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A Review on Replacement of Bricks by Hebel Blocks

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***Abstract*: Brick is the most commonly used building material for construction. The CO2 emissions in the brick manufacturing process affects the green environment. Therefore, focus should be now more on seeking eco-friendly solutions for greener environment. Hebel blocks is a fully integrated building system of panels and blocks that are used for residential, commercial and industrial buildings. Analysis of conventional and non-conventional material on cost, energy consumption and carbon emission parameters helps in highlighting suitable options for sustainable construction. Hebel blocks, an eco-friendly material, gives a prospective solution to building construction. In this paper, attempt has been made to replace the red bricks with eco – friendly Hebel blocks. The use of Hebel blocks also reduces the requirement of materials such as cement and sand up to 50%. Hebel blocks is a certified green building material, which can be used for commercial, industrial and residential construction. It is porous, non-toxic, reusable, renewable and recyclable. This paper highlights the comparative statistical analysis of cost effectiveness of using Hebel blocks instead of traditional red bricks. The usage of Hebel blocks gives a prospective solution to construction industry along with environmental preservation. In this paper, an attempt has been made to compare Hebel blocks as a replacement material to red bricks. The different types of tests were performed to determine various properties of Hebel blocks as compared to others. From the experimental results, it is observed that the compressive strength of Hebel block is comparatively more than traditional bricks and the density of Hebel block is comparatively les which helps in reducing the dead load of structure. It is found that upto 15 to 20%, The characteristic of Hebel blocks is helpful in green housings and saves fertile lands and a solution for fly ash disposal. The cost of construction can be reduced by using Hebel blocks. The energy consumed in the production process emits no pollutants and creates no by-products or toxic waste products. The work ability of Hebel blocks helps to eliminate waste on the jobsite. This paper clearly highlights Compressive strength of Hebel blocks is comparatively more than traditional clay brick and they ecofriendly than usual bricks and they are cost efficient too.**

***Keywords*: Hebel blocks, eco-friendly, green product, efficient**

1. Introduction

Brick masonry has been a primary technique used in building structures for at-least seven millennia, making it one of the oldest construction technologies in common uses. Its legacy in existing architecture still makes it a desirable, architectural choice in many locations. Bricks remain one of the most important building materials in the country. Brick making is a traditional industry in India, generally confined to rural areas. In recent years, with expanding urbanization and increasing demand for construction materials, brick kilns have to grow to meet the demand. It has directly or indirectly caused a series of environmental and health problems. At a local level, in the vicinity of a brick kiln, environmental pollution from brickmaking operations is injurious to human health, animals and plant life. At a global level, environmental pollution from brick- making operations contributes to the phenomena of global warming and climate change. Extreme weather may cause degradation of the brick surface due to frost damage. Global warming and environmental pollution is now a global concern. Various types of blocks can be used as an alternative to the red bricks, to reduce environmental pollution and global warming. Hebel blocks may be one of the solutions for brick replacement.

2. Replacing bricks by Hebel

Hebel, also known as autoclaved cellular concrete, autoclaved lightweight concrete, autoclaved concrete, cellular concrete, porous concrete, is a lightweight, precast, Foam concrete building material invented in the mid-1920s that simultaneously provides structure, insulation, and fire and mould resistance. Hebel products include blocks, wall panels, floor and roof panels and lintels. Hebel is a highly thermally insulating concrete-based material used for both internal and external construction. Besides Hebel's insulating capability, one of its advantages in construction is its quick and easy installation, because the material can be routed or cut to size on site using standard carbon steel power tools. Hebel is well suited for urban areas with high rise buildings and those with high temperature variations. Due to its lower density, high rise buildings constructed using Hebel require less steel and concrete for structural members. The requirement of mortar for laying of Hebel blocks is reduced due to the lower number of joints. Similarly, the material required for rendering is also lower due to the dimensional accuracy of Hebel. The increased thermal efficiency of Hebel makes it suitable for use in areas with extreme temperatures, as it eliminates the need for separate materials for construction and insulation, leading to faster construction and cost savings. Hebel.

