

Exploring the Potential of Hydraform Interlocking Block as a Building Material for Masonry Construction

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Received April 08, 2023; Revised May 13, 2023; Accepted May 21, 2023

Abstract The conventional brick walls, stone walls and even hollow concrete blocks require mortar to hold the individual building units in desired position. A new concept of concrete block construction without mortar has been developed, but due to lack of proper promotion and lack of confidence as to their structural stability, they have not been largely used in India. Many such ideas of different type and shape of blocks for jointing without cement or mortar have been developed and used in many countries. The basic theory behind elimination of mortar is to devise an interlocking system of blocks which are technically sound, structurally safe for vertical and wind loads. Interlocking in wall masonry is very unique and one such Technology is known as Hydraform Interlocking Building system that replaces the conventional brick and mortar by using Hydraform machine made interlocking blocks. Besides the cost of mortar itself the time spent in making and placing mortar can be reduced to lay up the blocks. This paper examines the case of Hydraform interlocking blocks as a building material and discusses the engineering viability and properties of such interlocking blocks in masonry construction. The paper concludes that Hydraform interlocking blocks are a viable alternative to conventional bricks with more intangible benefits attached to them.

Keywords: Hydraform interlocking blocks, building construction, building materials, masonry, sustainability

Cite This Article: Rupesh Surwade, and Mohammad Arif Kamal, “Exploring the Potential of Hydraform Interlocking Block as a Building Material for Masonry Construction.” *American Journal of Civil Engineering and Architecture*, vol. 11, no. 2 (2023): 45-51. doi: 10.12691/ajcea-11-2-3.

1. Introduction

Interlocking in wall masonry is very unique and one such Technology is known as Hydraform Interlocking Building system that replaces the conventional brick and mortar by using Hydraform machine made interlocking blocks. The other components of the conventional building system remain largely unchanged. The application can be as dry stacked or with cement slurry in Interlocking tongue and groove that enables speedier construction of high quality aesthetic and affordable building in stretcher bond as well as in the normal English/Flemish bond with mortar. The Blocks have an extremely appealing face-brick finish due to sharp edges. The walls may be left exposed, plastered or finished with cement paint.

This technology has been in use in a number of countries for almost 25 years as a load bearing option using the compressed stabilized earth blocks. In Indian subcontinent interlocking technology option has been put to use for the last few years. The versatility of technology has also been validated by use in construction projects by HUDCO and BMTPC in some of the projects promoting newer and sustainable building technology options. The self-alignment of interlocking blocks, without mortar results in very rapid construction, when compared to

conventional block construction. To get high strength of the blocks (for load bearing walls for 4 to 5 storey) the blocks are moulded under high pressure using a precision system rather than the usual casting process. The blocks can be cast mechanically but production is relatively slow.



Figure 1. A Hydraform interlocking block

Interlocking Technology is dry stacking mortar - less method of constructing walls. Block are not laid with mortar, they rely on the interlocking mechanism to provide resistance to applied loads. Hydraform interlocking dry stacking utilizes interlocking mechanisms of shear keys as well as self-weight to resist the external loads. Dry stacking results in reduction of construction costs due to saving in construction time, reduced requirement for skilled labour and costly material especially cement and reusability of the blocks. The requirement for unskilled labour makes dry stacking

particularly attractive to labour makes dry stacking particularly attractive to labour based work [1].

As per the requirement of IS 4326:1993, a thin mortar of the specified type can be used even in these Interlocking types of the Blocks. Interlocking block masonry has also been validated by Gujarat State Disaster Management Authority for use in earthquake resistant construction even in zone V with appropriate structural bands.

The blocks are mainly of following size and dimension to suit standard application requirements. However size can be tailored for large quantity application requirements [2].

