Concrete Blocks and Pavers Mix Design and Manufacturing

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1. Masonry
1.1 History of Masonry

The history of block making goes right back to the Stone Age, when man used the rubble (undressed stones) for building walls. Later on with the passage of time, man learnt the art of dressing stone and buildings with course rubble masonry walls came into existence. There are several old structures which stood the test of time and are still standing tall. The noted structures built with different types of stones are e.g. ‘The Great China Wall’, ‘Red Fort New Delhi ’Hawa Mahal Jaipur’ and numerous other forts, temples etc built several hundred years ago. The above examples prove that life of structure constructed with stone masonry in comparison to any other material is much higher.
Red Fort  Delhi

The Great China Wall

Hawa Mahal Jaipur
1.2 Brick Masonry

Only some time later the art of making clay bricks was invented. In our country bricks were found already in remains of old structures in Mohenjodaro & Harappa civilizations (now in Pakistan). Both bricks and stone masonry coexist till today. Both of them have some advantages and disadvantages.

Stone masonry has high durability and can be used in monumental buildings if course rubble (stone) is used. The main drawback is that the work progress is very slow as it takes a lot of time to dress the stone. Also due to its high density (heavy weight), the stone masonry is difficult to handle. The stone masonry nowadays has become a costly affair because of lack of skilled labour and hence high labour cost. In spite of stone being abundantly available, this type of masonry is becoming obsolete.

In comparison, bricks have certain advantages:
1) Light weight and hence easy to handle
2) Faster speed of construction.
3) They can be plastered and hence walls have smooth finish
4) Good thermal insulation characteristics.

The main drawback with clay bricks is consumption of top soil layer for their manufacturing. (As we know formation of soil involves lengthy geological process which takes thousands of years to form an inch of layer of soil). Another drawback is that a lot of heat is required for autoclaving the bricks, which results in carbon dioxide emissions and pollution.

To eliminate the mentioned drawbacks, it was necessary to look for another type of material. Such a material was found in concrete block masonry.
2. Concrete Blocks

There are two types of concrete blocks

Fig 1 Solid and Hollow concrete blocks

1) Regular concrete blocks
2) Hollow concrete blocks

2.1 Regular Concrete Blocks

They can be further classified into two types
1) Solid concrete blocks
2) Hollow concrete blocks

2.1.1. Solid Concrete Blocks

They are available in various sizes as per IS-2185 2005[PART I]
400x200x150 or 600x200x100 etc. They can be used as load bearing or partition blocks walls. As per IS 2185, the following physical parameters are required for solid concrete blocks

a) Compressive strength after 28 days—4 Mpa to 5 Mpa

b) Water absorption by percentage of mass should be less than 10%
c) Drying shrinkage should not be more than 0.06%.
d) Moisture movement of dried blocks after immersion in water should not be more than 0.09%.

Apart from this when blocks are to be used for external walls, special care should be taken so that blocks would be free from chips, cracks or other imperfections. They should be with proper and uniform finish.

**Mix Design**

Mix design mainly depends on the strength required & quality of material available. The main ingredients in manufacturing solid concrete blocks are:

1) Cement
2) Fly ash
3) Crushed sand (0-3mm)
4) Aggregates (5-10mm)

Typical mix design for solid concrete blocks is given below,

Mix design for block grade –7.5 Mpa (target strength)

<table>
<thead>
<tr>
<th>Material</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>O.P.C:</td>
<td>100 kg</td>
</tr>
<tr>
<td>Fly ash:</td>
<td>40kg</td>
</tr>
<tr>
<td>Aggregates (10mm)</td>
<td>250 kg</td>
</tr>
<tr>
<td>Crushed stone</td>
<td></td>
</tr>
<tr>
<td>Dust (0-3mm):</td>
<td>1000kg</td>
</tr>
<tr>
<td>Water:</td>
<td>42kg (excluding water absorption corrections)</td>
</tr>
</tbody>
</table>

It may be noted that the aggregate quantity (10mm) in above mix should be minimum 200 kg to acquire desired strength. The amount depends a lot on quality of crushed sand i.e. fineness of crushed sand available. If crushed sand available does not have suitable fineness, it can be partially replaced by fly ash upto 20 percent as per IS-2185-2005 PART- I for proper blending. For this purpose fly ash conforming to IS-3812-Part-II can be used. The water cement ratio for precast blocks is very low from 0.32 to 0.28

**Testing of Blocks**

Procedure of testing of solid blocks is mentioned in IS 2185-2005 part I.

