Construction process of Ferro cement sandwichpanel: Instigating an orderly approach in Bangladesh.

Abstract

This paper reviews the construction process of Ferro cement sandwich panels as non-load bearing units of buildings. The cast-in-situ construction process, on a small scale pilot project including materials and the steps of workmanship will be explored in this paper. The sandwich panels consisted of two thin Ferro cement layers reinforced with woven wire mesh. The core was 56 mm thick and made of lightweight expanded polystyrene sheets. Steel wires were used to tie the two layers of iron meshes together. A total of 100sft sandwich panel was constructed. The proposed panels are lighter in weight relative to the conventional brick walls. This kind of lightweight construction process would lead the construction industries for having a green and earthquake resilient environment.

Keywords: Ferro cement, Sandwich Panels, Wall Panels.

Introduction

The customary building construction trend in Bangladesh usually focuses on the use of burnt clay bricks for the infill or, to certain extent, as load bearing walls which are heavy in weight. In the long run they prove themselves to be uneconomic. It has become a matter of concern to use more lightweight materials in any construction, to make the process more cost effective by reducing the load of the structure. On the other hand, using burnt brick as the main component of construction has severe damaging impact on the environment. Production of burnt bricks has negative effects such as cutting of trees for burning fuel, and degradation of soil near rivers where the brick fields are located. Emission of huge quantity of toxic elements from brick kilns are causing serious health hazards. There are about 45000 of brick kilns in Bangladesh that were found to be producing 79% of CO2 in the last 10 years. It is also found that among the 692 acres of agricultural lands that are diminishing, 17.5% is due to the brick fields.

This particular paper concentrates on the construction technique of Ferro cement sandwich panel, which is an improvised adaptation of Ferro cement, emerged as an alternative to burnt bricks. Ferro cement is a type of thin walled reinforced concrete; commonly consisted of cement mortar reinforced with closely spaced layers of continuous and relatively small wire mesh. The closely-spaced and uniformly-distributed reinforcement in Ferro cement, transforms the otherwise brittle material into a superior ductile composite. Thus, Ferro cement has been regarded as highly versatile construction material possessing unique properties of strength and service ability. Its advantageous properties such as strength, toughness, water tightness, lightness, durability, fire resistance, and environmental stability cannot be matched by any other thin construction material. Ferro cement is the promising composite material for prefabrication and industrialization of the building industry.

On the other hand, development and construction of lightweight pre-fabricated sandwich elements is a popular trend now a day in construction industry all over the world. It contributes to a cleaner environment at a project site and a lower total construction time and cost. The post occupancy period involves less energy consumption due to its heat insulating quality. It also has distinct advantages over conventional structural sections, because it promises high stiffness and high strength to weight ratios. The introduction of new materials such as laminated composites; Ferro cement, for the face sheets and low density materials open- and closed-cell-structured foams like polyvinylchloride, polyurethane, polyethylene or polystyrene foams, balsa wood, syntactic foams, and honeycombs are commonly used as core materials. Open- and closed-cell metal foam can also be used as core materials, for the core presents new possibilities in the design of sandwich construction. Additionally, the properties of the core material within the composite panels have specific impacts on insulation performance, damp and moisture resistance as well as body strength.

In the context of Bangladesh, a demand has been felt for establishing lightweight, cost effective and sustainable construction materials to meet the ever increasing demand of housing. Housing and Building Research Institute (HBRI), which is the only Government research institute to research on housing in Bangladesh, has conducted many researches for the development of Ferro cement as building material and technology. It popularized Ferro cement folded plates, channels as roofing materials and also did a huge number of productions on Ferro cement water tanks. Various studies are undertaken with an aim to develop alternative cost effective building materials among which the application of both Ferro cement Sandwich panel and Ferro cement in non-load bearing walls is made on one of the staff quarters of HBRI. The construction procedure of Ferro cement sandwich panel is emphasized and depicted in the writing that incorporates two layers of Ferro cement as the face sheet and expanded polystyrene (EPS) as the core. The sandwich panel is assumed to be a more developed stage of Ferro cement construction technique as incorporation of polystyrene will improves the insulation property of the material against heat and sound. The increase in thickness of the wall further helps to install door window frames effectively in construction. In the context of Bangladesh, this is the very first effort to accomplish and systematically document a construction technique, associating Ferro cement sandwich panels as infill wall material.