Figure 2(a), (b) and (c) shows Size and Dimensions of Interlocking Block

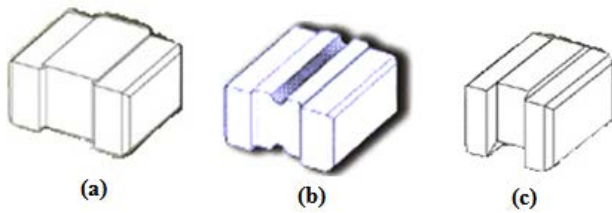


Figure 2. (a) HF: 220, (b) HF: 220mm Conduit, (c) HF: 150 mm

The following sizes are available in Hydraform Interlocking Blocks:

Table 1. Available sizes of Hydraform Interlocking Blocks

Types of blocks	Width	Length	Height	Weight (kg)
220	220 mm	100-240 mm	115 mm	9 – 11 (full size)
200	190 mm	240 mm	115 mm	8 – 9 (full size)
115 (Partition walls)	115 mm	100-220 mm	115 mm	– 6 (full size)

Figure 3(a), (b), (c) & (d) shows Isometric view, Side Elevation, End Elevation and Plan of an concrete interlocking block.

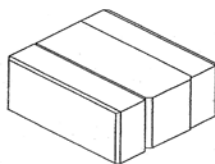


Figure 3 (a). Isometric View

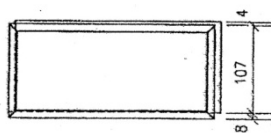


Figure 3 (b). Side Elevation

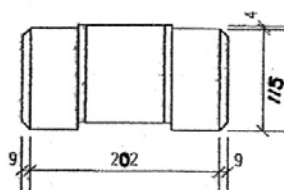


Figure 3 (c). End Elevation

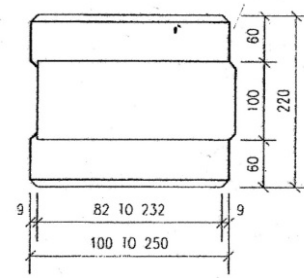


Figure 3 (d). Plan of a block

2. Research Methodology

In this paper, the qualitative research method has been used. The systematic literature review explores the basic concepts of Hydraform interlocking blocks through books, internet and secondary data from relevant published academic literature from journal's research papers. The data collected in the qualitative research is the data that comes from several case studies and examples that are described descriptively and are supported by illustrations and photographs to reinforce the arguments put forward. This study evaluates the properties and mechanism of Hydraform interlocking blocks. The purpose of this paper is to analyze the potential of Hydraform as a sustainable building material. The paper also presents the construction process, advantages and disadvantages of Hydraform interlocking block masonry.

3. Hydraform Block Making Machine

Hydraform Blocks are manufactured by high-pressure hydraulic compaction of the mixed material in a Hydraform Block making machine. Model of various range of interlocking Block making machines as per specification are available. The machine comprises of an engine or Electric motor, hydraulic power pack including cylinders, compression chamber, pre-compacting and double compaction, loading assembly on static frame are all fitted on a roadworthy frame inclusive of spring-axle, tow-hitch and road tyres (Figure 4). Hydraform has range of block making machines and mixing options to suit project requirement and location [2].



Figure 4. A Hydraform interlocking block making machine with integrated pan mixer

4. Mechanized Production of Blocks

4.1. Mix Design

The mix design indicating the proportion of various ingredients is worked out carefully keeping in view the target dry density of the block.

4.2. Batching of Ingredients

The quantities of various ingredients are proportioned on the basis of weight, with due correction being made to the quantities on account of inherent moisture content of other ingredients and quantity of water in the Fly Ash and sand.

4.3. Mixing of Ingredients

The ingredients are mixed in a pan mixer having preferably rollers & scrapers for mixing. Cleaned mixer is started before charging the materials, to obtain optimum performance. Sand and fly ash with other ingredients is first fed into the mixer, and thoroughly mixed to ensure even distribution of cement. The appropriate amount of water is slowly added thereafter, keeping on mixing till homogenous color is achieved.

4.4. Formation of Blocks in the Hydraform Machine

The mix is then fed in the Hydraform Blocks making machine moulding chamber through the hopper and hydraulic pressure is applied to make a block. The block to be extruded and placed at even grounded Stack yard.