### 2.1.2 Hollow Concrete Blocks

They are also available in same external dimensions as solid concrete blocks as per IS-2185-2005 Part –I. 90x190x390, 125x190x390, 140x190x390. There are two cavities in these types of blocks; the size of cavity depending upon size of blocks. The strength requirement for hollow blocks is obviously higher than that for solid blocks. As per IS-2185-2005. The strength requirement of various grades of hollow blocks vary from 3.5 mpa to 15 mpa as per usage, depending on height of the wall, load on the wall etc.
Mix design for hollow blocks also depends on the required strength and quality of material available. Here is a typical mix design for concrete blocks Grade A. 12.5mpa for density above 1800/m3.

Batch size is 0.5m3

<table>
<thead>
<tr>
<th>Material</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>O.P.C</td>
<td>125kg</td>
</tr>
<tr>
<td>Fly ash</td>
<td>40kg</td>
</tr>
<tr>
<td>Metal</td>
<td>200kg</td>
</tr>
<tr>
<td>Crushed sand</td>
<td>750kg</td>
</tr>
<tr>
<td>Water</td>
<td>42kg (excluding correction for water absorption)</td>
</tr>
</tbody>
</table>

It may be noted that for hollow concrete blocks the quality of material required must be much finer compared to solid concrete blocks, hence it is advisable to use more fly ash for proper blending of fines (gradation). The required finish must also be much better than that of solid blocks. For high rise buildings hollow blocks of higher grades are usually used.

### 2.2 Equipment Used for Blocks Manufacturing:

There are various types of equipment used in manufacturing of concrete blocks. The main machines used are as follows.

1. Simple manually operated modular machines
2. Block making machines with inbuilt table vibrator, without mixer
3. Block making machines with inbuilt table vibrator and mixer
4. Semi automatic machines
5. Fully automatic machines

The machines of first three types are normally used by small scale manufacturers and for big projects where blocks are manufactured at site. Two main problems with these machines is a lack of consistency in test results and finish. Many times, blocks do not have uniform finish due to improper mixing and insufficient vibration. One thing must be noted: for block manufacturing pan mixer or ribbon mixer should be preferred over drum mixer. Another problem with these machines is higher cement consumption. Therefore these machines are used only to manufacture block grades up to 7.5 Mpa.

#### 2.2.1 Semi-automatic machines:

There are many different models for different purposes. These semi automatic machines have equipment similar to ready mix concrete plants with mixing capacity 0.5m3 to 0.75m3. They apply heavy vibrations to blocks and ensure uniform finish as well as strength and can be used in manufacturing of masonry blocks as well paver blocks. Concrete blocks of higher grade up to M15 and pavers up to M45 can be manufactured. They are mainly used by large block and paver block making units, approximate concrete making capacity around 300m3 to 400m3 per day.
2.2.2: Fully automatic machines:

These machines are the latest fully automatic machines manufactured by most modern techniques. They consist of entire series of operations from mixing of raw materials to stacking of ready materials with minimum human interference. These machines can manufacture concrete blocks as well as paver blocks of various grades. Concrete blocks up to M15 grade and paver blocks up to M50 grade can be manufactured. They apply extreme vibrations to blocks and therefore are able to make concrete blocks at lower w/c ratio resulting in lower binder content as compared to any other machines.

These machines are mainly used by very large plants manufacturing pavers as well as concrete blocks.
2.3 Paver blocks

Today the paver blocks are widely used in pavement works especially for road junctions, foot paths and parking areas where frequent excavations for maintenance works is to be carried out. Due to their unique feature of interlocking they can be easily removed and fixed again without any damage. They are also suitable for places where immediate pavement work is to be done. They can be fitted overnight and traffic can start on the following day.