2. Significance of the Study

The development of lightweight, industrialized and sustainable construction techniques in Bangladesh is a need of the day. The prevailing construction trend involves Reinforced Cement Concrete and burnt brick as infill walls which are heavy in weight. Ferro cement structural elements are known as lightweight, high performance composite material which can replace the conventional heavy materials. This research and its findings will encourage the use of the new approach to produce lightweight composite wall elements. The

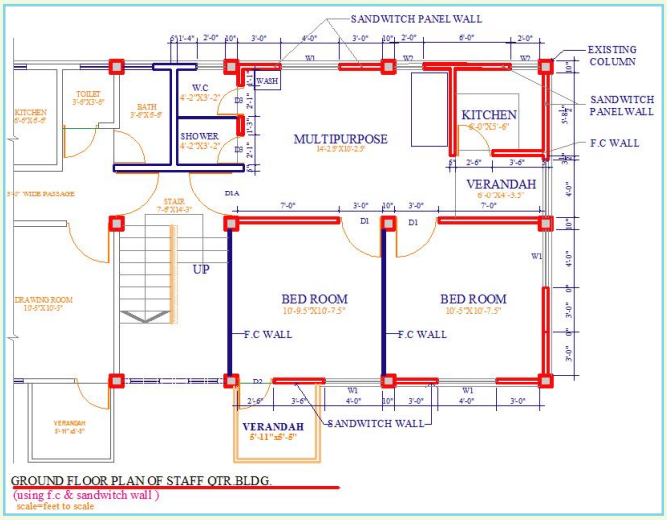
study, surely, is a step forward in the right direction to achieve quality products. The current project is able

- To produce a new potential structural composite, that is an integration of Ferro cement and expanded polystyrene for modular housing and building system which can be developed and marketed nationally and internationally.
- To develop a novel method of light weight construction resulting in a cost effective production.
- To help solve the housing problem of low and middle income earners.

4. Detail of the Pilot Project

As stated earlier, that a pilot project has been conducted on application of Ferro cement Sandwich panel and Ferro cement wall at HBRI's staff quarter in Dhaka. An apartment of approximately 530 sft was renovated with Ferro cement sandwich panel and Ferro cement wall.

The apartment consisted of a multipurpose room, two bedrooms, a kitchen, toilet, shower and a balcony. Ferro cement sandwich panels were applied on the overall outer surface for better heat and sound insulation purposes. Few interior walls were also constructed with sandwich panels. Ferro cement walls were used in the toilet and shower areas. Fig 1 shows the detail of the design and location of the sandwich panels and Ferro cement walls.



Ferro Cement Wall

Ferro Cement Sandwich panel

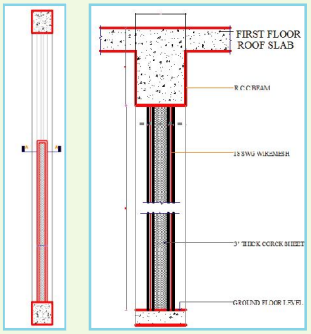


Fig 1: Floor plan and details of the pilot project

5. Construction Material and Process

5.1. Construction Materials

The following construction materials were used for the construction

- Expanded Polystyrene (EPS) sheets (2.25″ thick)
- Woven wire Mesh (18 gauge)
- Portland Composite Cement
- Sylhet sand as fine aggregate (FM 2.9)
- Potable water
- Binding wire
- Chalk marker
- 3″X3″ clamp
- Screw
- Royal plug

5.2. Construction Aids and Tools

The following aids and tools were used for the construction

- Masonry trowel of medium size
- Square rammer
- Nylon cord
- Aluminum scale
- Spirit level
- Plumb Bob
- Wire mesh cutter
- Mixing pan
- Binding hook
- Bucket
- Drill machines
- Spades

5.3. Construction Process

5.3.1. Preparation of mesh

At first, the length and height of the wall were measured. The opening was cleared from the measurement and mesh was cut accordingly. Two sets of meshes were prepared as per the measurement. Necessary splices were provided where there was a joint with columns and beams. The lap length was considered as minimum as three inches.

