM IV/B	45-64	-	36-55					-	-	-	0-5
CEM V	Blended Cement	CEM V/A	40-64	18-30	-	-	18-30	-	-	-	-	-	0-5
		CEM V/B	20-38	31-49	-	-	31-49	-	-	-	-	-	0-5

Table2: Concrete Classes and Strengths TS EN 206-1

Compressive strength class	Minimum characteristic cylinder strength fck,cyl (N/mm^2):	Minimum characteristic cube strength fck,cube(N/mm^2):
C 8/10	8	10
C 12/15	12	15
C 16/20	16	20
C 20/25	20	25
C 25/30	25	30
C 30/37	30	37
C 35/45	35	45
C 40/50	40	50
C 45/55	45	55
C 50/60	50	60
C 55/67	55	67
C 60/75	60	75
C 70/85	70	85
C 80/95	80	95
C 90/105	90	105
C 100/115	100	115

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Yapıchem Kimya Sanayi A. Ş. was founded in 2011, by a team of professionals with vast experiences in the construction chemicals business; to provide affordable and high quality chemicals to the Turkish construction industry. By it's state of the art laboratory and R&D facilities, Yapıchem is able to cater to its customers' specific needs by producing tailor-made, high performance products for each customer and project.

Yapıchem sees its customers as long term business partners and is dedicated to increase the quality of their products while reducing their production costs. Yapıchem's seasoned team of technical staff and engineers work together with the after sales support team to satisfy customer needs to the full extend.

Yapıchem Kimya Sanayi A. Ş. is dedicated to full customer satisfaction with utmost care and respect to the community, employees, suppliers and environment.

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- **Degaset**
  [New Generation Superplasticizer Concrete Additives]

- **Arset**
  [Special Concrete Additives and Complementary Products & Shotcrete Admixtures Group]

- **Arcem**
  [Cement Additives Group]

- **Yapıfine**
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