3. Types

However, unlike these foamed or light aggregate mixes, true aerated concrete relies on the alkaline binder (lime & cement) reacting with an acid to release gases, which remain entrained in the material. The aerated concrete is a one types of lightweight concrete. Aerated concrete is also well- known as a cellular concrete.

It can be divided into two main types according to the method of production. They are foamed concrete (non- Hebel (NHEBEL) and Hebel (HEBEL) Foamed concrete is produced by injecting preformed stable foam or by adding a special air-entraining admixture known as a foaming agent into a base mix of cement paste or Mortar (cement water or cement+sand+water)). The Hebel is produced by adding in a predetermined amount of Aluminium powder and other additives into slurry of ground high silica sand, cement or lime and water. Hebel consists of basic materials that are widely available. These include sand, cement, lime, gypsum, water and an expansion agent. Silica sand, the raw material used in the greatest volume in HEBEL, is one of the world's most abundant natural resources. Inspite of the price difference, construction industry wants to use Hebel blocks due to inherent advantages. The use of Hebel blocks in load-bearing elements is diffusely used worldwide and they possess interesting material properties regarding earthquake engineering. Indeed, their high deformability allied to their low weight reduces the inertia forces of these vertical elements and, in addition to their non-combustibility and fire- resisting nature of Hebel (earthquakes are commonly associated with fires), they may be an alternative to reinforced concrete frame structures. On the other hand, masonry structures are commonly associated, with poor seismic performance as observed in past earthquakes. This negative perception is caused mainly by many non-engineered masonry structures, mostly stone masonry houses which, if not properly designed and/or strengthened regarding seismic provisions, will not behave satisfactory under seismic excitations.

Fig. 1. Hebel blocks

4. Methods

Hebel block is manufactured with the used of sand, Quartz sand, calcined gypsum, lime (mineral) and/or cement and water in some countries, like India and China, fly ash generated from thermal power plants and having 50-65% silica content is used as an aggregate. Aluminium powder is also used in appropriate proportion in the process as based on the pre specified density.

A. Manufacturing process

Manufacturing process of Hebel contains five main steps which are as following

1. Mixing of raw materials.
2. Addition of expansion agent.
3. Pre curing, cutting.
4. Curing process with autoclave.
5. Packing and transporting.

After raw material preparation, next step of Hebel blocks manufacturing process is doing and mixing. Process of doing and mixing means the quality of final products. Maintaining ratio of all ingredients as

- Fly ash-69%
- Sand- 20%
- Lime- Cement8%
- Gypsum- 3 %
- Aluminium 0.08% of total dry materials
- Water ratio- 0.60-0.65

The cycle of mixing and pouring is 5.5 minutes. A dosing and mixing unit is used to form the correct mix to produce Hebel blocks. Fly ash is pumped into a container. Once the desired weight is poured in, pumping is stopped. Similarly, lime powder, cement and gypsum are poured into individual containers using conveyors. Once required amount of each ingredient is filled into their individual containers control system releases all ingredients into mixing drum. A smaller bowl type structure used for feeding Aluminium powder is also attached as a part of mixing unit. Once the mixture has been churned for set time, it is ready to be poured into moulds using dosing unit. Dosing unit releases this mixture as per set quantities into moulds. Dosing and mixing process is carried out continuously because if there is a gap between charging and discharging of ingredients, residual mixture might start hardening and choke up the entire unit. For Hebel blocks manufacturing, entire dosing and mixing operation is completely automated and requires minimum human intervention. Once mix of raw materials is ready, it poured is in moulds. Moulds can be of various sizes depending upon installed capacity like 4.2m x 1.2m x 0.65m in size. Before casting, moulds are coated with a thin layer of oil in order to ensure that green-cake does not stick to moulds. While slurry is mixed and poured into greased moulds, Aluminium reacts with Calcium Hydroxide and water and releases hydrogen gas. This leads to formation of tiny cells causing slurry mix to expand. Such expansion may be thrice its original volume. Bubble size is about 25mm.Thus, this is the reason behind light weight and insulating properties of Hebel block Usually rising and pre-curing process takes around 60-240 minutes. Rising is dependent on raw material mix and weather conditions. Due to this, pre-curing is also referred as ‘heating room pre-curing’. At end of precuring process, green- cake is hard enough to be wire cut as per requirements Autoclave Aerated concrete is cured in

