start somewhere

The Production of TwistBlocks

A Guide for necessary equipment and establishing the concrete mix design

TwistBlocks are made from concrete. The concrete is filled into a formwork, whereby the formwork stands on a vibrating plate and the vibration continuously compacts the concrete. After 1 day of hardening, the TwistBlock is demoulded and subjected to curing in a humid climate until the age of 7 days. At the age of 7 days the TwistBlock can be used for building. The final strength of the TwistBlocks is reached at the age of 28 days.

Content

Equipment

The following equipment is required for production:

Concrete mixer (e. g. capacity up to 200 litres)

TwistBlock moulds

Electronic balance

Vibrating table or vibrating plate

Buckets (for weighing the mixture components)

microwave oven

Trough (for handling the concrete mix)

hand shovel for filling the formwork

Concrete mixture

The production of TwistBlocks requires an appropriate concrete recipe that is tailored to the requirements of TwistBlocks. The 3 essential components of the concrete mixture are

- Cement
- Aggregate (mineral aggregates)
- Water

Cement

It is recommended to use a cement type with strength class 42.5. This strength class is recommended to ensure sufficient strength for demoulding 1 day after production. The cement can be CEM I, CEM II, CEM III or CEM IV depending on the availability.

Aggregates

The aggregates make up the largest proportion of the concrete mix in terms of quantity. The following requirements must be adhered to:

- **Maximum grain size 10 mm** (>95% sieve passage)
- Grading curve in the upper and lower limit area according to Diagram 1 (see excel-file TwistBlock Production.xlsx)

The following methods can be used to compile a suitable grading curve for the aggregates.

1. Method: Sieve analyses of the grain classes

For this method, sieve analyses of the individual grain classes have to be available. In previous TwistBlock production, grain classes in the range of 0 to 5 mm (sand grain classes) and grain classes in the range of 2 mm to 10 mm (coarse grain classes) have proven to be favourable. With the results of the sieve analysis for the individual grain classes, the necessary quantities of the grain classes for a grading curve in the permissible range (see diagram 1) can be determined using the Excel file “TwistBlock Production.xlsx”. The permissible range can be seen in diagram 1 for the upper and lower limits (black lines).

If part of the grading curve is below the lower limit, the surface of the TwistBlocks can be rough due to insufficient fines. If part of the grading curve is above the upper limit, the water requirement is usually too high to maintain the maximum permissible w/c value of 0.95 in the concrete mixture.

Example

Sieve analysis of the grain classes 0/5 mm (sand) and 2/10 mm (coarse) and resulting grading curve of the two grain classes

sieve	percentage passing			resulting grading curve for	
	0/5	2/10		30% 0/5 + 70% 5/10	40% 0/5 + 60% 2/10
mm	wt-%	wt-%		wt-%	wt-%
0.075	0.8			0.2	0.3
0.15	7.6			2.3	3.0
0.3	26.4			7.9	10.6
0.6	55.9			16.8	22.4
1.18	82.4			24.7	33.0
2.36	94.1	2.5		30.0	39.1
5	97.2	24.5		46.3	53.6
10	100.0	98.3		98.8	99.0
14	100.0	100.0		100.0	100.0

The resulting grading curves are plotted in diagram 1.

