6.0
GUIDELINES FOR
MANUFACTURING QUALITY
FLY ASH BRICKS
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In order to promote ash utilization in thermal power plants, NTPC has established pilot ash brick making plants at its 13 thermal power generating stations viz, Singrauli, Korba, Ramagundam, Badarpur, Dadri, Vindhyachal, Rihand, Talcher-Thermal, Talcher-Kaniha, Kahalgaon, Farakka, Unchahar, Tanda. About 150 million ash bricks have been manufactured in these pilot plants and used for various in-house consumption. All these pilot plants use processes similar to FAL-G technology by using fly ash, Cement/lime and gypsum to manufacture ash bricks. These bricks are water cured, thus avoiding the need of firing or steam curing of the bricks.

These guidelines have been prepared based on the inputs provided by various NTPC plants on their experience gained in running the pilot plants. Since all the pilot plants use processes similar to FAL-G Technology, the guidelines are applicable to only such processes. These guidelines can be uniformly followed by all ash brick manufacturing units so as to produce ash bricks of consistent quality conforming to IS : 12894.

6.1 PROCESS

The manufacturing process of Fal-G bricks requires fly ash, sand/stone dust, lime and gypsum to be mixed in a suitable proportion. Lime and Gypsum are first ground in pan-mixture with optimum water. Ash and sand/stone dust are then added into the pan-mixture to form a uniform mixture. When cement is used in place of Lime and Gypsum, first fly ash and sand/stone dust is mixed in pan-mixture and then cement is added into pan-mixture to have uniform dry mixture Water is added into the pan-mixture once the uniform dry mixture of fly ash, sand/stone dust and cement is achieved. The mixture is then transferred to the moulding machine. In the moulding machine, the FAL-G mixture is either hydraulically pressed or compacted through vibratory press. Once the bricks are taken out of the mould, they are air dried for about 1-2 days. Water curing is then done for about 14 days to allow required strength to be achieved.
It has been observed that at some places where the availability of lime is not there or the cost of lime is too high, sludge lime or cement is found to be a suitable replacement for lime, considering the easy availability of the same.

6.2 QUALITY OF BRICKS

The quality of the bricks produced by this process 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

The procedures being followed, difficulties encountered, and recommended procedure (as shown in bold letters) in each of the above aspects are elaborated below:

6.3 QUALITY OF RAW MATERIALS

6.3.1 Ash

NTPC pilot brick plants use dry fly ash collected from 1st or 2nd fields of ESP’s. Generally fly ash collected from 1st & 2nd field of ESP’s meet the requirement of Grade 2 of IS : 3812. As per the information collected, the minor variations in quality of dry ash & pond ash does not affect the quality of the brick significantly. Based on the above observations, the following is recommended for ash required for brick making:

Fly ash should preferably be collected from 1st/2nd field of ESP.

6.3.2 Sand/Stone dust

All plants use locally available sand/stone dust which is used for concreting works. The following practice generally followed by most of the plants is recommended.
Deleterious materials such as clay and silt in sand/stone dust shall not be more than 5%. Field test with the help of measuring cylinder to ascertain percentage of deleterious materials/silt content should be carried for every truck load of sand/stone dust.

6.3.3 Lime

Most of the NTPC pilot plants had used sludge lime, available as a waste from acetylene industries since hydrated lime confirming to IS : 712 is much costlier compared to sludge lime. Use of sludge lime also gives good quality bricks. However following problems have been noticed while using sludge lime.

i) The sludge lime contains extraneous materials.
ii) It is generally wet.
iii) It contains lumps.
iv) It is difficult to know the % of available lime (as CaO).

Based on the experience of sites, the following is recommended for use of good quality sludge lime.

i) Sludge lime/hydrated lime proposed to be used during the week should be tested for Calcium Oxide contents as per Clause-9 (Determination of available lime as CaO) of IS-1514.

ii) Sludge lime shall be free of extraneous materials, lumps etc. to the extent possible.

