GFRG/RAPIDWALL CONSTRUCTION MANUAL

Structural Engineering Division
Department of Civil Engineering
IIT Madras

Building Materials & Technology Promotion Council
Ministry of Housing & Urban Affairs
Government of India

GFRG / RAPIDWALL CONSTRUCTION MANUAL

[Construction of Buildings using
Glass Fibre Reinforced Gypsum (GFRG) Panels]

Prepared by

Structural Engineering Division
Department of Civil Engineering
IIT Madras

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Disclaimer

The information presented in this Manual is supplied in good faith and is based entirely on the test data and design guidelines furnished for GFRG building panel. BMTPC and Indian Institute of Technology Madras is not responsible for incorrectness, if any, in such data furnished for GFRG building panels.

Acknowledgment

The support of Rapid Building Systems Pty Ltd Australia, RBS India Pvt Ltd, Rashtriya Chemicals and Fertilizers (RCF) Mumbai, FACT-RCF Building Products Ltd (FRBL) Kochi – Govt of India Public undertaking, is gratefully acknowledged.

FOREWORD

BMTPC in its quest to bring sustainable construction systems replacing conventional cast-in-place RCC frame/brick & mortar systems has been promoting Glass Fibre Reinforced Gypsum (GFRG) panel system in collaboration with IIT, Madras. GFRG panel system is a load bearing panel with cavities which are filled with reinforced concrete as per design requirements. The technology is originally developed as Rapid Wall system in Australia and later researched, modified & adapted to suit Indian conditions by IIT, Madras. The panels are made from phospho-gypsum which is a by-product of a fertilizer plant after calcining the gypsum. The panels are structurally efficient & durable and can be used up to ten-storeyed buildings, however, the use of any new system involves number of challenges such as certification, development of sufficient technical literature, guidelines, design-aids, specifications, rates and its analysis including IEC activities. BMTPC being promotion council has certified the system and published number of documents related with GFRG panel system with the technical support of IIT, Madras.

Continuing this effort, BMTPC is pleased to publish this construction manual which gives the users step by step procedure for construction of buildings using GFRG panel. The manual will also be a useful training resource for imparting training to site engineers including other professionals involved into GFRG construction. The manual has been prepared by a team of researchers at IIT, Madras led by Prof. A. Meher Prasad & Prof. Devdas Menon. The efficacy of GFRG panel system has already been amply demonstrated in the field by constructing no.of buildings in the field. The two projects which have been recently completed by BMTPC & IIT, Madras are (i) construction of 36 houses in G+1 configuration at Nellore, AP (ii) construction of two-storeyed guest house at IIT, Madras. There is one ongoing project at IIT, Tirupati where a few buildings are being constructed using GFRG panel system.

I would like to place on record my sincere gratitude towards Prof. Bhaskar Ramamurthy, Director, IIT, Madras for supporting our cause and jointly promoting the system. I would also like to acknowledge all the researchers of IIT, Madras who have helped in developing the manual including Shri Gopinathan of Rapid Building Systems and Shri C.P. Dinesh, CMD, FACT – RCF Building Products Ltd.(FRBL), Kochi.

It is sincerely hoped that the manual will go a long way in mainstreaming the technology in the field.

Dr. Shailesh Kr. Agrawal
Executive Director, BMTPC

PREFACE

Construction using GFRG (Glass Fibre Reinforced Gypsum) panels has been identified as a potential solution addressing the problem of housing shortage. Building Materials & Technology Promotion Council (BMTPC), with the support of IIT Madras, has already published 'GFRG / Rapidwall Building Structural Design Manual', 'Manual on Waterproofing of GFRG / Rapidwall Buildings' and 'Schedule of Items & Rate Analysis for GFRG construction' to aid architects, structural engineers, construction engineers and builders in the structural design, planning and estimation of GFRG buildings. There is a need for a manuscript explaining the sequence and good practices to be followed at the construction site. The construction manual addresses this issue.

GFRG building system and method of construction have been adapted to suit the Indian conditions, with compatible structural design. The method of construction of GFRG buildings is explained in detail with illustrations and photographs of construction, equipment, tools and tackles, waterproofing treatment (as per GFRG water proofing manual) and finishing works.

This manual can also be used for training professionals (site engineers / technical supervisors) in the construction industry on the know-how of GFRG building construction. For labourers involved in construction, providing hands-on training in actual construction sites is needed to make them skilled and proficient in all aspects of construction, from the erection of wall panels to the final finishing works.

Prof. Devdas Menon Prof. A Meher Prasad

Department of Civil Engineering
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1. INTRODUCTION

GFRG (Glass Fibre Reinforced Gypsum) panels are building panels suitable for affordable mass housing construction, originally introduced in Australia in 1990 (as 'Rapidwall'). These are large load bearing building panels manufactured out of calcined gypsum, glass fibre rovings and special additives. In India, phosphogypsum (a by-product waste from the fertiliser industry) is used for the manufacturing. Currently, Rashtriya Chemicals and Fertilisers (RCF), Mumbai and FACT – RCF Building Products Ltd (FRBL), Kochi produce GFRG panels in India, in technological collaboration with Rapid Building Systems (RBS) Pty. Ltd., Australia. GFRG panels are manufactured to a size of 12m length, 3m height and 124 mm thickness with hollow cavities as shown in Figure 1. The cross-section of the panel is shown in Figure 2.

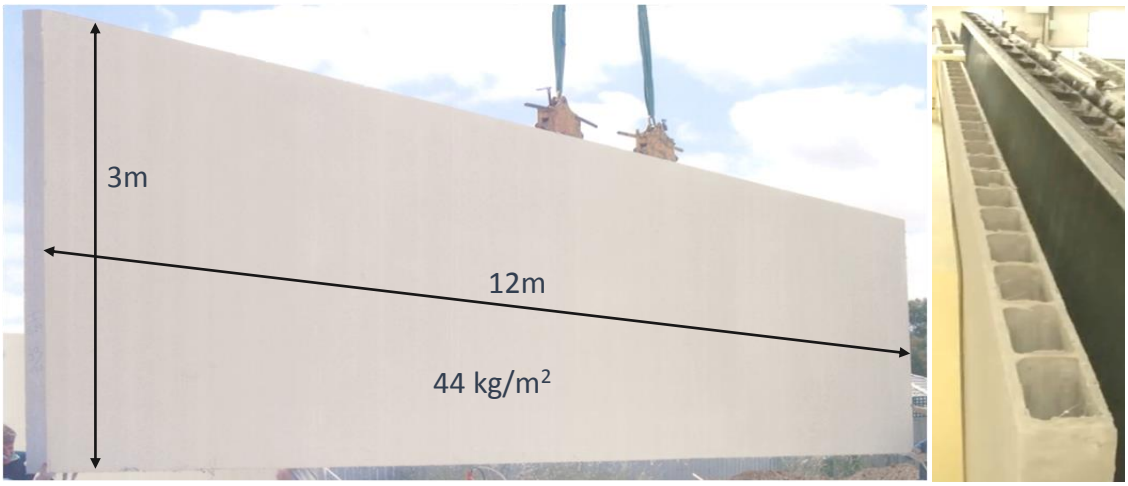


Figure 1: GFRG panels

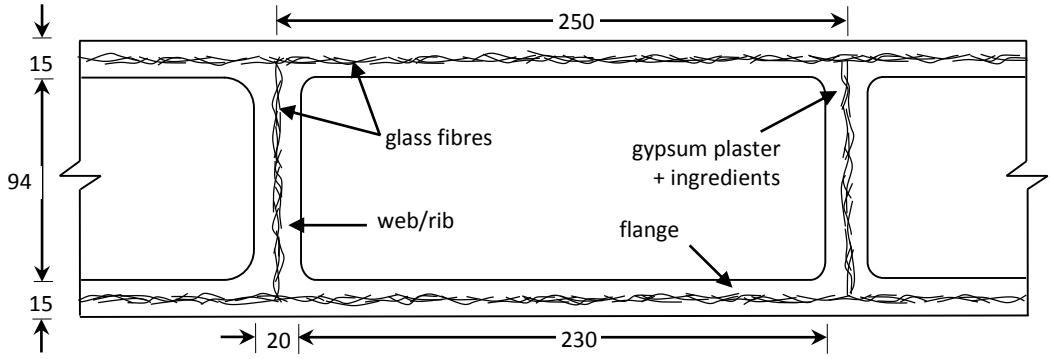


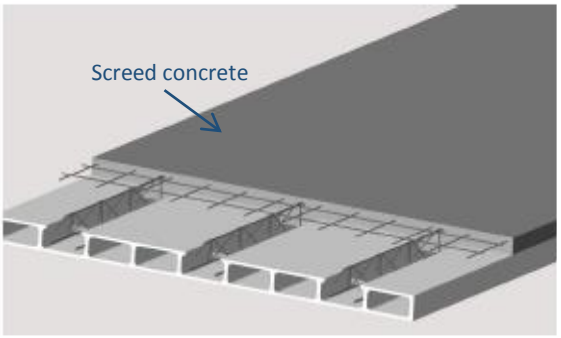
Figure 2: Cross section of GFRG panel
(all dimensions are in mm)

The cavities of the panel can conveniently be filled with concrete and reinforced with steel bars, which increases the load carrying capacity of the panel significantly. IIT Madras has been involved in the research and development of GFRG technology since 2003. The research group

at IIT Madras extended the application of this product (used only as load bearing walls in Australia and China) for the entire building system – including floors, roofs, parapets, sunshades, staircases and lift wells, thus significantly reducing the consumption of reinforced concrete (RC). IITM research group also conducted extensive studies on the use of wall panels as structural members for earthquake resistant design, and a detailed design methodology has been developed satisfying the provisions of National Building Code (NBC). Buildings built using this technology can go all the way up to 6 to 10 storeys in moderate seismic zones in India. The cavities in the panels can also be used for concealing electrical wiring and other plumbing works.

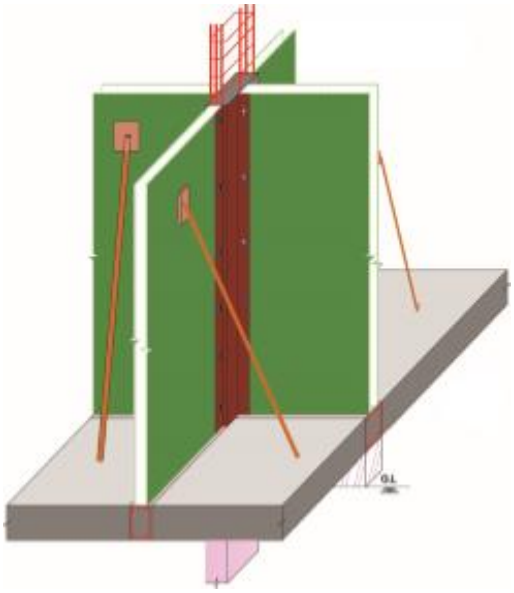
The applications of GFRG panels are illustrated in Figure 3.

a) As lightweight load bearing walls

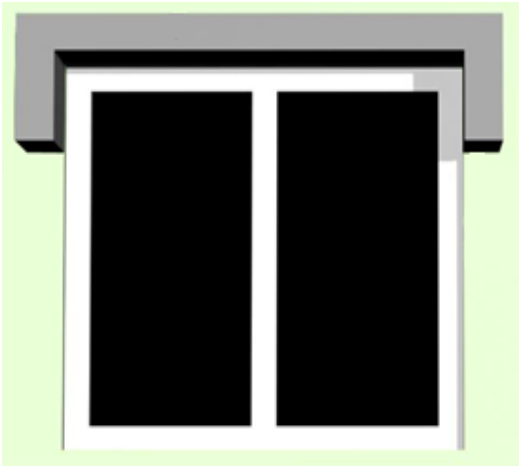


b) As floor slabs / roof slabs

c) As staircase waist and landing slabs



d) As infill walls in RC – GFRG hybrid building systems



e) As sunshade

Figure 3: Applications of GFRG panels

The GFRG building system comprises RC infilled GFRG wall panels and GFRG-RC floor / roof slab, together with a screed concrete at the top. The chemical additives included in the calcined gypsum during the manufacturing process render the panels water-resistant, and hence there is no need for any kind of waterproofing to be applied on the panel surface. But the construction joints in GFRG walls at vertical and horizontal joint locations need to be sealed and waterproofed to resist the ingress of moisture. One of the challenges of waterproofing of the construction joints of GFRG building is that the water proofing treatment (joint sealant application) needs to be compatible with gypsum based GFRG panel, concrete and also MS (mild steel) / aluminium / iron / wood, which are commonly used for window / door frames. In this regard, M/s Zydex Industries and M/s Alchimica India Pvt. Ltd. developed joint sealants based on nanotechnology and polyurethane based technology respectively, suitable for such applications in GFRG buildings. They also developed special primers suitable for use on GFRG panels to prevent peeling-off of paints in the long run. In addition to providing good bonding property of paint on the panel surface, the primer also enhances abrasion resistance and water repellent quality. These products were tested by IIT Madras and were found to perform satisfactorily.

Furthermore, in GFRG – RC slabs located at the roof level, toilet areas and balconies, it is desirable to provide waterproofing, as the thin screed concrete is not likely to be impermeable. Conventional waterproofing treatments may be applied. The methodologies of application of waterproofing products and primer have been detailed in the 'Manual on Waterproofing of GFRG / Rapidwall Buildings' [1].

GFRG buildings are found to have the following advantages over conventional buildings:

- High speed of construction
- Less built-up area for the same carpet area: wall panels are only 124 mm thick.
- Less embodied energy and carbon footprint: significant reduction in the use of cement, sand, steel and water; recycling of industrial waste gypsum.
- Lower cost of structure: savings in materials and labour input.
- Lesser building weight (panels weigh only 44 kg/m^2), contributing to savings in foundation and reduction in design for earthquake forces in multi-storeyed construction.
- Buildings up to 6 - 10 storeys can be constructed using this load-bearing system, without the need for beams and columns

- Excellent finishes of prefabricated GFRG panels – used for all the walls, floors and staircases, with minimal embedded concrete: no need for additional plastering.
- UNFCC approval under Clean Development Mechanism (CDM) of Kyoto protocol for carbon trading [2]
- Satisfactory performance under the event of fire
- Good thermal comfort: indoor is cooler in summer and warmer in winter – ideal for tropical climates
- Rot and termite resistant
- Recyclable

The limitations of this technology are:

- In this load bearing wall system, the same floor plan has to be replicated in all floors, in multi-storeyed constructions.
- Precast constructions, especially on a mass scale, calls for meticulous planning and preparation, prior to start of construction.
- All the prescribed guidelines for cutting of panels, transportation, erection, joints, application of primer and waterproofing need to be strictly followed to ensure fault free performance of this prefab building system.
- Spans exceeding 5m are not advisable.
- Building height is restricted to 6 to 10 floors depending on seismic zonation.
- Walls and slabs are required to be planar, not allowing for curvature.
- The electrical/plumbing fittings should be planned in such a way that most of the pipes pass through the cavities in order to facilitate minimum cutting of panels).

Building Materials & Technology Promotion Council (BMTPC), under the Ministry of Housing and Affairs, Government of India, approved GFRG / Rapidwall for design and construction of buildings up to 10 floors in India. BMTPC also approved and published a structural design manual titled 'GFRG / Rapidwall Building Structural Design Manual' [3] prepared by IIT Madras for the design of GFRG buildings including earthquake resistance requirement. The joint effort by BMTPC and IIT Madras also resulted in the development of a 'Manual on Waterproofing of GFRG / Rapidwall Buildings' [1] and 'Schedule of Items and Rate Analysis for GFRG Construction' [4], which can be used as an aid for the construction of such buildings in India. Code of Practice on the design of GFRG buildings is approved by BIS (Bureau of Indian Standard) and will be published shortly.

The method of construction of GFRG buildings has been developed so as to render it suitable for Indian conditions with reference to the 'Installation Manual' of RBS Australia [5]. The construction has been demonstrated by constructing a two-storeyed apartment building of 1981 sq.ft. built-up area inside the IIT Madras campus. (A video describing details of the construction can be seen at: http://www.youtube.com/watch?v=UUQEUcB7cMM)

The structural design of GFRG buildings should be done based on the BMTPC approved and published structural design manual [3], until the IS code on GFRG comes into effect. The method of construction of GFRG building is different from conventional building. The detailed methodology for construction to be followed, in addition to the provisions of 'National Building Code of India 2005' (SP 7 : 2005 [6]), is given in this manual. Also, the dos and don'ts in the various stages of construction that are to be strictly followed are mentioned in Annexure 1.

Durability / Life of GFRG buildings

In GFRG buildings, GFRG panels are used as walls, floor / roof slabs, staircases, etc., with many (if not all) cavities infilled with plain or reinforced concrete of M20 / M25 grade, as per the requirements of IS 456 : 2000. The reinforced concrete cores in the cavities are not directly exposed to the environment and are protected by the presence of the GFRG skin (15 mm thick) on either side in the case of wall panels and on the underside in the case of slabs. Further application of mandatory primer on all exposed GFRG panel surfaces and prescribed waterproofing treatment (specified in the 'Manual of Waterproofing of GFRG / Rapidwall Buildings') provides additional protection. Hence, if all the components of the GFRG building system are properly designed (as per the 'GFRG / Rapidwall Building Structural Design Manual' [3]) and constructed and finished (as per good practice, prescribed in this Manual), there is good reason to believe that the durability and life of the GFRG buildings will certainly not be less than that of conventional well-maintained buildings. The excellent performance of the oldest GFRG buildings in existence, presently located in Australia (close to 30 years), supports this assertion.

2. PRIOR PREPARATION FOR GFRG BUILDING CONSTRUCTION

Rapidity and cost effectiveness of GFRG buildings are best achieved when proper planning precedes the construction. Before starting the GFRG building construction, it is to be made sure that the following activities are appropriately carried out.

2.1 Preparation of Drawings and Obtaining Building Permit from Authorities

2.1.1 *Architectural and structural drawings*

An architect / structural engineer who is familiar with GFRG technology and its application shall prepare the drawings, keeping in mind the limitations of the technology (as stated in Chapter 1). By following the guidelines given in the structural design manual [3], a proper structural design shall be carried out. Any additional beams, cantilevered projections, balconies, etc., as provided by the architect in the building plan, shall be structurally designed, as done for conventional buildings.

Figure 4 shows the typical floor plan of a GFRG building (two – storeyed demonstration building constructed at IIT Madras). GFRG wall panels (124 mm thick) with cavity infill and reinforcement at appropriate locations shall be marked in the plan.

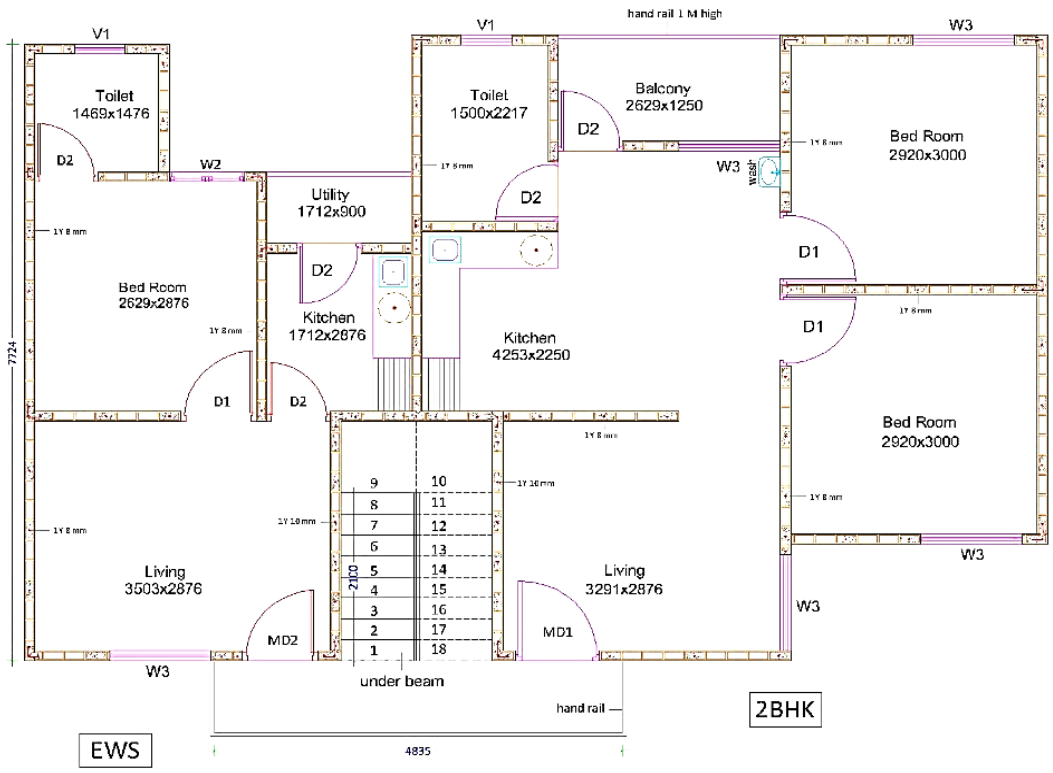


Figure 4: Typical floor plan of a GFRG building

2.1.2 *Approval for GFRG building construction*

As BMTPC has approved GFRG building construction up to 6 to 10 floors, building permission can easily be issued by local authorities based on the Performance Appraisal Certification (PACS) provided by BMTPC. Once the BIS code on GFRG building design and construction is published, the authorities can issue the permission based on this.

2.1.3 *Preparation of cutting drawings with notation markings for panels*

The conveyance facilities available in India, allows transportation of panels to a maximum length of only 6m. Based on this constraint and the plan dimensions, panels shall be cut in the factory before transporting to site. Cutting drawings shall be prepared with an intention to minimize the number of construction joints and wastage of panels. The dimensions of various cut panels (including the size of the openings, if any) which are to be used for different structural members like walls, floor / roof slabs, staircase, lift, parapet wall, etc., shall be marked in these drawings. Using an automated cutting facility, panels will be cut accurately in the factory as per the cutting drawings, thus reducing the construction time and effort. Notations of the cut panels shall be marked on the floor plan drawings, as shown in Figure 5 and Figure 6. Cutting drawings (Figure 7 and Figure 8) shall be prepared based on the architectural plan. This makes the construction easier, as the panels arranged in the stillages near the construction site can easily be identified by comparing the notations marked at the ends of the panel with those in the building plan and can be placed at their specified locations.

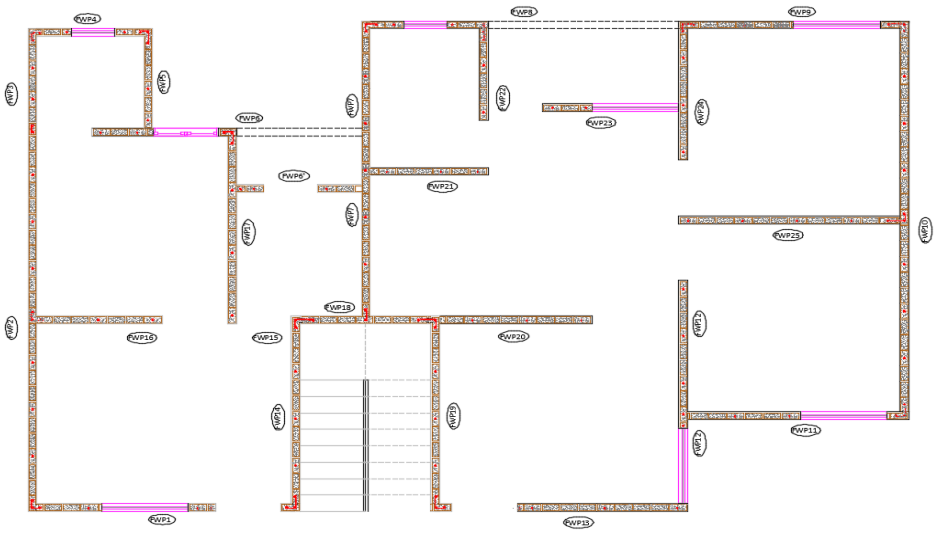


Figure 5: Typical floor plan of a GFRG building showing wall panel notations

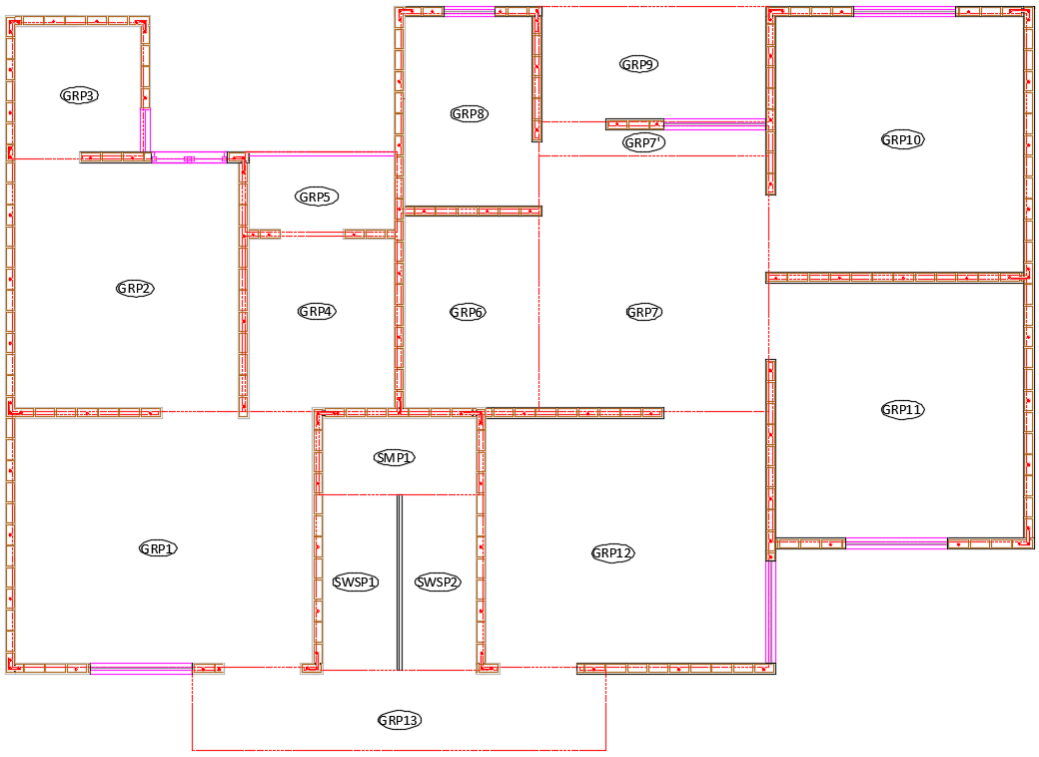


Figure 6: Typical floor plan of a GFRG building showing slab notations

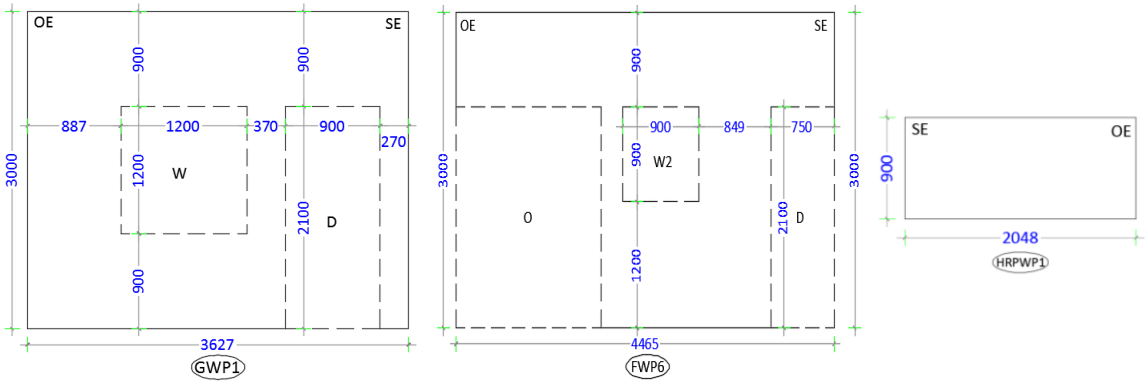


Figure 7: Wall/ parapet wall cutting drawings

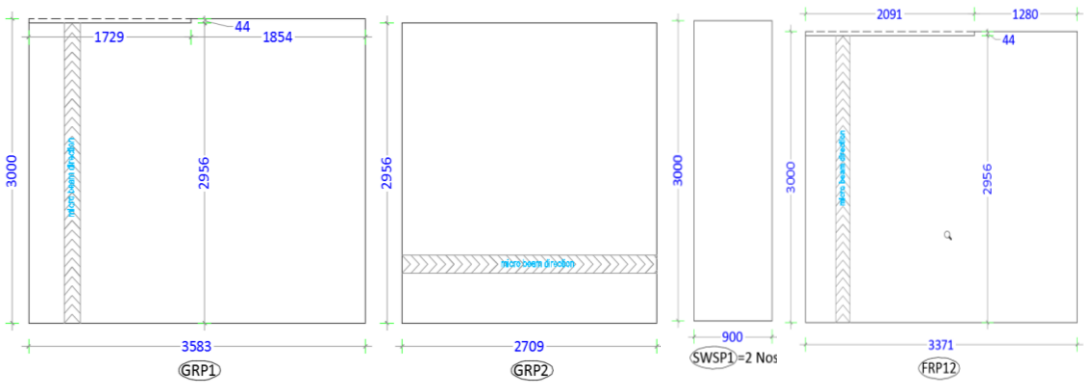


Figure 8: Floor/staircase waist slab panel cutting drawings

The notations, SE and OE, marked on the panels, refer to the Solid End (where a cavity ends with a web) and Open End (where the cut cavity remains open) of the cut panels. Other notations marked in Figures 5 – 8 denotes the following:

GWP	–	Ground floor Wall Panel
FWP	–	First floor Wall Panel
HRPWP	–	Head Room Parapet Wall Panel
GRP	–	Ground floor Roof Panel
SWSP	–	Staircase Waist Slab Panel
FRP	–	First floor Roof Panel

Other notations may be marked, according to convenience.

The cutting drawings have the following uses:

a) Preparation of BOQs
b) Cutting the panels in factory
c) Packing and loading in stillages
d) Identifying panels at site for lifting
e) Erection of wall panel, and laying of floor/ roof panel in correct position

After the required planning, the work can be awarded to a contractor / builder. The special tender conditions for GFRG building construction & terms of payment to builder / contractor are explained in Annexure 2. All adjustments in planning and cutting drawing shall be done in advance, prior to the actual cutting of the panels at the factory.

2.2 Preparation of Ancillary Drawings and Bar Chart Showing the Construction Sequence and Time Schedule

The drawings for electrical, water supply, piping and sanitary works should also be prepared along with the other drawings. Before the starting of construction, it is necessary to prepare a bar chart showing the sequence of construction activities and the probable number of days / duration required for each activity. There are certain activities that have to be carried out simultaneously by co-ordination, such as electrification, plumbing, pipe line work, staircase work, lift pit work, cutting of panel and insertion of reinforcement for RC lintel cum sunshade, waterproofing treatment of RC plinth beam and wall joints and wall corner joints, installation of window / door / ventilator frames etc.

2.3 Procurement of Panels and Transportation to Construction Site

Cutting drawings and the list of panels need to be sent to the factory for the purchase of panels. The panel notations (as provided in the cutting drawings) shall be marked legibly at both ends of the panel, in the factory itself. This helps in identifying the panels, stacked in stillages, at the site.

The panels supplied by the factory should satisfy the quality parameters prescribed in the PACS certification by BMTPC. Panels which do not satisfy the specifications shall not be used for the construction of structural elements.

2.3.1 *Loading of panels in vertical stillages*

Stillages are collapsible frames used for stacking the panels and for transporting thereafter. They are made of tubular steel sections and can be locked to ensure safety during transportation. There are two types of stillages; one which can hold 5 panels and the other which can hold 8 panels. The cut GFRG panels, stacked vertically in stillages, shall be loaded on to the trucks with flat deck (of length 6m or 12m, as the case may be). The stillages should be tied properly using soft steel rope through their eye on top and tied down to hooks on both sides of the truck body. In the case of small - sized panels (of width less than 2.27 m), up to 12 nos can be transported by arranging them one over the other in horizontal stillages (Annexure 3 shall be referred for more details). Up to 500m^2 of panels can be transported in a single truck of length 12 m. 6m long trucks can carry up to 200m^2 of panels. Figure 9 shows panels arranged vertically in stillages in the factory.

Figure 9: Panels in stillages

The order of loading of the cut panels onto the trucks and the subsequent unloading at site should be planned, keeping in mind the sequence of construction.

Necessary documents, such as packing list with details of panels, quality assurance document of each load of panel, list of stillages being sent (see Annexure 4 for format) should be given by the panel manufacturing company to the truck driver before starting the journey. The panel – related documents shall later be handed over to the site engineer or representative of the purchaser at site. The method of loading and transportation of panels is illustrated in Figure 10. The panels with open ends need special attention while transporting.

Figure 10: Loading and transportation of GFRG panels

2.4 Unloading and Stacking of Panels at Construction Site

Panels from the truck shall be unloaded and stacked at the site on a firm and flat ground (using suitable crane or fork lift), till they are used for the construction. The locations for various panels shall be based on proximity, sequence of construction and positioning of the crane during construction so that panels can be lifted easily and conveniently during erection. Typically in multi-storeyed construction, as soon as the panels from the stillages are

consumed for one floor, the wall and floor panels for the next floor shall be brought and placed nearer. The empty stillages can be dismantled and kept safely for sending back to the factory. Figure 11 shows panels stacked in different stillages at a construction site.

Figure 11: Panels stacked in stillages at construction site

Additional outriggers shall be attached to groups of stacked stillages at the extreme ends to avoid toppling during strong winds (Figure 12). If, for any reason, the usage of panels on stillages is delayed, it is recommended that the tops of the panels be covered with tarpaulin sheets and tied properly to keep them safe from fungal attack during heavy rain.

Figure 12: Stillages attached with outriggers

2.5 Procuring Materials and Availing Services

All the materials and services required for construction (for details, refer SP 7 : 2005 [6]) shall be arranged at site prior to the start of work. It shall be noted that the coarse aggregate used in concrete for superstructure construction shall be of size 6 – 10 mm. The quantities of waterproofing chemicals and primer (as per the 'Manual on Waterproofing of GFRG / Rapidwall Buildings' [1]) shall also be calculated and procured prior to start of the construction of superstructure. This is because the top surface of RC plinth beam needs to be waterproofed before the erection of wall panels.