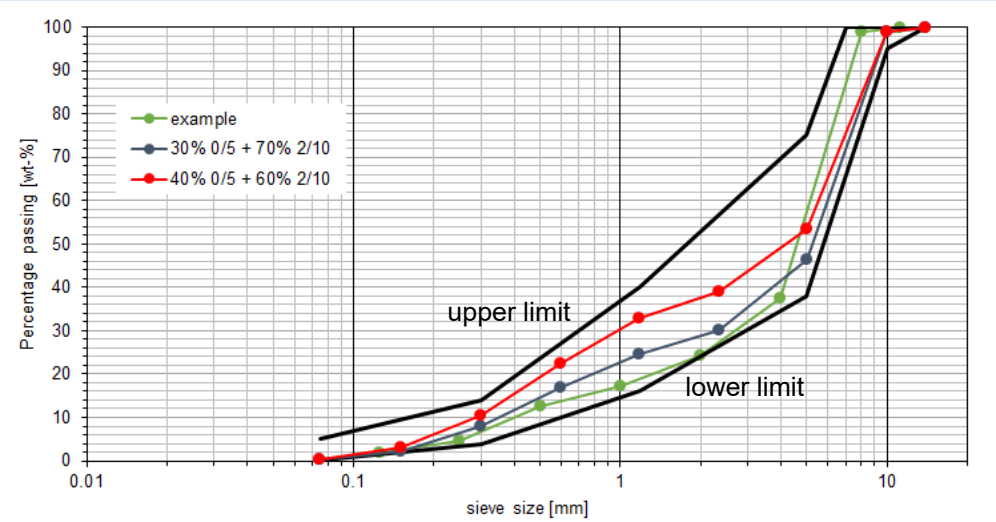

Diagram 1: Grading curve for 30% 0/5 + 70% 2/10 and 40% 0/5 + 60% 2/10; region with upper and lower limit for grading curves of the aggregates

2. Method: Tests with mixtures

If there are no sieve analyses results for the individual grain classes available, a suitable composition of the aggregates must be found using trial mixtures. It is recommended to start with an aggregate consisting of 30% sand fraction and 70% coarse fraction. The mixtures are carried out with a w/c of 0.9.

Mixtures with volumes of 16 dm³ should initially be produced. The exact composition for these mixtures can be found in the following chapter “Concrete mixture composition” or can be calculated in the excel file “TwistBlock Production.xlsx”.

Observe the consistency of the mix and after demoulding the surface of the TwistBlock. The consistency should lead to a filling time of one mould in the range of 1 to 1.5 minutes. In case there is a rough surface the amount of fine aggregates in the mix should be increased.

If there is some liquid water visible in the mix (bleeding) the w/c ratio should be reduced to 0.85.

Tip:

It is important to find a supplier who can provide the aggregates in sufficient quantities and of consistent quality. It might be helpful to ask in a concrete plant for suppliers of aggregates.

In the above shown example (Diagram 1) there are 2 possibilities for the grading curve lying within the lower and upper limits. It is 30% 0/5 + 70% 2/10 as well as 40% 0/5 and 60% 2/10. Now the mixture composition for both grading curves can be calculated and concrete mixtures have to be prepared and filled into the TwistBlock mould. After demoulding it will be seen how the surface of the TwistBlock looks like. The mixture resulting with a smooth TwistBlock surface is chosen. (see Chapter Demoulding the TwistBlock)

Concrete mixture composition

Adequate concrete strength for the TwistBlock can be achieved with a water-cement ratio (w/c) of 0.90 to a maximum of 0.95. The w/c value of 0.95 should not be exceeded. For a well-composed grading curve of the aggregates, a w/c value of 0.85 may also be possible.
The cement content is set at 220 kg/m³ of concrete.
The volume of the concrete mix for one TwistBlock is 8 litres (dm³).

The following mixture compositions are for the production of 2, 4 or 6 TwistBlocks with water-cement ratios (w/c) of 0.85, 0.90 and 0.95 (true density of aggregates: 2.73 kg/dm³). The calculation can be done with the excel-file TwistBlock Production.xlsx:

concrete mix design for 2 TwistBlocks (16 dm³)				
w/c		0.85	0.90	0.95
CEM II 42.5	kg	3.5	3.5	3.5
Aggregate	kg	31.1	30.6	30.1
total water	kg	3.0	3.2	3.3

concrete mix design for 4 TwistBlocks (33 dm³)				
w/c		0.85	0.90	0.95
CEM II 42.5	kg	7.3	7.3	7.3
Aggregate	kg	64.1	63.2	62.2
total water	kg	6.2	6.5	6.9

concrete mix design for 6 TwistBlocks (50 dm³)				
w/c		0.85	0.90	0.95
CEM II 42.5	kg	11.0	11.0	11.0
Aggregate	kg	97.2	95.7	94.2
total water	kg	9.4	9.9	10.5

Note: the mixture recipes for 4 and 6 TwistBlocks contain additional amounts of mixture volume to ensure that there is a sufficient amount of concrete available to fill all moulds.

