7.0 Guidelines for Manufacturing Quality Fly Ash Lime-Gypsum / Cement Bricks

In NTPC, Fly ash- lime / gypsum/ cement bricks are being manufactured in large quantity at its all coal based stations using Vibro / Hydraulic press machines. These bricks are being manufactured for in house construction works. The bricks are being manufactured using lime gypsum as well using cement and cement & gypsum also. The guidelines have been prepared based on the many years experience gained in manufacturing bricks. These guidelines can be followed by fly ash brick manufacturing units and also by the prospective fly ash brick manufactures for producing fly ash bricks of consistent quality conforming to IS: 12894 : 2002

The quality of the fly ash bricks produced depends on the following factors:

1. Quality of raw materials
2. Proportioning of raw materials
3. Handling and mixing of raw materials
4. Handling & pressing of the mix
5. Curing period

7.1 QUALITY OF RAW MATERIALS

7.1.1 Fly Ash

For production of good quality Fly Ash Bricks (FAB), fly ash should conform to its chemical and physical requirements specified in IS:3812 Part 1- 2003. It has been experience that fly ash collected from 1st & 2nd field of ESP's generally meet the quality requirement specified in above Indian Standard. Pond ash /Mound ash, if it is mixture of bottom ash and fly ash, should not be used for making Fly Ash Brick. This type of pond ash is comparatively less lime reactive than fly ash and also it will not have uniform reactivity and therefore, affect the Fly Ash Brick quality. The pond /Mound ash in which bottom ash is not mixed, can be used for making Fly Ash Brick after testing and making trial. Fly ash should be stored either in bags or in silos or in covered bins to avoid fugitive dust emission. Fly ash is transported from thermal power station to the Fly Ash Brick factory areas either by closed tankers or trucks / trolleys covered with tarpaulin or in bagged condition.
7.1.2 Sand / stone dust:

The locally available sand/stone dust which is used for concreting works can be used for making Fly Ash Brick. IS: 383 : 1970 specify the requirement for the sand to be used for cement concrete and mortar work. Very fine quality of sand / stone dust should be avoided as it increases the cement/ lime requirement for obtaining required strength. In sand/stone dust the deleterious materials such as clay lumps, silt, coal particles shall not be more than 5%. This can be judged by doing field test with the help of measuring cylinder with water for every truck load of sand/stone dust. Sand/ stone dust should be stored in bins which can be covered with tarpaulin during rain to protect from increasing the moisture content.

7.1.3 Hydrated Lime/ Sludge lime

Hydrated lime is used for Fly Ash Brick making should conform to class C grade as specified in IS: 712 : 1984. The CaO purity in the lime should not be less than 85% which can be ascertained by testing and as well as taking test certificate from the lime suppliers. The lime should be stored in bags or silos or in covered bins as it has tendency to react with CO₂ present in the air in presence of moisture and produces CaCO₂ which does not have biding properties and spoils the quality of lime to be used for Fly Ash Bricks.

Sludge lime which is a by-product of acetylene gas plant can also be used with few precautions as CaO content in this type of lime varies between 25 - 50% and is available in wet condition having lumps. Therefore, each lot of sludge lime should be tested for CaO content and accordingly its quantity in raw material mix should be adjusted. The testing for hydrated / sludge lime should be carried out as per testing method specified in IS: 1514:1990 method of sampling and testing of quick lime and hydrated lime.

7.1.4 Gypsum

Chemical or mineral gypsum can be used for making Fly Ash Brick. The gypsum should be free of lumps and having purity to the about 60%. If lumps are found, same should be removed by screening and remainder over the screen can be crushed and re-screened before it is used for making bricks. The purity of gypsum can be tested by the testing method specified in IS: 1288 : 1982. Mineral gypsum generally has less purity compared to chemical gypsum, therefore, in such case the percentage of gypsum in the mix should be adjusted to obtain desired quality of finished bricks. Gypsum should also be stored in bins with cover or in bags.
7.1.5 Cement

Ordinary Portland cement of 43/53 grade can be used in place of lime and gypsum. Since it is a factory finished product and thus generally does not require any testing.

7.2 Raw Material Proportion

Proportioning of raw materials is an important aspect for making of desired quality of Fly Ash Brick. The proportioning will depend on the quality of the raw materials and the compressive strength & water quality of brick required. The following mix proportion can be adopted for manufacture of Fly Ash Brick.

Fly ash, sand, sludge lime and gypsum bricks.

- Fly ash: 55-60%
- Sand/Stone dust: 20-25%
- Sludge lime: 15-20%
- Gypsum: 5%

Fly ash, sand, hydrated lime and gypsum bricks

- Fly ash: 60-65%
- Sand/Stone dust: 18-27%
- Hydrated lime: 8-12%
- Gypsum: 5%

Fly ash, sand and cement bricks

- Fly ash: 50-60%
- Sand/Stone dust: 32-40%
- Cement: 8-10%

About 1% gypsum can also be mixed by reducing same percentage in sand / stone dust in this proportion.