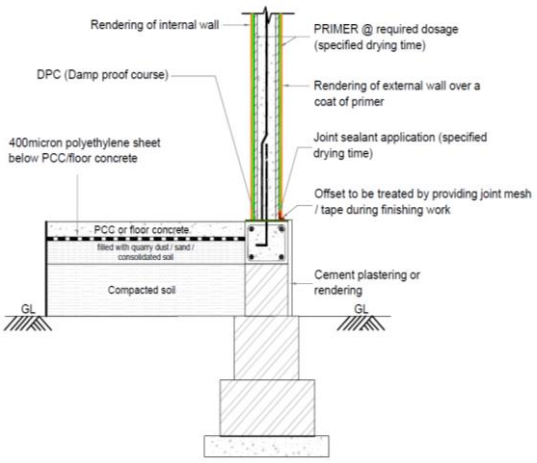
2.6 Construction of Substructure

The construction of substructure comprises of the following activities:

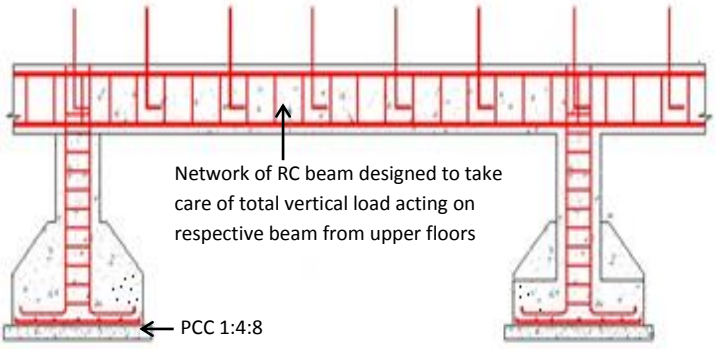
a) Construction of foundation below ground level
b) Construction of network of RC plinth beams (with starter bars in position) above the ground level
c) Infill of foundation / basement with soil / earth / sand and subsequent compaction
d) Plain Cement Concrete (PCC) floor concreting up to top level of RC plinth beam network
e) Waterproofing treatment over the top of RC plinth beam (as per the 'Manual on Waterproofing of GFRG / Rapidwall Buildings' [1]).

2.6.1 *Construction of foundation*

The foundation for GFRG buildings is constructed in the same way as that of conventional buildings, following the traditional good practices. If the bearing capacity of the soil is adequate, strip footing will suffice. Pedestals on isolated footing need to be provided in cases where the bearing capacity is lower. Figure 13 shows two types of foundation that can be used in GFRG buildings, based on the bearing capacity of soil. The strip footing shown in the figure was used for the demonstration building at IIT M campus and pedestals on isolated footings were used for the mass housing project at Nellore, Andhra Pradesh.



Strip footing



Pedestals on isolated footing

Figure 13: Types of foundation

2.6.2 *Construction of network of RC plinth beams*

A network of RC plinth beams shall be provided, with starter bars in position as per the structural drawing, with perfect horizontal top surface for proper erection of wall panels. Figure 14 shows the plan of network of plinth beams of a typical building. The red dots in the figure represent the starter bars.

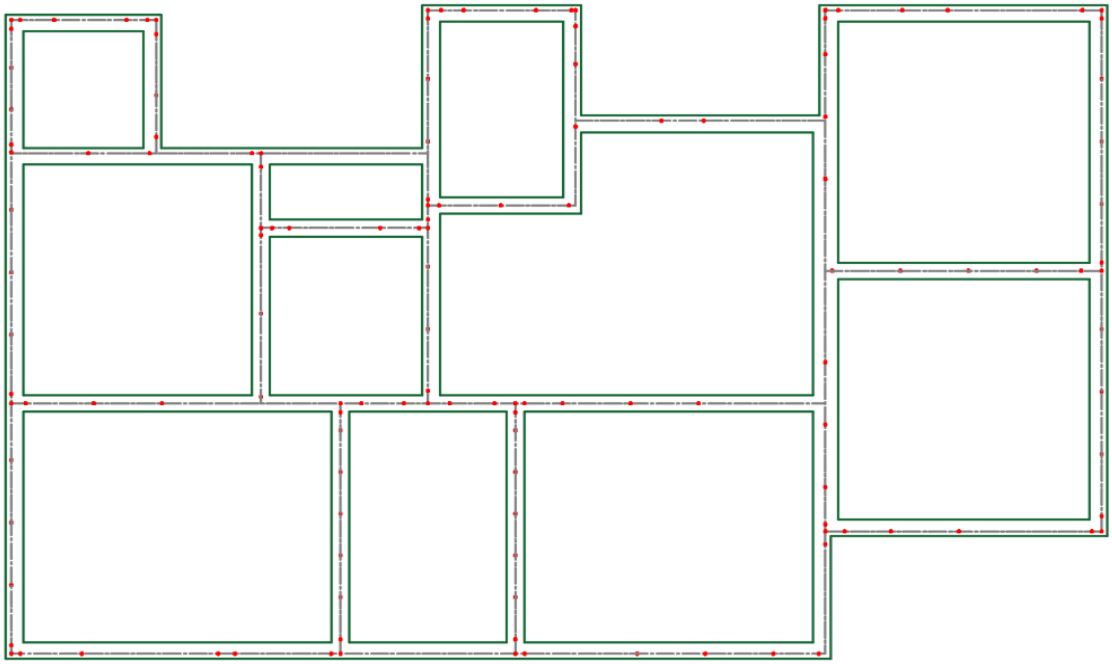


Figure 14: Typical network of RC plinth beams

Starter bars (having same diameter as that of the vertical bar as per structural design), provided in the plinth beams, should have sufficient development length for anchorage and lapping with the main reinforcement in wall panels. This ensures proper connection of wall panels with foundation. Figure 15 shows the method of providing starter bars in RC plinth beams.

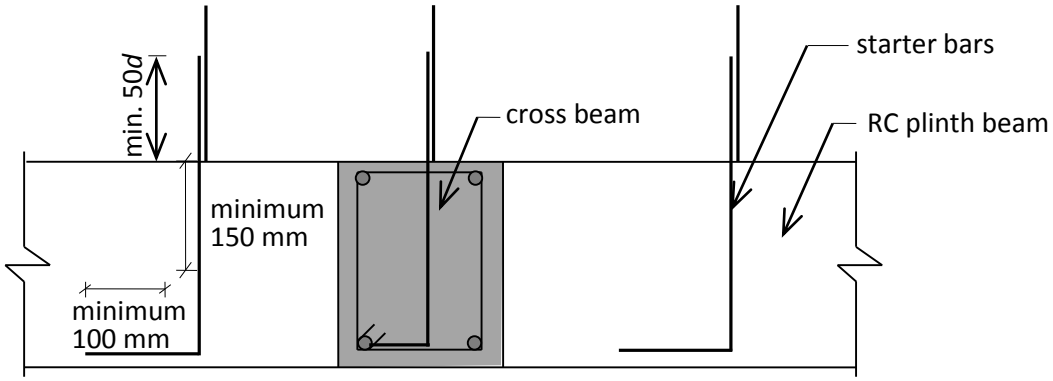


Figure 15: Starter bars in plinth beams

For constructing an additional storey using GFRG above an existing RC building, connectivity between GFRG wall and the existing floor shall be achieved by inserting starter bars (with proper anchorage) into the already existing beam / roof slab as per the advice of a structural engineer, as shown in Figure 16. If the existing floor slab does not have sufficient depth for anchorage, an additional RC beam may be constructed above the roof before erecting the GFRG walls.

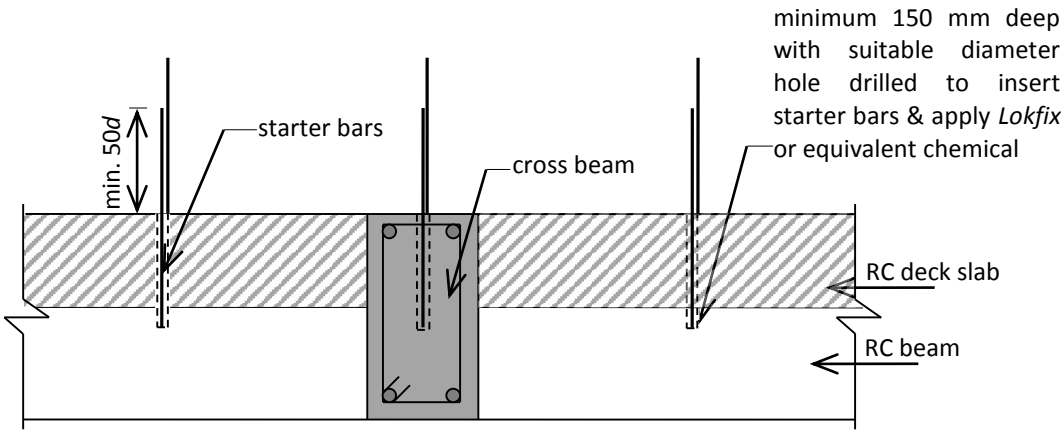


Figure 16: Starter bars for existing floor/roof slab

The arrangement of reinforcement, including starter bars, in RC plinth beams are shown in Figure 17 and Figure 18.

Figure 17: Reinforcement for RC plinth beam

Figure 18: Inserting starter bars

The concreting shall be done subsequent to the placement of bars. Later foundation/basement shall be infilled with soil/earth/sand and properly compacted, above

which PCC floor concreting shall also be done up to the top level of RC plinth beams as per building plan and shall be water cured before starting panel erection.

Figure 19 shows the completed foundation with protruding starter bars, ready for the erection of panels. It is not recommended to leave the top of the starter bars exposed, as it may cause injury to people. Instead, reusable plastic caps may be provided temporarily on the top of the starter bars, as shown in figure. Before panels are placed, the plastic caps may be removed and stored for the next job.

Figure 19: Completed foundation with starter bars in position (a) wrong practice (b) right practice

2.6.3 *Waterproofing treatment of foundation*

It is very important and critical to carry out waterproofing treatment on top of RC plinth beam before starting erection of wall panels. The 'Manual on Waterproofing of GFRG / Rapidwall Buildings' [1] shall be referred to, for the detailed guidelines.

2.7 Checking of Foundation Measurements

Before the erection of panels, it is necessary to check whether the foundation measurements match with the building plan and structural drawings, and rectification shall be done for any discrepancies observed. The spacing of the starter bars and their position shall be checked and verified by the construction engineer. In case of any inconsistencies observed, either the existing starter bars shall be bent slightly or new ones shall be provided with suitable anchorage (by lock – fixing). For checking perfectness of horizontal surface in ground floor as well as upper floor slab concreting, suitable laser equipment can be used (shown in Figure 20). If the top surface of the floor slab is not level, then rectification needs to be done either

by grinding the surface or by using packing materials (preferably cement sheets of appropriate thickness). However if suitable packing material is not available, it is necessary to provide cement plaster (1:3) with aggregate size of 5 mm or less, evenly to provide perfect level. This should be done before-hand and water cured for at least 2-3 days before the erection of wall panels. Subsequently, the mandatory Damp Proof Course (DPC) shall be applied as per the GFRG waterproofing manual [1]. The external vertical edge of the plinth beam should also be a straight line and perfectly 90° at corners.

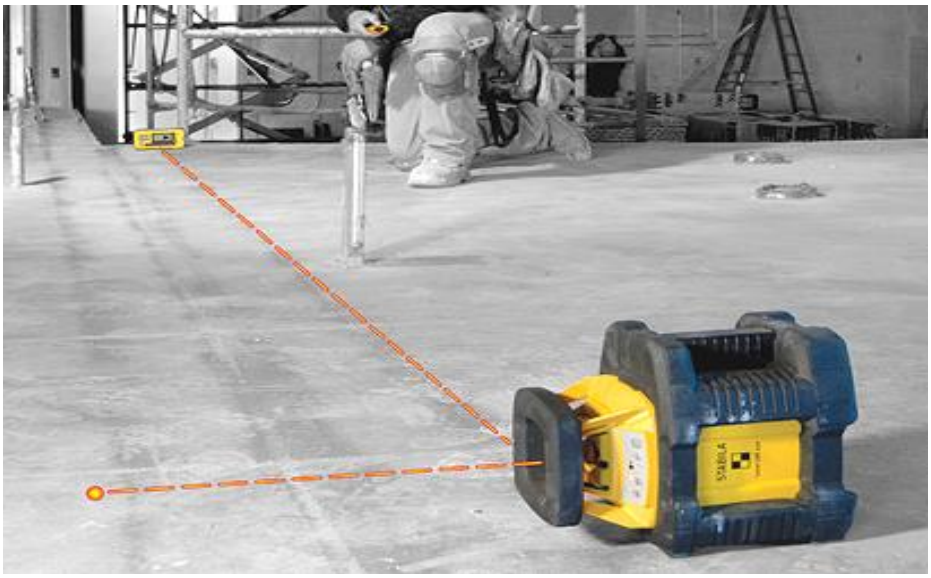


Figure 20: Laser equipment for checking horizontal level

2.8 Checklist of Activities to be Completed Prior to the Erection of Wall Panels

a) Measurements of the basement footing
b) Horizontal level of RC plinth beam (outer side length-wise) and top level of network of all RC beams
c) Waterproofing of RC plinth beam
d) Application of DPC
e) Bar bending works for vertical bars, RC lintel and staircase reinforcements

3. CONSTRUCTION TOOLS & TACKLES, PROFESSIONALS AND MANPOWER REQUIRED FOR GFRG / RAPIDWALL CONSTRUCTION

The various construction tools and equipment that are used for conventional building construction shall be used for GFRG construction also. SP 7 : 2005 [6] shall be referred to for details on use of such resources and their related safety practices. The following additional tools and tackles shall be used for GFRG building construction.

3.1 Tools and Tackles for GFRG Construction

- ***Crane fitted truck (or local crane)***

Figure 21: Cranes for lifting panels

Cranes are required for lifting the panels from stillages stacked at site and transferring them to the location of erection. Panels need to be hooked to the crane till they are placed on top of the plinth beam or floor slab.

- ***Lifting jaws and spreader bars***

The panels shall be hooked to the crane using lifting jaws.

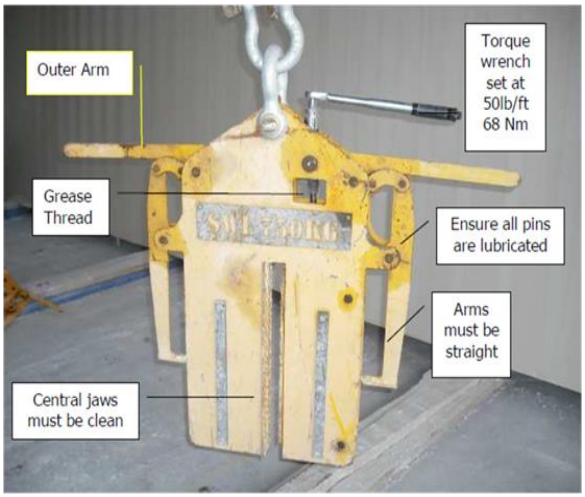


Figure 22: Parts of a lifting jaw

A lifting jaw has three levers, one each on either side and one at the centre (Figure 22). The central lever is used to tighten the central clamp on to the web (held by friction), by rotating the lever in a clockwise direction. The side clamping levers (on left and right sides) shall be pushed down (one at a time) to horizontal level in order to pierce the web / rib of panel and to lock the webs/ribs properly.

The functional conditions of the jaws shall be checked before usage. Lifting jaws are to be cleaned to get rid of cement plaster or other foreign objects including rust. The threaded section of the clamp needs to be greased often, especially before erection. The supervisor / site engineer shall check / inspect the lifting jaws every month. The lifting jaws shall not be used if they are damaged or broken or in need of repair. For panels up to 4m length, only one lifting jaw is required to be used (hooked close to centre of gravity) for lifting. For panels of length more than 3.5m, two lifting jaws (Figure 23) with a spreader bar are to be used (to distribute the weight of panel and to avoid local damage of web/rib). Spreader bars of different lengths shall be made available for construction. Jaws shall be placed equidistant from the central lifting point. Lifting jaws shall be inserted into the appropriate cavities in such a way that the centre of gravity of GFRG panel and centre of lifting jaws lie in the same vertical line.

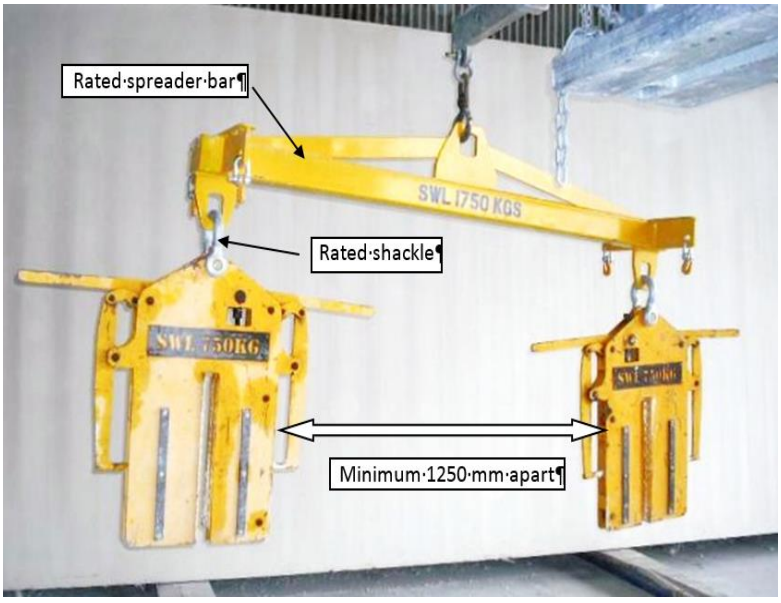


Figure 23: Spreader bar with lifting jaws

The procedure for handling and lifting of panels using lifting jaw is explained below.

Step-1: Before inserting lifting jaws into the cavities, loosen the central jaw clamp by turning the central nut in anti-clockwise direction with a ratchet with handle. This is to insert the clamp to central web;

Step-2: Push both outer arms upwards to vertical position to open up the side arms, in order to enable insertion into two cavities holding the respective web/rib;

Step-3: Insert jaw into both cavities of panel;

Step-4: Tighten central jaw firmly by turning the central nut clockwise using ratchet/socket with handle. It means the central jaw is pressed from two sides against the central ribs;

Step-5: Now, push the outer arms from vertical position into horizontal position by pushing down one after another. By this each side arm pin is pierced into respective ribs;

Step-6: Both outer arms will now be in horizontal position;

(Holding of panel by lifting jaw is by: (i) central friction clamp, (ii) two side arm pins pierced into both ribs on either side of the central ribs);

Step 7: Now remove the ratchet handle;

Step 8: If for some reason, the panel is to be re-lifted, the position of spreader bar and the locking position of lifting jaws shall be changed to suitable cavities. This is to prevent any possible accident on account of tearing of web due to damage caused to web/skin;

Step 10: Tie rope by drilling holes at the bottom of panel through rib section to guide its flight for erection;

- ***Under panel spreader bar***

Figure 24: Under panel spreader bars

For the purpose of lifting the GFRG slab panels in a horizontal position, under panel spreader bars shall be provided, as shown in Figure 24, for enhanced stability during the movement.

- ***Wooden blocks***

Wooden blocks (preferably, of size 150 x 150 x 150 mm) are used for supporting the wall panel at the base just before erection for the purpose of tying vertical rebars with the starter bars in the RC plinth beam / floor slab (Figure 25).

Figure 25: Wooden block for supporting wall panel

- ***Adjustable lateral props***

Adjustable props are to be fixed to GFRG panels to keep the wall panel in position and to make the panel ready for concrete infill. They are typically made of 2850 mm long square hollow section with top and bottom bases with holes in order to be fixed to the floor using 60 mm deep concrete fastener. The top shall be tightened to wall panel using nut and bolt and the bottom to floor slab, by using threaded rods. The panel shall be continued to be hooked to the crane using lifting jaw, till the first pour of concreting is done. Figure 26 and Figure 27 give the details of a typical lateral prop.

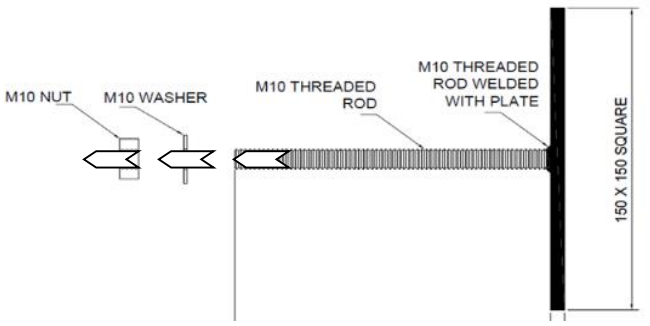


Figure 26: Fixing Plate with threaded rod 180 mm long

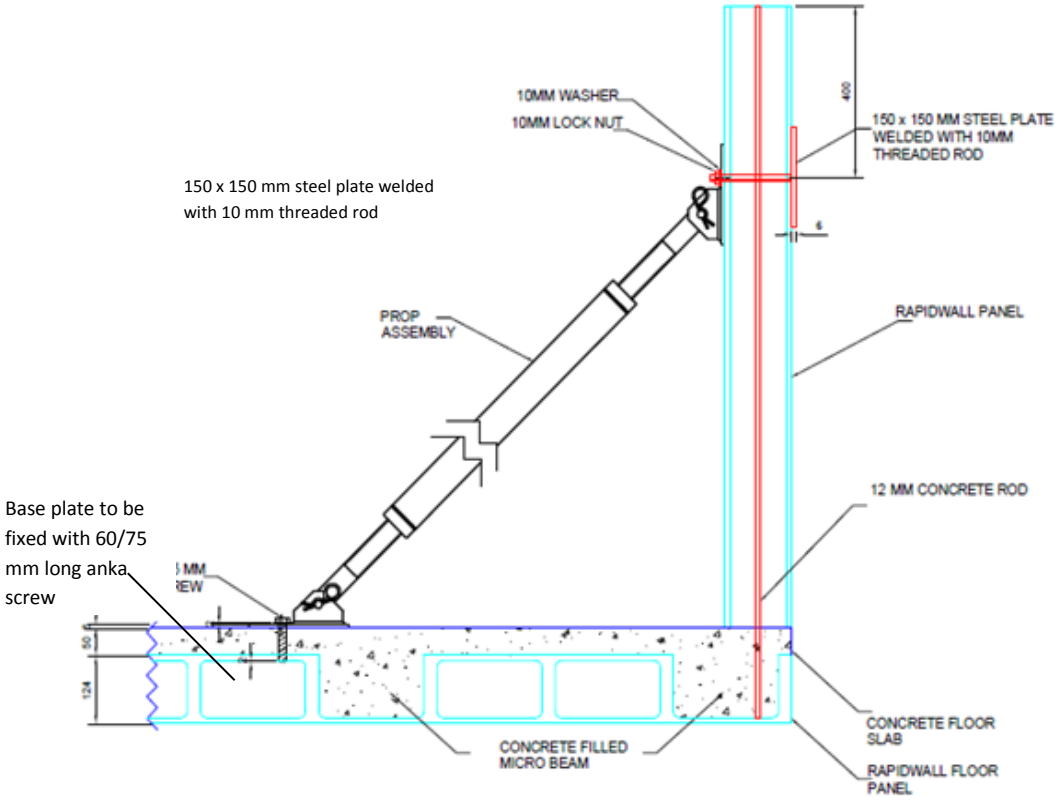


Figure 27: Lateral props for supporting wall panels

The tip of the adjustable lateral props shall be at least 400 mm below the panel top. It shall be above window/ door / lintel level. In short, it shall preferably be fixed at a height of 2.1m to 2.4m from the floor slab. Drill 10 mm diameter hole through the panel close to or through the vertical web (hole should not be oversized). On the other side of the hole, provide square plate of minimum dimension 50 x 50 mm and thickness of 3 mm. Insert the threaded rod through the hole. It shall not be over-tightened. After adjusting the level of the panel (positioning it exactly vertical), base hole shall be marked by drilling on to the floor concrete / slab. Anka screw shall be inserted into the prop base plate and tightened with a rattle gun or spanner.

In upper floors of multi-storey buildings, props for lateral support can be provided only from inside. The outer wall panels shall be safely secured in position by using adjustable lateral prop fixed on floor slab using Anka screw and with proper steel plate using nut and bolt on outer side at top. The same shall be done for other internal walls and cross walls also. The maximum spacing of lateral props shall be 2.7m and the maximum panel overhang (distance from last prop to the panel end) shall be 1.3m as shown in Figure 28.

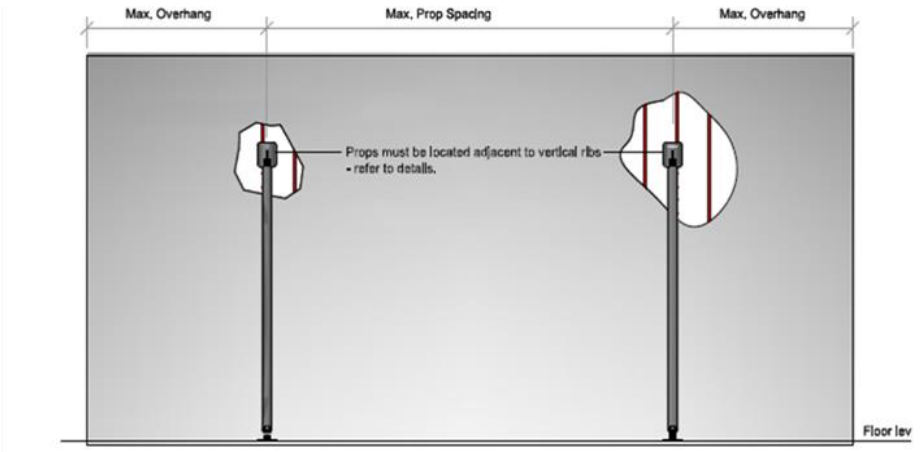


Figure 28: Typical propping detail - elevation

Spacing of lateral props for various floor / storey heights considering the effect of wind:

1-3 storeys : 2.7m spacing, allowing 1.3m overhang on both ends

4-6 storeys : 2.3m spacing, allowing 1.2m overhang on both ends

7-9 storeys : 2.1m spacing, allowing 1.1m overhang on both ends

10 storeys : 2m spacing, allowing 1m overhang on both ends

- ***Clamping system***

Clamping system consists of suitable angle section (preferably 40 mm × 40 mm), made of iron plates (for inner side) / mild steel flat plates (for outer side) of suitable thickness. This shall be provided on wall corner joints, before infill of concrete, to keep the walls in position and to prevent bursting-off. Holes shall be made at a distance of 0.5m from the top and bottom edges for tightening the threaded rods and nuts. Threaded steel or iron rods shall be inserted and tightened on both sides with mild steel sheet of 3 mm thickness using washer of 50 mm x 50 mm. The clamping system for “L“, “T”, "+" and horizontal joints are shown in Figure 29.

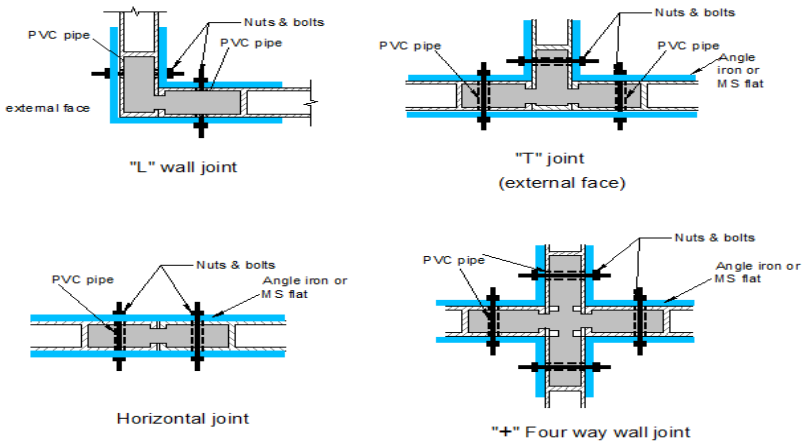


Figure 29: Clamping system for various kinds of wall joints

Figure 30 shows the clamping system connected to all the wall corners to prevent movement while concreting.

Figure 30: Wall corners held firmly using C-clamps / L-angles

- ***Marble/wood cutter***

Marble/wood cutters are required at site mainly for cutting the top flange of GFRG slab panels. Bosch wood cutter GSA 1100E or any other suitable cutters shall be used for this purpose.

Figure 31: Wood cutter

- ***Pole sanding machine (Giraffe sander) or any other grinding machine***

A pole sanding machine - Giraffe sander (Figure 32 a), or a wood grinder with sand paper discs (Figure 32 c), or other similar machines available in the market, shall be used for smoothening the GFRG panel surface (if required), before carrying out finishing works, like, rendering,

painting, etc. A concrete grinder (e.g., Figure 32 b - concrete grinder by Hitachi) shall be used for grinding and smoothening of the wall surface (especially where concrete has bulged out from the cavities). Any other suitable grinding machine available in the Indian market may also be used.

Figure 32: a) Giraffe grinder b) concrete grinder c) wood grinder with sand paper discs

In addition, the following tools shall be used for the waterproofing treatment / application:

- Sprayer machine or pump suitable for spraying waterproofing chemicals, primer, etc.
- Pump for pressure grouting

Regarding safety precautions, other than the safety items described in SP 70 : 2001 [7], the following additional items shall be used to ensure safety of workers in the construction site.

- Hand gloves (full length) for workers handling the panels
- Safety glass during cutting of panels

3.2 Manpower for GFRG Construction

One of the critical resources for the construction of GFRG / Rapidwall building is the crew of skilled workers and construction/site engineers/supervisors, trained and experienced in GFRG construction. It is preferred to have the following professional and manpower trained and experienced in GFRG building construction:

1. Construction engineer and site engineer / technical supervisor
2. Waterproofing applicator / supervisor and team of applicators.
3. Erection crew

The construction crew shall consist of the following 4 sub - teams:

1. Panel erection team consisting of 6 persons including team leader.
2. Team for reinforcement work, shuttering and support system, marking, plumbing, electrical, staircase work, etc. This team also shall comprise 6 persons including the team leader.
3. Concreting team shall consist of 2-3 skilled workers, who are to be supported by semi-skilled and unskilled workers. For other related works, local workers can be deployed.
4. Waterproofing applicator team of 5 persons including an experienced supervisor. This team shall carry out waterproofing application, repair, rendering and finishing works. The members of the team shall have accreditation from the waterproofing technology/products provider.

For more details of the construction crew, refer Annexure 5. Multiple crews shall be deployed in case of large projects.

4. CONSTRUCTION OF SUPERSTRUCTURE

The sequence of activities to be followed in the construction of the superstructure are explained below.

4.1 Erection of Wall Panels

Construction of superstructure starts with the erection of wall panels on completed foundation (concreted and waterproofed) with starter bars in position. The series of tasks that need to be done in association with the erection of wall panels are described below.

4.1.1 *Fixing position of cranes*

There shall be prior planning regarding the proper positioning of crane (Figure 33) to enable systematic handling of panels, sequence of erection and moving the crane around the building (if accessibility is available for crane movement). The GFRG panels shall be unloaded and stacked at site in stillages at a place, convenient for the process of lifting and erection. While unloading and stacking the panels at site, the sequence of panel erection shall be considered.

Figure 33: Positioning of crane

4.1.2 *Marking wall position*

Before a wall panel is lifted by crane, the wall panel position (inner and outer lines) shall be marked on the plinth beam/floor slab to facilitate correct positioning of wall panel. Alternatively, this may be done by temporarily screwing long wooden planks (preferably 100 mm wide and 50 mm thick) on either sides of wall panels into the RC plinth beam / floor slab. This will enable the erection of wall panel in correct position. The notation mark should be written on the concrete floor using crayon/ paint. In the case of outer wall panels of a building,

the wooden planks shall be provided at the inner side. Once the panel is fixed rigidly, the wooden planks shall be removed. Simultaneously, bar bending works shall be carried out by the team consisting of bar benders.

4.1.3 *Lifting of panels*

The panels shall be identified by comparing the notations marked on their sides as well as in building plan. The lifting jaws shall be fixed and locked correctly on the selected GFRG panel for lifting it safely. If the panel requires any processing like cutting (such as cutting of web for corner joints), the panel shall be hooked on to the crane until all the preparatory works are completed. Then the GFRG panel shall be erected at the exact location as per the drawings. It is advisable to erect the panel without removing door / window cut pieces from the panel, unless a proper assessment is made of the centre of gravity of the wall panel to maintain its verticality while lifting. This is illustrated in Figures 34, 35 and 36.

Figure 34: Identifying the panel based on notation mark and fixing the lifting jaws

Spreader bars shall mandatorily be used if two lifting jaws are used.

Figure 35: Lifting of long panels using lifting jaws and spreader bar

Figure 36: Lifting and placing of panels

Only a trained / experienced skilled worker (rigger) shall be allowed to fix and lock the jaws for safe handling, lifting and placing the panel in position.

'A' side and 'B' side of panel

The smoother side of the panel, called as 'A side', shall be used as the external surface in case of outer walls and ceiling in case of floor/roof slab, since rendering of internal side is easier as no scaffolding is needed and wastage of material will also be less. When 'A' side is used as outside surface, it will give a good finish once painted. The inside surface can be rendered for smooth finish and painted later.

In any case if 'B' side (rough side) is used as the external surface of outer walls, then rendering shall be done using the water-resistant rendering product (specified in the waterproofing manual [1]) for smoothening the surface before painting.

4.1.4 *Reinforcement for wall panels*

Reinforcement for walls shall be inserted into those cavities as indicated in structural drawings and shall be tied with the starter bars provided in plinth beams (as shown in Figure

37). To facilitate tying of rebar with the starter bars, the panel should be placed on wooden blocks kept over the plinth beam or floor slab for the erection of panel on upper floor. The wooden block must be placed only in the ribbed region and not in the hollow region. While doing this, the panel shall be safely hooked on to the lifting jaw.

Figure 37: Tying of starter bars with the vertical bars while erecting panel

Wall corner joints like “L joints“, “T” joints, four way (+) joints or horizontal joints shall be provided with additional reinforcement as per structural design. Typical detailing for the wall corner joints is shown in Figure 38. Corners should be cut-opened before joining the wall panels. The ties shall be provided at a distance of 25 mm from the top and bottom ends.

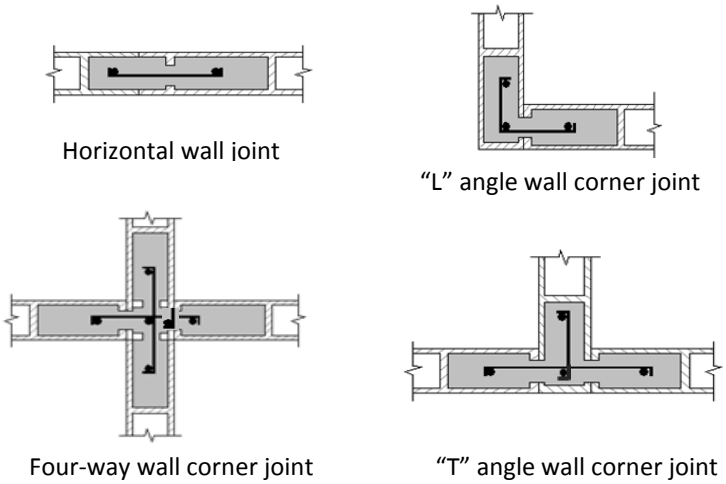


Figure 38: Typical wall corner joints

Once the panel is placed in position, the horizontal and vertical orientations shall be checked to make sure it is flush with line and plumb (Figure 39).

Figure 39: checking of vertical plumb

Minor level difference of the top of RC plinth beam (in GF)/floor slab base line (in upper floors) shall be corrected by placing cement sheets of 3 to 5 mm thickness, cut to a size of 120 x 50 mm, under web/ rib section (not under skin/ flange of panel). If level difference is more, it shall be filled using cement mortar along with water resistant compounds.