an autoclave – a large pressure vessel. Autoclave is normally a steel tube of 3m diameter and 45 meters long. Steam is fed into the autoclaved at high pressure, typically reaching a pressure of 800kpa to 1200 kpa and a temperature of 180°C.Once green cake has achieved cutting strength, it is ready to be demoulded and cut as per requirements Once a mould is out of pre-curing room, it is lifted by crane for demoulding operation.

5. Materials selection of ingredients

A. *Sand*

Fine aggregate are basically sand consists of crushed stone with maximum particles passing through a 4.75mm sieve.

B. *Aluminium*

Aluminium is an expansion agent. When the raw material reacts with Aluminium powder, air bubble introduced due to reaction between calcium hydroxide, Aluminium and water and hydrogen gas is released. Aluminium powder is used at a rate of by volume. Aluminium power reacts with calcium hydroxide and water to form hydrogen. The hydrogen gas forms and doubles the volume of raw mix creating gas bubbles up to 3 mm (1/8 inch) in diameter. At the end of the foaming process, the hydrogen escape into the atmosphere and is replaced by air.

C. *Quartz sand*

The sand which is used to increasing the strength of blocks. Before the sand is used for manufacturing it should be tested. In sand the silica content, moisture content and residue is to be checked. The silica content should be below 98% and residue ranges from 98 – 100%. The wastages should not be more. Moisture content 0.06%. some cases the sand is not to be used.

D. *Calcined gypsum*

Gypsum is easily available in the market and is used in powder form. Gypsum is easily available in the market and is used in powder form. It is stored in silos. Gypsum is a very soft mineral composed of calcium sulphate dehydrate. It has the chemical formula of caso4. 2H2O.gypsum is almost PH neutral. It is colourless to white, may be yellow, blue. And it is translucent, very soft, and water-soluble. Nearly 20 kg of gypsum is used for 3.024 m3 mould.

E. *Lime (mineral)*

Limestone is made up of calcite aragonite. Limestone is obtained either by crushing to fine powder at Hebel factory or by directly purchasing it in powder form from a merchant. Lime powder is obtained either by crushing limestone to fine powder at Hebel factory or by directly purchasing it from the market.

F. *Cement*

Portland cement is generally preferred. Mostly India cement where used in manufacturing of Hebel blocks. Cement is a binding material, used to binding the ingredients. The amount of cement is used for 3.024m3 mould is 440 kg – 450 kg. Initial and final setting time of the cement is checked. It ranges from 165 – 180 minutes. Cement is a binder, a substance used in construction industry that sets and hardens and can bind other materials together. Density of cement -1440kg/m3 Type - OPC Grade 53 Compressive strength – 53 Mpa

G. *Water*

Potable water should be used which should conform with the general requirements of the concrete.

H. *Fly ash*

Fly ash is waste industrial product used for reduction of construction cost. The density of fly ash ranges from 400-1800kg/m3. It provides thermal insulation, fire resistance and sound absorption. The type of fly ash used is of Class C with contains 20% lime (cao) and loss of ignition not be more than 6%,. A by- product of thermal power plants and is an important raw material in the manufacture of HEBEL. Fly ash is a by-product from burning pulverized coal in electric power generating plants. Fly ash is the best known and one of the most commonly used pozzolans. The amount of fly ash is used in manufacturing of Hebel blocks is 1150 – 1160 kg for 3.024m3. The factor for waste slurry and pure slurry is 150 &550 (for blocks).for lintels 200 &700.

