Concrete Building and Paving Blocks

Concrete building blocks are exclusively used for walling purposes in the building construction process. Building blocks have different properties than other masonry units and conventional concrete.

Concrete paving blocks are normally laid in close formation to form a structural layer capable of accommodating various traffic entities and imposed loads. The pavers need to be durable and attractive.

Both blocks and pavers are manufactured by similar machines using semi-dry concrete mixes.

Concrete building blocks need to adhere to standards regarding strength, thermal, acoustical, fire resistance and aesthetics.

Due to the manufacturing process concrete building blocks are generally less dense than normal concrete. Top quality concrete blocks will have the appropriate strength required for general construction purpose as well as having a good quality surface texture conducive to good bonding with mortar.

The physical standards concerning compressive strength, dimensional tolerances, drying shrinkage, moisture expansion and appearance is set out in SANS 1215.

Compressive Strength Derivatives

Compressive Strength = maximum load/gross area

- Hollow Blocks -3.5mpa
- Solid Blocks – 7mpa -21mpa
- Blocks with a compressive strength above 10mpa are generally solid.

Shrinkage

Shrinkage occurs due to a lack of moisture and carbonation and the maximum shrinkage factor is 0.06%. At the completion of the curing process blocks should be allowed to dry out and laid in a dry state thus reducing the risk of possible shrinkage in the wall during the construction process.

Moisture expansion with a maximum tolerance of 0.02% usually occurs when crushed clay brick, certain slag and clinker are used as an aggregate.

Criteria concerning tolerances, squareness, surface texture and appearance are dealt with by SANS 1215.

An important feature of concrete bricks and blocks is the close tolerances to which they can be manufactured i.e. fair face surfaces can be obtained on both faces of a wall.

The thickness of the block, concrete density and aggregate quality used will determine the acoustic, thermal and fire resistant properties of the block.

Concrete Paving Blocks

The same materials and machinery are normally used in the manufacturing of both concrete blocks and concrete pavers.

Various paver shapes

- Dentate

- Rectangular
- Square
- Curved

Denticulate Pavers are approximately 200-250mm long, 100-112mm wide and 50-80mm thick. Rectangular or square pavers in plan are normally a bit bigger.

Pavers are usually manufactured with a base of lower strength and a topping of greater strength and can be pigmented; this process reduces production cost and enhances work performance.

Efficiency in the topping process will be achieved by the application of proper production techniques, appropriate ingredients and prescribed concrete mixes.

SANS 1058 specification on concrete paving blocks deal with

- Physical requirements viz. strength and abrasion resistance
- Water absorption
- Dimensional tolerances
- Chamfers and appearance

Pavers are classified in two strengths known as “class of block”

Block shape specifications

- Type S-A: Geometrical interlock between all vertical faces of adjacent blocks
- Type S-B: Geometrical interlock between some vertical faces of adjacent blocks
- Type S-C: No geometrical interlock between vertical faces of adjacent blocks.

Manufacture

Prerequisites

- The fresh mix to have a dry crumbly consistency, however care should be taken that sufficient quantities of water be added without jeopardising the production process.
- The units are to be manufactured in moulds under high compressive forces using high frequency vibration and/or pressure
- The units are to be demoulded within seconds after compression and the shape to be maintained by the interaction between the aggregate, capillary forces and the surface tension.

Machine Operation

- The concrete to be poured into the multiple united moulds.
- The concrete will then be compressed with vibration and/or high frequency compression.
- The units are then ejected either onto a pallet or on a concrete slab known as an egg laying machine

Processes

The process can be broken up in 5 cycles with duration of 10-30seconds per cycle. Paver cycles are normally faster due to the large area and lower depth of the mould to be filled with concrete, vibrated and extrude.

Cycles

1. Concrete fed into mould

The concrete is poured into the feeder box which passes backwards and forward over the mould filling it. This however does not always render an even distribution as the outer sides and the end away from the supply of concrete receives less than the other parts, the outer parts may thus differ in density from the other parts, important properties of units may differ in a single drop. Circumspection should thus be exercised in the feed arrangement and units should be tested to determine the variance of products in the same mould. Weighing units and comparing results will thus be necessary.