4.1.5 *Fixing of adjustable lateral props*

Figure 40 shows lateral props with base plate at bottom and fixing plate on top, supporting the wall panels in the ground floor of a GFRG building. The procedure explained in Section 3.2 shall be followed for fixing lateral props.

Figure 40: Lateral props fixed tightly and the panel in rigid position

Before the top and bottom base plates are bolted or fixed, the level and plumb line of panel shall be rechecked and if required, necessary adjustments shall be made. Once the lateral

props are properly fixed and the panel is in rigid position, the lifting jaws shall be released by turning the ratchet in anticlockwise direction. Appropriate joint sealant (as suggested in the waterproofing manual [1]) shall then be applied into the joint between RC plinth beam and wall panel before the first pour of the concrete. After the structure is completed, the joint shall be sealed off smoothly, and if offset is provided to the plinth / basement, coving of external face shall also be done (Figure 41).

Figure 41: Sealing-off of joint with joint sealant

4.1.6 *Electrical wiring and piping works*

All electrical/plumbing/other service pipelines shall be placed in the specified cavities (as per the electrical/plumbing drawings) before concreting (Figure 42 and Figure 43). For cutting the holes/opening for electrical/plumbing work, proper tools shall be used. Before concreting the cavities, all the holes made for piping works need to be sealed off properly (including application of patching compound) with recommended joint sealant, as per the waterproofing manual [1].

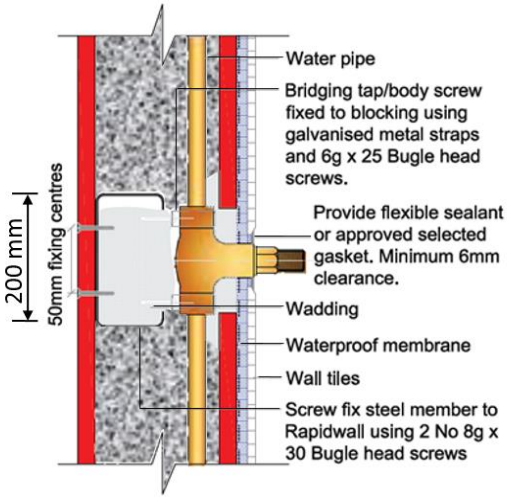


Figure 42: Providing pipe connection through GFRG wall panel

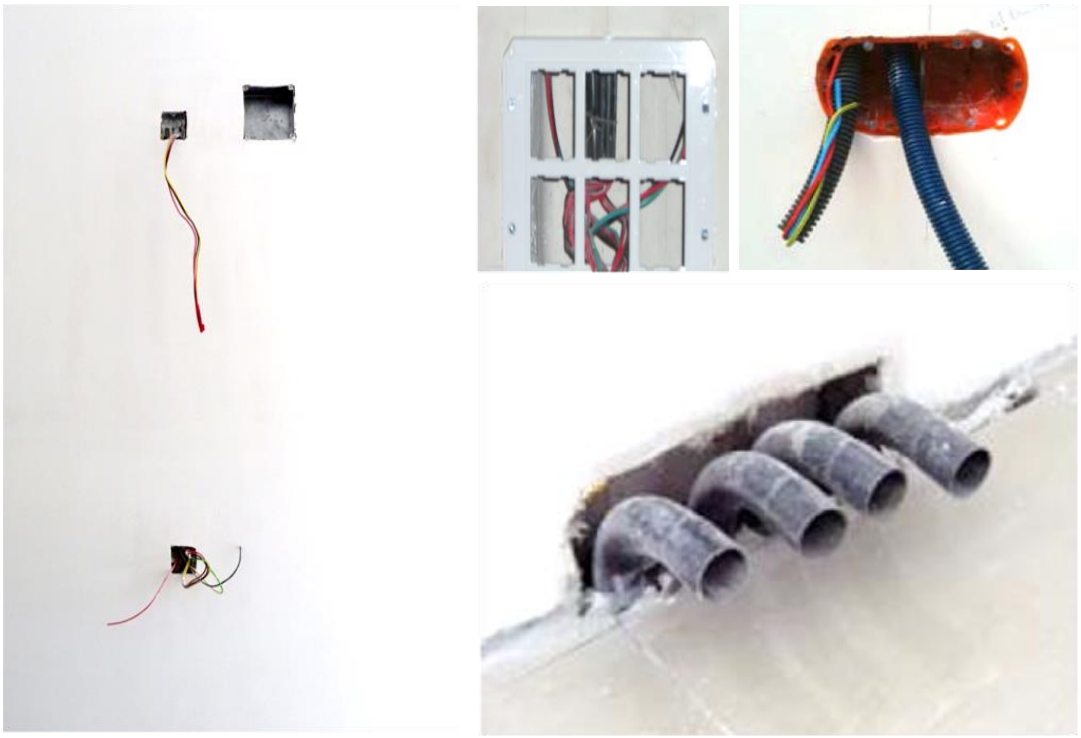


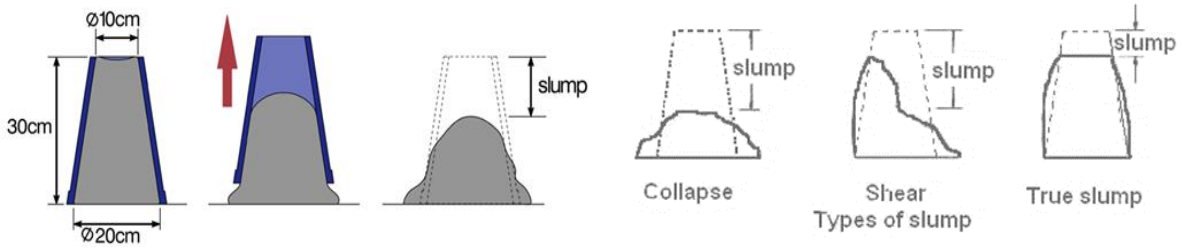
Figure 43: Electrical wiring and pipe connections provided through GFRG panels

4.2 Pour/ Infill of Concrete

Usually, M20 concrete is used for infilling the cavities of wall panels. Coarse aggregate of size 6 to 10 mm is used normally. The slump of concrete shall be 70 mm ± 20 mm and water cement ratio shall be 0.50 to 0.55. The slump is to be measured at site using the standard test procedure with slump cone (Figure 44 and Figure 45).

(a) (b)

Figure 44: (a) Test Apparatus – Abrams cone or slump cone (b) Concrete Slump



(a) (b)

Figure 45:a) Slump measurement b) types of slump

The concrete infilling shall be done in four stages. There shall be a minimum time gap of two hours (for allowing initial set of concrete) between each stage of infilling. First pour of concrete shall be of maximum 300 mm height from the base of panels. 2nd pour of concrete shall be done up to window sill level. Simultaneously, the cavities which do not require any infill as per structural design can be infilled with lean concrete or quarry dust mixed with cement (dry) in stages (Figure 46).

Figure 46: Filling concrete inside cavities

Notes:

- When concrete is poured from top, it is necessary to check whether any bulging / bursting is taking place at the base of panel. If any bulging is observed, infilling shall not be done in the bulged cavity as well as the adjacent one. The bulged / burst off cavity shall be repaired immediately before the concrete gets hardened. Subsequently these cavities shall be filled after taking necessary precautions.
- If the concrete falls on the surface of panel, it shall be cleaned/wiped immediately with wet cloth/sponge before it get stick to the surface.

3rd pour of concrete shall be done up to window/ door top (2.1m height. The vertical side of the window/door opening can be a closed end (with web) or an open end (Figure 47). For an open end, necessary shuttering shall be provided before concreting those cavities and these openings should be treated, as detailed in the waterproofing manual [1].

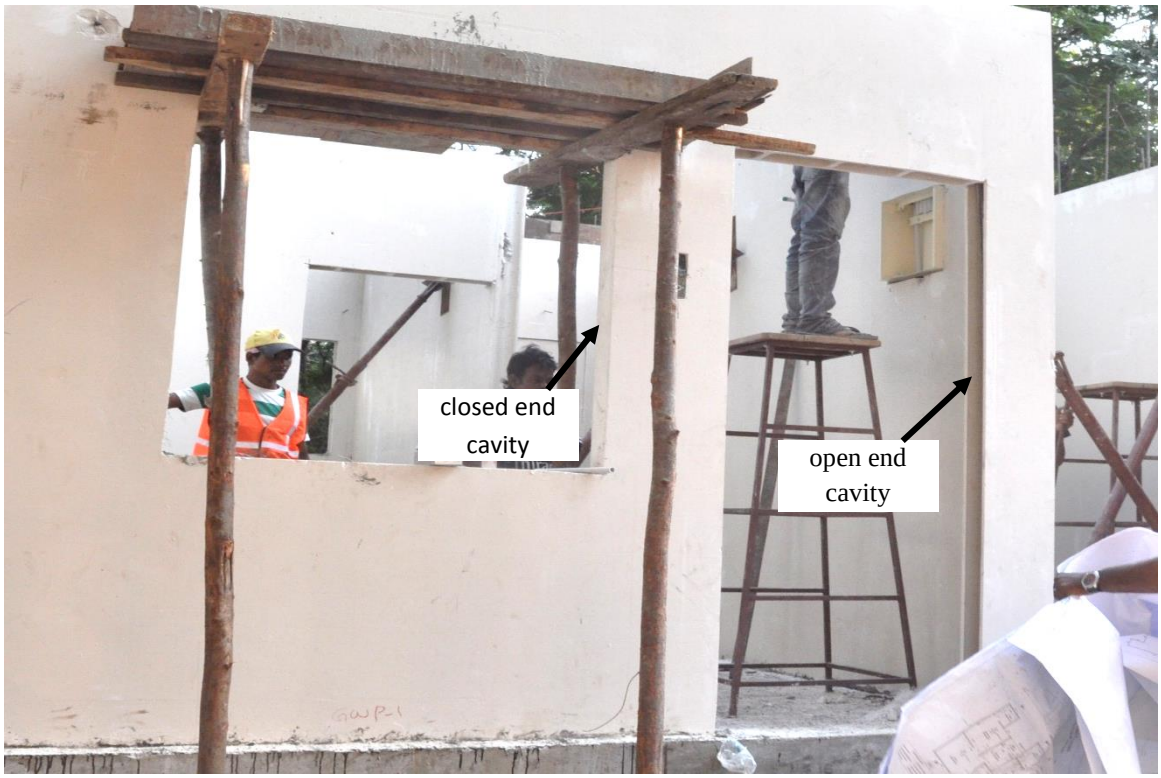


Figure 47: Openings with closed end and open end cavities

4.2.1 *Providing RC lintel cum sunshade*

The RC lintel cum sunshade works shall also be started after the 2nd pour of concrete. Lintels shall be provided for window or door openings of span greater than 1.2 m. RC lintel cum sunshade shall be provided by cutting the external flange of wall panel. Required shuttering

with support shall be provided. In addition to the specified rebars as per structural design, adequate 'L' anchorage shall be provided up to the mid depth of embedded RC tie beam (before infilling of cavities above lintel) through each cavity of the lintel (Figure 48) . The concrete infilling team shall go on infilling the 4th pour, leaving the cavities for RC lintel. These cavities shall be infilled after the casting of RC lintel cum sunshade. Figure 49 shows the method of providing RC lintel cum sunshade.

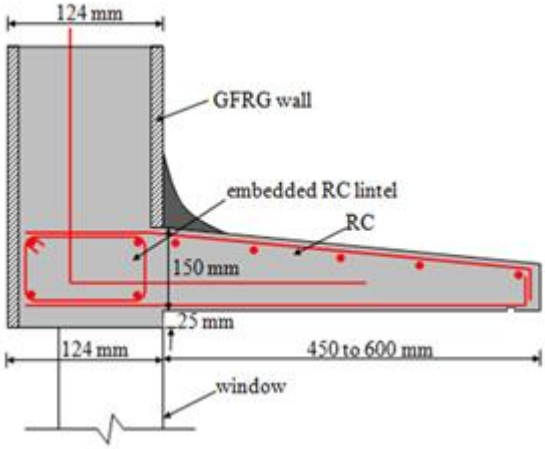


Figure 48: Reinforcement detailing for RC lintel cum sunshade

Figure 49: Providing RC lintel cum sunshade

The concreting of cantilevered RC sunshades can be done separately later after providing required shuttering with supports. The RC lintel cum sunshade joint shall be waterproofed as per details given in waterproofing manual [1]. Groove or beading of sufficient depth shall be provided under the sunshade to prevent water seepage.

Alternatively, sunshade can also be constructed using the cut panel of window / door openings. As illustrated Figure 50, panel cavity of required length (600 mm in the figure), 270 mm width and 124 mm thickness can be inserted into adjoining cavities on either sides of window opening by cutting external flange. 44 mm wide groove shall be provided on top of skin (necessary groove on bottom) to allow the vertical bars to pass through and the panel should touch the inner side of internal flange/ skin (i.e. 109 mm inside the wall). Prescribed reinforcement for cantilever shall be provided in position. GFRG panel of 600 mm width and required length shall be provided over these protruded cavities with necessary cutting. This panel shall also be inserted 109 mm inside the wall, touching the internal part of the inside flange. Required reinforcement stirrups linking cantilevered cavities and top sunshade panels shall be provided and concreting shall be done. Then the window frames shall be installed. After that, joint sealant shall be applied all around (inside and outside) the opening as per GFRG waterproofing manual [1].

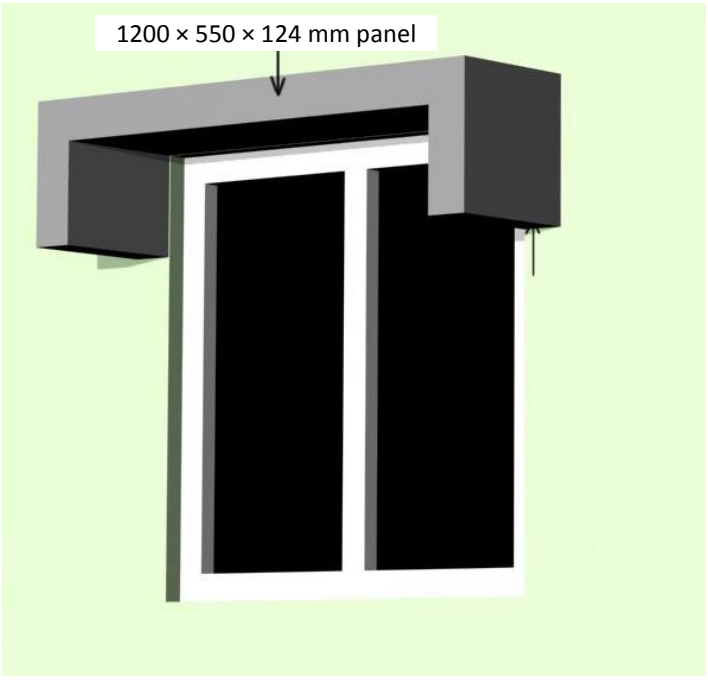


Figure 50: Sunshade using GFRG panels

In fourth stage of concreting, infilling shall be continued up to the bottom of the horizontal embedded RC tie beam, if specified in the structural design. Door/window/ventilator frames shall be installed either after concrete infill (after removing shuttering) or during the finishing works (Figure 51).

Figure 51: Installation of window frames

Concrete compaction

Concrete inside the cavities shall be compacted by hand tamping using sufficiently long iron bars. It shall be made sure that the conduits/pipes placed inside the cavities, if any, are not disturbed or affected during compaction. Mechanical vibrators shall never be inserted into the cavity to compact the concrete as it may result in formation of cracks on the panel.

Note

Erected wall panel shall never be left without infilling of concrete overnight. The panel shall be filled at least partly to attain enough stability, as unexpected storm or strong wind may make the panel vulnerable to instability. If any panel is partially filled, it shall be covered and tied with tarpaulin sheets properly. If water is trapped in the partially infilled cavities, before continuing to further concreting, a hole shall be drilled on the panel just above the level of infilled concrete using a drill bit to drain out the trapped water. Any other method can also be adopted to drain the trapped water such as pumps, siphon, etc.

4.3 Construction of Staircase

Construction of staircase shall be carried out simultaneously with the progress of wall panel installation in the respective floors so that staircase work will be completed when the floor slab above a particular floor is ready to be cast. This will help movement of people for floor work (roof of respective floor), eliminating the need for any extra ladders. The same sequence shall be followed for upper floors till roof slab.

Staircase landing beam, under beam/ other cantilever beams can also be constructed using GFRG cut panel pieces. Figure 52 shows the reinforcement detailing of a typical staircase using GFRG panels.

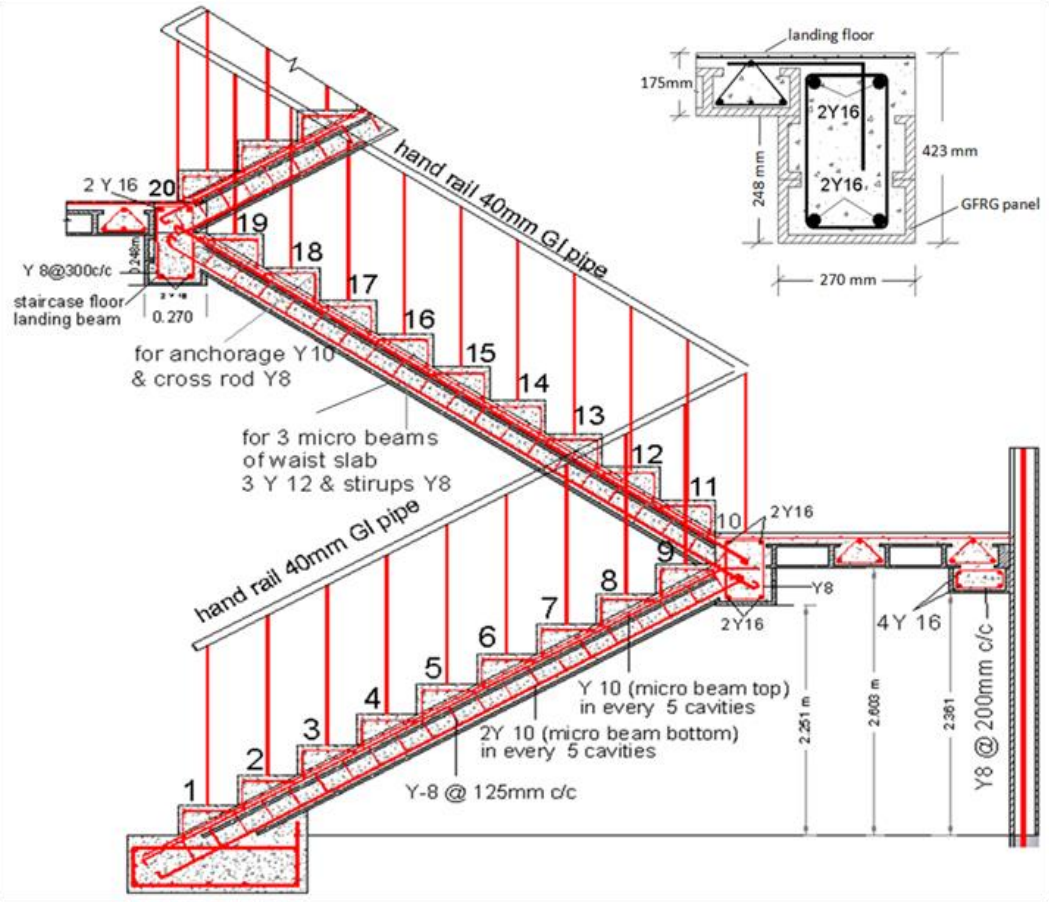
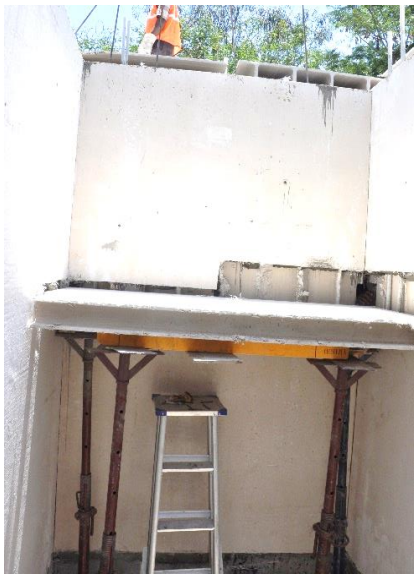


Figure 52: Reinforcement details

The procedure to be followed for construction of staircase is illustrated in Figure 53.

1. Mark the position of mid-landing slab, waist slabs and profile of staircase on the adjacent wall panels

2. Cut out the marked positions of mid-landing slab and waist slab from adjacent wall panels



3. Place the GFRG slab on the cut opened portion of adjacent walls and support using shuttering and vertical props

4. Keep the inclined waist slab panels

5. Cut open the top flanges of panels for inserting reinforcement cage

6. Concrete the steps after concreting waist slabs

Figure 53: Construction of staircase using GFRG panels

Note:

- The start-up rods shall be bent into the waist slab at bottom and the longitudinal reinforcement of first flight of waist slab shall be bent into mid-slab.
- The longitudinal reinforcement of second flight of waist slab shall be bent into mid- landing slab at bottom and roof slab at top.

4.4 Tie System for GFRG Buildings

In GFRG multi-storeyed buildings, an embedded RC horizontal tie beam (94×200 mm size) shall be provided on top of all the walls to facilitate integral action.

The ribs of the GFRG wall panels shall be cut and removed to a depth of 200 mm from the top of the wall panel, to facilitate placing of the reinforcement cage for horizontal tie beam. It shall be ensured that all the cavities are filled with structural/non-structural infill up to the soffit of the tie beam (200 mm deep). The bar bending and caging works for the tie beam shall be completed prior to cutting of web, to be ready for laying in position. Once the reinforcement cage is placed, concreting shall be done using M25 grade mix (Figure 54).

Figure 54: Embedded RC tie beam reinforcement inserted into the wall panel (mandatory for buildings above 4 floors)

Construction of embedded horizontal tie beam can be time consuming as it involves cutting of panel ribs locally at the site. This can be avoided, for buildings up to 4 floors, by providing a simplified tie system comprising of two 8 mm dia horizontal bars at top and bottom 150 mm apart (with 6 mm links at 250 mm centre to centre spacing), all around at the slab-wall junction. (Figure 55). The bars shall also be tied to all the vertical bars in the cavities of walls.

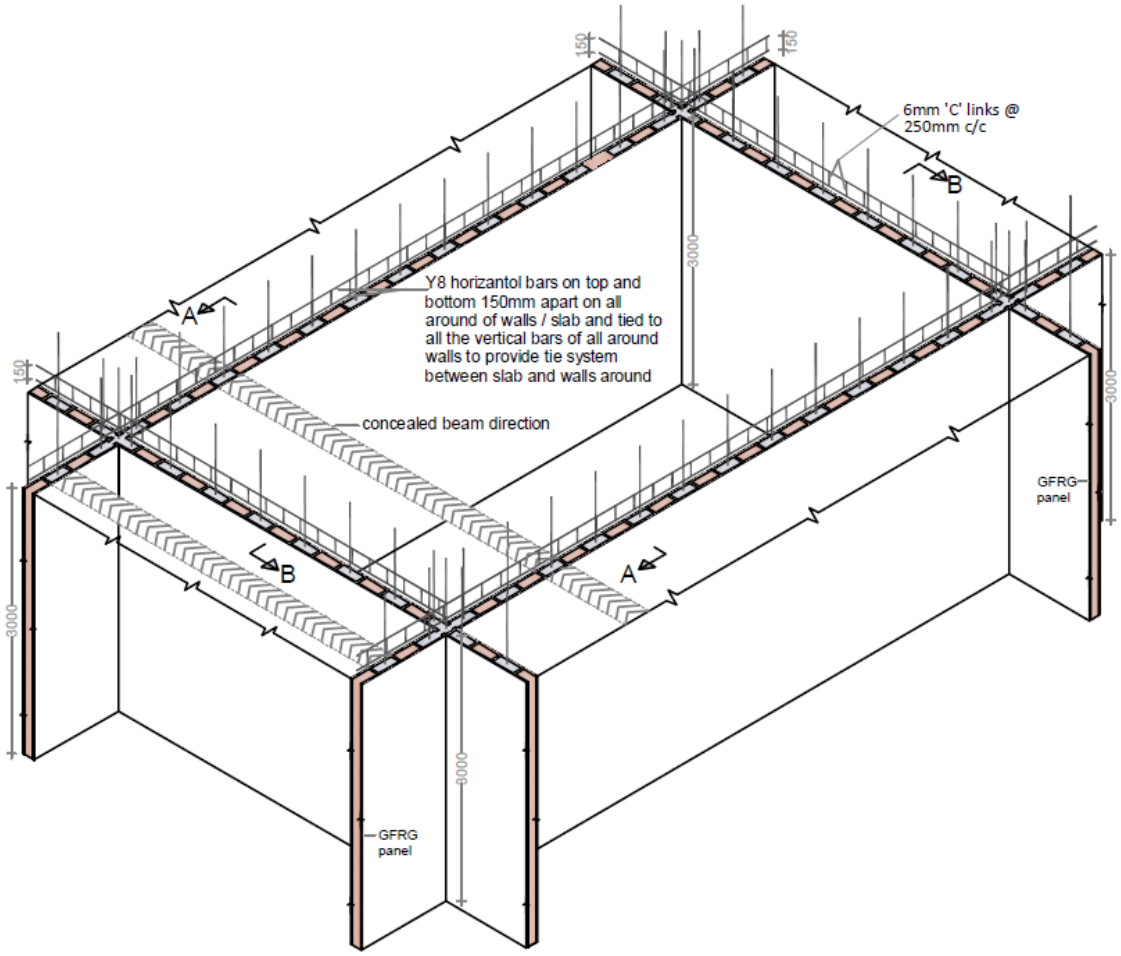


Figure 55: Tie system for GFRG walls

4.5 Construction of GFRG – RC Slab

GFRG slabs consist of a series of concealed RC beams with a screed concrete (typically 50 mm thick) on top. Figure 56 and Figure 57 show the details of the concealed beams and screed concrete in a GFRG – RC slab. The network of the hidden RC beams inside the GFRG slabs is shown in Figure 58.

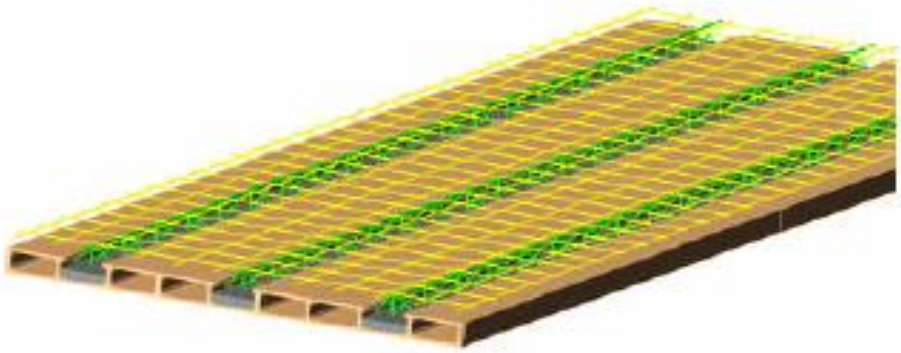


Figure 56: Floor slab with concealed beams

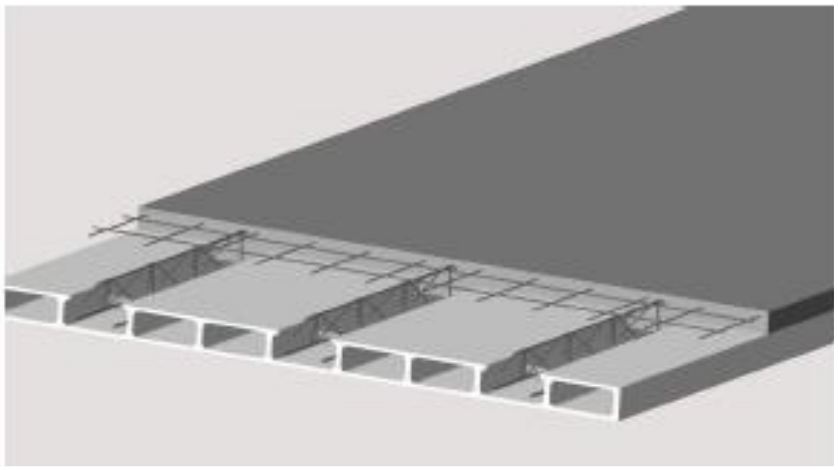


Figure 57: Concrete screed over slab

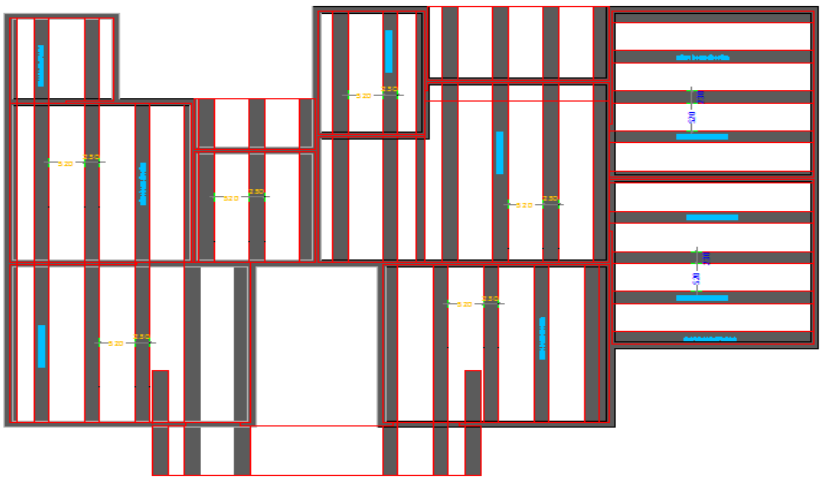


Figure 58: Network of embedded RC beams (concealed beams) in a floor of a typical building

The reinforcement detailing of a typical floor slab in a residential building (to carry live load up to 2 kN/m^2) of span less than 5m is shown in Figure 59. The minimum grade of concrete shall be M25.

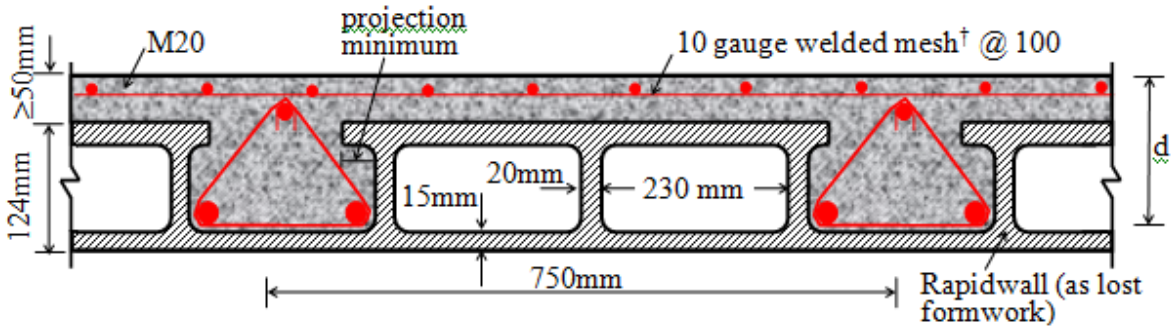


Figure 59: Cross-section of GFRG slab panel (every 3rd cavity reinforced)

Floor / roof slab of commercial / public buildings

For commercial or public buildings, slabs with clear span up to 4m and live load up to 4 kN/m^2 can be constructed using GFRG panels. The thickness of screed concrete shall be 60 mm. Figure 60 shows the reinforcement details of a typical slab for commercial buildings.

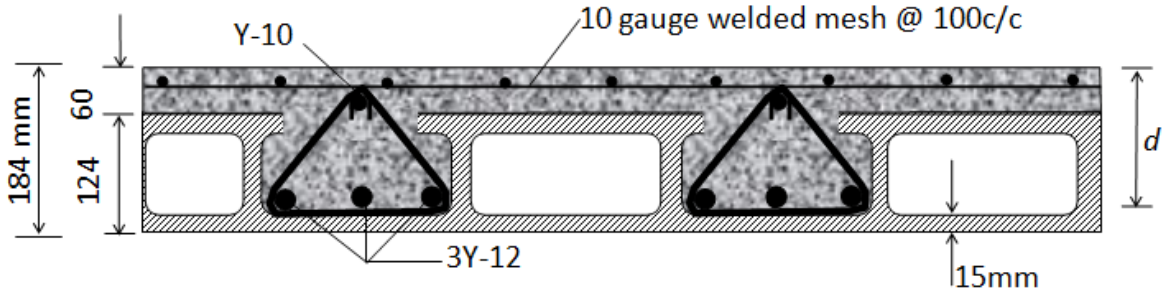
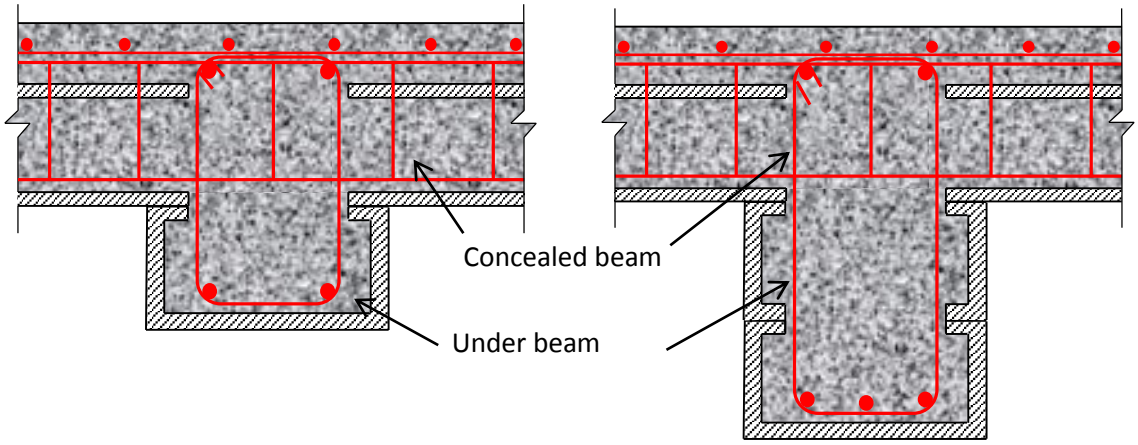


Figure 60: Cross-section of GFRG panel (every 2nd cavity reinforced)

Slabs of higher span (more than 5m in residential buildings and 4m in commercial buildings) shall be provided with under beams constructed with concrete infilled GFRG panels (Figure 61). In such cases, there shall be GFRG-RC columns on both ends to support the simply supported under beam (Figure 62).



a) Under beam with lesser depth

b) Under beam with more depth for larger span as per structural requirement

Figure 61: GFRG-RC under beam for long span floors

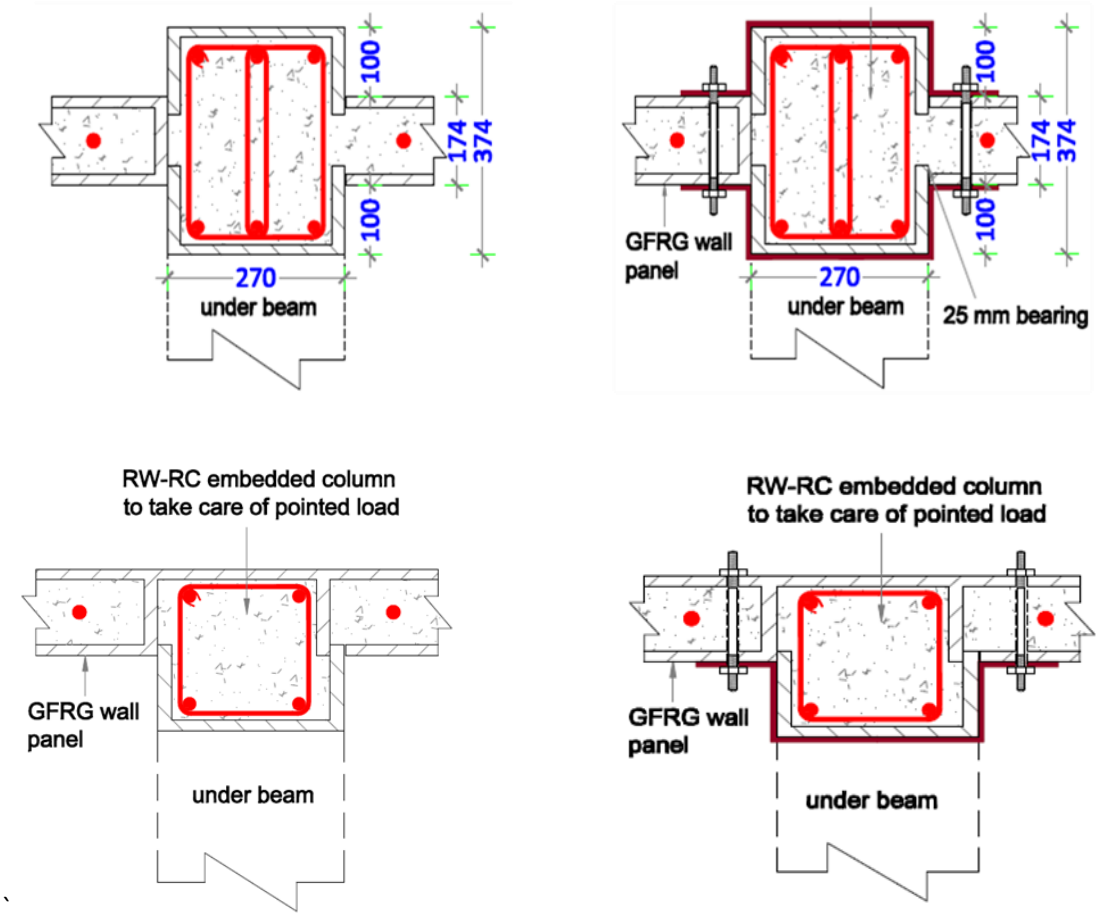


Figure 62: GFRG-RC columns

4.5.1 *Laying of floor/roof slab panels*

Support system for laying slab panels consists of adjustable vertical props, telescopic span and suitable runners (typically 400 mm wide) (Figure 63). Before providing support system for the floor slabs, the lateral adjustable props of wall panels shall be removed.