6. Testing

A. *Initial rate of absorption*

Initial rate of absorption (IRA) test was conducted, in accordance with ASTM C 67 . The specimen was kept in a tray containing distilled water up to a depth of 25 mm from the bottom of the tray for 60 Seconds. Later, the specimen was removed from the tray and weighed, thus the initial rate of absorption is obtained

B. *Dry density*

This test was carried out on blocks samples collected randomly in and around Bangalore City. IS: 2185- (Part I) 1979 specifications were followed to conduct this test. The density of Hebel ranges from 250 to 1,800 kg/m3, as compared to 2400-2600 kg/m3 for conventional concrete. Therefore, the weight of a structure built with foam concrete would undoubtedly be reduced significantly, leading to tremendous savings in the use of reinforcement steel in the foundations and structural members. Hebel blocks are ideal for the entire building structure and Possess high structural integrity. The product is light weight and easy work ability means that it is very quick to install on site, thereby saving in steel, cement, and mortar and plastering costs.

C. *Water Absorption*

The blocks were tested in accordance with the procedure laid down in IS: 2185 (Part I)-1979. The code specifies two methods to be adopted, by 5 hour boiling water test or the 24-hour cold-water immersion test. The latter method was adopted. Water absorption for blocks should not be greater than 20% by weight

up to class 12.5 as per IS: 1077- 1992 specifications.

D. Wet Compressive Strength

The compressive strength of the block is the main contributing factor for the strength of masonry. IS: 2185 (Part-I)-1979 specifies the minimum compressive strength. The minimum compressive strength for a non-load bearing unit is 1.2mpa while that for a load bearing unit, it varies from 1.6mpa to 5.6 Mpa. This test was conducted as per the specification laid in the IS: 3495-1992.

E. Flexural Strength Test

The test specimen was placed centrally on two roller supports and load was applied through another roller, taking care not to cause local failure. The transverse load was applied at a uniform rate not exceeding 300 N/min through the central roller. The individual breaking load was recorded and flexural strength was calculated using pure bending equation.

7. Advantage of hebel block

1. *Eco-friendly:* Hebel helps to reduce at least 30% of environmental waste as compared to traditional concrete. There is a decrease of 50% of greenhouse gas emissions.
2. *Lightweight:* It is 3-4 times lighter than traditional bricks and therefore, easier and cheaper to transport.
3. *Energy Saver:* It has an excellent property that makes it an excellent insulator.
4. *Great Acoustics:* Hebel has excellent acoustic performance. It is able to be used as a very effective sound barrier.
5. *Fire Resistant:* Just like the regular concrete, ACC is fire resistant. This material is completely inorganic and not combustible. It has one of the highest hourly fire resistance ratings per inch of any building material currently used in homebuilding. This makes it an ideal choice for fire protection around steel columns and steel beams and in the construction of shaft walls, stairwells, corridors and firewalls.
6. *Low Maintenance:* Hebel reduces the operating cost by 30% to 40%. It also reduces overall construction cost by 2.5% as it requires less jointing and reduces the quantity of cement and steel.
7. *Faster Construction:* It reduces construction time by 20%. As these blocks are lighter, it makes construction easier and faster.