In order to keep the w/c value constant, the moisture content of the fine aggregate (sand) must be taken into account and subtracted from the total water content of the mixture (see the following example and the chapter Moisture Determination of the sand and gauging water).

Example: Production of 4 TwistBlocks
Grading curve of the aggregate: 40% sand + 60% coarse; true density 2.73 kg/dm³
Moisture content of the sand: 5 wt-%
Mixture composition

concrete mixture for 4 TwistBlocks (33 dm³)				
w/c		0.85	0.90	0.95
CEM II 42.5	kg	7.3	7.3	7.3
sand (m_{sand})	kg	25.7	25.3	24.9
coarse	kg	38.5	37.9	37.3
total water	kg	6.2	6.5	6.9
water from moisture W	kg	1.2	1.1	1.1
gauging water	kg	5.0	5.4	5.8

Note: the water from moisture W is reduced of 0.5%. Thus W = m_{sand}*0.045! The reduction of 0.5% takes the core moisture of aggregates into account.

Slump of the concrete mixture

A grading curve of the aggregates lying inside the area between upper and lower limits ensures that it will result in a concrete mixture with a sufficient slump for the production of TwistBlocks with a water/cement ratio of 0.9 or in maximum of 0.95.

Superplasticiser

It might be of interest to use a superplasticiser for adjusting the slump of the concrete mixture. Be aware that it will increase the cost of a TwistBlock. Superplasticiser are water reducers with retardation effect. With superplasticisers a more plasticising slump can be achieved without higher or even lower water content in the mixture.

Usually the recommended dosage of superplasticisers is between 0.4% and 1.5% by weight of cement. Depending on the slump to be achieved it should be added in the range of 0.4% to a maximum of 1.0%.

When using a superplasticiser start with a trial mixture with w/c of 0.9 and 0.5% by weight of cement water reducer. For 1, 2, 4 and 6 TwistBlocks the following amount of superplasticiser for dosages of 0.5%, 0.75% and 1.0% have to be added:

	cement	Superplasticiser dosage		
		0.5%	0.75%	1.0%
	[kg]	[g]	[g]	[g]
1 TwistBlock	1.8	9.0	13.5	18.0
2 TwistBlocks	3.5	17.5	26.3	35.0
4 TwistBlocks	7.3	36.5	54.8	73.0
6 TwistBlocks	11.0	55.0	82.5	110.0

In general, for TwistBlock production a superplasticiser is not required when the grading curve of the aggregate is within the upper and lower limit as shown in diagram 1. The usage might be of interest if the slump of the concrete mixture with w/c of 0.9 is still quite stiff and the filling of the TwistBlock moulds takes more than 2 minutes. With the superplasticiser the filling time of a mould might be reduced to approx. 1 minute, which is the fastest possible filling time. The necessary dosage of superplasticiser must be determined by trial mixtures.

Mixing procedures

Tilting drum mixers with a capacity of up to 200 litres are well suited for producing a concrete mixture for TwistBlocks. There are basically 2 mixing procedures possible:

Method 1

1. Add water, 2. Add cement and mix until the cement is finely dispersed, 3. Add the aggregates (first coarse fraction, then fine fraction), 4. Mix until homogeneously mixed (approx. 2 to 3 minutes)

Method 2

1. Add aggregates and mix until homogeneously distributed, 2. Add cement and mix until homogeneously distributed, 3. Add water and mix until homogeneously mixed (approx. 2 to 3 minutes)

Which of the methods is most suitable for the respective mixer must be determined using a trial mixture. It is recommended making the same mixture recipe once using Method 1 and once using Method 2. After the end of mixing, the consistency of the mixture can be assessed. The method leading to a softer consistency is preferred.

Filling the TwistBlock mould

The filling of the TwistBlock mould is best performed with a hand shovel or a bucket and pouring the concrete into the mould. The mould has to stand on a vibrating plate which vibrates the concrete into the mould and compact the concrete. The mould if full when the concrete reaches the opening. Do not fill the opening of the mould completely, only up to the lower end of the “mouth”.
With the optimized slump of the concrete mixture (adjusting the grading curve of the aggregates) a filling time of about **1 minute** is reached. This is the fastest time for filling a mould.