Figure 63: Support system for laying floor slab panel in position

4.5.2 *Lifting of floor/roof slab panels*

After providing proper support system, the floor slab panel, identified based on the notation marking, shall be lifted. The procedure for lifting slab panels is explained below:

i) The panel shall be lifted carefully from stillages using lifting and shall be lowered to a level ground. It shall be placed horizontally on top of wooden reapers or over empty stillage spread on level ground.

ii) Centre point of the panel shall be marked by drawing diagonals (using a chalk piece), on the 'B' side of the panel. For small panels of length less than 4m, a hole shall be drilled at this point to insert sling chain rope or soft iron rope and a loop shall be formed to insert spreader bar.

iii) When long panels are to be lifted, the centre point shall be marked for each half of the panel. This will give two centres at one-third distance from either sides. The stability of the panel while being lifted will depend on the accuracy of the marking.

iv) The maximum length of panel that can be lifted with a single lifting point centred over the slinging point is 4m. Longer panels (up to 9m) shall be lifted using a 4m long spreader bar with two equidistant sling points for balance. For panels of length more than 9m, one spreader bar of 8m length with two equidistant sling points shall be used.

v) The spreader bar shall be placed with the narrow side facing the panel and the sling rope shall be tied tightly lifting panel.

Figure 64 shows the lifting of slab panel with spreader bars attached.

Figure 64: Lifting of slab panel in horizontal position using under panel spreader bar and sling rope

vi) Lifted panel shall be guided to the correct position and shall be lowered slowly and safely to rest on the top of walls. A bearing of 40 mm (including the flange thickness) shall be ensured for the slab over the wall before the removal of spreader bar and soft sling (Figure 65).

Figure 65: Bearing of slabs over walls

Note:

Panel shall be placed in such a way that 'A' side of the panel will be the bottom / ceiling side of slab. ('A' side is the smooth face of GFRG panel). This should be kept in mind while lifting also.

4.5.3 *Concreting of slab*

After placing the panel on the supports, the top skin/ flange of the cavities shall be cut open, as per the drawing, leaving minimum 25 mm flange on either sides protruded to serve as a key to concealed RC " T " beam (Figure 66). The reinforcement cage for the concealed beams, shall be laid in the cut opened cavities. The cables and pipes for electrical/plumbing works shall also be laid simultaneously in the cavities.

Figure 66: Flanges cut open for casting concealed beams

Side shuttering shall be provided with 6 mm groove before the concreting of slab starts. The details of the side shuttering system are given in Figures 67, 68 and 69.

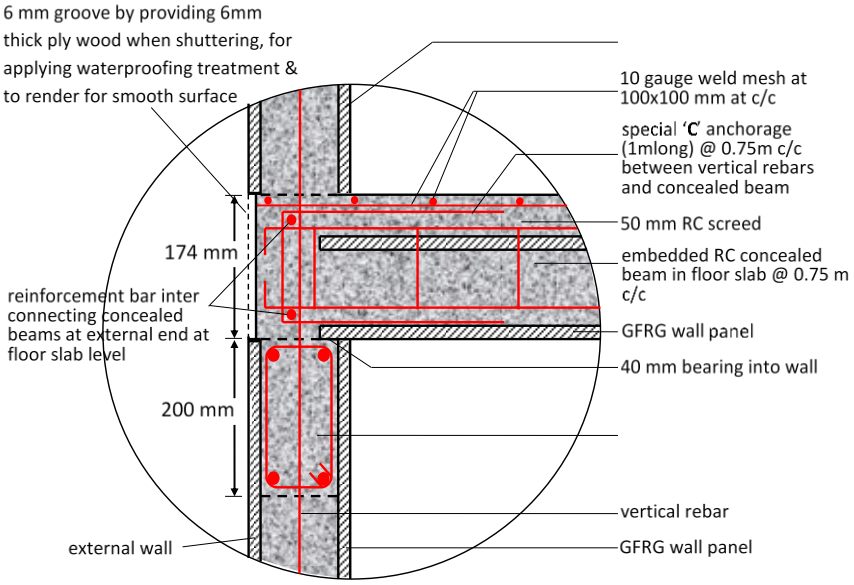


Figure 67: Connectivity between floor slab and wall-Type 1

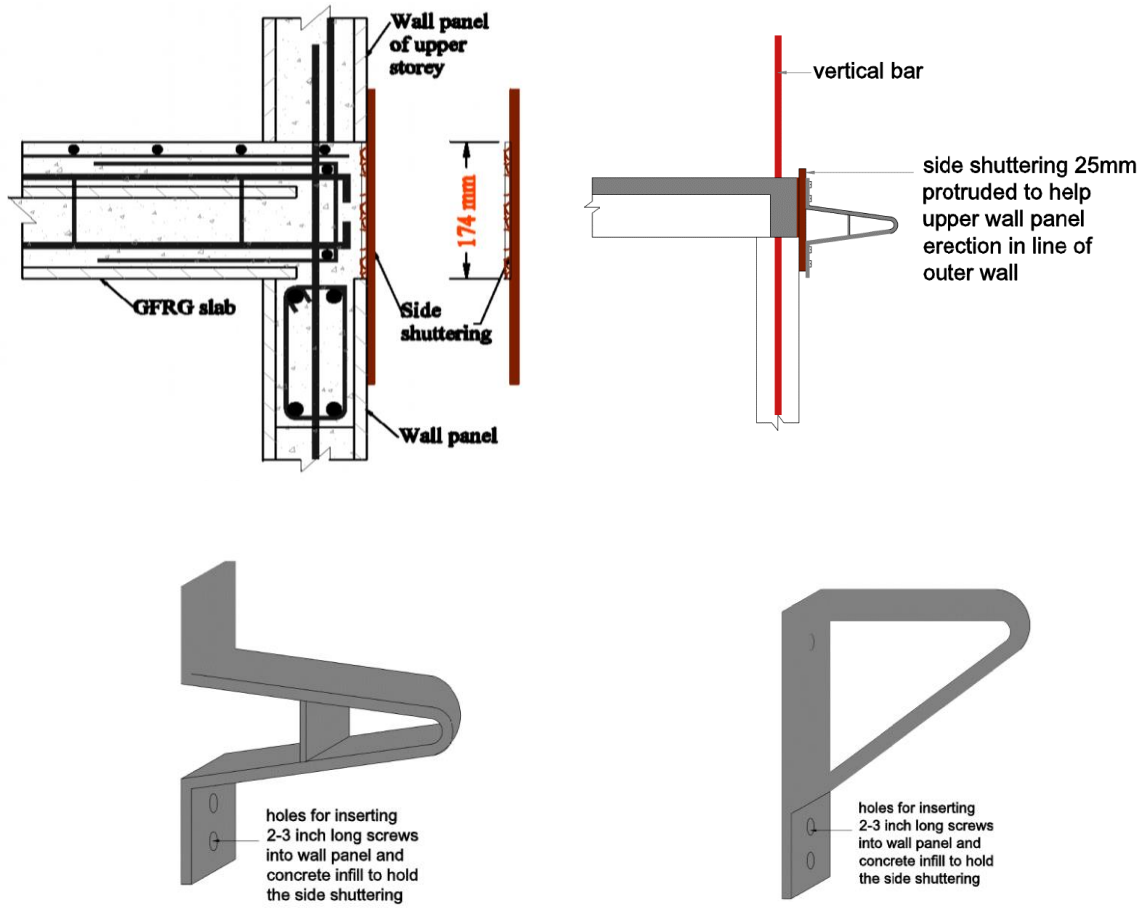


Figure 68: Specifications for side shuttering system

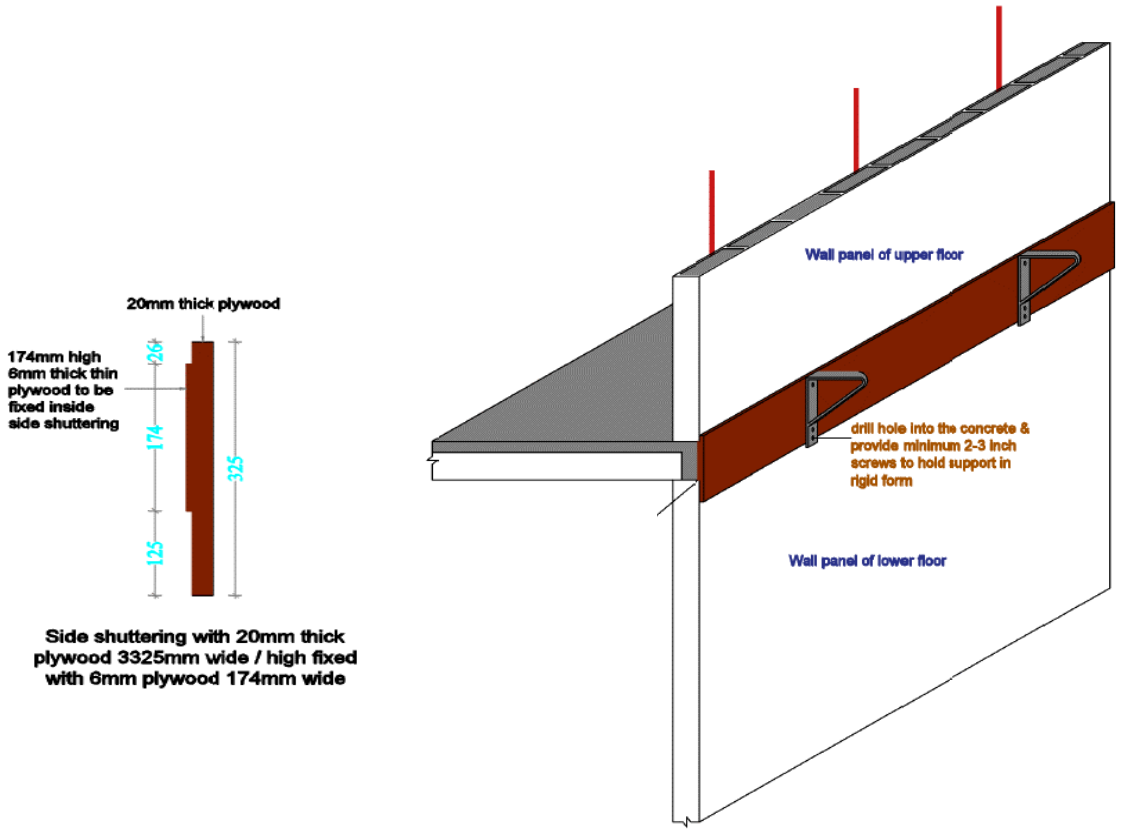


Figure 69: Side shuttering system

Alternatively, there is a system which avoids providing external shuttering for the floor/roof slab. For this, the top of the wall panel shall be cut in such a way that the external flange will have a projection of length equal to the total depth of slab (as shown in Figure 70).

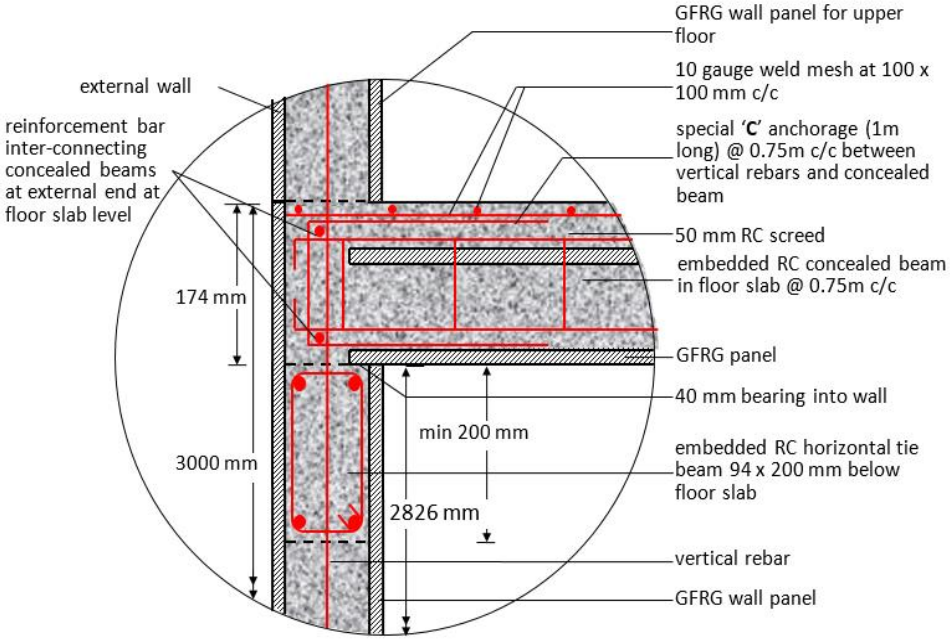


Figure 70: Connectivity between floor slab and wall - Type 2

Concrete of grade M25 and water cement ratio of 0.55 (slump of 80 mm ± 20 mm) shall be provided for floor slab. Compacting of concreting shall be done using 20 mm needle vibrator or by hand tamping. Figure 71 shows the concreting of concealed beams.

Figure 71: Concreting of concealed beams

Standard wire gauge (10 gauge at 100 mm centre – to centre – spacing) weld mesh shall be laid over the entire slab. Concrete cover blocks of size 20 × 20 × 20 mm (30 × 30 × 30 mm for roof slab) shall be provided at 750 mm spacing in both directions to hold the weld mesh in correct position without any sagging. Additional layer of welded mesh of width 1m shall be provided over GFRG slab panel joints and over intermediate supports. Concreting shall be done for a thickness of 50 mm from the top flange of panel and shall be finished smoothly maintaining the correct level for upper wall panel erection. For terrace roof slab, an average thickness of 60 mm shall be provided with necessary slope for free flow of drain water into the drain water outlet pipe from terrace. Suitable admixture shall be used to make the roof slab impervious.

Figure 72: Concreting of slab

If the span of slab exceeds 3 m, a joint will be required inter-connecting two GFRG panels. The special joint detailing illustrated in Figure 73 and Figure 74 shall be adopted.

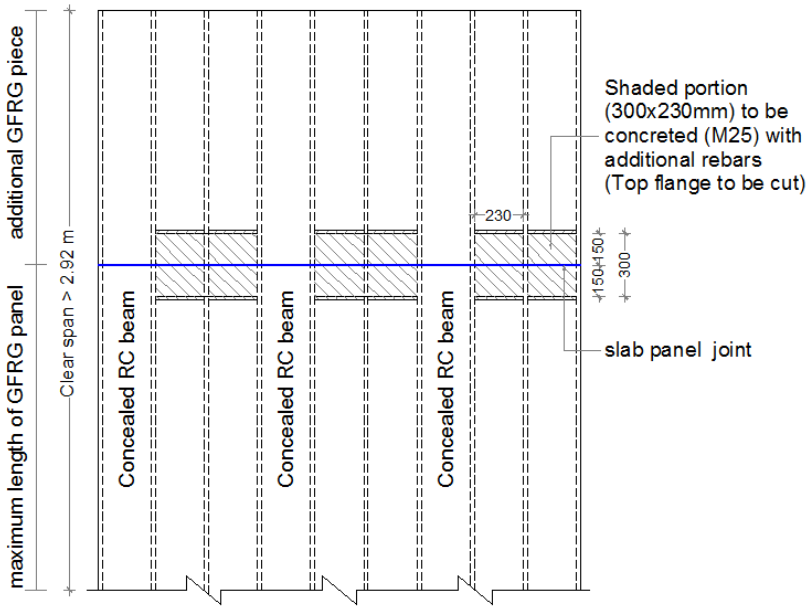


Figure 73: Joint in GFRG slab panel

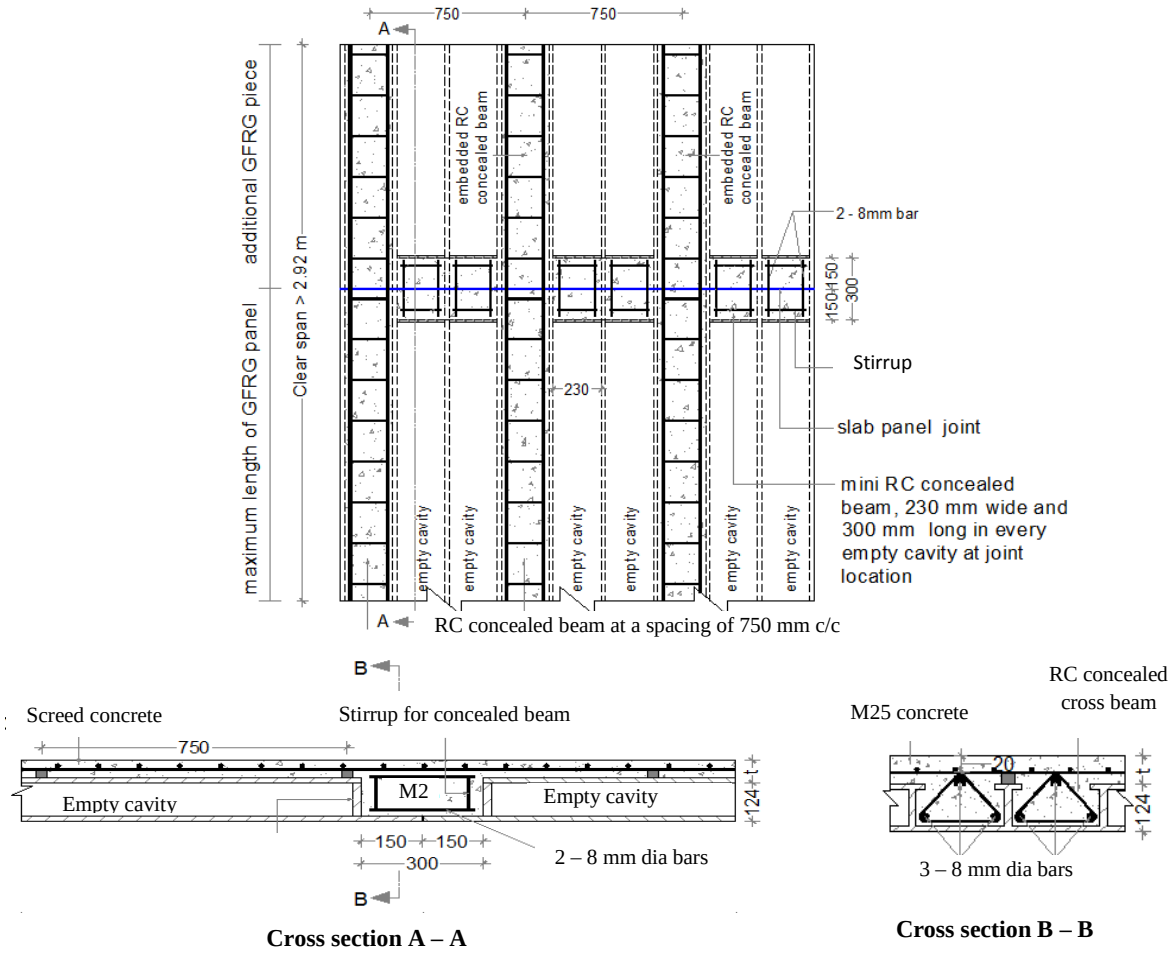


Figure 74: GFRG slab: plan of bottom layer reinforcement

4.6 Erection of Wall Panel for Upper Floor

Preparatory works for the erection of wall panels on the upper floor shall be started one day after the concreting of the floor slab, by following the same procedure adopted for ground floor. The wall panel positions and notation marks shall be marked by the concerned team on the floor slab. Damp proof course of 150 mm width shall be applied on top of the floor slab in the case of outer walls and walls of bath/ toilet rooms, before the erection of wall panels. The same method and sequence of construction adopted for the ground floor shall be repeated for all the upper floors (Figure 75). The 2.7m centre – to – centre spacing of lateral props shall be reduced as the construction progresses to the 4th floor in order to account for the effect of wind. Support system for the floors below shall be removed 5 days after the completion of casting of the respective floor slabs.

Joint sealant application of lower floor including treatment of openings for doors/windows/ventilators as detailed in the GFRG waterproofing manual [1] shall also be started.

Figure 75: Application of DPC and erection of wall panel

5. FINISHING WORKS AFTER COMPLETION OF SUPERSTRUCTURE WORK

5.1 Pre-finishing Works

The following works shall be carried out prior to the start of finishing works of superstructure:

a) Scaffolding for waterproofing treatment, application of primer, plumbing, rendering and painting works (Figure 76).

Figure 76: Scaffolding provided for a GFRG building

b) Sealing off and waterproofing treatment of RC lintel, sunshade and window joints as per GFRG waterproofing manual [1].
c) Waterproofing treatment of openings for door, window, ventilator and services.
d) Installation of door / window / ventilator frames.
e) Fixing of door / window / ventilator with sufficient number of coach screws of suitable length (150 mm for doors and 100 mm for windows/ventilators).
f) Fixing of switch boxes and other electrical and plumbing appliances (Figure 77).

Figure 77: Windows and switch boxes fixed on to panel

g) Treatment of external horizontal joint between RC plinth beam and wall, also upper floor slab and wall, roof slab and parapet wall (both external and internal (terrace slab side)).
h) Treatment of 6 mm thick, 174 mm wide groove / band all around the floor / roof slab to be carried out.
i) Treatment of vertical wall joints (external wall, bath / toilet walls). Depending on the gap of joints, suitable backer rods (made of insulation form material) shall be provided under effective supervision.
j) Waterproofing treatment of bath rooms / toilet floors (in case of sunken floor, Annexure 7 shall be referred) as per the waterproofing manual [1].
k) Application of joint sealant between roof slab and parapet wall including making of coving.
l) Waterproofing treatment of vertical joints of parapet wall as per the manual including treatment of parapet wall top with suitable coping.
m) Waterproofing treatment of roof slab/terrace.

All waterproofing works shall be done in accordance with the 'Manual on Waterproofing of GFRG Buildings' [1]. The brochures describing methodologies of waterproofing, and a general checklist containing the various activities involved, are given in Annexures 8, 9 and 10.

5.2 Application of Special Primer on GFRG Panel Surfaces

Special primer, suitable for GFRG, shall be applied on the external and internal wall surfaces (including parapet walls) and ceilings of floor slabs, after completion of waterproofing treatment. The waterproofing manual [1] shall be referred for the details. Primer shall be applied before rendering (application of thin layer of 0.5 to 2 mm thick plaster) of plastering of external wall and internal wall surfaces for superior finishing (Figure 78).

Figure 78: Spraying of primer on GFRG panel surface

5.3 Grinding of Wall Surface

Before fixing the glazed tiles or doing the finishing works, if the surface of the panel is not level (due to bulging of panel while concreting), the surface shall be scraped using giraffe grinder or any other suitable concrete grinder. This is depicted in Figure 79.

Figure 79: Grinding of wall panel surface using giraffe grinder

5.4 Fixing of Glazed Tiles on Bath / Toilet Vertical Walls

Special adhesives suitable for GFRG panels shall be used to fix glazed tiles or marble tiles on the vertical walls of bath / toilet (such as those manufactured by Kerakoll and Ardex Endura). Before the application of adhesives, the wall surface shall be roughened suitably by scratching with knife till the glass fibres are exposed. For this area, application of primer need not be done.

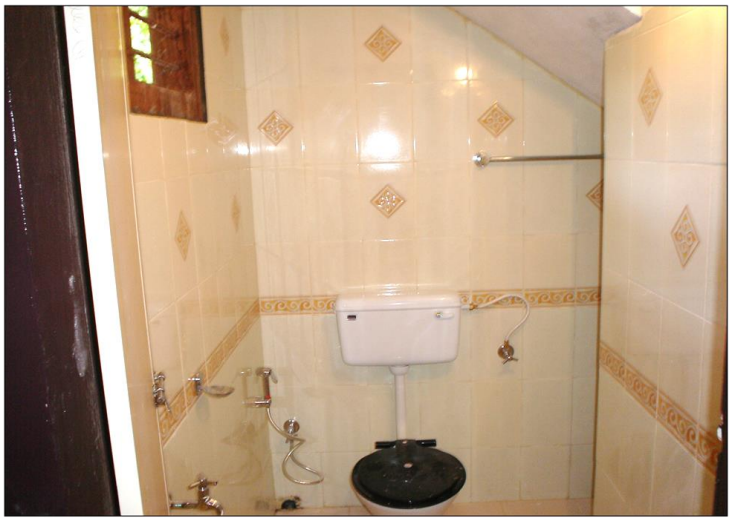


Figure 80: Glazed tiles fixed over the GFRG panel surface using special adhesive

5.5 Rendering for Giving Smooth and Fine Finishing

Normally, 'A' side of the panel is used for the external face of the building. In order to have smooth finish for the interior wall panel surfaces and ceiling, a thin layer (1 to 2 mm thick) of plaster may be applied on all the internal wall panel surfaces by trained and experienced PoP plasterers. For this purpose, calcined gypsum based wall plaster manufactured by FRBL Kochi or Birla / JK wall putty shall be used. This process is called *rendering*. In order to get extremely smooth finish for the building exterior, this may be done on external wall panel surfaces also (based on the customer's preference). The tools used for rendering are shown in Figure 81.

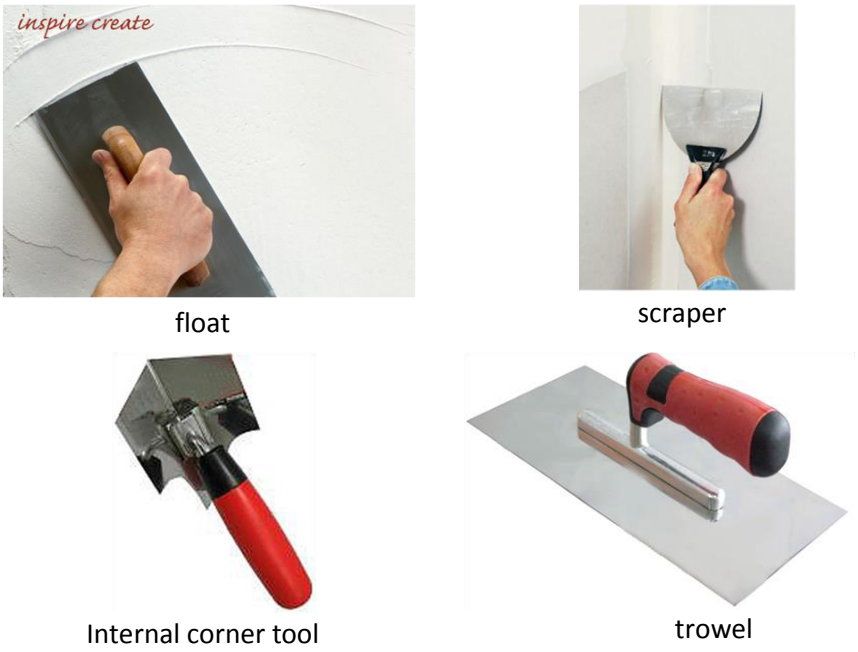


Figure 81: Tools used for finishing works

Rendering of the GFRG panel surface with Rapidwall plaster is shown in Figure 82.

Figure 82: Rendering of GFRG wall panel surface using Rapidwall plaster mix

5.6 Repair or Rectification of Damaged Panels

Any damage / dent to the panel during handling or erection can be repaired / rectified using specified patching compound. If bursting of panel happens during pour of concrete, fibre tape or fibre mat shall be affixed and patching compound shall be applied for smooth finish (the 'Manual on Waterproofing of GFRG / Rapidwall Buildings' [1] shall be referred for more details).

Treatment for algal and fungal affected walls:

Sodium hypochlorite (13%) mixed with formaldehyde (5%) is found to be the best biocide (Rank-1) for removing the fungal affection. For removing algae from panel surface, the panel shall be wetted and dry bleaching powder shall be sprinkled over the wetted area. The area shall be wiped using a dry white cloth after 15 to 30 minutes.

6. PROPOSED LAYOUTS FOR AFFORDABLE HOUSING

India needs millions of houses, both clustered and scattered, in urban, suburban and rural areas, to materialize the dreams of BPL (Below Poverty Line) families to have a strong and safe shelter. Typical building plans for rural housing and urban housing, with plinth area of 25 m^2 and 30 m^2 respectively, are shown in Figure 83 and Figure 84.

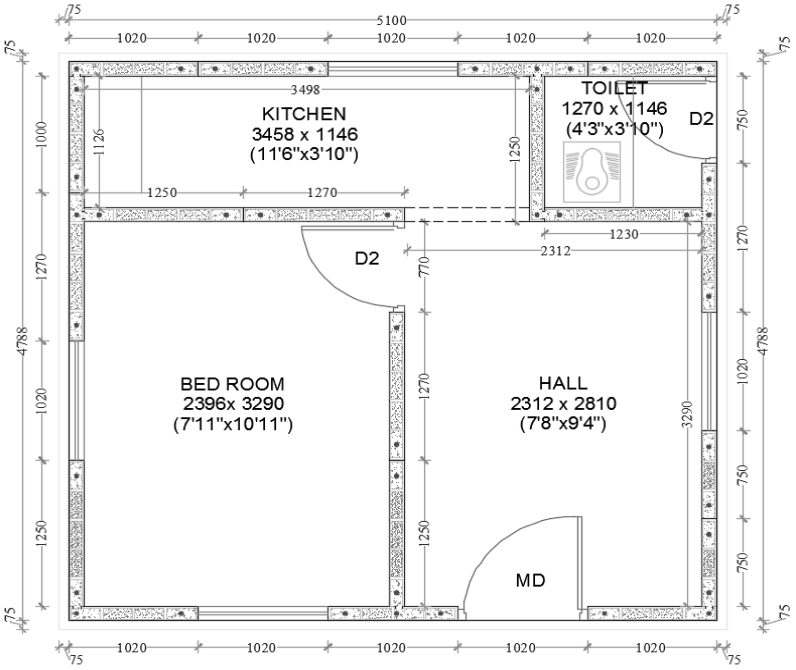


Figure 83: Typical building plan for rural housing with 25 sq.m. plinth area

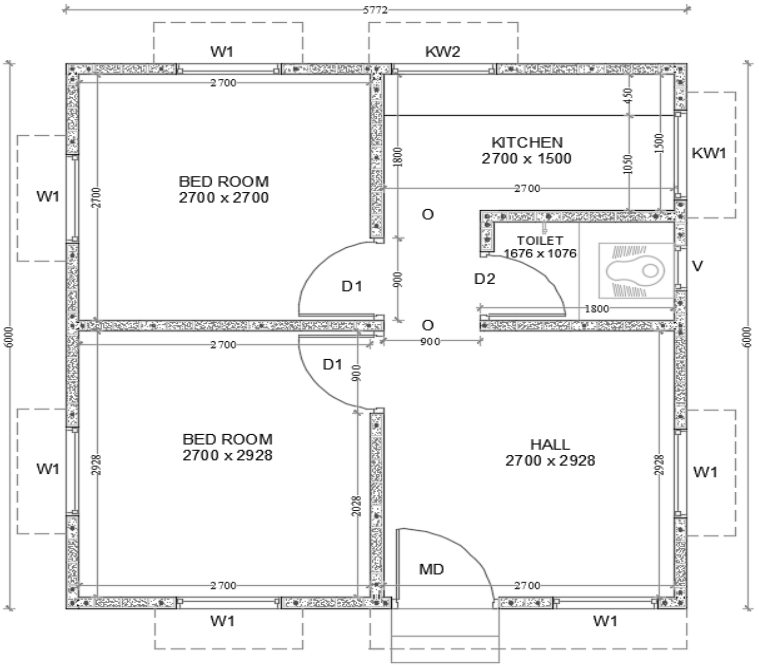


Figure 84: Typical building plan for urban housing with 30 sq.m. plinth area

Flat roof as well as sloped roofs can be adopted as per the requirement (Figure 85 and Figure 86). For pitched roofing, GFRG panels without concealed RC beams and RC screed will be sufficient.