Where pavers are to be topped the moulds must be filled with base concrete up to 5-10mm below the top of the mould and a feeder box containing the topping mix passes over the mould. Due to the large plan area of the paver moulds are filled with ease and speed.

2. Preparatory vibration

The loose concrete in the mould is compacted during the preliminary vibration. The duration of the vibration will determine the degree of compaction. The duration of the vibration can be a fraction of a second to 10 seconds, the longer the vibration period the more material needs to be fed into the mould. The uniformity and compatibility of the concrete fed into the mould will determine the uniformity of the initial compaction.

3. Second filling of the mould

In this process vibration brings the concrete flush with the mould, in the case of pavers a more accented pigmentation needs to be applied.

4. Compaction of concrete in the mould

The concrete is compacted under vibration and/or pressure when the tamper head comes into contact with the concrete. The accuracy of mould dimensions are reflected in the plan dimensions. The height is sensitive to the operation of the tampering head and the level to which it is allowed to fall; this is controlled to limit variance in height or the degree of compaction.

5. Mould Extrusion

The mould can be lifted whilst the tamper head remains static or the tamper head can force the units out while the mould remains static. Care needs to be exercised prohibiting the reactive movements of the tamper head and mould resulting in cracks and deformed units.

Fresh demoulded units are fragile and easily damaged. Pallet movement should therefore be even and regular to avoid racking and vibration movements.

Measures should ensure that the slab thickness on which the egg laying machine operates be of a nature that only a minimal proportion of vibration used to drop units is transmitted to other recently demoulded units.

If the depth of the tamper head is controlled at a certain height the height of the units will be accurate, but concrete densities will vary if the amount of concrete fill in the moulds differ.

The density of the concrete will be consistent if the height is controlled by the duration of the vibration, however the heights may be inconsistent.

Strength Development

Critical stages during strength development

Demoulding

The units are extruded from the mould within seconds of compaction and the hydration of the cement at this stage doesn't contribute to the unit strength. The strength of the unit is dependent on the interaction between the aggregate particles, capillary forces and surface tension hence the rather dry mixes used.

Depalletising

Stresses in handling units with inadequate strength may result in breakage.

Delivery

SANS 1215 (concrete masonry units) and SANS 1058 (concrete paving blocks) deals with the prerequisite strength of units on delivery.

Water content

Aggregate characteristics, mix proportions and type and operation of the block machine will determine the water volume added to the mix. As much water should be used without causing production problems, slump and distort to units at extrusion of the moulds.

Compaction in dry mixes tends to be problematic due to the high internal friction and resistance to movement, consequently producing units of high porosity, low green strength and low compressive strength. Wet mixes have a tendency to stick to the moulds, be difficult to extrude and sticking to the tamper head. Wet mixes produced by egg laying machines tend to stick to the surface they are laid on, thence breaking at removal.

The final adjustment and control of the water content is done by eye and is normally 6 and 9% of the mass of the green unit.

A method to the determine the water content of the mix is to take a handful of the mix and rub it with a 16mm diameter smooth steel bar, if the concrete shows water sheen and moisture ripple marks , the moisture content is almost perfect, water sheen should also be evident on the vertical sides of the unit during extrusion.

A too dry mix will occur when the fine contents of the mix is too high, causing the mix to be viscous before the optimum moisture content is reached. Adjust the aggregate grading the mix proportions until the viscosity is eliminated, this is of utmost importance in the manufacture of high strength units where increased cement content contributes to the high viscosity in the mix.

Mix ratio

Quality factors

- Combination of aggregates
- Ratio of blended aggregate to cement

- Size and shape of the mould
- Thickness of the shell and web of hollow masonry units
- Amount of water
- Duration of mix
- Compaction capabilities of the machine
- Degree and extent of curing

The proportions of a final mix cannot be determined by theory or by virtue of laboratory tests. Intensive studies on actual production need to be conducted to assess all the variables affecting the unit quality; however samples of aggregate should be tested in an accredited laboratory for analysis on their physical and chemical attributes.