The strength of FAB produced with the above proportions is generally of the order of 7.5 to 10.0 N/mm² at 28 days. Mix proportion as suggested above can be used as guidelines. The exact mix proportion may be finalized by trial mixes to produce good quality Fly Ash Brick of required compressive strength.
7.3 Batching

The raw materials are brought by wheel barrows/pull carts or by mechanized means to the mixers. Weigh batching of all raw materials is ideally suited for the large capacity Fly Ash Brick plants. It can be also by volume batching through calibrated wooden/steel boxes. Name of material to be measured by these boxes should be written in Hindi/English & local language so that it will be known to the workers and mistakes will be avoided. Measurement of the raw materials should not be done by Baskets/Tokaris.

7.4 Mixing

Pan mixer of adequate capacity should be used for thorough mixing of all ingredients. The pan mixer also helps to break lumps in lime / gypsum during the mixing. When sludge lime and gypsum are used as binding material, first sludge lime and gypsum (in measured quantity) is wet ground in a pan mixer with some water till the mix becomes a paste without lumps. Sand/ Stone dust and fly ash shall then be added along with required quantity of water and mixing/grinding shall be continued at least for about 3 to 5 minutes so as to get homogeneous mix of uniformity in colour.

In case hydrated lime and gypsum, the required quantity of sand/stone dust, fly ash, hydrated lime and gypsum are initially dry mixed and then required quantity of water is added to get homogeneous mix. The same procedure can be adopted when cement is used as binding material in place of hydrated lime and gypsum.

The total quantity of raw materials proposed to be loaded in the pan mixer for each mix should not exceed the rated capacity of the mixer. Small lumps of lime, if left in the mix, starts hydrating later after the curing period are over and causes cracks to the brick structure, thus weakening even those bricks which have passed the compressive strength test conducted just after curing period is over.

7.5 Molding of bricks

The semi dry homogeneous mix is fed into vibro / hydraulic press manually or through conveyer belt to mould it into brick shape. The molded bricks are kept in wooden / steel pallets and taken to stacking area for air drying. Following precautions should be taken during molding/stacking:

i) Water content should be kept at optimum level especially while using vibro press.
ii) Green bricks should not be stacked one above the other in case vibro press is used and not more than four layers in case hydraulic press is used.

iii) The pallets should be strong enough to carry the stack of green bricks without sagging.

Green bricks shall be air dried for 1-2 days. Thereafter, air dried bricks should be water cured for a minimum period of 15-20 days. Curing is carried out by sprinkling water manually or by any other means. It is recommended that the curing period may be extended during cold/wet weather.

### 7.6 Quality Requirements

#### 7.6.1 Wet Compressive strength

Minimum average wet compressive strength of brick shall not be less than 7.5 N/mm² when tested as per IS:3495 (Part-I) : 1976. The compressive strength of any individual brick shall not fall below the minimum average compressive strength by more than 20%. In case any test result of compressive strength exceed 10.0 N/mm² the same be limited to 10.0 N/mm² for the purpose of averaging.

#### 7.6.2 Water absorption

The bricks when tested in accordance with the procedure laid down in IS:3495 (Part-2) - 1976 after immersion in cold water for 24 hours, shall have water absorption not more than 20%.

#### 7.6.3 Drying Shrinkage

The average drying shrinkage of the bricks, when tested by the method described in IS - 4139 - 1989 being the average of three units, shall not exceed 0.15 percent.

#### 7.6.4 Sampling and Criteria for Conformity

Sampling and criteria for conformity of the bricks shall be as given in IS:5454 - 1976.

Tests for wet compressive strength & water absorption shall be carried out on the brick samples of everyday production. The other tests shall be carried out when the source of raw material is changed. The wet compressive strength and water absorption for various classes of bricks have been specified in IS:12894- specification for Pulverized Fuel ash Lime Bricks 2002 and tabulated below:
<table>
<thead>
<tr>
<th>Class Designation</th>
<th>Size of Bricks (l x w x h in mm)</th>
<th>Wet compressive strength not less than (N/mm²)</th>
<th>Water Absorption (Percent by mass)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.0</td>
<td>For modular size (190 x90x90 or 190x90x40)</td>
<td>5.0</td>
<td>20</td>
</tr>
<tr>
<td>7.5</td>
<td>Non-Modular size 230x110x70 or 230x110x30</td>
<td>7.5</td>
<td>20</td>
</tr>
<tr>
<td>10.0</td>
<td>Non-Modular size 230x110x70 or 230x110x30</td>
<td>10.0</td>
<td>20</td>
</tr>
<tr>
<td>12.5</td>
<td>Non-Modular size 230x110x70 or 230x110x30</td>
<td>12.5</td>
<td>20</td>
</tr>
<tr>
<td>15.0</td>
<td>Non-Modular size 230x110x70 or 230x110x30</td>
<td>15.0</td>
<td>15</td>
</tr>
</tbody>
</table>

In order to carry out all the tests for raw materials and the quality of ash bricks produced, it is suggested to have an independent laboratory having all the testing equipments, attached with the brick making units to ensure regular production of quality bricks.