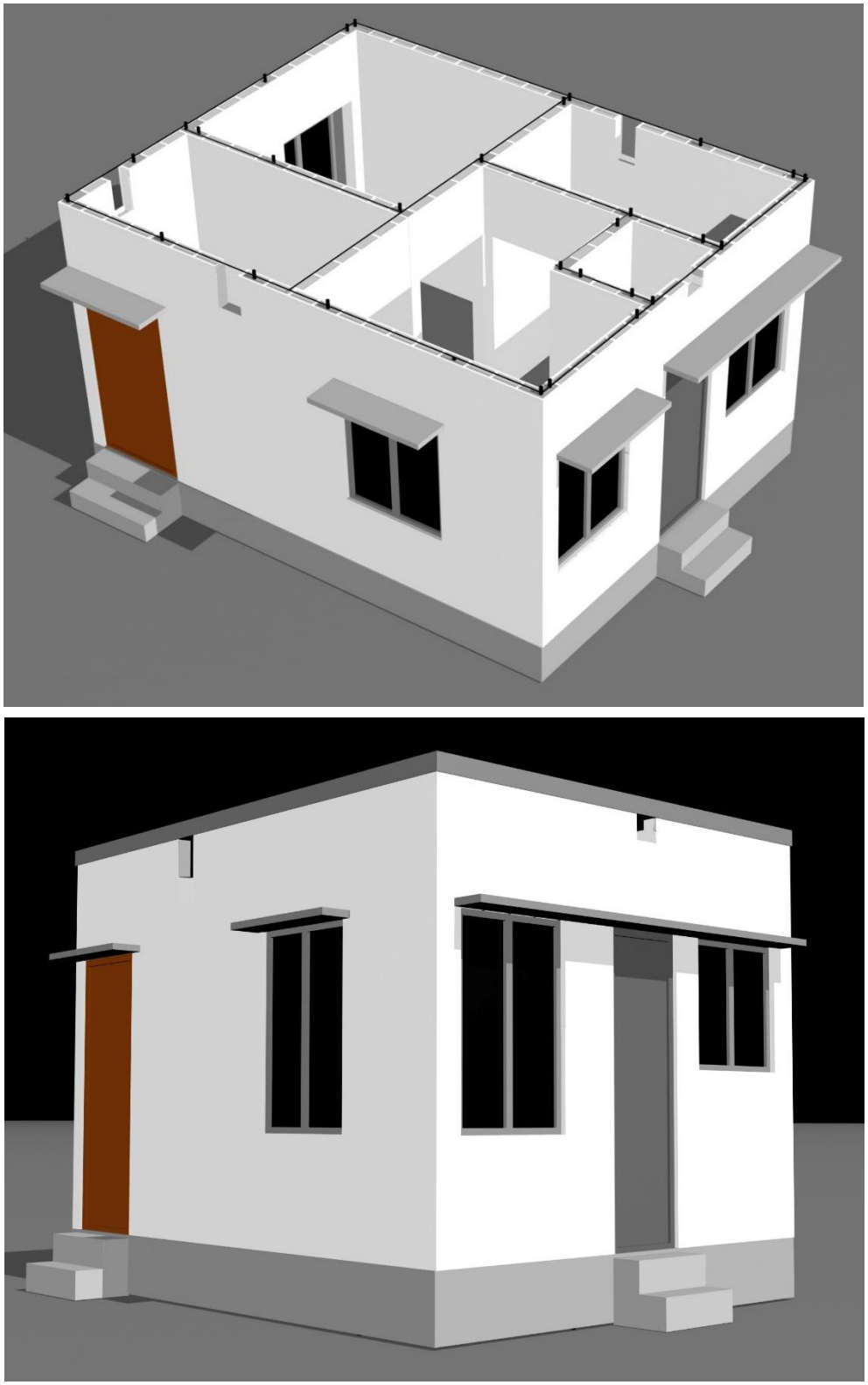


Figure 85: Housing with flat roof

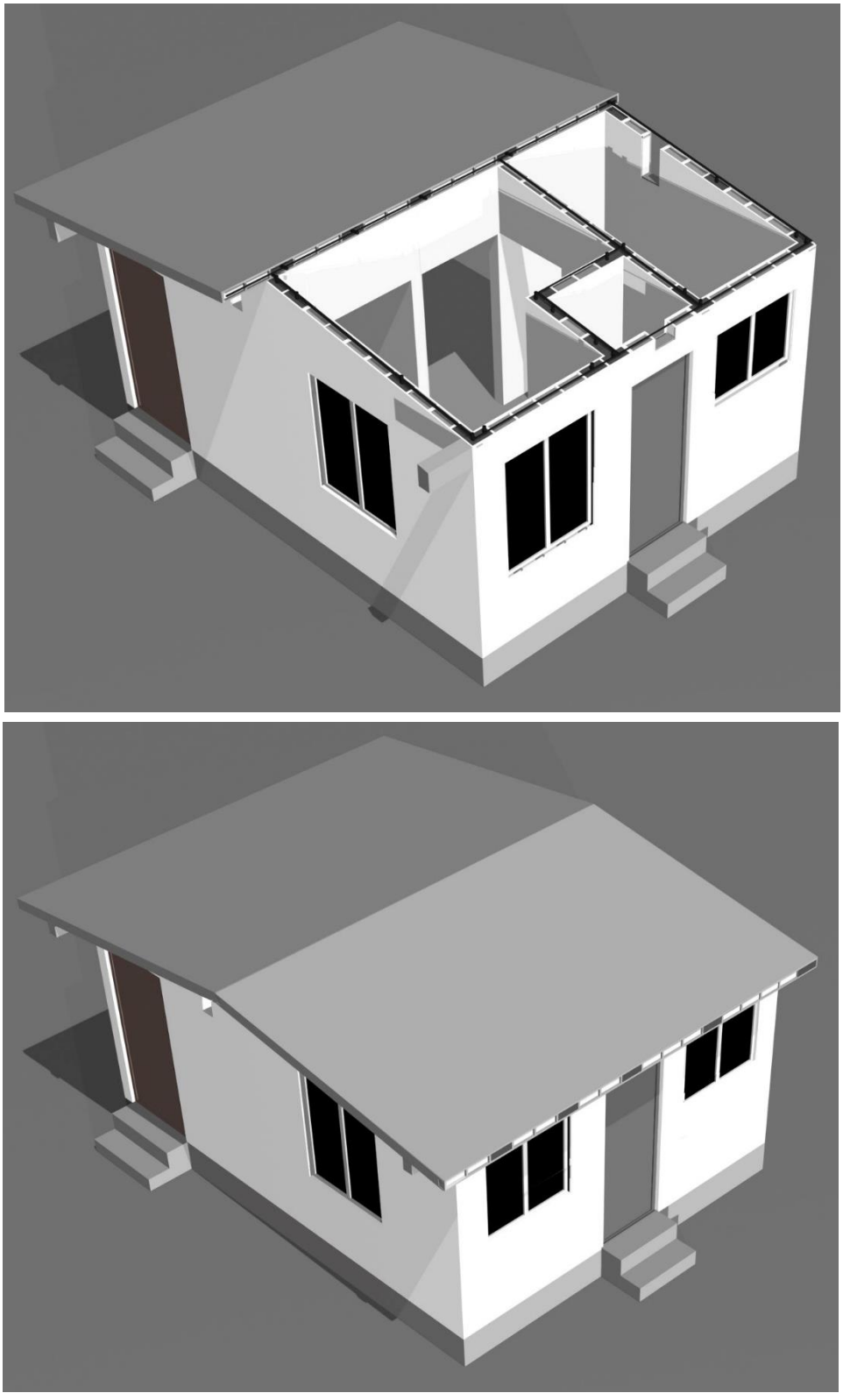


Figure 86: Housing with pitched roof

The structural detailing and waterproofing for an affordable housing are illustrated in Annexure 11.

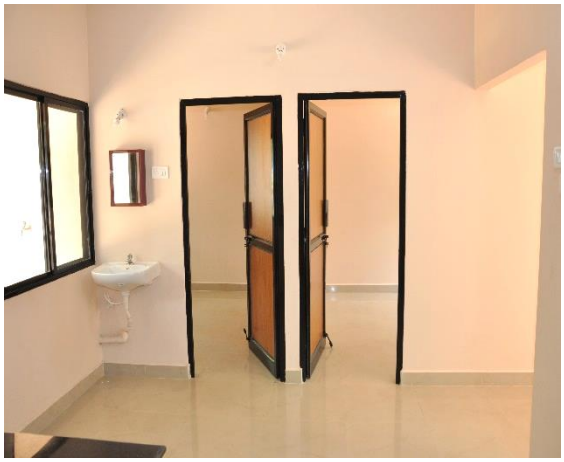
7. GFRG BUILDINGS IN INDIA

At present, more than 600 GFRG buildings have been constructed across the country, mostly individual houses. The first of the group housing projects carried out has 36 units of 2 storeyed houses with single (32 nos.) and duplex (4 nos.) units each of built-up areas 43 sq.m. and 38 sq.m. respectively at Nellore. This is the first mass housing project in the country, which is a huge project for the EWS (Economically Weaker Section) and LIG (Low Income Group) class. The first GFRG building in India was constructed inside the campus of Rashtriya Chemicals and Fertilisers Ltd., Mumbai, using panels exported from Australia. Some of the GFRG buildings constructed so far in our country are mentioned in this section.

❖ **Demo building at RCF campus, Mumbai (2006)**

❖ **Demo building at FACT, Kochi (2008)**

❖ **Demo building at IIT Madras campus**



- Built inside IIT Madras campus (2013)
- Demonstrated rapidity and affordability of GFRG construction
- 2 storeyed 4 flat building of built area 1,981 sq.ft., built in 30 days (superstructure alone) and with Rs. 23 lakhs

❖ **Utility building for Konkan Railway - Madgao, Goa**

Architect: Sudhir Acharya

Constructed by: Hastha Pvt. Ltd, Bangalore (2011)

❖ **Residential building – Manipal, Udupi**

Architect: Sudhir Acharya

Constructed by: Hastha Pvt. Ltd, Bangalore (2013)

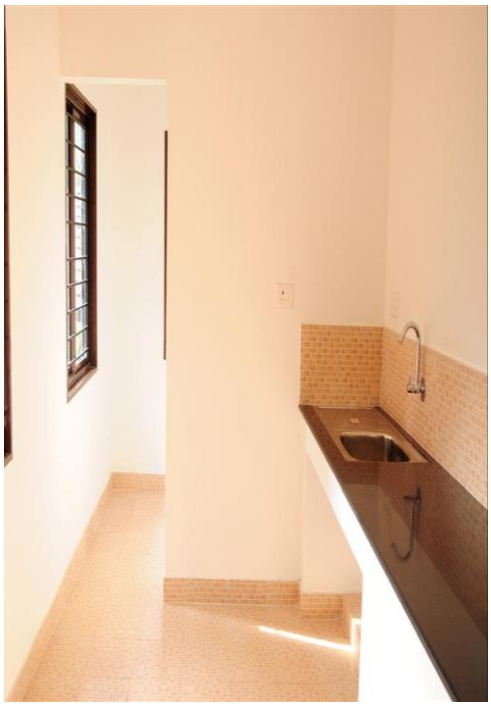
❖ **Residential building – Chitpady, Udupi**

Architect: Sudhir Acharya

Constructed by: Hastha Pvt. Ltd, Bangalore (2013)

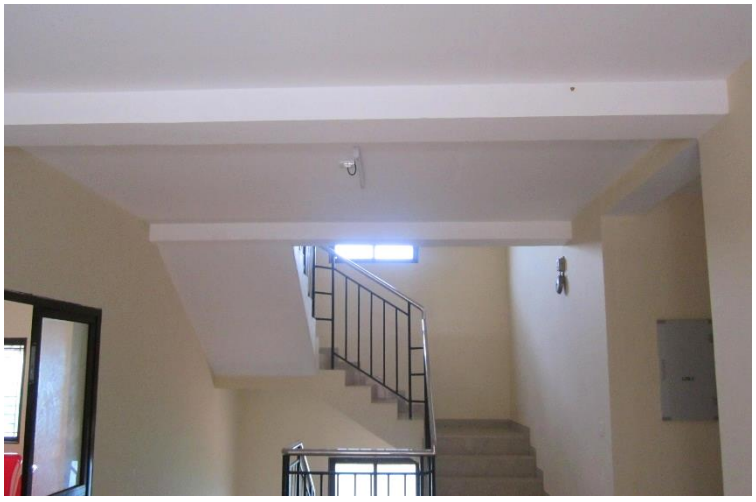
❖ **3 storey residence – Calicut, Kerala**

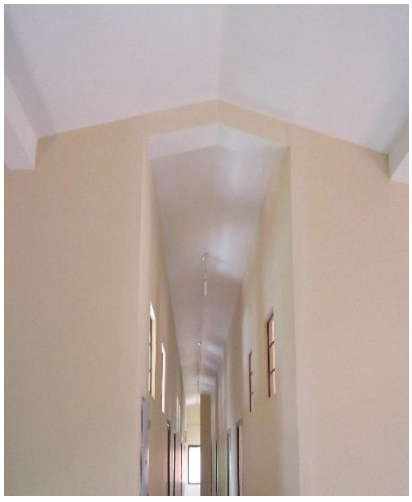
Architect:	N.M Salim & Associates
Constructed by:	NMS Rapidwall Construction Company, Calicut (2014)
Built-up area:	3,295 sq.ft.



❖ **SAFI college boys' hostel, Malappuram**

Architect:	N.M Salim & Associates
Constructed by:	NMS Rapidwall Construction Company, Calicut (2015)
Built-up area:	12,175 sq.ft.





❖ **Nursing Home – Thrissur**

Architect:	N.M Salim & Associates
Constructed by:	NMS Rapidwall Construction Company, Calicut (2015)
Built-up area:	5,000 sq.ft.

❖ **Library cum class room and canteen buildings of Malayalam University, Tirur, Kerala**

Built-up area: 10,000 sq.ft.

Library cum class room building, Built-up area: 10,000 sq.ft.

Canteen building, Built-up area: 1,600 sq.ft.

❖ **Few Office Buildings of Kerala State Electricity Board**

Location: Haripad, Built-up area: 10,000 sq.ft.

Location: Manimala, Built-up area: 4,000 sq.ft.

❖ **Luxury Villa near Bangalore University**

Architect: Sudhir Acharya

Constructed by: Hastha Pvt. Ltd, Bangalore

❖ **School Building at Perinjanam, Thrissur**

Constructed by: NMS Rapidwall Construction Company, Calicut

Built-up area: 16,000 sq.ft.

❖ **Building at MES Campus, Chennai**

Constructed by: MES contractor

Built-up area: 2,500 sq.ft.

❖ **Three storey building at Coimbatore**

Constructed by: NMS Rapidwall Construction Company, Calicut (2015)

Built-up area: 22,000 sq.ft.

❖ **Mass housing Project at Nellore, Andhra Pradesh**

Architect:	BMTPC/Threshold Architects, Chennai
Client:	BMTPC
Constructed by:	Hastha Pvt. Ltd., Bangalore
Built-up area:	36 dwelling units.

❖ **Typical Vila by Dalai Lama Secretariat, Tibet**

Client:	Central Tibetan Administration
Constructed by:	NMS Rapidwall Construction Company, Calicut (2015)
Built-up area:	650 sq.ft.

❖ **Take-a-break Building, Sanghumugham, Trivandrum**

Client: Kerala State Tourism Development Corporation

Built-up area: 500 sq.ft.

20 such buildings have been constructed along the National and State highways in Kerala. Roofing is done using a different material.

❖ **Anganwadi (Nursery School) at Piravom, Ernakulam**

Built-up area: 650 sq.ft.

ANNEXURE 1

DOs AND DON'Ts IN VARIOUS STAGES OF CONSTRUCTION USING GFRG PANELS

A1.1 Loading and transportation of panels

DO…

1. Mark notations on the cut panels at factory itself.
2. Load the panels stacked in stillages onto trucks based on the construction sequence followed at site (for example: panels for GF walling first, then staircase and lift walls, followed by GF roof slab, etc.).
3. Load panels of length less than 2.27m in horizontal stillages in flat position.
4. Tie the stillages properly with suitable steel rope or chain through the eyes of stillages to the hooks provided on either sides of truck platform. Provide corner angle steel sheets to protect the panel from any damage during transport.

DON'T…

1. Transport panels of width more than 2.1m without stillages.
2. Transport panels without the panel packing list indicating notation marks of panels.

A1.2 Unloading of panels on stillages and stacking at site

DO…

1. Collect the packing list from truck driver
2. Stack unloaded panels at a place convenient for erection.
3. Support the outriggers of the stillage on a solid surface to prevent any movements.

DON'T…

1. Unload the stillages with panels on undulated/sandy or clayey areas.

A1.3 Construction of foundation

DO…

1. Check the level of foundation with network of RC plinth beams prior to the start of wall panel erection.
2. Complete basement infilling, compaction and floor concrete or PCC up to RC plinth beam level before start of erection of panels.

3. Apply waterproofing treatment/damp proof course (as per the GFRG waterproofing manual [1]) on RC plinth beam/floor slab and ensure proper drying time before erection of wall panel.

DON'T…

1. Erect panel on undulated RC plinth beam/floor slab.

A1.4 Lifting and erection of panels

DO…

1. Use lifting jaws that are in perfect working condition and spreader bars with hooks at spacing of 1250/1750/2250/2750 mm for lifting panels.
2. Lift panels of width less than 4m using a single lifting jaw.
3. Adopt spacing of the lateral props as specified in the construction manual.
4. Provide the copy of cutting drawing for each team, if multiple erection teams are deployed (as in large GFRG building construction sites).
5. Apply joint sealant to joints between plinth beam and wall panels on external sides before the first pour of concrete.
6. Infill concrete in 4 stages in the cavities with an intermittent gap of 2 hours.

DON'T…

1. Insert the lifting jaws into the same cavities as before for re-lifting.
2. Lift panel if the wind speed is more than 20 km/hr.
3. Stand under the panel when the panel is lifted using crane.
4. Erect the panel on unlevelled / undulated RC plinth beam surface or floor slab.
5. Erect the panel over RC plinth beam or floor slab without applying and curing waterproofing / damp proof course.
6. Fill concrete until it is ensured that all services (electric cables, water pipes, etc.) are installed.
7. Pour concrete until the panel is in level and plumb, and lateral props are fixed.
8. Pour concrete in one go as the panel will burst-off / crack.
9. Fill concrete in the cavity adjacent to a burst one. The infilling should be done only after the concrete in the damaged cavity is set.

10. Remove the lateral prop until horizontal tie concreting is completed and wall panels are in rigid position.
11. Infill concrete during rain
12. Keep unfilled panels on position overnight, as an unexpected wind can make the panel fall down.

A1.5 Laying of floor / roof slab

Do…

1. Place runners with vertical props and acrospans in position before the floor / roof slab is lifted by crane.
2. Decide whether the panel is to be lifted by holding at a single point at multiple no of points, to put holes to insert soft slings. This is to fix the under panel spreader bar below the slab. Identify the centre of gravity of the panel and mark the hole positions (equidistant from the CG) for drilling suitable holes.
3. Tie the soft sling to the under panel spreader bar through the holes put in the slab before connecting to the crane hook for craning / lifting the panel into air (with the help of trained / skilled workers or riggers).
4. Provide 40 mm bearing for floor slab panel on to the walls on all the four sides.
5. Make sure that the support system consisting of wooden runners with vertical props, and acrospans are in position before cutting the top flanges of respective cavities for providing embedded concealed RC beams leaving 25 mm protruded flanges on either sides.
6. Provide side shuttering (174/184 mm wide) with a 6 mm groove (inside) for the waterproofing treatments to be carried out after concreting and before rendering of the external walls.
7. While concreting the RC slab, an erection team member should watch the slab from below for any problems related to movement of support or sinking of panel, etc. If anything found, signal the concreting team to stop the work and resume concreting only after rectification work is done.
8. Remove vertical props / acrospan only after at least 5 days of concreting of floor / roof slab, or when the support system is required for the slab in the next floor.

9. For roof slab, the screed concrete should be 60 mm thick and necessary waterproofing admixture as per manufacturer's specification should be used. The concrete should be properly compacted using mechanical vibrators. Roof slab should be provided with necessary slope (at least 1 in 150) for rain water drainage as per the instructions.
10. Waterproofing treatment to RC roof slab should be done using approved waterproofing treatment, including staircase head room slab / lift room roof slab and following the treatment of parapet wall panel top and parapet wall-roof slab joint treatment.

DON'T…

1. Lift the floor/ roof slab GFRG panel without proper support system with vertical props is in place.
2. Concrete the floor / roof slab before electrical cables / PVC pipes for cabling or wiring, fan hooks, etc., are put in place as per the engineering service drawings.
3. Use coarse aggregate of size more than 10 mm for concreting.
4. Leave the external side of floor / roof slab (174 / 184 mm high) without water treatment and should be smooth finish by rendering afterwards.

A1.6 Waterproofing treatment of door / window / ventilator openings

DO…

1. Seal-off the joints on all exterior and interior edge of openings using approved joint sealants after installation of door / window / ventilator frames, as specified in the manual.
2. Joints between parapet wall and roof slab; parapet wall top and lintel cum sunshade joints.

DON'T…

1. Fix the window frame flushing the external wall face. It is better to keep it flush with the internal face, if not, at the centre.
2. Leave pipe joints without treating with specified sealant.

A1.7 Application of Primer

DO…

1. Ensure minimum drying time as per manufacturers' specification for primer.

2. Apply primer only after completion of waterproofing treatments. Rendering (application of 1-2 mm thick rendering plaster) shall be done if fine/superior finish of external and internal wall panel surfaces and ceiling are required, and shall be applied by experienced PoP plasterers or accredited applicators having experience in rendering.
3. Mix the primer as per the proportions of components specified by manufacturer.

DON'T…

1. Add water to primer while mixing.
2. Use any primer other than the ones suitable for GFRG on the GFRG panel surfaces, as it will not have any effect on GFRG and if done, paint will eventually peel off.

A1.8 Rendering and painting

DO…

1. Use water resistant rendering compound for fine finish of surfaces of external walls and wet areas.
2. Apply painting directly over the primed panel surfaces if rendering (fine finishing) is not required.
3. Ensure proper drying (as specified by the manufacturer) after rendering.
4. Use paint primer over special primer/rendering compound applied surface, if the paint manufacturer prescribes the same.

DON'T…

1. Use locally available PoP (Plaster of Paris) for rendering or any other works in GFRG building. This is because GFRG panel is manufactured using high quality calcined beta gypsum plaster whereas the locally available PoP will be manufactured either from marine gypsum, low purity gypsum or chalk powder.

ANNEXURE 2

SPECIAL TENDER CONDITIONS FOR GFRG BUILDING PROJECTS & TERMS OF PAYMENT TO BUILDER / CONTRACTOR

GFRG building system and method of construction is different from conventional construction. It is possible to achieve substantial saving of time with proper planning and execution. For construction of GFRG buildings by any organisations / institutions / public undertaking / statutory boards or agencies / private sector in the country, tenders shall be invited on turnkey basis. The turnkey project shall include structural design of the shell (structure) and preparation of cutting drawings, in addition to execution work. Thus, tenders can be invited, for the preparation of structural drawings for approval and execution of the work, as per the design and specifications of items of work for the specified total built area, at the rate quoted per unit sq.ft.

To make advantage of the saving of time in construction, it is necessary that the payment towards the construction based on the physical progress shall be disbursed to the contractor on time at different stages / milestones specified in the work order / agreement. Finance is one of the basic requirements for the progress of construction. To process and make the payment with clear clarity, it is better to list out the items of work involved in each stage / milestone, which will also help in speedy implementation of work. Also, it will help to avoid disputes and confusion not only for the construction professionals, but also for the accountants / financial functionaries / administrative authorities of the organization which envisage or undertake construction.

GFRG building system construction can be summarized in the following stages and these can be treated as milestones for disbursing running / part payment and final payment.

A2.1 Construction of substructure

This includes the construction of foundation, basement, and network of RC plinth beams with starter bars in position, basement filling and laying of floor concrete.

A2.2 Procurement of panels

This includes purchase of GFRG / Rapidwall panels from factory (cut as per the cutting drawings), transportation in stillages to construction site, unloading at site using crane or fork

lift and stacking at site in stillages. If necessary, supply of panels shall be clubbed with the superstructure construction.

A2.3 Construction of superstructure

Superstructure construction can be subdivided into following stages:

(i) Erection of wall panels, infilling the cavities with RC, and construction of RC lintel cum sunshade and RC embedded tie beam.

(ii) Waterproofing treatment of plinth beam top, joints between RC plinth beams and walls, and concealed pipe joints.

(iii) Construction of floor / roof slabs

(iv) Electrical wiring, cabling, water supply / sanitary works

(v) Construction of parapet wall

(vi) Construction of staircase, staircase head room and lift well with machine rooms (if mechanical lift is included)

A2.4 Pre-finishing work

The following items of works are included in this stage:

(i) Waterproofing treatment of construction joints, windows, ventilators, door openings, etc.

(ii) Sealing of joints.

(iii) Supply and installation of door frames and shutters, window frames and shutters, etc., as specified in the specifications of items of work.

(iv) Waterproofing treatment of bath rooms / toilet floors and terrace slab including treatment of joint between head room / parapet wall and roof slab.

(v) Providing glazed vertical wall tiles.

(vi) Laying of flooring tiles and skirting.

(vii) Application of primer.

A2.5 Finishing work

(i) Waterproofing treatment of external sides of floor / roof slab band all around and smooth finishing by rendering.

(ii) Fitting of sanitary items, wash basins, etc., as per drawings.

(iii) Rainwater drainage pipe from terrace to basement / plinth with necessary clamping.

(iv) Rendering of external and internal wall surfaces, as specified in the specifications of items of work.

(v) Rectification work using water resistant patching compound

(vi) Painting.

Notes:

Based on the volume of work and cost of construction involved, construction companies / contractors for GFRG building construction shall be chosen on a case to case basis for the successful implementation of work.

a) Terms of payment, supply of any material by owner and advance towards mobilization payable, duration of construction time allowed and any special conditions involved shall be specified while inviting the quotations.

b) Similarly, accreditation or empanelment of construction companies / contractors in different classes / grades based on the cost of construction or PAC (Probable Amount of Contract) shall be accounted for based on the total built-up area of construction in sq.m. / sq.ft., or number of storeys of construction, etc.,

c) Based on BOQ with specification of items of work prepared, quotations shall be invited. The work shall be awarded to the successful quotationer with lowest quoted rate / lowest total cost of construction after assessing and analysing the financial implications of all the quotes.

d) Architectural plan, foundation design drawings, structural design drawings, cutting drawing and list of panels with their areas specified, shall be sealed and signed by both parties which shall be part of the agreement.

A part of payment can be given as advance towards mobilization (including advance towards supply of panel and transportation). The following stage-wise payments are recommended**:**

1. Advance towards mobilization after executing the agreement: up to 10% of total cost, less cost of material supply.

2. Foundation, basement and network of RC plinth beams: 15% (this can vary if the depth of foundation and site conditions, etc., varies).

3. Advance procurement and supply of panel and transportation and unloading at construction site: 25% (based on cost of panel, distance of transportation, etc.), which can vary from work to work.
4. Cost towards construction of superstructure: 40% (if the construction is multi-storeyed, this amount shall be paid proportionate to the total built area / superstructure built area works that is actually completed. It is to do this floor-wise; for example, floor slab of ground floor, first floor, second floor, etc.
5. Cost towards pre-finishing work: 10%
6. Cost towards finishing work (after completion of work): 10%

Advance of 10% paid shall be deducted from each mile stone payment as shown below. Once the bill of claim is received, the owner has to make the payment within a maximum of 5 working days.

1. Foundation work: 2%
2. Superstructure: 3%
3. Pre-finishing work: 2%
4. Finishing work: 3% (final payment)

Advance towards supply of panel and transportation, if paid shall be deducted from mile stone payment towards the construction of superstructure in proportionate basis. If bank guarantee is required to secure the advance, the same shall be specified while inviting quotations.

Generally, it is seen that disputes happen over the total built-up area of GFRG building construction while the payment is settled at the final stage. In such cases, there is a need for clarity on the total built area of a GFRG building. The following are the two ways of calculating the total built area.

1. If the common facilities like staircases, lift-wells, head rooms for both, lift machine room and its head room in terrace floor, covered balcony area with roof, entrance, common passage, etc., are not included in the total built area, these shall be specified in the tender

document. Total built-area shall also be stated in the quote. There shall be an option for the bidder to specify the total cost of construction, other than the rate per unit sq.ft.

2. Whereas, if the built-area cited under item 1 above includes the total built-area including all the facilities, then these shall be specified in the tender document. There shall be an option for the bidder to specify the total cost of construction, other than the rate per unit sq.ft.

This will avoid or prevent disputes arising on the cost of construction. The following shall also be specified in the tender document.

ANNEXURE 3

LOADING OF PANELS IN STILLAGES

A3.1 Vertical stillages

Panels of length more than 2.27m shall be transported only in vertical stillages. The number of stillages that can be loaded on a truck depends on the size of the deck. In India, the width of deck is usually 2.4m and the length can be 6m, 8m or 12m. The maximum permissible weight that a truck can carry is 9, 16 and 24 tonnes respectively for deck lengths 6m, 8m and 12m. Also, the maximum height of goods loaded on to truck is limited to 5 m from road level. There are two types of stillages. (i) with 5 panels and (ii) with 8 panels. Figure A3.1 and Figure A3.2 show the detailed drawings of stillages.

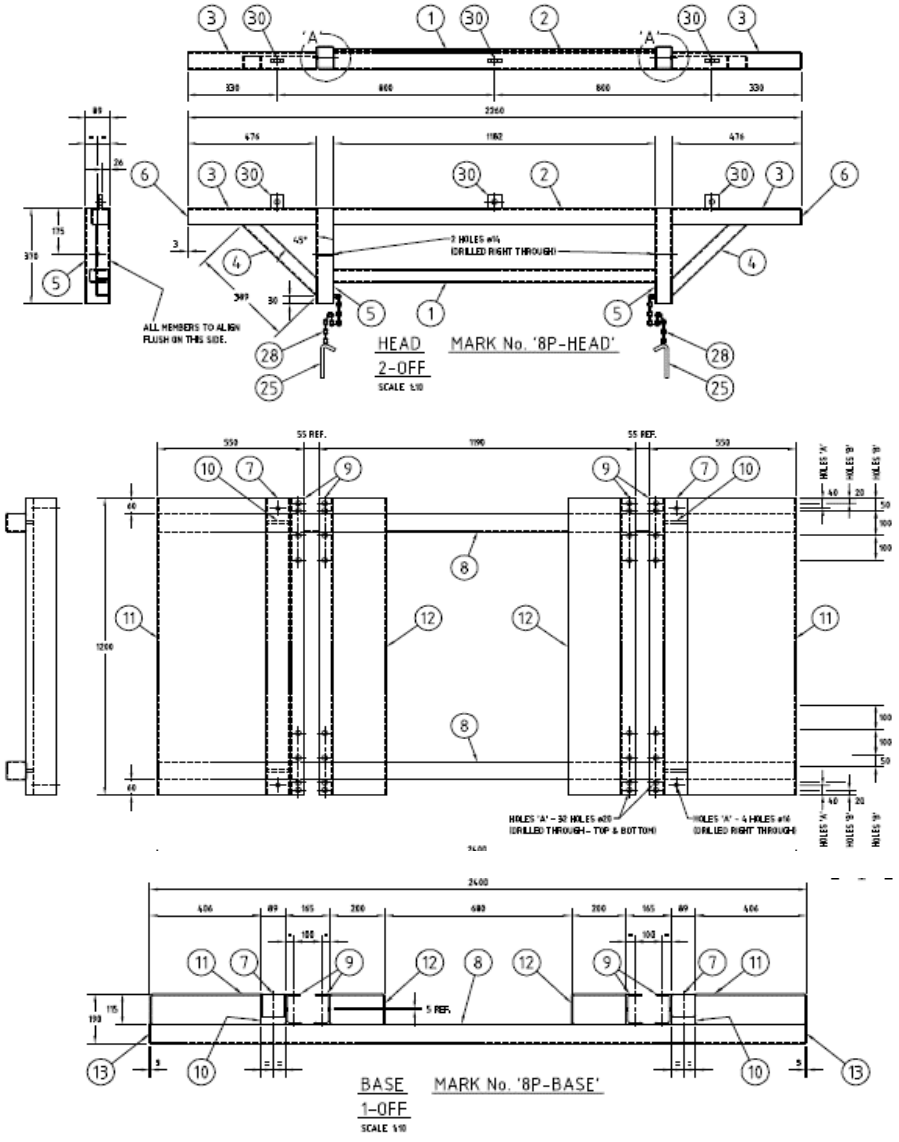
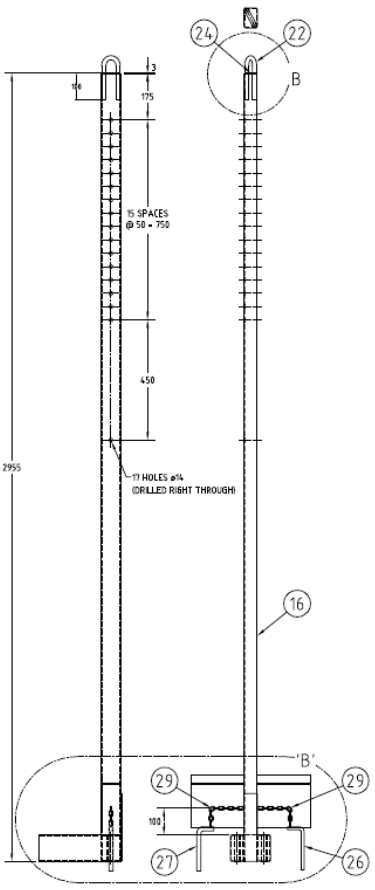
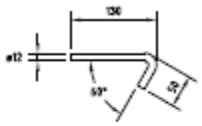


Figure A3.1: Parts of a stillage

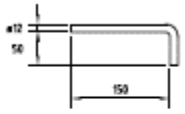


LEG MARK No. '8P-LEG'
4-OFF
SCALE 1:10

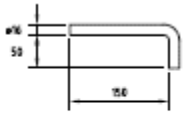
ITEM	DESCRIPTION	LENGTH	Q.TY.	COMMENTS
1	75 x 50 x 3 RHS	1182	2	
2	65 x 65 x 3 SHS	1182	2	
3	65 x 65 x 3 SHS	476	4	
4	50 x 50 x 3 SHS	389	4	45° MITRE EACH END
5	4 M.S. PLATE	370 x 136	8	PRESSING - REFER TO DETAIL
6	3 M.S. PLATE	59 x 59	4	END CLOSURE FOR ITEM 3
7	89 x 89 x 3.5 SHS	1200	2	
8	75 x 75 x 3 SHS	2394	2	
9	55 x 55 x 6 EA	1200	8	
10	90 x 12 FLAT BAR	26	4	SUPPORT FOR ITEM 7
11	5 M.S. PLATE	1200 x 513	2	PRESSING
12	5 M.S. PLATE	1200 x 307	2	PRESSING
13	3 M.S. PLATE	69 x 69	4	END CLOSURE FOR ITEM 8
14	75 x 75 x 4 SHS	1200	2	
15	ø10 M.S. ROUND BAR	67	4	
16	75 x 50 x 3 RHS	2952	4	
17	100 x 50 x 3 RHS	306	8	
18	6 M.S. PLATE	255 x 150	4	CLOSURE - REFER TO DETAIL
19	6 M.S. PLATE	200 x 200	8	
20	6 M.S. PLATE	200 x 69	8	
21	15NB LIGHT STEEL PIPE	97	8	21.3 O.D. x 2.0mm WALL
22	ø16 M.S. ROUND BAR	350	4	LIFTING LUG
23	3 M.S. PLATE	144 x 94	4	END CLOSURE FOR ITEM 17
24	3 M.S. PLATE	69 x 44	4	END CLOSURE FOR ITEM 16
25	ø12 M.S. ROUND BAR	170	2	LOCKING PIN
26	ø12 M.S. ROUND BAR	207	4	LOCKING PIN
27	ø16 M.S. ROUND BAR	207	2	LOCKING PIN
28	3mm LONG LINK GALV. CHAIN	300 NOM.	2	PWB ANCHOR - PL03 3mm
29	3mm LONG LINK GALV. CHAIN	180 NOM.	4	PWB ANCHOR - PL03 3mm
30	50 x 12 FLAT BAR	50	6	
31	M16 M.S. GALV. 'ALLTHREAD' BAR	1150	6	
32	M16 M.S. GALV. FLAT WASHER		12	
33	M16 M.S. GALV. HEX. NUT		6	



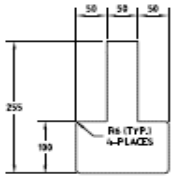
DETAIL OF ITEM '25'
(LOCKING PIN - HEAD)
SCALE 1:5



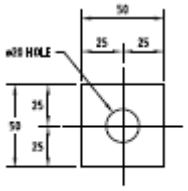
DETAIL OF ITEM '26'
(LOCKING PIN - LEG & OUTRIGGER)
SCALE 1:5



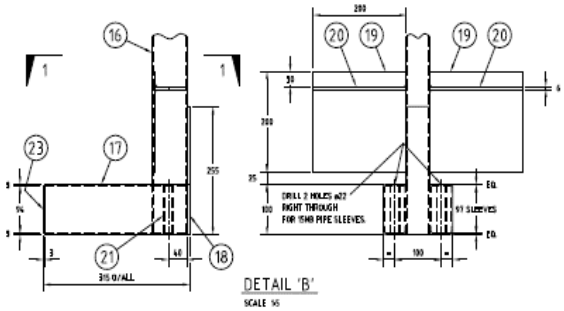
DETAIL OF ITEM '27'
(LOCKING PIN - LEG)
SCALE 1:5



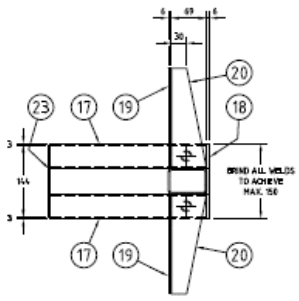
DETAIL OF ITEM '18'
(CLOSURE PLATE)
SCALE 1:5



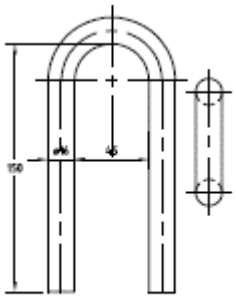
DETAIL OF ITEM '30'
SCALE 1:2



DETAIL 'B'
SCALE 1:5



SECTION 1-1
SCALE 1:5



DETAIL OF ITEM '22'
(LIFTING LUG)
SCALE 1:2

Figure A3.2: Details of stillage

Before loading in trucks, it is necessary to plan the sequence and arrangement of rows. Longer panels are to be in the centre part of stillages and shorter length panels on either sides of longer panels (at central part of stillages). Figure A3.3 shows the arrangement of stillages in trucks of different length.