4.5. Curing of Blocks

The green blocks are immediately covered with Polythene sheet to protect moisture within the block. The blocks are sprinkled water cured at least twice a day for 14-21 days. The curing period shall depend upon contents of cement / lime and weather.

5. Classification of Hydraform Blocks

Different classes of blocks can be made as per compressive strength requirement in accordance with:

- SEB (Soil Earth Stabilized) Blocks in accordance with IS 1725-1982.
- FAL-G (Flyash - lime) Blocks in accordance with IS 12984-1984.

6. Raw Materials Used in Manufacturing

The main raw materials for production of Hydraform interlocking blocks are Soil and Flyash, which are available cheaply and in abundance. Using SEB & FAL-G blocks is a low cost, attractive and eco-friendly option available for constructing dwellings. Both soil and flyash are stabilized by various stabilizing agents such as cement,

lime, gypsum etc. and then compressed and compacted in the Hydraform block machine to give the finished product [2]. These blocks are made following respective Codes prescribed for different Raw Materials viz

- IS: 1725:1982 (Specification for soil-based blocks used in general building construction)
- IS: 12984: 1990 (Flyash- lime bricks- specification)

7. Properties of Hydraform Blocks

7.1. Compressive Strength

The Hydraform Interlocking blocks/bricks when tested in accordance with IS: 3495 Part I-1976 should have a minimum compressive strength after 28 days of curing as follows:

Table 2. The Compressive Strength of SEB Blocks

S. No.	Class designation	Compressive strength in (Kg/cm ²)
1	30	not less than 30
2	75	not less than 75

Table 3. The Compressive Strength of Hydraform Flyash (FalG) Blocks

S. No.	Class designation	Compressive strength in (Kg/cm ²)
1	75	not less than 75
2	100	not less than 100
3	125	not less than 125

7.2. Test Procedure

The compressive strength of the blocks can be easily tested at the site by using the Hydraform blocks testing Machine. Compressive strength test is done in compression testing machine. Block is placed between the jaws and load is applied gradually. Precaution is taken such that load is applied to the flanged portion of the blocks. For this two steel plates of sizes 50mm x 240mm and thickness 10 mm are placed on top flange and gradual load is applied over the plates till the failure occurs and not the maximum load at failure (Figure 5).

The test result shall be calculated as given below:

$$\text{Compressive strength} = \frac{\text{Maximum load at failure}}{\text{Average net area of flanged portion}}$$

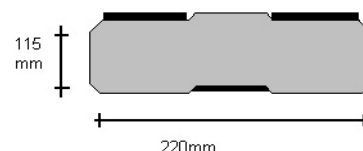


Figure 5. Steel Plates placed on the flange for performing compressive test

7.3. Water Absorption

The Hydraform Interlocking Blocks when tested in accordance with the procedure laid down in IS 3495 Part

II-1976, after immersion in water for 24 hours, an average absorption should not be:

- For the blocks/bricks with (FAL-G (Flyash/Cement) Bricks/ Blocks) more than 15% (by weight).
- For the blocks/bricks with (SEB (Soil Earth Stabilized) Bricks/ Blocks) more than 15% (by weight).

7.4. Drying Shrinkage

The average drying shrinkage of the blocks when tested by the method described in IS: 4139:1989 shall not exceed 0.15%.

7.5. Weathering

When tested in accordance with IS: 1725-1982, the maximum loss of weight shall not exceed 5%.

8. Construction Process of Hydraform Block Masonry

A dry stacked interlocking building is laid on conventional strip footing. Foundation walls are built with blocks of higher strength laid in mortar bed or even conventional type foundation. The courses are laid on mortar up to the floor level. Courses above floor level are dry stacked up to lintel band. The top three courses are held together by mortar to form a ring beam at the top. The alternative is to cast a reinforced concrete ring beam. In areas with low technical skills, it is preferred to use bricks force and mortar option. The roof is tied to the ring beam to prevent uplift. Different conventional finishes can be applied to suit the aesthetic needs of the owner.