The cement aggregate ratio for masonry units may vary from 5-20%.

Cement paving blocks (class 2) have a cement aggregate ratio of 14-18% with a topping mix ratio of 18-23%.

With the application of pigmentation the final choice of the pigment and dosage thereof will be determined by a visual examination of dry concrete in which the pigment has been implemented. Pigment dosage ratio of pigment by mass of cement is from 3-5% to a maximum of 9%.

Admixtures used to improve the properties of the fresh and hardened concrete should be done strictly to the supplier's advice. The final decision will rest with on the result of trial mixes and cost comparisons.

Aggregate Assessment

Having determined the base properties of the aggregate viz. consolidated bulk, loose bulk, and relative density and grading an initial estimate is then conducted of the likely blend of aggregates.

The initial estimate will be based on the following factors:

1. Minimum voids of the aggregate blend, information gathered from laboratory tests of the consolidated bulk density of the blend from which the solid content, and thus the voids are calculated. The void content of a blend reflects all the vital characteristics of aggregates viz. particles, shape, grading and surface texture, which affects the aggregates performance in concrete. A concrete mix based on minimum voids in the aggregate's performance in concrete.

2. Reference to grading limits take into account the particle size distribution only, not describing particle shape and surface texture which are important characteristics in assessing aggregates for semi-dry concrete. Refer to table 1-"grading limits".

3. The maximum aggregate size for the topping mix for pavers will depend on the required finish it will normally vary from 3.5mm to 4.75mm.

4. Reference to fineness modulus. An estimate of the initial blend is based on target fineness modulus, 3.7 for coarse textured solid masonry and paving units and 2.8 for fine textured hollow units. A check on the blend for materials the 0.300-, 0.150- and 0.075mm sieves is made and the blend adjusted.

5. **Reference to arbitrary proportions of various fractions of coarse, medium and fine materials. A brief classification of these fractions are**

   - **Coarse (chips 9.5 or 6.7mm) 25-40%**
   - **Medium (coarse river sand) 35-70%**
   - **Fine (plaster or building sand) 5-20**

   Weighing the unit while green will provide an indication of its quality. Heavier units will indicate denser compaction and are usually stronger.

   Surface texture of the units should be noted for each blend. Should the texture be to smooth, some fines should be removed from the blend, should the texture be to rough more fines should be added.

Curing

The production process and equipment will largely determine the type and extent of the curing. The curing can be effected by low-pressure steam curing in special curing chambers or no curing at all. Curing assists units to gain strength faster ultimately gaining greater strength. Green units should be protected as soon as possible from drying out. If there is no risk of units being damaged by a specific curing process, curing should start immediately. There is a delay of between 3-4 hours in the steam curing process before steam is introduced. Please note that temperatures of above 65 degrees Celsius are not advisable.

Efflorescence can be caused by mist spraying. For the same reason water curing of coloured units is not recommended, however units should not be allowed to dry out as this may have the same effect. Plastic shrink wrapping prevents units in wrapped cubes from drying out. The type and extent of curing affects unit colours, better curing resulting in lighter colours. Curing of the topping mix of pavers is vital to ensure high resistance to abrasion.

Table 1: Grading Limits

Sieve Size (mm)	Percentage Passing			
	Normal Units	Target grading split face masonry units texture		
		Coarse	Medium	Fine
19.0	100			
13.2	90-100			
9.5	75-100	100	100	
4.75	60-85	80	95	100
2.36	40-65	60	85	95
0.300	10-25	15	25	35
0.150	5-15	4	15	15

0.075	**2-10**			
Fineness Modulus	**3.2-4.2**	**3.65**	**2.75**	**2.5**

References

1. **Fulton's Concrete Technology, Cairns, J, et.al**
2. **SANS 1215: 2008, SABS 2008**
3. **SANS 1058: 2008, SABS 2008**