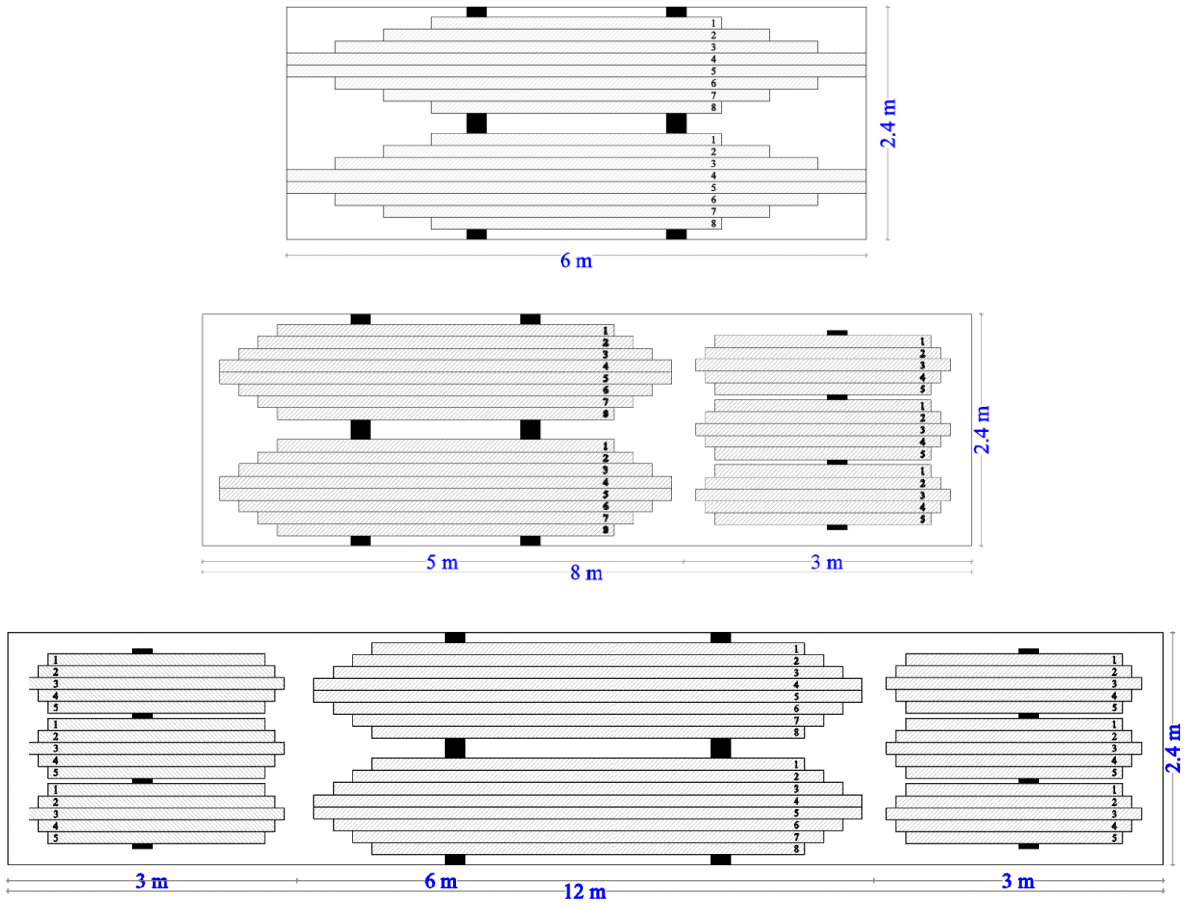


Figure A3.3: Arranging stillages in trucks of different deck size

The stillages have to be loaded side by side so that the upright legs of the stillages are next to each other as the lifting lashes on the top of the stillages are all in one line when the chain is inserted to tie the stillages to the truck. The chain shall never be tied over panels because the flange may get crushed and the stillages can fall off the truck.

Outriggers shall be attached to the stillages to withstand wind load and to prevent toppling of stacked stillage. Length of outriggers for 5 panel and 8 panel stillages are different. These outriggers shall be fabricated as per the drawing indicated in Figure A3.4 and kept at site by the GFRG construction contractor for safe stacking.

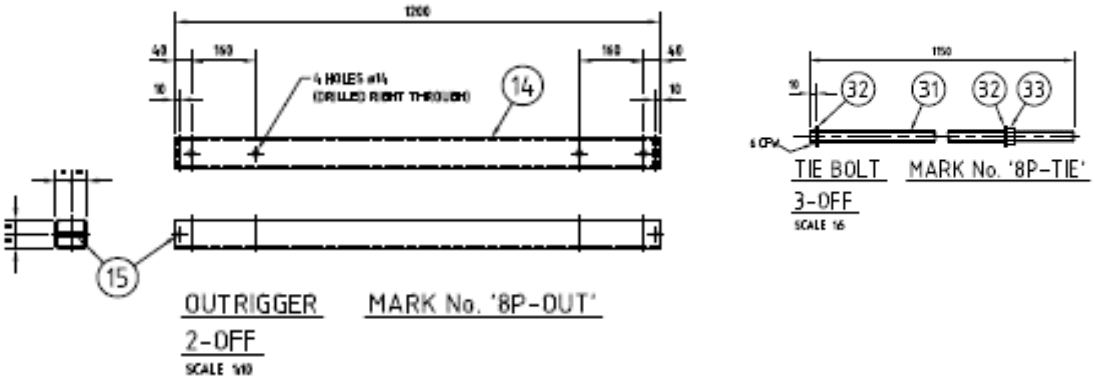


Figure A3.4: Details of outriggers

The 5 panel stillage have outriggers with total length of 1900 mm of which 1495 mm will be projecting out from the stillage. For 8 panel stillage, outrigger length is 1200 mm and the projection will be 900 mm.

A3.2 Horizontal stillages

If the panel length is less than 2 m, it can be loaded on to the truck deck in flat or horizontal position on one up on another (maximum 12 nos). These panels shall also be tied safely to the hooks on the sides of truck plat form for safe transportation. Figure A3.5 and Figure A3.6 show the loading and handling of panels in horizontal stillages.

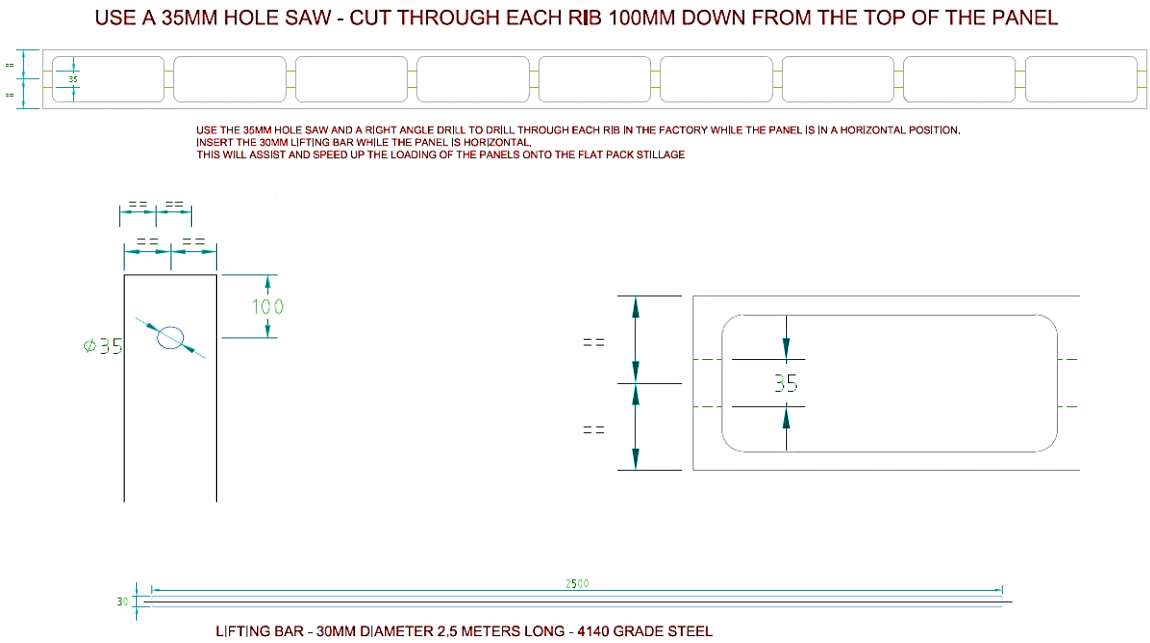
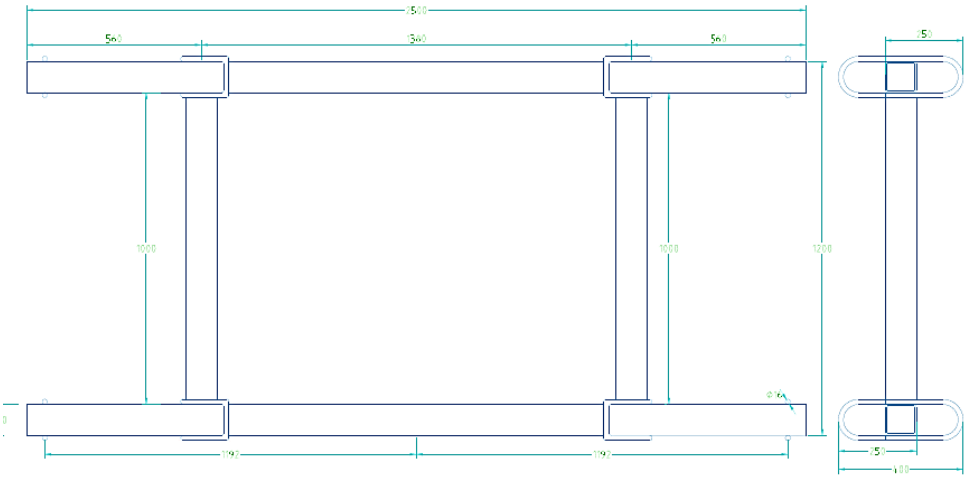
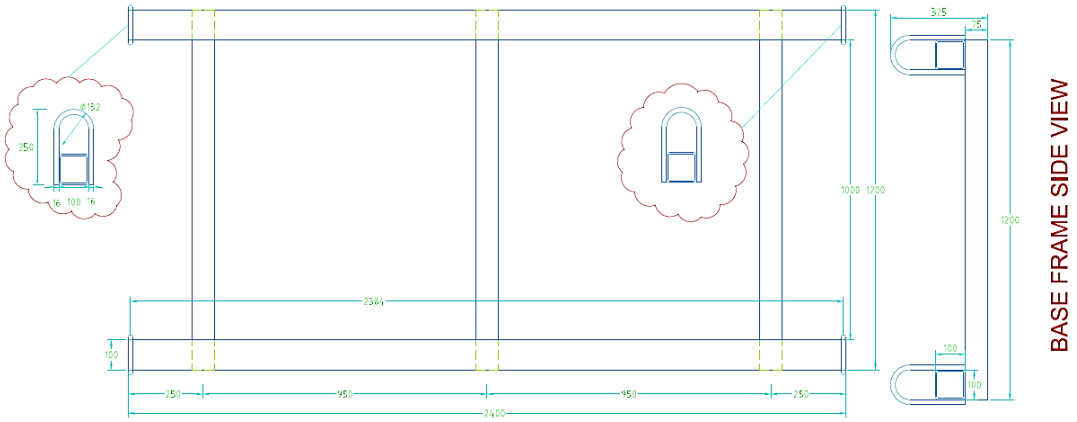


Figure A3.5: Panels loaded in horizontal stillage



Top view of spreader bar frame



Top view of base frame

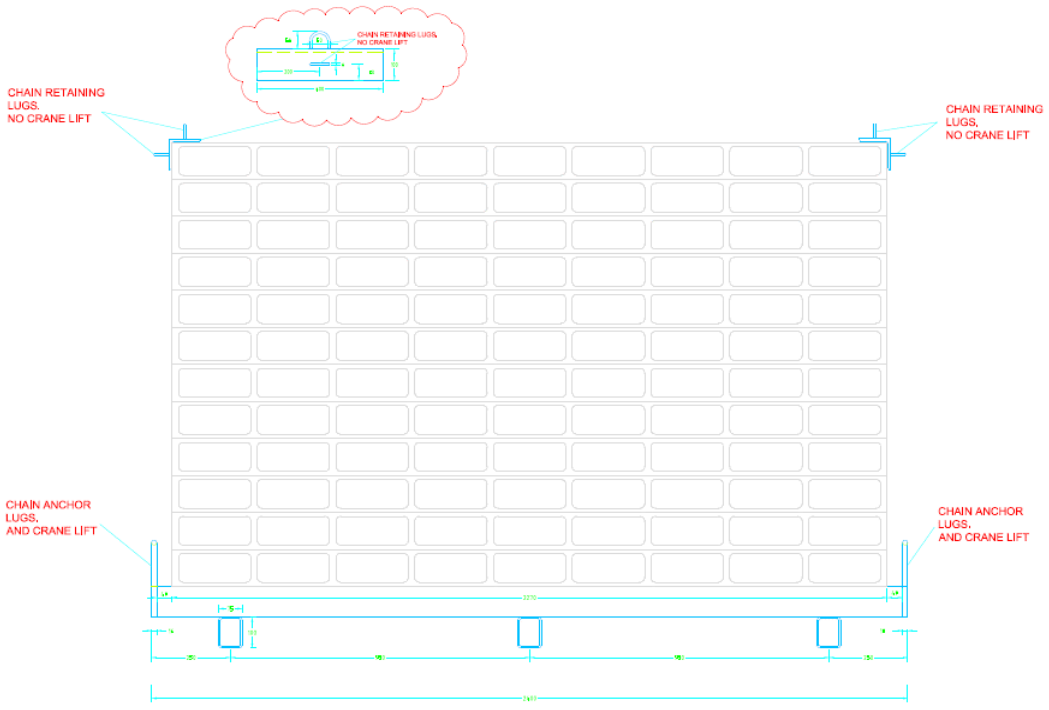


Figure A3.6: Loading and lifting of panels in horizontal stillages

ANNEXURE 4

PANEL STILLAGE COMPONENT LIST

Five Panel Stillage

Stillage No. _____ Date Out _____ Site _____

	Quantity	Yes	No	Comments
Base	1			
Legs	4			
Spreader Bars	2			
Stabilizer Legs	4			
Locating Pins	4			
Heads	2			
Bolts & Nuts Legs	8			
Bolts Base	4			

Date Returned _____

Signed _____

Eight Panel Stillage

Stillage No._____ Date Out _____ Site _____

	Quantity	Yes	No	Comments
Base	1			
Legs	4			
Stabilizer Legs	4			
Locating Pins	8			
Heads	2			

Date Returned _____

Signed _____

Please ensure that the 1.90m stabilizing legs are used on all the stillages.

ANNEXURE 5

ROLE AND SIGNIFICANCE OF VARIOUS TEAMS OF SKILLED WORKERS IN GFRG CONSTRUCTION

There shall be multiple teams with 6 – 7 skilled and experienced persons in each team, with each team, led by team head, for constructing GFRG buildings efficiently and to take advantage of saving of construction time. All the team heads constitute the core construction team (CCT) under the leadership of site construction Engineer / Technical Supervisor. Before the start of construction, every day, it is necessary for this core construction team to meet at site under site Engineer / supervisor to brief / discuss and note down each day's work / task. In turn, each team should also meet and discuss the work concerning them for that day.

In a large or mid-sized GFRG building construction project, it will be ideal to have many different teams. The scope of work of each team is indicated below for guidance. It is very important for the teams to have inter and intra co-ordination as the building is the outcome of cumulative efforts of all the workers and supervisors, engineers and managers involved.

Foundation work: Foundation for GFRG building is same as that for conventional buildings, designed based on soil condition and weight of superstructure. The works involved like earth work excavation, construction of foundation below the ground level and basement above ground level up to RC plinth beams shall be done by skilled workers / masons, etc., having experience in conventional foundation construction.

Difference of GFRG building foundation from conventional one: Difference for GFRG building foundation compared to conventional building foundation is the network of RC plinth beams on the top of basement for GFRG buildings, which need to have perfect zero – zero top surface level with starter bars in position, as per structural drawing (before the cast of concrete, starter bars are to be inserted in correct position, by team 1 or its members responsible for reinforcement / bar bending / side shuttering work, etc.)

Once the RC plinth beams are cast and cured, earth filling and consolidation of basement including floor concreting up to RC plinth beam top level shall be completed with perfect level and cured before start of erection of wall panel. Damp-proof course as per the waterproofing manual shall be applied at least 3 to 4 hours on plinth beam top before the start of wall panel erection.

a) **Team 1** (5 + 1=6 Nos)

Team 1 is responsible for shuttering, marking of wall panel position, bar bending and reinforcement work, cutting of top flange of GFRG slab, RC lintel cum sunshade and staircase related works, electrical and plumbing works. Before start of panel erection, this team should ensure zero-zero level on top of RC plinth beam.

Job description / scope of work and responsibilities:

(i) Their job include shuttering work of RC plinth beam, reinforcement works, insertion of starter bars in position as per structural drawing and making the RC plinth beam top in perfect zero - zero level using water level / laser level equipment, after concreting. They also have to make sure that floor concreting of GF (ground floor) is in perfect level with all the RC plinth beams.

RC plinth beams shall be cast at least 5 - 7 days before wall panel erection (for water curing of RC plinth beams and GF floor concreting). It is mandatory to check the levels and measurements of all the plinth beams of external walls and internal cross walls at least two to three days before wall panel erection starts, as a preparatory work. If any level adjustment is to be done, it should be done with cement mortar (1:3). After drying, wall panel positions shall be marked with colour crayons.

(ii) Marking the position of wall panels as per the cutting drawing in the GF and upper floor slabs using crayon or paint (using small sized brush) so as to be easily identified by panel installing team. This is to speed up the panel erection process. This shall be done with the involvement (by co-ordination) of an erection team member. Wall panel with 124 mm width shall be marked in perfect line. Panel number should be marked facing the wall panel at least 50 to 75 mm away from the line. A copy of the cutting drawing plan has to be with team head of team 1.

(iii) Electrical work

(iv) Plumbing work: They have to provide packing / sealing of pipe joints to ensure that the joints are sealed-off perfectly.

(v) Bar bending work and placing reinforcement in position

(vi) RC lintel cum sunshade work including external flange cutting, providing reinforcement and shuttering of RC sunshade related work.

(vii) Cutting of web of wall panel to a depth of 200 mm for horizontal tie beam

(viii) This team is responsible for undertaking the staircase work in parallel with wall panel erection, so that by the time the floor slab is erected above the wall panels, the particular floor can easily be accessed.

(ix) Cutting of top flange of floor slab for providing concealed beam, side shuttering (174 / 184 mm high) with plywood (6 mm groove) and fixing of special angle support to side shuttering side shuttering in perfect line and plumb.

b) Team 2 (5 + 1=6 Nos)

Erection / installation team: This team shall consist of youthful, healthy and committed carpenters, masons, concrete workers, bar benders, plumbers and ITI tradesmen. It will be best if this team can be headed by a person who is an ITI tradesmen, so that he can read / follow the building plan and cutting drawings. The team members shall be in uniform, wearing helmet and safety shoes for safety protection. They shall be familiar with all necessary tools and tackles and their operations and maintenance. They shall have attitude and skill for getting coordination and convergence with other team members for getting work done in time and also to extend their help to other's works whenever necessary. All teams are for the common purpose of proper and efficient construction of superstructure and its best finish.

This team shall get trained on all aspects of GFRG construction, though their focus is on erection of wall panels in position in perfect line, plumb and level and on floor slab works. This team shall have the required set of tools such as carpenter's saw, electrically operated chain saw, measuring tape, and small 5m long steel tape, spirit level, drilling machine, laser levelling equipment, suitable ladder, long rod for concrete tamping, etc. They shall be thorough on the use of adjustable lateral props (including fixing properly in position), lifting jaws like fixing to panel, fixing to spreader bars and linking to the crane and craning. Use of drilling machine with various drilling bits, use of Anka screws and use of laser level equipment shall be known.

Job description / scope of work and responsibilities:

(i) One of the members of the team shall identify panels from the stack of stillages in sequence with construction, by referring to the floor plan and cutting drawing with panel notation marking. Lifting jaws shall be fixed properly. In case of large panels, two

members of the team can be involved in this task. Members of this team shall work in perfect co-ordination with crane operators and riggers.

(ii) If the panel require any preparation like removing the door / window / ventilator, panel lifted from the stillage shall be properly placed on a firm ground in a slanting position with a firm wooden support to carry out the required action. The lifting jaw shall remain in position while the work is being done. While this work is being attended by some members of the team, others can move on to lifting other panels from stillages as detailed above.

(iii) Application of damp proof course within the marked panel position (200 mm wide): Once the RC plinth beam / floor slab and erection team is ready for panel installation, panel shall be lifted up and navigated through the air only after the DPC is applied by team 1 and team 2 members in proper co-ordination)

(iv) When the panel is brought in position for erection, place 2 nos of wooden cubes (preferably 200 x 200 x 200 mm) just above the marked position of panel close to each other and away from the ends, so that starter bars and vertical bars can be tied properly. After tying all the starter bars and vertical bars, the wooden cube shall be removed and the panel shall be placed in position. Check for line and plumb - vertical and horizontal plumb and adjust the panel accordingly to make the panel in proper position. If, due to floor variations, packers are required under the panel, please ensure that the packers are placed under rib section and not under the skin section.

(v) Provide lateral props in position as per instructions at required spacing of 2.7m apart (for storeys more than 3 floors, spacing changes) as per the length of panel. Anka screws, drilling machine and necessary attachment, drilling bits, etc., necessary to be ready with the team.

During this process of wall panel installation, team 1 who is responsible for electrification, plumbing and staircase work shall be carrying out their works in parallel. Team 3 who is responsible for concrete infilling of cavities can start the infilling process. In the meantime, team 2 shall carry out RC lintel cum sunshade related work, cutting of 200 mm deep web for horizontal tie beam and placing of reinforcement cage, etc. Team 3 responsible for concreting shall do this in co-ordination before the floor / roof panel is placed in position)

Floor / roof slab related work shall be done by perfect co-ordination among members of team 1 (cutting of top flanges, side shuttering, placing of concealed beam reinforcement cage, electrical works, etc.), team 2 (panel laying), team 3 (concreting) and team 4 (telescopic beam span, vertical props, etc.)

c) **Team 3** for concreting: (2 skilled persons; Additional labours for concreting work shall be organized from local labour / manpower supply)

Cavities shall be concrete-infilled in such a manner that panel the does not burst-off or bulge due to wet concrete pouring from top (3m high) and development of hydrostatic pressure from wet concrete at panel bottom.

Job description / scope of work and responsibilities:

(i) In-filing of cavities in 4 stages as given below.

Concreting shall be done using aggregate of size 6 – 8 mm. For walling, M20 grade of concrete shall be used, with a water-cement ratio of almost of 0.52 and slump of 70 mm ± 20 mm. For concealed tie-beams and slab, M25 grade of concrete shall be used. Concrete shall be infilled manually or using a concrete pump.

First pour of concrete: First pour shall be limited to less than 300 mm depth from bottom. Continue with the first pour for infilling all cavities. While infilling is done by one member of team, one or two members shall watch whether any bulging or bursting is taking place. If any problem is noticed, immediately give signal to stop infilling. Leave the next cavity also unfilled and return to these later when the concrete in the burst cavity has set. A member of team 2 shall rectify the busted cavity where the problem occurred, so that remaining pour can be completed later.

Before infilling the cavities, team 1 shall make sure that electrical work and piping work including proper cutting of openings for piping work, are done by team 1.

Second pour of concrete: After a minimum of 2 hours of first pour, concrete would have achieved initial set and will be ready for second pour, up to window sill level in the case of external walls and up to 1.0m for internal walls (concreting up to 0.7m height in second pour). During the second pour also, one of the members of team 1 or 2 shall watch the pour to see whether any problem occurs and to signal if anything happens. It shall be rectified and kept ready for the next pour by team member 2.

Third pour of concrete: Same as above after 2 hours of second pour, third pour shall be done up to door / window top / lintel level (2.1m high).

Fourth pour of concrete: Same as the above after 2 hours of third pour, remaining concrete infill shall be done up to bottom of horizontal tie beam. During this pour, concreting of RC lintel and sunshade shall also be done No mechanical vibration shall be done. A 16 mm rod, longer than panel height shall be used for tamping the concrete in the cavities if there are more number of piping or vertical rods or conduits which may block settling down of concrete by its own weight.

Infill of quarry dust and 5% cement dry mix: During or after the concrete infill, infilling of quarry dust and 5% cement dry mix / lean concrete of M7.5 grade or any approved inert infill material shall be done by team 3 in all the left-over cavities.

Dry mix shall be infilled in at least 3 stages. After every stage of infill, pour half litre of water to make it in cake form.

Casting of GF roof / floor slab:

Before the floor slab panel is lifted and brought in position by team 2, team 1 shall make sure that the bottom support system including telescopic beam and vertical adjustable prop with runner is provided in position.

(i) Casting of concealed / embedded horizontal tie beam

(ii) Casting of staircase waist slab, concealed beams, mid-landing slab and staircase steps

(iii) Concreting of concealed beam and screed: M25 concrete with 6 mm to 10 mm aggregates shall be used. The water cement ratio of the mix shall be 0.52 and the slump be 90mm ± 20mm. No mechanical vibrator shall be used.

(iv) While concreting the concealed beam, one member of team 1 or 2 shall watch the slab support system. If any problem is noticed, immediately stop concreting to check / rectify the problem and to continue immediately.

(v) Top concrete level of slab shall be marked on the side shuttering. 25 x 25 x 25 mm concrete cover block shall be provided below 10 gauge weld mesh to keep the mesh in position. This is the responsibility of team 2. But co-ordination between teams 1, 2 and 3 are a must. Mechanical vibration shall be done for slab concreting.

(vi) The floor dimension and flatness shall be checked on the day before placing panels so as to have sufficient time to decide what rectification to choose or which panel (bottom of panel) needs to be packed or cut due to floor unevenness.

(vii) While concreting bath / toilet and terrace slab, the concrete shall be made dense to reduce permeability, and concreting shall be done so as to achieve the required slope as per the direction of construction Engineer.

d) **Team 4**: (4 skilled workers under a supervisor: 4+1=5 persons)

This is the in-house accredited applicator team for waterproofing treatment. Rendering of external walls, internal walls and ceiling for quality finishing work are also to be done by them. So a PoP plasterer / one worker from a painting group shall also be included in this team. There shall be an exclusive waterproofing supervisor to make sure that the applicator team does the work properly.

The best option for waterproofing treatment is to have in–house applicator team for waterproofing treatment, as such a team can have effective co-ordination and convergence with the other teams. Basically, this is due to the fact that certain waterproofing treatments need to be done prior to (on the eve) panel erection start (for example, damp proof course on plinth beam - 200 mm wide on external walls; that on all floor slabs -150 mm wide for external wall and bath/toilet wall in upper floors).

He shall be an experienced applicator / supervisor

Job description / scope of work and responsibilities:

(i) Waterproofing over RC plinth beam top: Application of damp proof course over network of RC plinth beams in GF / floor slabs in upper floors (200 mm / 150 mm wide) after marking wall panel position.

(ii) Waterproofing treatment of all vertical wall corner joints of external walls, internal vertical joints of external walls, bath / toilet walls, and bath and toilet floor slab waterproofing treatment.

(iii) Backer rod of insulator form material of varying diameters in coil forms shall be used for proper treatment of joints – vertical joints and horizontal joints

(iv) Waterproofing treatment of RC lintel cum sunshade

(v) Waterproofing treatment of window / door / ventilator openings.

(vi) Treatment of 174 mm floor / roof slab sides (bands)

(vii) Treatment of terrace slab and parapet wall joints

(viii) Parapet wall top treatment

(ix) Piping joint treatment (this shall be done basically by team 1 – plumber member)

(x) Treatment of openings in external walls and bath / toilet / wet area walls.

(xi) Application of primer

(xii) After primer is applied, with a curing or drying period of 12 hours in sunny day or 24 hours in cloudy day, for external wall surface including band around, basement above ground including RC plinth beam, rendering shall be done using FRBL / RCF wall plaster or JK / Birla wall putty mixed with Elastobar EB 50 at 10:1, or Alchimica rendering product.

Pre- Finishing and finishing (painting) works

A. Installation of door, window, ventilators, etc. If this is an out sourced activity, this is to be done either by a responsible sub-contractor or as per the arrangement made for the work by the in-house team.

B. After installation of door / window / ventilator frames, joint sealant treatment shall be done.

C. Glazed tiles / marble slab shall be fixed in bath / toilet rooms by skilled tile layers by using Kerakoll or Ardex Endura special additives.

D. Floor tiles / marble slab shall be laid.

e) **Team 5 :** Painting team

Normally painting is outsourced. But for small GFRG / Rapidwall buildings, painting shall be done by the waterproofing / rendering team members who are basically drawn from painting groups.

In short, a total of 5 teams with 20 skilled workers will form the core construction crew. There can be multiple teams with 20/40/60/80/100 nos of skilled workers based on the project size and volume of work involved.

ANNEXURE 6

CONSTRUCTION OF COMPOUND WALLS USING GFRG PANELS

GFRG panels can also be used for the construction of compound walls. The detailing of a typical compound wall of height 1.5m is shown in Figure A6.1. Concrete reinforced with one 8 mm diameter bar shall be infilled in every fourth cavity and in cavities adjacent to wall joints. Rest of the cavities shall be infilled with a mixture of quarry dust and 5 % cement. The drawing for the compound wall is shown in Figure A6.1.

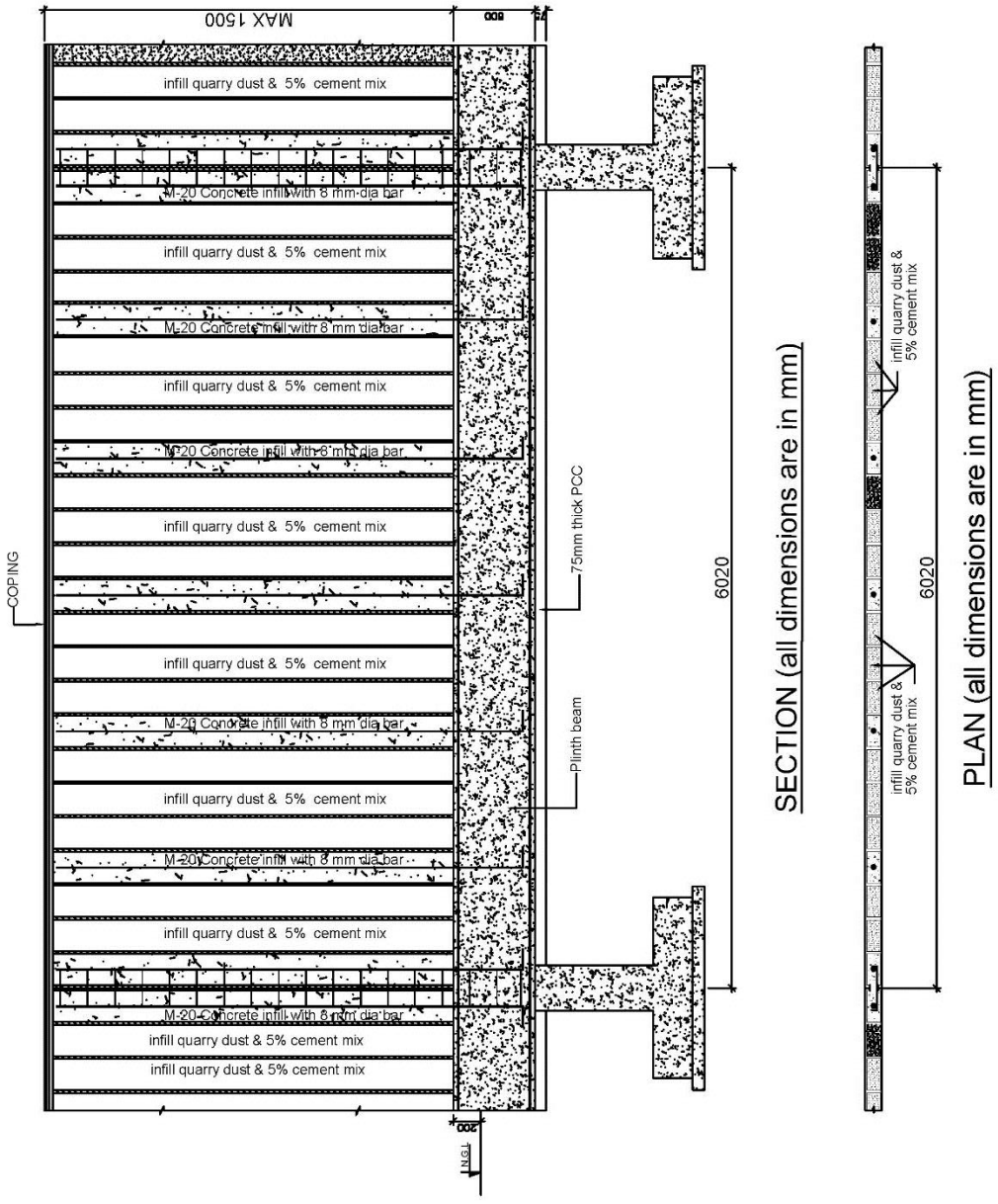


Figure A6.1: Compound wall using GFRG panels

ANNEXURE 7

SUNKEN FLOOR FOR TOILET / BATHROOM

Sunken floor can be provided for toilet/ bathroom, if required, in GFRG buildings. Figure A7.1 gives the details of the same.