The Bureau of Indian Standards have recently published standard for pavers IS-15658-2006. For Heavy Duty Road Pavements, pavers of minimum M40 TO M50 grade are required. Pavers are now categorized into two types

1) Decorative light pavers
2) Heavy duty pavers

2.1:- Decorative pavers:-

These are used for the purposes where there is no heavy traffic, especially on foot paths, parking areas & porch areas etc. They consist of two layers: one grey base layer and top layer which is usually manufactured with white cement and colour pigment in it. They can be manufactured on automatic or semi automatic hydraulic press machines. Minimum strength requirement for these types of paver blocks varies from 200kg/cm2 to 300kg/cm2. Their manufacturing process is quite similar to cement tiles manufacturing process.

2.2:- Heavy duty pavers:-
These are used for road pavements with heavy to very heavy traffic movement. Normally they are designed for grades from 400 to 500 kg/cm² depending on location where they are to be used. These pavers can only be manufactured on semiautomatic or fully automatic machines as the other light machines are unable to achieve consistent strength due to the low degree of vibration. That is the reason why they can be manufactured only in big plants. It is very difficult to achieve these strengths with consistency, but if strict quality control is maintained these grades can be achieved.

Typical mix design for M40 grade pavers for Columbia machine 0.5m³ batch.

<table>
<thead>
<tr>
<th>Material</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>O.P.C</td>
<td>200kg</td>
</tr>
<tr>
<td>Fly ash</td>
<td>40kg</td>
</tr>
<tr>
<td>Crushed sand-(0-3mm)</td>
<td>650kg</td>
</tr>
<tr>
<td>Metal (3-5mm)</td>
<td>150kg</td>
</tr>
</tbody>
</table>

The above mix design has to be suitably modified after observing the type of raw material available. It is very difficult to procure consistent quality material and hence it requires experienced employees in the relevant field to look after parameters of mix design.

One point is to be noted for all pre-cast elements: adequate arrangements of curing have to be made. Preferably immerse curing should be done and if not possible all the blocks should be stacked strictly in shed where sprinkle curing is to be done. It should be ensured that each and every block is cured. If curing is not done in a proper manner, blocks may not gain the required strength. Moreover, test results are inconsistent.

3. **Cellular light weight concrete blocks (CLC)**

1. Autoclaved aerated concrete blocks
2. Non Auto-claved aerated concrete blocks.

3.1 Autoclaved aerated concrete blocks.
A good example of available autoclaved aerated concrete blocks:

3.1.1 Siporex blocks (Swedish Ytong technology)
When this method is used concrete is aerated by using alumina powder and foaming agent due to which density of concrete is reduced by one fourth of the original density. The average density of these blocks is in range of 600—700 kg/m³.
3.1.2. Advantages of Autoclaved Aerated Concrete Blocks.

1. Due to high temperature and high pressure blocks are cured in a short time and can be delivered within 24 hours after casting
2. The compressive strength is enhanced by 10-20% on average
3. The surface is made rough adequately so that they have good bond with mortar - durable plaster
4. Provide effective thermal insulation
5. Reduced shrinkage

Typical mix design for light weight blocks

<table>
<thead>
<tr>
<th>Material</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>OPC</td>
<td>8%</td>
</tr>
<tr>
<td>Fly ash</td>
<td>30%</td>
</tr>
<tr>
<td>Silicious clay</td>
<td>60-62%</td>
</tr>
<tr>
<td>Foaming agent.</td>
<td></td>
</tr>
</tbody>
</table>

Above values are for total volume of mix.

3.2 Non Autoclaved aerated concrete blocks.

The manufacturing process of this type of blocks is very simple and requires quite a small set up as compared to autoclaved aerated concrete blocks. The process involves mixing of concrete along with suitable foaming agent and casting. Following curing is done by conventional methods.

Advantages of non autoclaved light weight blocks
1. Require smaller set up, hence small units can manufacture these types of blocks
2. Low cost of manufacturing hence available at cheaper rates as compared to autoclaved blocks
3. They are suitable for partition walls

Drawbacks of non autoclaved aerated concrete blocks

1. Require more time for curing and delivery time is delayed
2. Density is high as compared to autoclaved aerated blocks.
3. Low compaction strength
4. High moisture movement hence not suitable for external walls
5. Smooth external surface hence weaker bond with mortar so difficult to plaster
Futuristic wishes

1. Light weight concrete as well as blocks with high compressive strength
2. Low water absorption
3. Low moisture movement
4. High volume fly ash mixes
5. Rapid manufacturing process

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