8.1. Interlocking Mechanism

The locking of a male face of one block with the female face of another or the locking of the bed of one block with the ridge of the one below it is called 'Interlock' (Figure 6).



Figure 6. The interlocking mechanism of masonry blocks.

8.2. Bed and Ridge

The recessed under surface of the block is referred to as the bed. The raised top surface of the block is called the Ridge (Figure 7).

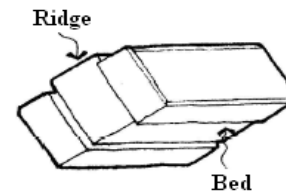


Figure 7. The bed and ridge of the interlocking block

8.3. Laying of Courses

One (horizontal) layer of Hydraform blocks is called a course.

Height of a course = 115 mm (with a new set of wear plates). Figure 8 shows the odd and even courses of the masonry.

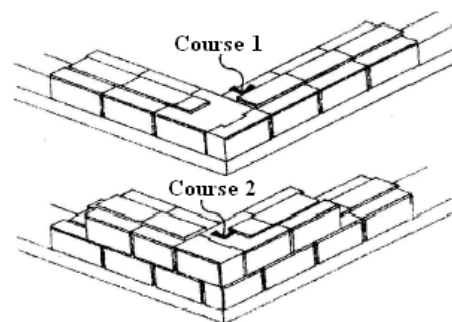


Figure 8. The odd and even course of the interlocking block masonry

8.4. Corner Masonry Details

For a corner, shaved full blocks or shaved $\frac{1}{2}$ blocks are required. Also for the corner block shave off the ridge and male face of the corner block, as shown in Figure 9. Ensure that the shaved ridge points upward and the shaved male face point's outwards. One must start the first course with a $\frac{1}{2}$ block.



Figure 9. The corner masonry using interlocking blocks

9. Compatibility with Earthquake Resistant Construction

The Hydraform interlocking blocks can be easily reinforced (because of the grooves) against the conventional masonry. All the relevant bands i.e. roof bands plinth band, lintel band, gable band etc. can be easily be incorporated in the masonry. Both vertical and

horizontal reinforcement can be provided by means of the grooves. For use in earthquake prone areas and their specifications are given in the Gujarat State Disaster Management Authority Guidelines.

10. Load Bearing Masonry Construction

Since blocks are of 220 mm width and can be made of strength > 75 kg/ sq.cm, same can be safely used for Load Bearing construction. Depending on structural requirements of the building, appropriate lintel & roof bands can be used. Hydraform Company has done tests from time to time for conformity of dry stacked masonry in G+2 storey buildings. Fly Ash based interlocking blocks can be made of higher compressive strength to suit the Load bearing construction requirements beyond Ground floor to suit structural requirements. In terms of IS 1905, masonry of M7 grade requires use of brick / block to be of M7 grade and mortar of class I. Use of Interlocking blocks of M7 grade with thin mortar slurry of 1:3 (1 cement: 3 fine sand), if required, will satisfy this requirement. Figure 10 and Figure 11 shows the use of Hydraform interlocking blocks in mid-rise buildings in the state of Gujarat, India.



Figure 10. A Four storeyed housing with interlocking blocks at Vapi, Gujarat, India



Figure 11. A Three storeyed housing with interlocking blocks at Anjar, Gujarat, India

11. Block Masonry in Framed Structures

The framed construction mainly require block work to be used as an infill only, therefore dry stacked interlocking block can be used in walls of 220 mm, 190 mm thickness. For block work of lesser width it is recommended to use

slurry of 1:3 mix mortars. The blocks have standard height of 115 mm which makes it easier to design the beam height for required number of courses. Figure 12 shows the use of interlocking blocks in multi-storeyed housing.



Figure 12. A multi-storeyed housing with interlocking blocks

12. Reinforced Masonry Construction

Interlocking Blocks with horizontal and vertical cavity provide an ideal solution for using reinforcements to suit the structural design requirements for Earth quake resistance (Figure 13 and Figure 14).



Figure 13. A Reinforced Masonry using interlocking blocks.