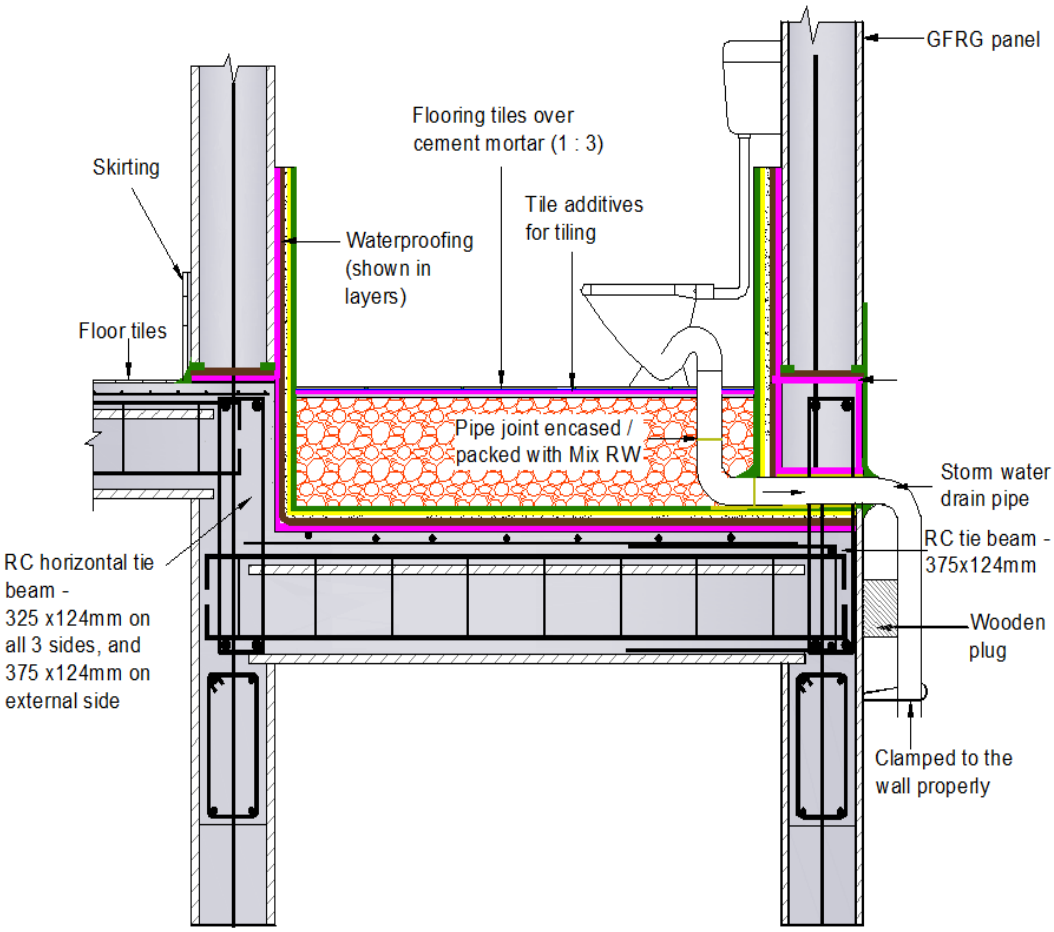


Figure A7.1: Sunken floor for bathroom / toilet (with 200mm level difference)

ANNEXURE 8

BROCHURE DESCRIBING METHODOLOGY OF WATERPROOFING OF GFRG BUILDINGS USING ZYDEX PRODUCTS

Waterproofing Treatment of GFRG Buildings using Zydex Products

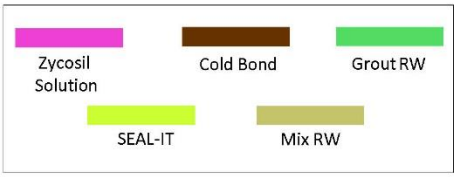
Zydex Industries

RAPIDWALL® Building a Better World

GFRG demo-building at IIT Madras (built in 2013)

Use of Glass Fibre Reinforced Gypsum (GFRG) panels for rapid construction of buildings (comprising GFRG walls and slabs, in combination with reinforced concrete (RC)), significantly reduces the number of joints as compared to conventional buildings. GFRG panels are as such water-resistant and hence do not require any kind of waterproofing to be applied, but the joints and wet areas like bath / toilet and terrace floor necessarily need to be waterproofed. Based on the past experiences of the waterproofing treatment of GFRG buildings, the waterproofing manual had recently been revised. This brochure provides guidelines for waterproofing treatment of GFRG buildings, for use by various Engineers, contractors, builders and supervisors of construction companies.

Waterproofing compounds used



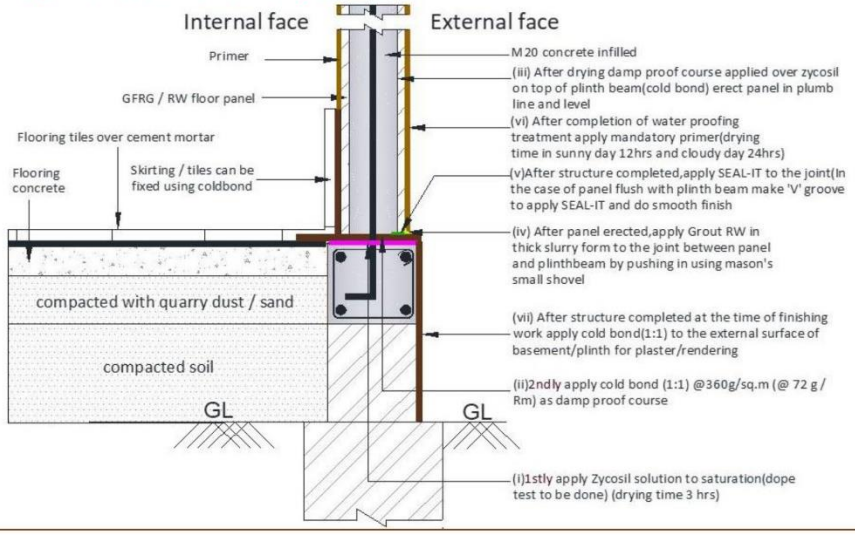
Special Primer & rendering compound

NOTE: Standard waterproofing treatment shall be carried out on terrace / roof slab by any proven and accepted method effective for concrete and GFRG

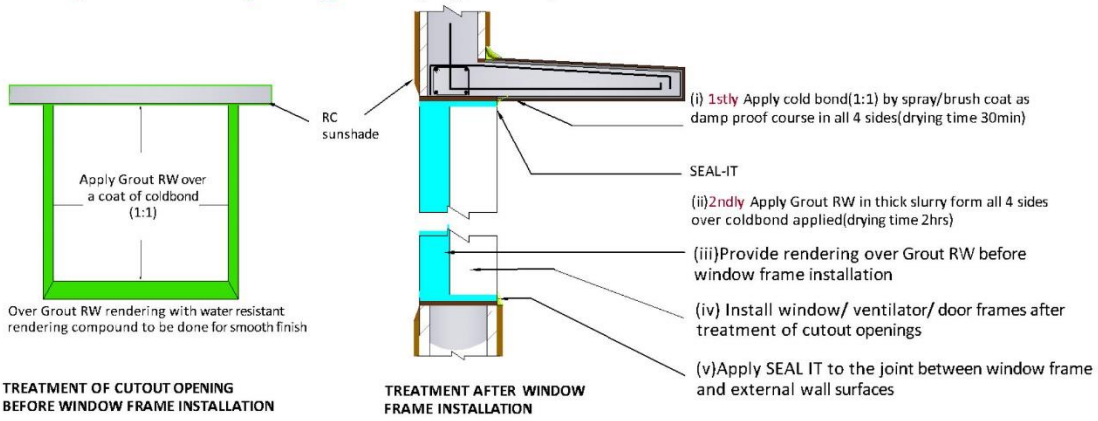
Areas of application

1) Top of RC plinth beam
2) Interface of RC plinth beam and GFRG wall in ground floor, floor slab and wall in upper floors, roof slab and parapet wall
3) Lintel and sunshade
4) Window / ventilator cut-outs
5) Joint between door / window / ventilator frame and GFRG wall
6) Vertical joints in GFRG walls (incl. parapet) – external, bath / toilet walls
7) External side of exposed RC floor / roof slab (174/184mm) wide band all around
8) Waterproofing treatment of bath / toilet floor and terrace slab
9) Top of parapet wall / capping of parapet wall

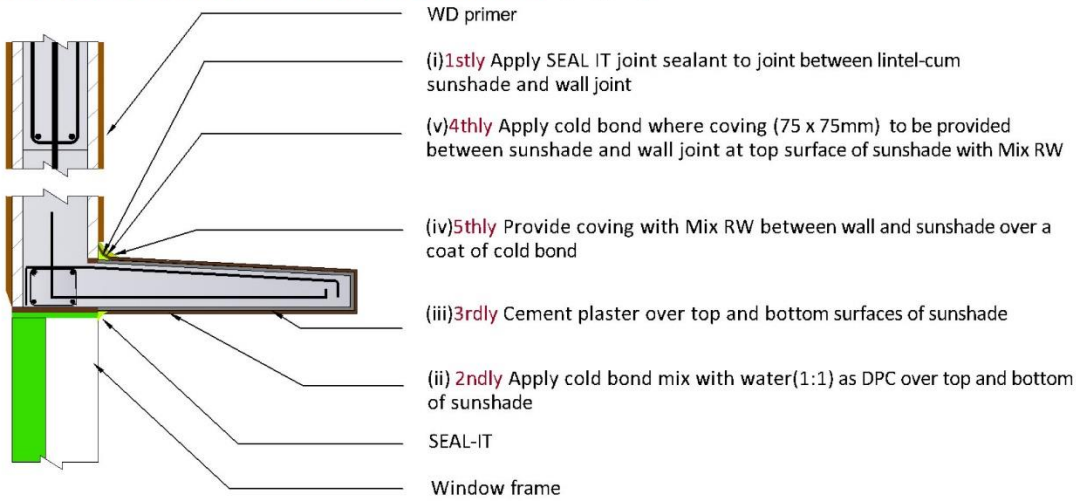
Treatment of RC plinth beam and wall joint at 'A' (Fig. 1):



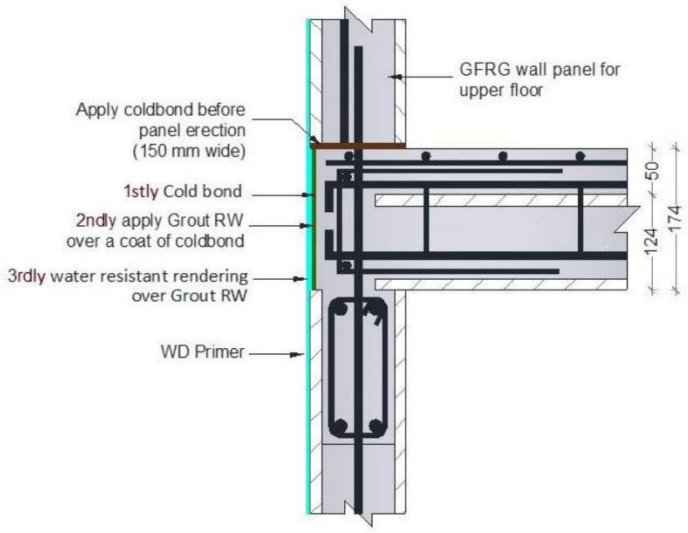
Window / ventilator opening at 'B' (Fig. 2 & 3):



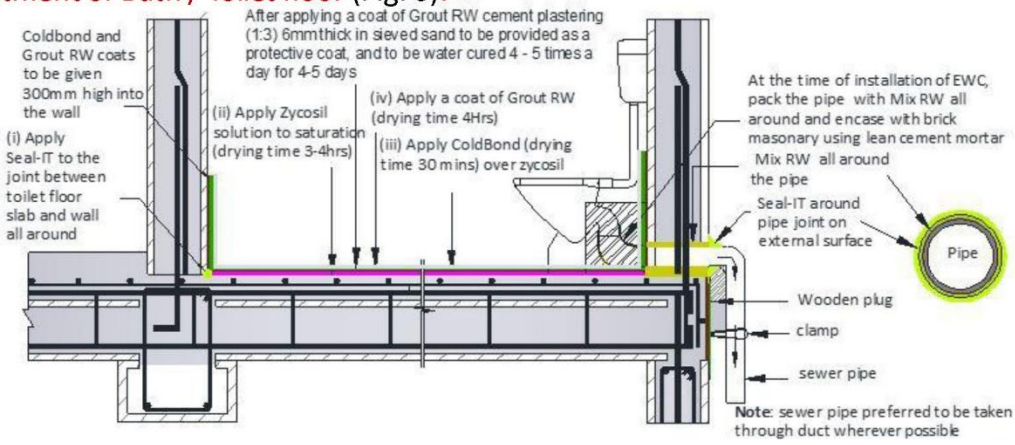
Treatment of RC lintel cum sunshade joint at 'C' (Fig. 4):



Treatment of 174 / 184mm wide band all around exposed RC floor / roof slab (Fig. 5):

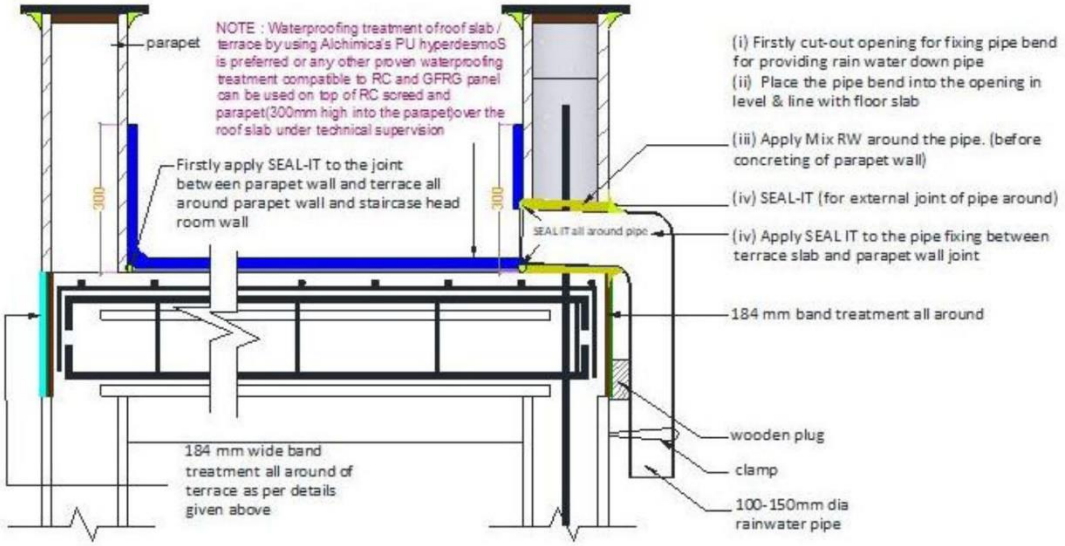


Treatment of Bath / Toilet floor (Fig. 6):

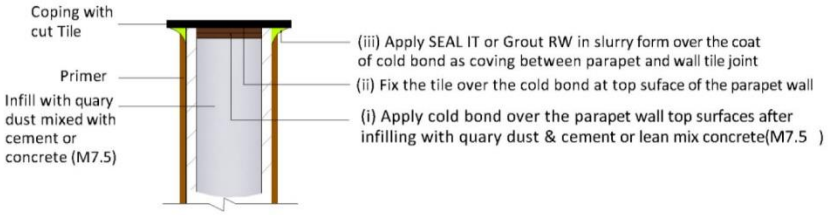


Note: 1. If drop test on zycosil solution applied is failed re-apply solution to saturation.
2. EWC (European water closet) and other toilet and bathroom fittings to be installed only after completing water proofing treatment.
3. For pipe connection pipe bend to be installed before water proofing and joint to be treated as illustrated and detailed in GFRG Revised waterproofing manual

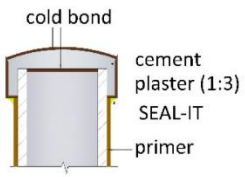
Treatment of terrace slab (Fig. 7):



Treatment of parapet wall and parapet wall coping (Fig. 8 & 9):

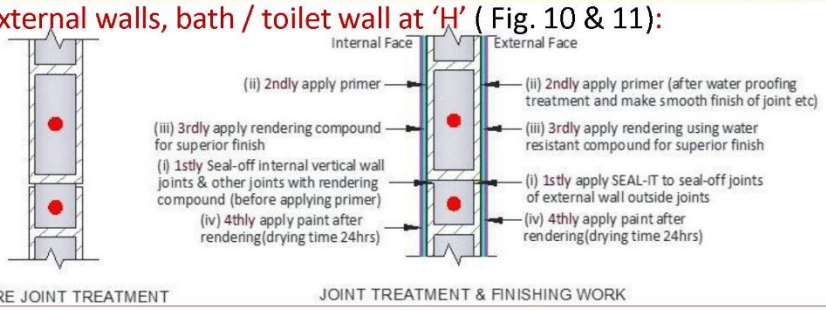


Treatment of parapet wall



Coping of parapet wall-an alternative option

Wall joints of external walls, bath / toilet wall at 'H' (Fig. 10 & 11):



Note:

- Vertical wall joints of external walls and internal walls of bath / toilet room and other wet areas to be sealed off with SEAL-IT joint sealant.
- Vertical wall-corner joints of the internal walls and ceiling joints, rendering compound can be used to seal off joint and make smooth finish, and then apply primer (drying time od mandatory primer is 12hrs on sunny dry and on cloudy day 24hrs)
  - For external wall surface and internal bath / toilet wall etc., use water resistant rendering compound.
- If rendering to be done before painting for superior finishing, use gypsum wall plaster(FRBL/RCF)mixed with Elastobar EB50 @(10:1) to make water resistant external wall surface

Preparation of solution / compounds at site:

Compound	Mix and proportion	Coverage	Drying time
Zycosil Solution	Zycosil + Water + Zycoprime (1 : 20 : 2)	1.648 sqm/ kg	3 – 4 hours
Cold bond	Mixing with water at 1:1 (damp proof course)	3.75 sqm/ litre	0 - 0.5 hour
Grout RW (white)*	Elastobar EB50, White cement & 100mesh silica (1 kg + 1.5 kg + 1 kg)	50 rm / kg	0 - 3 hours
Grout RW (grey)*	Elastobar EB50, Grey cement & 100mesh silica (0.8 kg + 1 kg + 1 kg)	40 rm / kg	3 – 4 hours
Grout RW (grey)*	Thick slurry form for horizontal surface (0.4 kg Elastobar, 0.5 kg cement, 0.5 kg sieved sand and 0.25 litre water)	0.625 sqm / kg	3 – 4 hours
SEAL-IT	Ready-to-use sealant (require no mixing)	15 rm / kg	4 – 6 hours
Mix RW	Elastobar EB50, Cement, 100 mesh silica & Water (1-2 kg + 10 kg + 30 kg + 8 kg)	0.75 cft coving	3 – 4 hours
WD Primer (Mandatory)	Mix WD P30 & WD Thinner (1 : 1) to make primer	22.3 sqm / kg	12 – 24 hours
Rendering compound	Elastobar EB50 & Gypsum based wall plaster or JK / Birla wall putty (1:10)	0.5 sqm/ kg rendering @ 1.5mm thick	12 – 24 hours

* when required in slurry form, add water as per requirement to the above formulation

- Grout RW using white cement is used for aesthetic appeal. If cost is a concern, use of grey cement instead of white cement for affordable mass housing.
- 'SEAL-IT' is an acrylic based ready-to-use joint sealant,For affordable mass housing Grout RW can also be used as an alternative to SEAl-IT.
- If JK /Birla wall putty, which is white cement based, is used for preparing rendering compound, water curing is to be done for 2 days. If gypsum based wall plaster is used, there is no need for water curing. It should be mixed with Elastobar at 1:10 to make it water resistant and to give bonding.

Note:

1. Whenever Zycosil solution is applied (only over concrete surface), it is important to perform drop test to check its effectiveness and if drop test fails, re-apply Zycosil solution. Zycosil solution should not be applied to GFRG panel surface.
2. Special primer (WD P30 mixed with WD thinner at 1:1) developed for GFRG after being applied on the exposed panel surfaces acts as a base coat with strong bonding to rendering plaster and / or finishing coat of paint (water based, acrylic, distemper or cement paints). Priming also enhances abrasion resistance of the panel. Application of WD primer is mandatory.
3. Primer not applied to the panels can result in peeling-off of the paint and reduced durability in the long-run. Primer need not be re-applied for re-painting the building. If the already painted surface gets abraded by 0.2 to 0.3mm, a fresh primer coat shall be re-applied.
4. For painting paint primer can be applied as per paint manufactures. But this paint primer is not a substitution for WD primer, which is mandatory to be applied as specified.
5. For further details, refer 'Manual of Waterproofing of GFRG Structures Revised Dec 2017'.

ANNEXURE 9

BROCHURE DESCRIBING METHODOLOGY OF WATERPROOFING OF GFRG BUILDINGS USING ALCHIMICA PRODUCTS

Waterproofing Treatment of GFRG Buildings Using Alchimica Polyurethane Products

ALCHIMICA BUILDING CHEMICALS RAPIDWALL Building a Better World

- GFRG building system comprises both gypsum based GFRG (Glass Fibre Reinforced Gypsum) / Rapid wall and conventional RC (reinforced concrete), both of which co-exist as composite structural materials in the building. Water proofing treatment of the construction joints of GFRG buildings involving two different building materials has been a major challenge, as most of the existing water proofing chemicals available world over are developed for conventional building materials like concrete/ cementitious only.

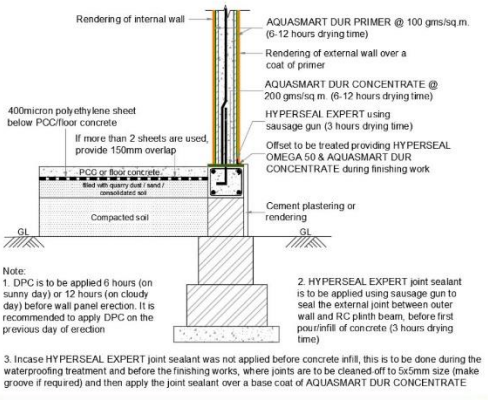
- Specially formulated PU products developed by Alchimica have been used on gypsum buildings in Greece and other European countries. Their Coatings and sealants are compatible for both concrete and GFRG (gypsum based); Compatibility of PU with GFRG has been confirmed based on studies and test conducted at IIT Madras.

NO	PRODUCT DESCRIPTION	COLOUR CODE	AREAS OF APPLICATION
1.	AQUASMART DUR CONCENTRATE		Plinth Beam Protection (DPC).Treatment of cutouts. External band protection. Parapet wall top protection.
2.	HYPERDESMO S		Wet areas like Toilet, Balconies, Window, Door.
3.	HYPERDESMO CLASSIC		Terrace and sunshade treatment.
4.	HYPERSEAL EXPERT		All vertical and horizontal joints of walls Concrete, Window and door Frame joints.
5.	AQUASMART DUR PRIMER		External and internal wall and coating before rendering or painting.
6.	AQUASMART EXTERNAL PATCHING COMPOUND		Used as final finish product to develop thickness around 0.5 mm to 1mm.
7.	AQUASMART EXTERNAL WALL PUTTY		Water resistant product For repair / rectification of dent or damage caused during transport or handling or erection of panels of external side
8.	HYPERLATEX INTERNAL PATCHING COMPOUND		For repair / rectification of dent or damage caused during transport or handling or erection of panels internal structure an ceiling
9.	HYPERLATEX INTERNAL WALL PUTTY		For rendering of Internal surface an ceiling by providing (Av:1mm thickness) thin layer plastering by pop or wall putty applicators
10.	MICRO SEALER 50		For sunshades and terrace

Damp proof course (DPC)

AQUASMART DUR CONCENTRATE : The components A, B and C are mixed in the ratio 1:1:2.25 (I.e.) Part A 4kg+ Part B 4Kg + Part C 9Kg by weight to form homogenous mix with help of slow speed stirrer (300 rpm), is applied with spatula or Stiff and short bristle brush at a dosage of 200 gms/rmt (in single or multiple coats) and allowed to dry over night.

After GFRG/ RAPIDWALL panels placed over the fully cured DPC in position with all support, before the first pour concrete in to the panels, the gap / joint of external side is to be sealed off with HYPERSEAL EXPERT (PU sealant) to avoid outflow of slurry from the concrete. (Curing time for PU Sealant is 3 Hrs. A layer of HD Polyethylene Sheet (400 Micron) is spread over the compacted earth or PCC on the entire floor area to prevent dampness from ground below to rise up to floor .



Treatment of joints

HYPERSEAL EXPERT should be applied for sealing all joints over a base coat of AQUASMART DUR BASE COAT (except for application of joint sealant to external joint between RC plinth beam and wall before first pour of concrete into the cavities). The components A, B and C are mixed in the ratio 4:4:4 by weight to form homogenous mix with help of slow speed stirrer (300 rmp) , is applied with spatula or Stiff or roller or Spray machine. The coverage of this primer depends on the area of application. (General recommendation is 25 grams per rmt for joints.)

HYPERSEAL EXPERT recommended for all external side of Panel to Panel Joints / Panel to Concrete surface / Concrete to Metal frames , Concrete to Concrete joints etc. Curing time depends upon the thickness of the sealant used – STD curing time 2 - 3 mm per day). Kindly consult Alchimica Technical service team for fast curing sealants (ts@alchimica.co.in).

Coverage of HYPERSEAL EXPERT sealant per 600 cc (720 grams) sausage in running meters (rmt) is given in Table 1. HYPERSEAL OMEGA 50 FAB strip is used in all critical areas for additional reinforcement.

Table 1 HYPERSEAL EXPERT sealant coverage

Depth Considered	Width of gap		
	< 5 mm	5 mm	10 mm
< 5 mm	30 rmt		
5 mm		24 rmt	12 mt

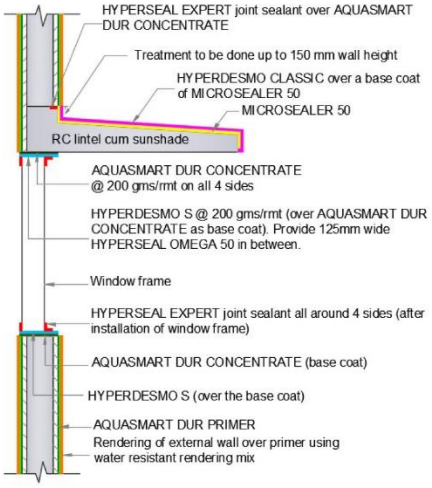
Treatment of cut-outs / door / window openings

Firstly cut out of window/door/ ventilator to be treated and cured before installation of window/ door/ventilator frames.

Treatment of periphery of doors, windows and ventilator frames

After installation of door / window / ventilator frames it is very critical to provide joint sealant between the frame and cut out of the GFRG Panel. A pencil of HYPERSEAL EXPERT sealant is applied with Sausage Gun and tooling finish is recommended immediately after application to get smiling face for free flow of water striking the window panels. Sealant is applied between the base cured HYPERDESMO S surface and Metal frame.

Coverage of HYPERSEAL EXPERT is based on the gap width (follow Table 1 for dosage, Normally the gap is around 5 – 10 mm width (Refer Figure 2). A strip of HYPERSEAL OMEGA 50 FAB can also be used in selected area for additional reinforcement.



Note:
Same treatment for external door, toilet/bath door, balcony door, ventilator and sun/rain shades

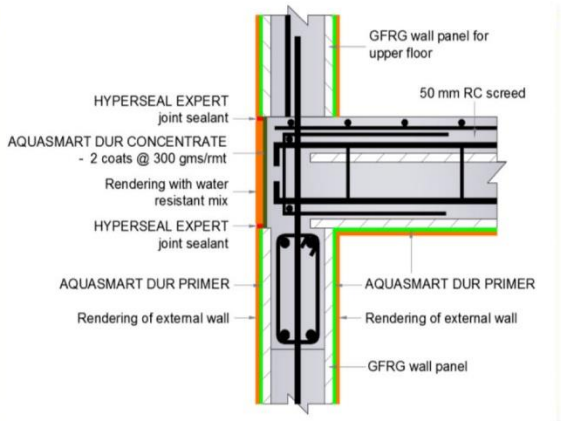
Treatment of RC lintel cum sunshades

After the completion of providing RC lintel cum sunshade as per recommended procedure for GFRG building construction, the joint between the concrete and the cut GFRG panel should be treated with HYPERSEAL EXPERT joint sealant.

The top surface of the Sunshades should cement mortar plastered to slope as per standard construction practise.top, bottom and sides. Shall provide drip drop groves. A coat of Micro sealer 50 primer is applied @ 100 gms/sqmt and allowed to cure over night. On the dried surface HYPERDESMO CLASSIC membrane is applied @ 1.25 kg/sq.m. This coating is applied in two coats and carried on the vertical wall covering the Lintel Joint.

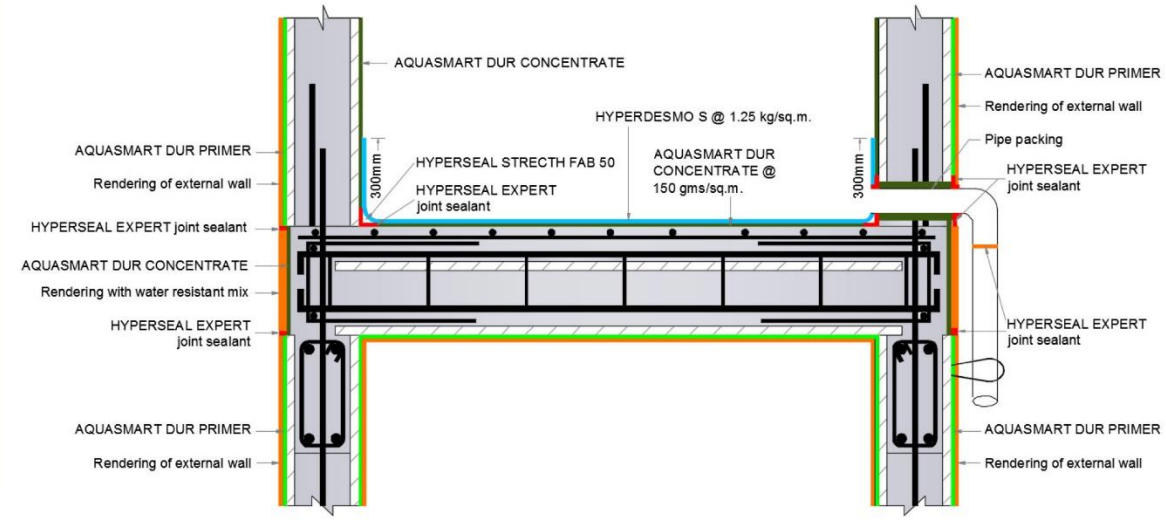
Treatment of 174/184mm wide band external side of floor/ roof slab around the building.

The exposed band floor slab / roof slab around the building at every floor level is to be treated with AQUASAMRT DUR CONCENTRATE @ 200grm per rmt. First the joint between the Concrete slab and GFRG wall panel is routed first to a depth of max 5mm and filled with HYPERSEAL EXPERT sealant and allowed to cure before application of AQUASAMRT DUR CONCENTRATE with Spatula.This layer is applied in two or three layers and allowed to cure and dry (2 to 3days) before the surface is finished with Rendering compound.



Waterproofing treatment of bath / toilet floor open balconies

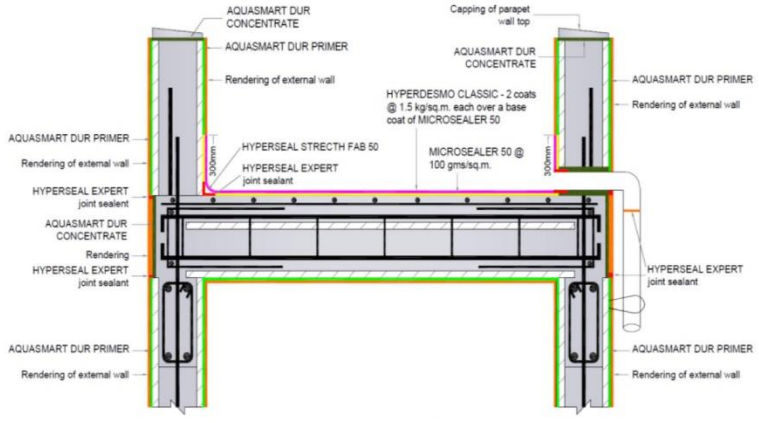
Before starting waterproofing treatment inside the bath / toilet floor, the joint between the GFRG panel and floor slab, all pipe joints, WC connections, waste water and water supply pipes are to be sealed off properly with HYPERSEAL EXPERT , as was already explained .The concrete floor surface is to be cleaned first and then apply a base coat of AQUASMART DUR BASE COAT at a dosage of 100 gms/sqmt. and allow it to dry for 6 - 12 hours. A strip of HYPERSEAL OMEGA 50 (50 mm wide) is to be applied at the junction of wall and slab as a additional reinforcement. Over cured primer coat HYPERDESMO S is applied using roller at dosage of 1kg/sqmt. Waterproofing of toilet / bathroom / Balcony.



HYPERDESMO S is applied up to 300 mm on inner wall of bathroom. Curing time for this coating is 24 - 48 hours. Cement plaster (1:3) 15mm thick is recommended as a protective layer over the HYPERDESMO S coating. This can be the base for providing flooring tiles. Refer Figure 4 for more details. For any further technical support kindly contact our application team.