6.3.4 Gypsum

Based on the feed back from sites the following recommendation are made for use of Gypsum in ash brick making.

i) Gypsum should be free of lumps. Lumps, if any, should be screened and remainder over the screen should be crushed and re-screened before use.

ii) Gypsum should be tested for its purity as per IS 1288-1982. Its purity should be above 80%. However, in case of variation in purity, percentage of Gypsum in the mix should be adjusted to obtain desired quality of finished bricks.
6.3.5 Cement

Many pilot plants faced difficulty in regular supply of consistent quality sludge lime. Some NTPC projects have switched over to cement as the binding materials in place of sludge lime. When cement is used, use of gypsum can be avoided.

Ordinary Portland cement conforming to IS-269, IS-8112 or IS-12269 (latest revision) should be used.

6.4 STORAGE

All raw materials should be stored in covered sheds and suitably protected from the rains.

6.5 PROPORTIONING OF RAW MATERIALS

Proportioning of raw materials in an important aspect of ensuring quality of ash bricks. The proportioning will depend on the quality of the raw materials and the class of brick required. The following mix proportion is being adopted by various sites.

1. For fly ash, sand, sludge lime and gypsum bricks.
   Fly ash 55-60%
   Sand/Stone dust 20-25%
   Sludge lime 15-20%
   Gypsum 5%

2. For fly ash, sand, hydrated lime and gypsum bricks.
   Fly ash 60-65%
   Sand/Stone dust 18-27%
   Hydrated lime 8-12%
   Gypsum 5%

3. For fly ash, sand and cement bricks
   Fly ash 50-60%
   Sand/Stone dust 32-40%
   Cement 8-10%
The strength of bricks manufactured with the above proportion is generally of the order of 7.5 to 10.0 N/sq.mm after 28 days.

Mix proportion as suggested above can be used as guide lines. Mix proportion largely depends upon characteristics and quality of raw materials used. Based on the qualities of raw materials, the exact mix proportion may be finalized by trial mixes to produce good quality bricks of required compressive strength.

The characteristics of raw materials vis-s-vis mix proportion finalized after trial mixes should be suitably tabulated for future use.

6.6 HANDLING & MIXING OF RAW MATERIALS

Fly ash is transported from ESPs to the storage areas either by trucks/trolleys either in loose or in bagged condition. Transporting in loose condition causes dust nuisance. The raw materials are brought by wheel barrows/pull carts to the mixers. Mixing of raw materials are done in pan mixture. Required amount of water is added in the mixer. The raw materials are mixed in the pan mixture for about 3 to 5 minutes.

Small lumps of limes, if left in the mix, starts hydrating later after the curing period is 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.

Taking into account the experiences of various sites, the following guidelines are recommended.

6.6.1 Batching

Weigh batching of all raw materials is ideally suited for the process. Considering the practical difficulties, it is also permitted to use volume batching for sludge lime, sand/stone dust and fly ash.

It is suggested that equivalent volume of sludge lime, sand/stone dust and fly ash for the required weight should be marked with paint inside wheel barrow/pull carts at its angle of repose/naturally staying slope. It should be regularly checked/verified at every fortnight or change of source/type.
of ash, sand/stone dust and its moisture content. However, weigh batching should invariably be used for cement, or lime and gypsum. A calibrated spring balance which will be handy to use is recommended for this purpose.

Name of material being transported should be written in Hindi/English & local language known to the workers.

Wooden or steel measurement boxes may also be used in place of wheel barrows. However, Baskets/Tokaris for the purpose of measurement should not be used.

No. of wheel barrows/measurement boxes poured in each load should be supervised carefully.

6.6.2 Mixing

Pan mixer of adequate capacity should be used for mixing/grinding various raw materials. 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.

a) When sludge lime and gypsum are used as binding material, first sludge lime and gypsum (in required quantity) is wet grinded 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 to get a homogeneous mix.

b) In case hydrated lime and Gypsum is used as binding material, 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.