Figure 14. The corner reinforced masonry with

13. Interlocking Block Masonry in Boundary Walls

The dry stacked Interlocking block work is well suited for this application and is very fast, aesthetically pleasant

and cost effective. Depending on height, width, area, application and other parameters, structural design can be made to adopt intermittent columns, coping band, foot stripping can be designed. Conduit blocks etc. for intermittent horizontal reinforcement to act as tie beam / lintel (Figure 15).



Figure 15. A boundary wall constructed with interlocking blocks

14. Advantages of Hydraform Interlocking Blocks

There are many advantages of Hydraform interlocking blocks when used in masonry construction [2]. They are summarized below:

- Mortarless blocks have high earthquake resistance due to interlocking and staggered position of units.
- The joints being without mortar are flexible. The wall shall bear the shocks during the Earth-quake. It may be noted that the interlocking block technology is safer in earth-quake than the rigid brick/block masonry due to its flexible behavior. The energy generated during earthquake is dissipated due to interlocking non-rigid behavior.
- Torsional strength of mortarless block wall is greater than that of brick wall or conventional block wall.
- Due to greater percentage of air space inside the blocks hollow spaces, it has a high insulation value.
- The construction is very simple and normal workers can erect a wall with ease and speed.
- There is a great flexibility of design because of the small size of basic units.
- The block can be reused in any construction.
- The blocks have sharp finished chamfered edges; therefore aesthetically the appearance of the wall looks pleasant. The external wall can be kept exposed finish with or without paint. Practically no plaster is required.
- For the internal wall finish direct cement based putty can be used without cement plaster.

15. Disadvantages of Hydraform Interlocking Blocks

In some conditions, Hydraform interlocking blocks are not suitable for masonry construction. They are summarized as below

- The blocks shall be economical whether either the flyash (for flyash blocks) or particular type of soil (for soil blocks) is available nearby. However, blocks of cement-sand without flyash have also been used, but the blocks become heavy and sometimes uneconomical.
- While chase cutting for conduits and water pipes etc., fine dust powder (due to fine flyash particles) is generated. Avoid inhaling the same.
- It is essential to lay the corner blocks with cement slurry / thin cement-fine sand mortar for stability during erection of wall.
- The wall should not be raised beyond lintel level unless lintel band is provided or the wall is loaded as the wall can topple due to high wind.
- The gaps if any between the blocks may become source of water penetration.
- In high rainfall areas, it may be necessary to finish external wall with cement plaster.
- Hammering or drilling in wall may dislodge the blocks until the wall is loaded from above

16. Conclusions

The most popular building material in India is burnt clay brick, which not only contributes significantly to greenhouse gas emissions but also removes a large amount of topsoil from agricultural land each year. Traditional burned brick places a great deal of strain on the environment because the burning process produces greenhouse gases [3]. The United Nations Sustainable Development Goals (SDGs), in which Goal 9 targets to build resilient infrastructure, promote sustainable industrialization and foster innovation. A functioning and resilient infrastructure is the foundation of every successful community. To meet future challenges, our industries and infrastructure must be upgraded. For this, we need to promote innovative sustainable technologies and ensure equal and universal access to information and financial markets [4]. This will bring prosperity, create jobs and make sure that we build stable and prosperous societies and communities across the globe. In this regards, low energy, eco-friendly sustainable building materials are required for the infrastructure development [5,6]. The Hydraform interlocking blocks are energy-efficient, eco-friendly, and agricultural-friendly building materials for sustainable development.

Hydraform interlocking blocks technology is a modern method of producing blocks that offers several advantages over traditional brick-making methods. This paper discusses the engineering viability and properties of Hydraform interlocking blocks. These blocks outperform burnt clay bricks in many respects [7]. The efflorescence doesn't arise in the case of Hydraform interlocking blocks. Hydraform interlocking blocks provide great comfort and accessibility for the architect to realize the specified size and design. This paper concludes that hydraform interlocking blocks are a viable alternative to conventional bricks with a lot more intangible benefits attached to them.

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