Figure 2: Preparation of mesh

5.3.2. Surface Preparation

Firstly The area was cleaned by brush and water before starting the construction. The base, top and sides of the wall were marked by chalk to make two lines with the spacing of 2.25 inch with the help of nylon cord and aluminum patty. Two lines of L-shaped angles were then fixed with the floor, wall and beams. The EPS sheet was placed inside the angle. The required opening space was made into EPS sheet as well as wire mesh. The side of the opening was strengthened by extra steel to provide protection against crack. At the edge of the opening, a 4″X4″ column was made by using 4-10 mm diameter as main steel and 5mm diameter stirrup @ 6″c/c. The mesh was placed gently on both surface of the EPS sheet and was extended up to the face of the edge of the column. The mesh was fixed and held by clips that are fixed on both side of the EPS sheet.

Figure 3: Surface Preparation

5.3.3. Casting Procedure

A standard wall size of 10′-0″ x 10′-0″ needs at least 20 kg's of square wire mesh; size of about 144 mm2 (18 G) (2 layers) and 200 gm of binding wire. Cement mortar was prepared in a clean surface using Portland composite cement and Sylhet sand with FM value of 2.90. Mixing ratio for Ferro cement is very important and was strictly followed. The water: cement: sand (W: C: S) ratio for Ferro cement casting was 0.45: 1: 3 by weight. Sand and cement were first evenly mixed; the required quantity of water was added afterwards. For a wall size of 10'-0"X10'-0" and thickness 1/2″ on both side of EPS sheet; approximately 125 kg cement, 10 cft Sylhet sand and 55 kg of water is required. Mortar was gently placed on prepared surface of EPS sheet. Firstly, mortar was placed on one side (say side 1) of the EPS sheet. Other side (side 2) was then supported by flat wood and bamboo so no displacement was occurred at the time of first mortar placement. Casting was stopped after completing 3 to 4 feet on side 1. Then casting was started to side 2 of the wall after half an hour and double height of side 1 was achieved. It was then left for the next day.

Figure 4: Initial Mortar Placing

Next day water was sprayed on previous day's casted surface. After 24 hours of casting and plastering, curing with spraying water was started. Water was sprayed each hour of the day and it was maintained for continuous even days. The placement procedure is called bottom up process and masonry trowel was used for the application. The mortar thickness was maintained slightly below ½ inch on both sides of the sheet. When the mortar was slightly hard (approximately after ½ hour of placing mortar) it was then plastered using same mortar and final thickness of 1/2″ was achieved. Special care was taken to finish the top, sides and edges of the wall neatly. The edge of the opening was left for another RCC casting. Care was taken about the verticality of the wall using spirit level and plumb bob. The wall was then kept untouched for 24 hours before starting curing. Precaution was taken to make sure that nobody touches it. Curing started after the 24 hour period was over. After seven days of curing the RCC column was casted and cured for another seven days by wrapping jute bag on it.

After 24 hour of casting and plastering, curing started by spraying water. were. Water was sprayed until overflow each hour of the day and it was maintained for continuous seven days.

5.3.5. Finishing

After seven days of curing, the wall was left for three days to dry. Then it was cleaned by sand paper and stone and, after proper brushing, it was ready for primer coatings. A mastic paste made from chalk powder and white cement primer paint was prepared and it was applied on the two surfaces. After the mastic has dried, it was sandpapered and final paint coat was applied.

6. Conclusion and Remarks

6.1. Development and Application

The above described technique was a pilot project at HBRI. Once it is mastered, several improvements can be undertaken

- Commercial plasticizer can be used to augment the workability of the mortar mix and to reduce the water content thus enhancing the mortar strength.
- Precast wall panel can be made in the factory and it can be transported to the site to fix.
- For precast panel, standard sized panel can be made and there should be groove on each panel to fix with the other.
- EPS can be replaced with any other light-weight materials such as, aerated concrete.

6.2. Problems faced during construction and some possible recommendations

- Installation of wooden frames for doors and windows are complex compared to brick masonry wall.
- Hard to control good workmanship due to manual handling of materials.
- Possibility of lateral bending during the casting procedure if proper care is not taken.

Further research initiative has been undertaken at HBRI to overcome the problems associated with the practical use of sandwich panels. Comparative analysis of cast in situ and precast technique will help to find appropriate solutions to the problems.

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