Mixing should be carried out till such time uniformity in colour and homogeneous mix is obtained. This is likely to take about 5 minutes
time. The mixing time should be adequate to ensure uniform and homogeneous mix without lumps.

6.7 HANDLING & PRESSING OF THE MIX

Properly mixed raw material is generally transported through a belt conveyor to the press feed hopper. The mix is then fed to hydraulic rotary press, where the moulds are automatically filled in. Set of 2 moulds each are located 120º apart at the rotary table. Bricks are formed at a pressure of 150-200 kg/cm². The pressed bricks are taken manually and laid on wooden pallet in 4-5 layers. Brick laden pallets are transported on hydraulic trolley from press area to stackyard. Finished bricks are then air-dried for 1-2 days.

In case of vibro presses, the mix is manually brought from the pan mixer and filled into the moulds. The table, on which the moulds are kept, is vibrated. The mix is also pressed lightly. The pallets from the table with the bricks are taken manually to stackyard.

Generally bricks made from both these presses are of acceptable quality. However the practice of stacking green bricks one over another on the wooden pallets sometimes creates problems due to the sagging of pallets. More care needs to be taken for optimum quantity of water in case of vibro press to avoid bulging of green bricks.

Based on the above experiences the following precautions are recommended:

i) Green bricks should not be stacked one above the other in case vibro press is used and not more than 4 layers in case hydraulic press is used.

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

iii) Water content should be kept at optimum level especially while using vibro press.

6.8 CURING

Green bricks shall be air dried for 1-2 days. Thereafter, air dried bricks should be water cured for a minimum period of 14 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.

6.9 ACCEPTANCE CRITERIA:

6.9.1 Compressive strength

Minimum average compressive strength of brick shall not be less than 7.5 N/sq.mm 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/sq.mm the same be limited to 10.0 N/sq.mm for the purpose of averaging.

In case the locally manufactured clay bricks are of strength less than 7.5N/sq.mm, ash bricks of compressive strength less than 7.5N/sq.mm but not less than 5.0N/sq.mm can also be manufactured to compete with locally manufactured clay bricks.

6.9.2 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%.

6.9.3 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.

6.9.4 Efflorescence Test

The bricks when tested in accordance with the procedure laid down in IS:3495
6.9.5 Sampling and Criteria for Conformity

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

Each lot of ash bricks conforming to the above tests shall be declared ACCEPTED and allowed to be used for various masonry works.

Test for 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.

6.10 TESTING LABORATORY

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

6.11 CONCLUSION

It is expected that these guidelines will serve the purpose of manufacturing good quality ash bricks.

LIST OF APPLICABLE IS CODES:

- IS-12894-2000 Fly Ash lime bricks-Specifications
- IS-712:1984 Specifications for building limes (Third revision)
- IS-1514:1990 Method of sampling and test for quick lime and hydrated lime.
- IS-3812 (Part-1) : 2003 Pulverized Fuel Ash - Specification for use as pozzolana in Cement, Cement Mortar and Concrete (Second Revision-draft)
IS 3812 (Part-2) : 2003 Pulverized Fuel Ash - Specification for use as Admixture in Cement Mortar and concrete (Second Revision-draft)

IS-1727:1967 Method of test for pozzolanic material (first revision)

IS-269:1989 Ordinary Portland Cement;33 grade specification (fourth revision)

IS-8112:1989 Specification for 43 grade Ordinary Portland Cement (1st Revision)


IS-3495 (Part-1) : 1976 Method of test for burnt clay building bricks : Determination of compressive strength (second revision)

IS-3495 (Part-2) : 1976 Method of test for burnt clay building bricks : Determination of water absorption (second revision)

IS-3495 (Part-3) : 1976 Method of test for burnt clay building bricks : Determination of efflorescence (second revision)

IS-4139:1989 Specification for calcium silicate bricks (second revision)

IS-5454:1976 Methods for sampling of clay burnt building bricks (First revision)