Table 1
Comparison between Hebel and bricks

Parameter	Hebel Blocks	Red Clay Bricks
Raw Materials	Cement, fly ash, water and air entraining agents	Locally available clay
Size	400-600mm x 200mm x 150mm – 300mm	225mm x 75mm x 100/150mm
Variation size	1.5 mm (+/-)	5 mm (+/-)
Compressive strength (as per is codes)	3-4 n/mm^2	3.5 n/mm^2
Dry density (as per is codes)	550-650 kg/m^3 its one-third of the weight of clay brick which makes it easy to lift and transport	1800 kg/m^3
Cost benefit	For high rise buildings there will be reduction of dead weight which leads to saving in concrete and steel quantities.	As easily available in local market hence it is beneficiary for low rise structure.
Fire resistance (8″ wall)	Upto 4 hours	Around 2 hours
Quality of end product	Factory made product. So, the quality of end product is consistent and good	Locally made product. Quality depends on various parameters like quality of raw materials used, process of manufacture etc.,
Sound insulation	Better sound absorption/insulation as compared to bricks	Normal
Energy saving	Low thermal conductivity (0.24 kw-m/c) helps in saving electricity costs 30% for heating and cooling of house	High thermal conductivity (0.81 kw-m/c). So, no significant cost savings
Environmental friendliness	In Hebel block there is no top soil consumption and it emits very low carbon dioxide as compare to red clay bricks while manufacturing	One sq. ft of carpet area with clay brick walling will consume 25.5 kg of top soil (approx.). It actually damages environment
Internal and external plaster	As these bricks have dimensional accuracy, the internal and external plaster thickness can be reduced	Requires thick plaster surface as there are variations in the dimensions
Cost of construction	1 cum costs – Rs. 4200/-	1 cum costs – Rs. 2440/-
Joining process	Chemical mortars can be used for joining the brick. This reduces the material consumption for cement and also avoids curing process	Traditional mortar needs to be used and the brick work should be cured at least for 7 days before plastering
Availability	Factory setup cost is high. not many factories, so availability is a concern.	Available locally in all cities and villages.
Thermal insulator	Hebel blocks are very good thermal insulator if cooling is an major component of any building monthly expenses it will save cost for entire lifetime	It has low thermal insulation as compare to Hebel and clc block
Tax contribution	Contributes to government taxes in form of central, excise, vat and octroi	No tax contribution
Cylindrical structures	For cylindrical structure these blocks are not much useful	Cylindrical manholes or sewage chambers need small size of bricks so that the curvature can be formed hence red clay bricks are useful
Water absorption	Absorb 12- 15% by total volume of hebel blocks	Absorb 17 -20% by total volume of red clay brick
Range of application	They are suitable for non-load bearing or Rcc structure in partition wall	They are useful in both load bearing and non-load bearing structure

8. Hebel combines insulation and structural capability in one material for walls, floors, and roofs. Its light weight/cellular properties make it easy to cut, shave, and shape, accept nails and screws readily, and allow it to be routed to create chases for electrical conduits and small-diameter plumbing runs. This gives it design and construction flexibility, and the ability to make easy adjustments in the field.
9. *Durability and dimensional stability*. A cement- based material, Hebel resists water, rot, mould, mildew, and insects. Units are precisely shaped and conform to tight tolerances.
10. *Fire resistance is excellent*, with 8 in. Thick Hebel achieving a 4-hr rating (actual performance exceeds that and meets test requirements for up to 8 hr). And because it is noncombustible, it will not burn or give off toxic fumes.

Fig. 2. Chart of Hebel blocks advantages

8. Conclusion

From this review it is clear that Hebel combines insulation and structural capability in one material for walls, floors, and roofs. Its light weight/cellular properties when compared to red clay bricks. It is easy to cut, shave, and shape, accept nails and screws readily, and allow it to be routed to create chases for electrical conduits and small-diameter plumbing runs. This gives it design and construction flexibility, and the ability to make easy adjustments in the field. But the material does have some limitations. It is not as widely available as most concrete products, though it can be shipped anywhere. If it has to be shipped, its light weight is advantageous. Because it is lower strength than most concrete products or systems, in load-bearing applications, it must typically be reinforced. It also requires a protective finish since the material is porous and would deteriorate if left exposed. Hebel block buildings can be used for producing net zero energy buildings.

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