Demoulding the TwistBlock

After demoulding the TwistBlock according to the mould’s instructions the surface is inspected. In figure 1 there is left a TwistBlock with a smooth surface and right with a rough surface. The rough surface indicates that there is too little amount of fine aggregates. Thus the fraction of the fine aggregate has to be increased.

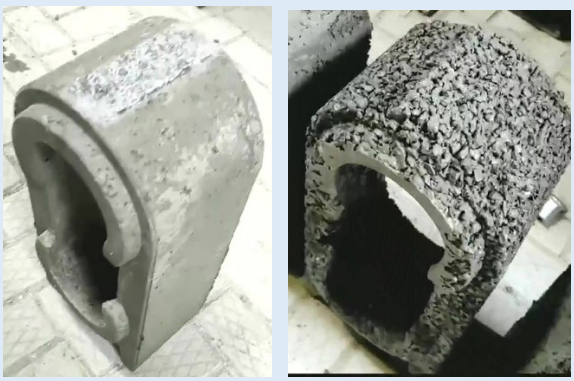

Figure 1: TwistBlock with left: smooth surface, right: rough surface

In the above example for an aggregate with fraction 0/5 mm and 2/10 mm the grading curve 30% 0/5 + 70% 2/10 has led to rough surface. Changing to 40% 0/5 + 60% 2/10 resolved the problem and led to a smooth surface.

There are **2 criteria** for the aggregate: 1. the grading curve has to be between the upper and lower limit, 2. the amount of fine fraction (sand) has to be high enough in order to get a smooth surface of the TwistBlock.

Curing and storage

After demoulding the TwistBlocks at the age of 1 day, they should be covered with a foil. Ideally, the TwistBlocks remain under foil until they are 6 or 7 days old.

The curing process could be like this:

The production of 2 days is stored under a foil. A total of 3 stacks of TwistBlocks are then made per week. After 3 days, water can be added to a stack to ensure constant humidity under the foil. After 7 days the 1. stack is brought to the storage area and a new stack started with the freshly demoulded TwistBlocks and so on.

In case the TwistBlocks are stored in a closed room after demoulding, a stack can be produced in such a way that the production of 2 to 3 days is always covered. The coverage should be kept until the upper most TwistBlocks reach an age of 7 days. After this the TwistBlocks can be brought to the storage area.

Final strength of material and TwistBlock

The final compressive strength of the TwistBlock concrete mix after 28 days of hardening is supposed to be no less than **20 N/mm²**. A standardized cube test at a certified laboratory should be done once every month to ensure this strength is maintained. Especially when reducing cement or adding water it can lead to lower strengths of the TwistBlock.

The overall compressive strength of the TwistBlock is supposed to be **~9 N/mm²** including the hollow space. It is measured by cutting off the extensions on top and applying a layer of gypsum on top and bottom before conducting a compression test. This test can be done once annually as it is assumed to maintain the same properties if the compressive strength of 20 N/mm² of the material is maintained.

Figure 2: TwistBlock preparation for overall compressive test. Left: cutting off of extensions; middle: application of gypsum; right: compression test

Moisture Determination of the sand and gauging water

1. Weighing:
   T....weight of the empty plate in [g] (Tare)
   A....weight of the plate plus the moist sand in [g] (use approx. 300 g of moist sand)
   B....weight of the plate and the dry sand in [g] (dry in a microwave oven for 10 min; weight and dry for further 2 minutes; weight and dry for further 2 minutes; and so on until the change of weight is less than 2 g)

Tare T	moist sand + T	dry sand + T
g	g	g

2. Calculating the moisture:

M = (A-B)/(A-T)*100 [%]	M
	%

3. Calculating the amount of water from moisture for subtraction from the total water:

$W = m_{Sand}*(M-0.5)/100$ [kg] m_{sand}...Weight of Sand in the mixture [kg]	W
	kg

4. Calculating the gauging water G:

G = total water - W [kg]	G
	kg