Waterproofing treatment of terrace / roof, and stair case / lift head room roof slab :

After cleaning the surface to be treated, the joints between the concrete slab and GFRG parappet panel should be treated first with HYPERSEAL EXPERT and allowed to dry.



First coat of Micro sealer 50 is applied @ 100 gms/sqmt and allowed to dry over night. HYPERDESMO CLASSIC is applied as second coat at a dosage of 0.65 kg/sq.m. and allow to dry for 12 -24 hours. Third coat is applied @ 0.6 Kg over the dried second coat. After the first coat 50mm wide HYPERSEAL OMEGA 50 fab can be provided all along the joint between parapet wall and roof slab in order to reinforce the particular joint part. Refer Figure 5 for more details. It is to be noted that the whole treatment procedure needs to be done on to 300mm height of parapet wall also. The application can be by brush / spray / roller technique. Top of parapet wall also to treated as illustrated in the sketch / figure 5.

Treatment of parapet wall top

Apply AQUASMART DUR CONCENTRATE on top of the concrete filled parapet wall at a dosage of 200 gms/rmt. After allowing this to dry for 6 - 12 hours, suitable coping can be provided as per the architect's or designer's plan .

AQUASMART DUR PRIMER for external and internal panel surfaces

AQUASAMRT DUR PRIMER is a solvent free primer which is to be applied on the internal and external surfaces of the GFRG wall panels and ceiling to improve the bonding strength and abrasion resistance of the panels. purpose of primer is to make wall Surface to take painting or rendring The components A, B, C are mixed in the ratio of 4 : 4 : 4 by weight is to be applied in a dosage of 150 gms/sqmt for external / internal walls, allowing it to dry for 6 – 12 hours.

Mixing is to be done at the site with a slow speed stirrer (300 rmp) to get uniform mix. After mixing the compound, it should be consumed within 45 minutes (summer) to 60 minutes (winter) depending upon the weather condition.

The left-over mix cannot be stored for further application beyond 1 hour. It can be applied using brush / roller / spray gun on the GFRG panel surfaces. During rainy or windy period, it is better not to apply the primer. Primer should be applied only after completion of all the waterproofing works like joint sealant. It is recommended to apply the primer only on the eve of rendering work; or if rendering is not to be done, priming can be done 5-6 days before the commencement of painting work.

Rendering of the wall panel surfaces (external and bath / toilet walls) with a water–resistant rendering compound is Aquasmart external wall putty

There is a need for a water-resistant rendering compound for rendering (thin layer of plaster of thickness of average 1 mm) of the GFRG panel surfaces in order to also have smooth fine finish of external wall surfaces and bath / toilet walls.

AQUASMART EXTERNAL WALL PUTTY :
Comp A 4Kg + Comp B 4 Kg + Comp C 16Kg + water 1.2Kg coverage 0.8Kg per sqmt depends upon the thickness required at the site. Applied with spatula made up of thin flexible steel sheet (tool should be free from rust/corrosion).

HYPERLATEX INTERNAL WALL PUTTY :
Comp A 20Kg + Comp B 60Kg + Water 8Kg coverage 1.5 Kg per sqmt depends upon the thickness required at the site. Applied with spatula made up of thin flexible steel sheet (tool should be free from rust/corrosion).

AQUASMART EXTERNAL PATCHING COMPOUND :
The damages caused during the transport/ handling panel at site or erection of panels(external surface) can be repaired or rectified or leveling up using water resistant patching compound. Compound / mix can be prepared at the site in the ratio of Comp A 4 Kg + Comp B 4kg + Comp C 12 kg. After mixing, it is the putty consistency and applied with spatula, over the damaged part of the GFRG panels. After curing for a day, the treated surface can be further finished with sand paper and rendering can be carried out incase rendering is to be provided before painting .

HYPERLATEX INTERNAL PATCHING COMPOUND :
The damages caused during the transport or handling panel at site or during erection of wall panels or concrete infill can be repaired or rectified using (internal wall surface , except in wet areas ,) Hyper latex patching compound . Compound /mix can be prepared at the site in the ratio of Comp A 20Kg + Comp B 60kg. After mixing it is the putty consistency and applied with spatula, over the damaged part of the GFRG panels(internal wall surface). After curing for a day, the treated surface can be further finished with sand paper and render, if rendering to be provided. Other wise apply painting .

ANNEXURE 10

CHECKLIST FOR WATERPROOFING TREATMENT AND FINISHING WORKS OF GFRG BUILDINGS

1. Damp proof course (DPC) application, before erection of wall panels, on top of,
   i. Reinforced concrete (RC) plinth beam (200mm wide); ☐
   ii. Upper floor slab (150mm wide), below external wall panels; ☐
   iii. Roof slab (150mm wide), below staircase / lift head room walls, parapet walls, etc. ☐
2. Use of joint sealants, at the construction joints formed between,
   i. External walls & RC plinth beams in ground floor, floor slabs in upper floors; ☐
   ii. Roof slabs & staircase / lift head room walls, parapet walls; ☐
   iii. Bath / toilet walls & floors; ☐
   iv. Wall panels and RC lintel cum sunshades; ☐
   v. Wall panels (vertical joints of exterior and toilet wall panels). ☐
3. Sealing of joints between door / window / ventilator frames and wall panels. ☐
4. Treatment of exposed portions of,
   i. External sides of floor / roof slabs - 174 / 184mm wide; ☐
   ii. Parapet top, before providing cement plaster coping - 124mm wide. ☐
5. Treatment of wet areas (extending appropriately onto adjoining wall panels) of,
   i. Terrace / roof slab, staircase / lift well head room slab (300mm onto parapet walls); ☐
   ii. Bath / toilet floor in floors (other than GF) and open balconies (300mm onto walls); ☐
   iii. RC sunshade top and side surfaces (150mm onto RC lintel). ☐
6. Waterproofing over PCC floor in ground floor. ☐
7. Treatment of cut-outs on external wall panels, done for,
   i. Door / window / ventilator openings (124mm wide) all around; ☐
   ii. Openings made across walls for piping. ☐
8. Application of special primer on external & internal panel surfaces and ceilings. ☐
9. Rendering of primed panel surfaces, for providing smooth surface finish of,
   i. External walls and exposed GFRG panel surfaces, using water-resistant rendering compound; ☐
   ii. Internal walls and ceilings, using non-water-resistant rendering compound. ☐

ANNEXURE 11

STRUCTURAL DETAILING AND WATERPROOFING FOR A TYPICAL SINGLE STOREY AFFORDABLE HOUSE

Figure A11.1 shows the sectional elevation of a typical single storey affordable housing with pitched roofing. Typical rebar sizes are also given in the figure.

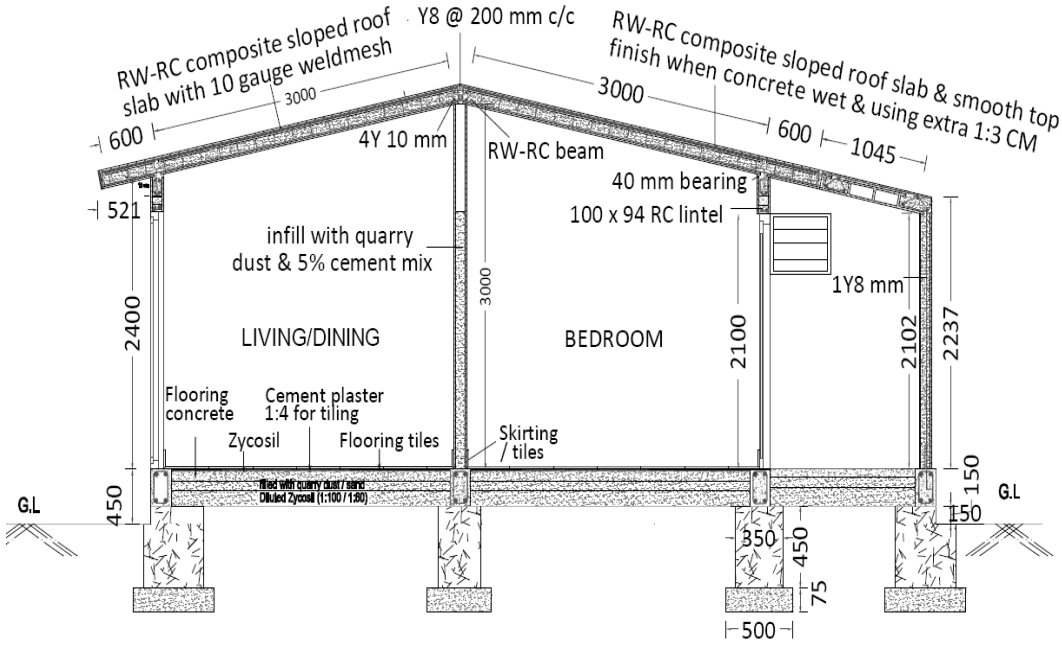
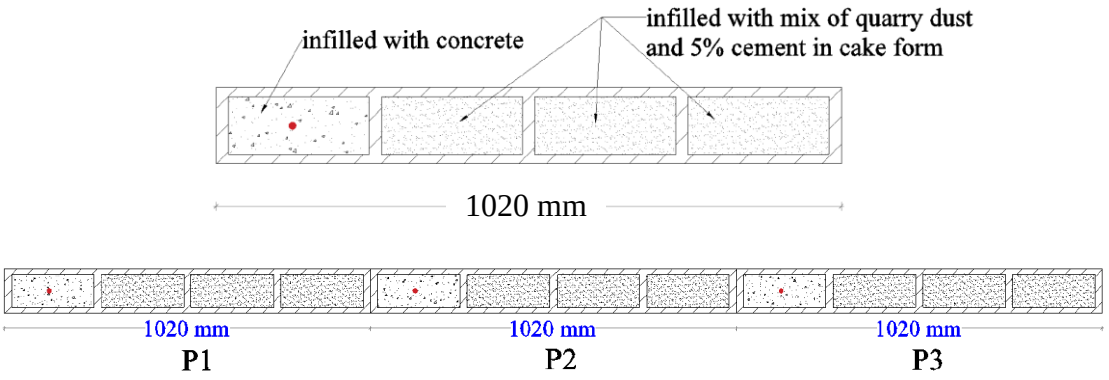


Figure A11.1: Sectional elevation

For making the construction more affordable by avoiding the use of cranes, smaller size panels (of length less than 1.27m), which can be handled manually shall be used. Walls shall be constructed by joining required number of panel pieces as required. Similarly, for door / window openings, cut panels can be used for the top part of door opening and bottom (sill) and top of window opening (Figure A11.2).



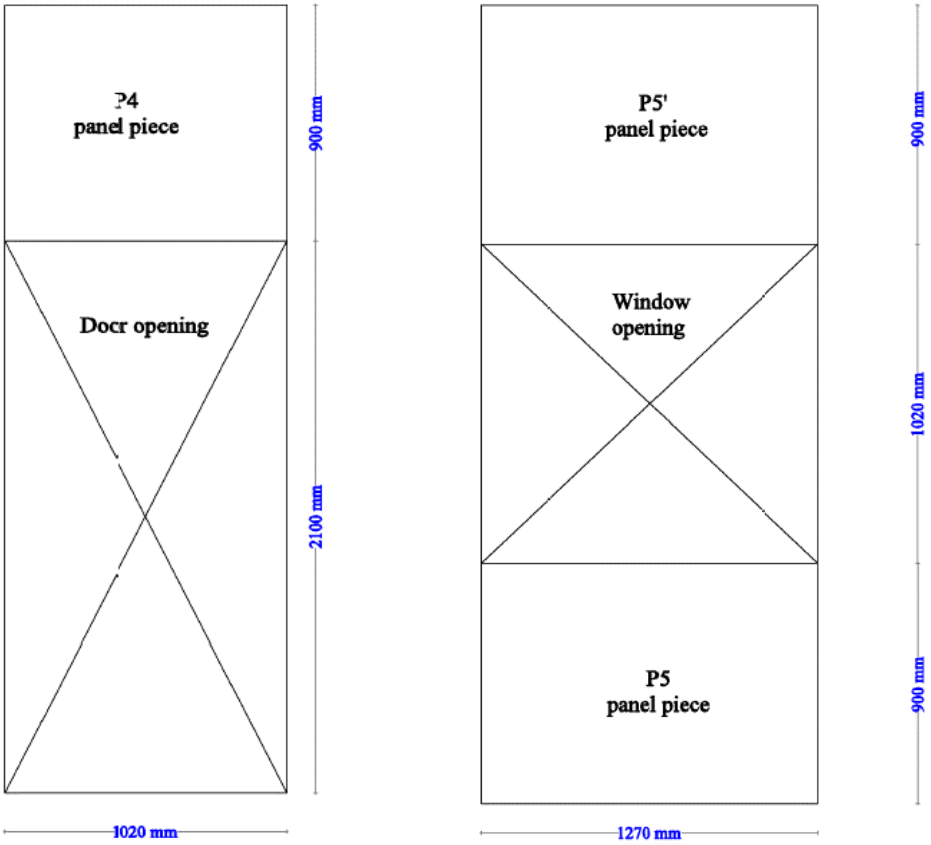


Figure A11.2: Construction using small panel pieces

Typical waterproofing of a single storey house is illustrated in Figures A11.3 and A11.4.

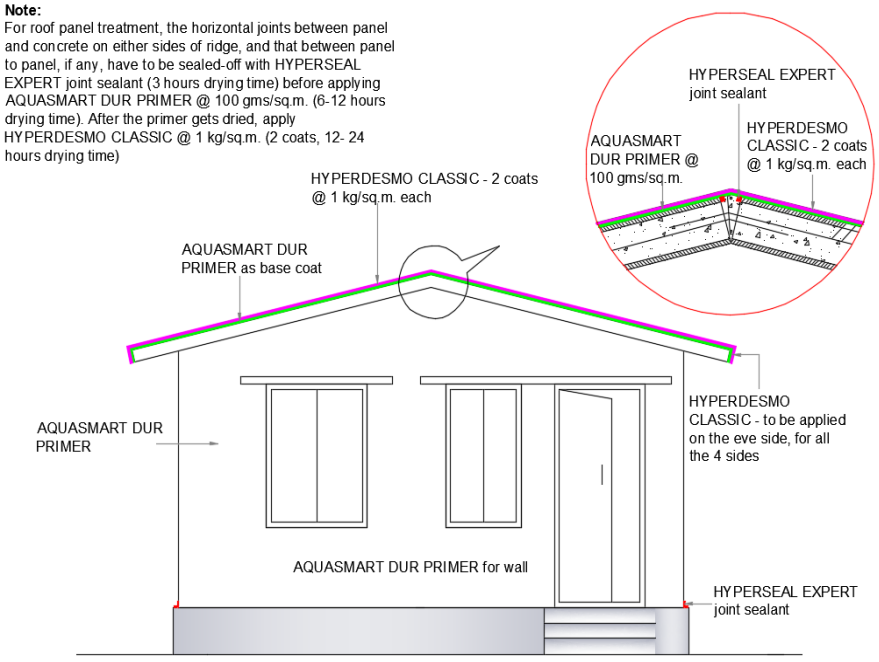


Figure A11.3: Waterproofing using Alchimica products

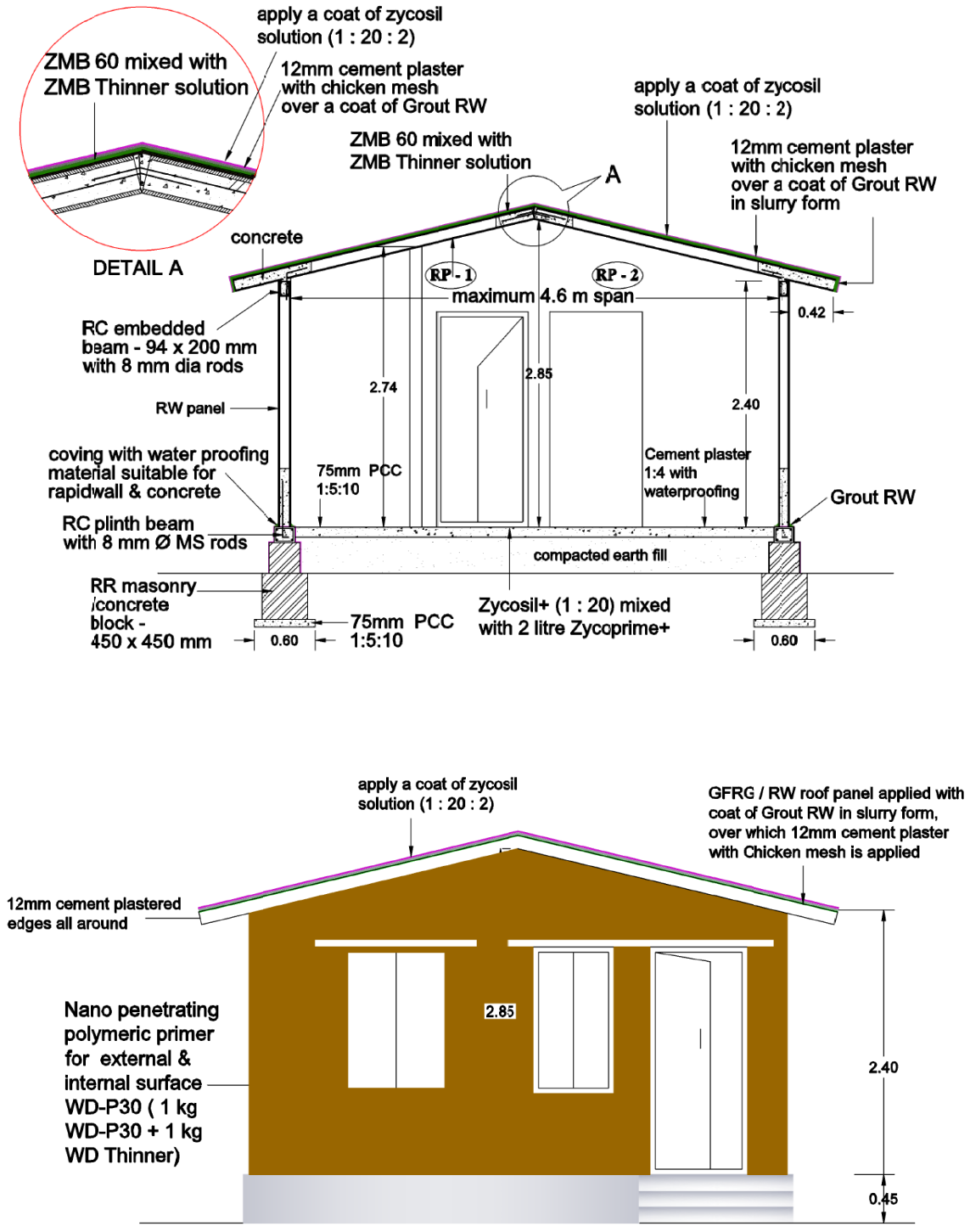


Figure A11.4: Waterproofing using Zydex products

ANNEXURE 12

GUIDELINES ON ACCREDITATION OF CONSTRUCTION COMPANIES / CONTRACTORS / BUILDERS / CONSTRUCTION UNITS

It is proposed to accredit construction companies / builders by a committee formed by representatives from BMTPC, IITM and the GFRG Panel Manufacturing Company, into any of the following categories / classes (single build), based on their capability for construction:

Category / Class E: Single storey up to 60 sq.m. or 800 sq.ft. built area (affordable housing)

Category / Class D: G+1 up to 200 sq.m. built area.

Category / Class C: G+2 up to 500 sq.m. built area.

Category / Class B: G+3 up to 1000 sq.m. built area.

Category / Class A: G +7 up to 5000 sq.m. built area.

Category / Class A: G +9 more than 5000 sq.m. built area.

The professionals and personnel of the various teams need to be trained and provided with essential equipment required for construction.

Representatives suggested for the committee:

1. Nominee of Executive Director, BMTPC: Chairman
2. Two representatives from the Civil Engineering Department, IIT Madras.
3. A representative from the Civil Engineering Department, IIT Tirupathi.
4. Representative from the GFRG Panel Manufacturing Company.
5. Representative of CREDAI / BAI of respective region or state or national level.

Note:

1. The validity of the issued Accreditation Certificate shall be one year, and is to be reviewed every year for the grade / class to be re-assigned or even cancelled if needed, based on the performance and feedback from the customers.
2. The builders shall follow the good construction practices mentioned in the GFRG Construction Manual.
3. Construction workers shall have health insurance from Pradhan Mantri Bhima Yojana and other welfare measures.
4. When other IITs / NITs get involved in the GFRG technology, representatives from those institutions can also be included.

Requirement of technical professionals, construction personnel and skilled workers

Table A12.1 Eligibility criteria for accreditation of construction companies / contractors / builders

	Single storey (≤ 800 sq.ft.)	G+1 (≤ 2,000 sq.ft.)	G+2 (≤ 5,000 sq.ft.)	G+3 (≤ 10,000 sq.ft.)	G +7 (≤ 50,000 sq.ft.)	G+9 (> 50,000 sq.ft.)
	E	D	C	B	A	A
Professionals (Civil Engineering) and personnel required for the construction team						
B Tech (Experience)	-	- (-)	1 (6 months)	1 (1 year)	1 (2 years) + 1 (1 year)*	1 (3 years) + 3 (1-2 years)*
Diploma (Experience)	-	1 (1 year)	3 (1 year)	5 (2 years) + 3 (1 year)*	10 (2 years) + 4 (1 year)*	15 (2 years) + 7 (1 year)*
ITI / ITC (Experience)	1 (1 month)	3 (2 months)	6 (3 months)	8 (6 months)	12 (1 year)	20 (2 years)
Skilled (Experience)	3 (3 months) + 6 (2 years*)	9 (3 months) + 18 (2 years*)	12 (6 months) + 24 (-)	20 (> 1 year) + 30 (3 months)	40 (> 1 year + 6 months) + 50 (2 years*)	100 (> 2 years) + 100 (6 months)
Minimum number of erection teams required for GFRG building construction						
Min. no of erection teams	1	3	6	8	12	20
Equipment required for construction (minimum nos)						
Lifting jaw (pairs)	1	3	4	6	10	20
Spreader bars	1	1	2	3	5	7
Lateral props	20	50	75	150	300	500

The experience shown in the table above (in months and years) refers to that acquired in GFRG construction

* Experience acquired in conventional construction

All the professionals and other personnel involved in construction need to undergo training in GFRG construction.

In addition to the skilled workers, each team shall also consist of 6 nos. of trained workers

Knowledge / expertise in GFRG building construction:

In addition to the experience required in construction, the Construction Engineer or the Engineer-in-charge representing the company, is required to have the technical know-how in construction. A questionnaire can be prepared on the following topics to check the competency level of the professionals (Diploma, ITI / ITC and other skilled personnel), in order to examine their knowledge on the following:

1. GFRG panel handling, their quality check and mechanical properties.
2. Cutting drawings & list of panels with notation marks, including, loading of cut panels in stillages and transportation in trucks without causing damages, unloading at construction sites and stacking prior to start of superstructure work.
3. Lifting jaws and spreader bars, used for erecting panel safely using cranes.
4. GFRG building system and the connectivity between foundation and superstructure; significance of perfect horizontal zero-zero level of RC plinth beam in ground floor and upper floor slabs.
5. Identification of panels from the stack, lifting of wall panels for installation / erection using crane and the method of infilling of cavities of panel with concrete / inert materials.
6. Adjustable lateral props for fixing the wall panel rigidly in position in ground floor and upper floors; and supporting and laying panels for floor / roof slab.
7. Staircase construction and staircase head room construction on terrace floor.
8. Method of providing RC lintel cum sunshades in GFRG building construction.
9. Integration of various other engineering services like electrification, water supply pipe lines, plumbing and sanitary lines, rain water down pipes and so on.
10. Waterproofing treatment of horizontal joints, vertical wall joints, and treatment of 174 / 184mm band all around with perfect horizontal and vertical level with external walls in lower & upper floors, toilet / bathroom floors, terrace slab and joint between parapet wall and terrace slab.
11. Concealed beam and horizontal tie beams and floor / roof slab system.
12. Mandatory primer application.
13. Repair / rectification of dent or damaged wall panel in position.
14. Smooth finishing of joints and other finishing works, rendering of external wall surface, wet indoor areas like toilet / bath, internal wall surface and ceiling.

The committee shall also take into account the following:

1. All the tools and tackles required for GFRG building construction, as specified in the "GFRG / Rapidwall Construction Manual (2016)" shall be made available in adequate numbers
2. The manpower required for other works related to the construction and finishing works shall be followed as specified under 'Manpower for GFRG Construction' in the "GFRG / Rapidwall Construction Manual (2016)"
3. There should be adequate financial base for executing the work within the contractual time frame and terms of payment
4. For granting A class, the builder or the construction company need to be experienced in constructing a GFRG building of at least 3 storeys with a minimum built-up area of 2000 sq.m. Experience in using bucket system for concrete infilling and screed concreting is necessary
5. For granting A+ class, the builder or the construction company need to be experienced in constructing a GFRG building of at least 4 storeys with a minimum built-up area of 10,000 sq.m. Experience in using concrete pump with suitable facilities for infilling concrete is necessary
6. The certificate on the accreditation class shall specify the period of validity
7. The accreditation fee shall be fixed by the committee, and shall be revised from time to time. It is suggested to charge Rs. 1000/-, Rs. 2000/-, Rs. 3000/-, Rs. 4000/-, Rs, 5000/- and Rs. 10,000/- each for classes E, D, C, B, A and A+ respectively (for a year), which may be revised later.
8. During the first 1 to 2 years, the accreditation can be a bit relaxed.
9. Details of the builder / construction firm / construction company shall be furnished in the application.
10. For E and D classes, each erection team shall consist of 6 nos each of skilled and construction workers. Of these, 3 skilled workers need to be trained and experienced in GFRG construction for at least 3 months. The construction workers shall have 2 to 3

years of experience in conventional construction and hands on work experience, along with training, in GFRG construction.

11. For all other classes, each erection team shall consist of 6 nos. of skilled workers with multi-tasking skills. Of these, one person shall have completed ITI / ITC course, and trained and experienced in GFRG building construction. After gaining experience for 2 – 3 years on all aspects of GFRG construction, this person can become a supervisor, specialised in jobs like, waterproofing, staircase construction, rendering work, etc. There shall be adequate number of sub-teams for other associated works. The details on formation of sub-teams is given in the "GFRG / Rapidwall Construction Manual (2016)". Sub-teams can work on concrete infilling, construction of staircase, waterproofing application, shuttering and scaffolding, electrical, plumbing, water supply and sanitary works, patch work / rectification and rendering works.

12. If a building construction company desires to take-up a large GFRG construction project, they may be allowed to undertake the work under the condition that a sub-contractor with expertise and experience in GFRG construction is tied up with them for the work. After the project is successfully implemented and executed, the company can be accredited, upon request.

ANNEXURE 13

FINE FINISHING OF GFRG BUILDINGS AS PART OF FINISHING WORKS

Various treatments with regard to waterproofing of GFRG buildings, application of mandatory primer and rendering, as stated in the 'Method of Waterproofing of GFRG / Rapidwall Buildings', are part of the final finishing works of GFRG buildings. Broadly, waterproofing of GFRG buildings include treatment of the various construction joints, lintel cum sunshade, exposed areas of RC floor / roof slab and wet areas of floor / roof slab, balconies, etc. Application of special primer (WD P30 & WD Thinner in 1:1 ratio or Aquasmart Dur primer) on the exposed panel surfaces is followed by patching, rendering and painting.

Figure A13.1 Three storeyed GFRG school building at Guindy, Chennai (constructed in 2017), after the required waterproofing treatment and application of mandatory primer

After the completion of the structural works and waterproofing treatment of GFRG buildings, the following sequence of works are involved in the finishing of GFRG buildings.

1. Patching work using water resistant patching compound to repair / rectify dents or damages caused during handling of wall panel during transportation, erection etc.
2. Grinding for leveling and smoothening of areas of wall joints, 174 / 184mm exposed band and adjoining wall areas of upper & lower floor walls, using a light-weight wooden grinder with sandy disc, by an experienced and skilled worker.

3. Rendering (application of thin layer of plaster - 1.5 – 2 mm thick) on the panel surfaces using rendering compound.
4. Painting.

Now-a-days, there are various brands of paints available in the market, suitable for application on building surfaces. Each of these brands also produce their own primers that are recommended for application on the surface before painting. A majority of such primers are cementitious primers for use on cementitious surfaces, in order to reduce the consumption of paint and also for providing additional bonding for the paints on to the substrates. Special primer for GFRG, recommended mandatorily for use on the GFRG panel surface is different from the paint primers available in the market. Conventional paint primers do not bond with GFRG panel surface. Hence special primers are used for this purpose. Such primers not only provide bonding to paint, but also impart hardness to the panel. Patching and rendering works, if required, shall be carried out only on the primed surface. Once the mandatory primer is applied on the panel surface (before / after patching and rendering), conventional paint primers may also be used, if required, before painting. If the special primer is not applied on the GFRG panel surface, it is likely that the paint will eventually get peeled-off, as GFRG panel surface is hydrophobic in nature.

Finishing work is one of the most important phase of GFRG building construction. For providing superior finishing, skilled workers with the know-how (hands on working skill) and experience for proper smooth finishing under effective supervision, are required. The following tools are required to be used:

1. Sander machine (Hittachi or Bosch other proven brands) with suitable sandy disc (weighing about 2 kg), that are normally used for grinding wooden planks are required for the purpose of levelling / sanding of exposed RC band or concrete surfaces.
2. Wood plainer (Carpenter’s tool, suitable for leveling and smoothening of GFRG panel surface)

Sanding machine with sandy disc are used for grinding wall surfaces (that are bulged) adjacent to joints. They can be carefully grinded to make even and smooth surface finish. Wherever necessary to fill-up or for levelling-up of any dents or cracks, water resistant patching compound (with bonding) shall be applied first and dried before grinding.

The 6mm grooves of the 174 / 184mm wide external sides of floor / roof slab shall be waterproofed first and the remaining depth shall be filled with rendering / patching compound.

Figure A13.2 Patching of dents on walls and 174 / 184 mm wide band using water resistant patching compound / rendering compound, by a putty applicator

Figure A13.3 Blower used along with grinder to blow away the fine gypsum dust

Figure A13.4 Putty applicators grinding the patched-up spots / areas for levelling and smoothening, using wooden grinder with sandy disc

In the case of 174 / 184 mm band around (exposed floor / roof slab), if there is a level difference or difference in plumb between walls panels of upper / lower floors and the exposed band, it is necessary to level it up by grinding using wood grinder with sandy disc. Grinding shall be done after the application of patching compound.

In the case of affordable mass housing / budget housing, better finishing can be provided even without rendering. This can be done by patching the panel surface using patching compound in order to level / smoothen the panel surface. This shall be done only by experienced workmen.

If the primed surface of GFRG panel gets scraped-off during grinding, then primer shall be re-applied over the said area before painting. If rendering is envisaged, painting shall be done only after rendering.

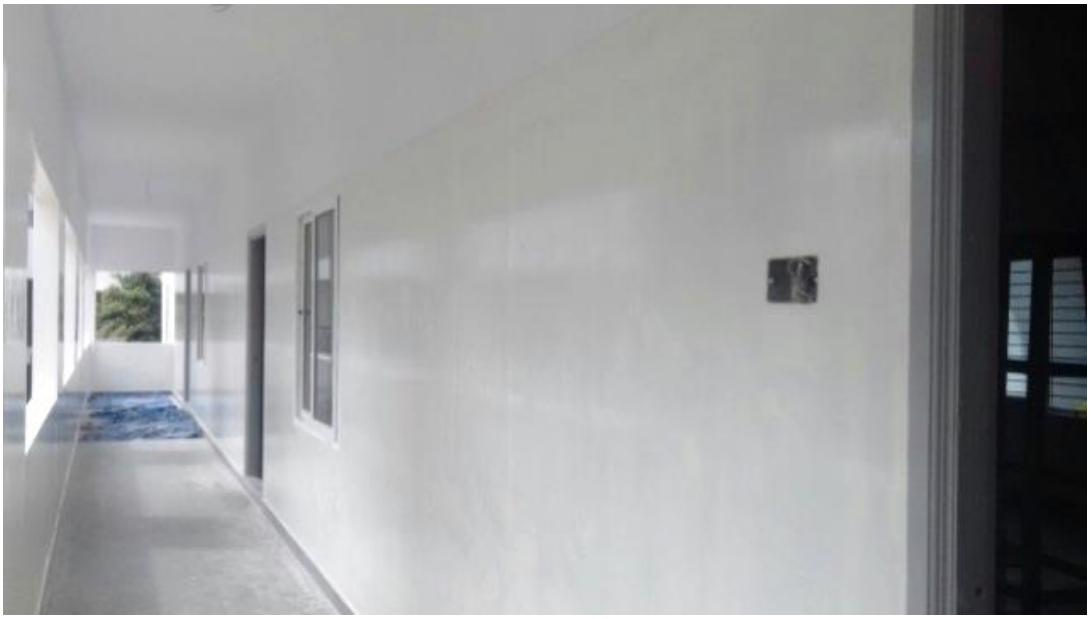


Figure A13.5 Finished wall surface of GFRG school building at Guindy, Chennai, after application of finishing coat of paint (before rendering)

Figure A13.6 Front view of the GFRG school building; after application of special primer, finishing of patching work, grinding of 174 / 184 mm wide band using wood grinder and filling-up to level and smoothen the surface and painting, without rendering

Figure A13.7 Rear view of the GFRG school building at Guindy, Chennai, before rendering

For superior / up-market finishing, it is recommended to render the wall panel surfaces.

Figure A13.8 Rendering (using water-resistant rendering compound) being carried-out for the maintenance building of IIT Tirupati

The various finishing steps have been shown in Figures 99 to 106.

In summary, the finishing team (construction engineer / site engineer, site supervisor and waterproofing application team leader) shall audit / check each and every part of the building regarding the waterproofing and other allied works (Annexure 10) before the start of the painting works. Any faults noticed shall be rectified with the use of patching compound followed by sanding. Construction of GFRG building including their finishing involves team work with proper coordination and convergence of various engineering services. The Construction Engineer-in-charge of the work shall have full knowledge on the process of construction, methodology of waterproofing and finishing works including the sequence of application for successful completion of GFRG building construction.

ANNEXURE 14

HOUSING USING GFRG PANELS FOR THE RURAL POOR

For construction of GFRG houses in the rural areas, minimum infrastructure and accessibility to transport panels (with required head clearance from hanging electrical wires and telephone wires) is necessary. Also, a small vehicle mounted crane for panel handling, erection of wall panels and laying of roof panels is required. The trained skilled and semi-skilled workers are also necessary. There is a need to create a skilled crew, which would take the responsibility of the superstructure construction of the GFRG building without finishes. As the erection and building a storey could be completed in a week, the economies of scale can be achieved with the deployment of the specialized crew. The trained semi-skilled workers can take up the construction work from foundation up to plinth beam. The finishing work can be taken up by another set of workmen or by the beneficiary. These facilities will normally be available in suburban areas with proximity to metros, large cities and large, medium and small towns, but not generally in the areas under rural Panchayats. GFRG building construction may catalyse improved infrastructure at rural areas. In remote rural areas without proper roads and skilled manpower, the GFRG building construction will be difficult. Different types of houses (with and without verandah) suitable for rural housing for the rural poor, of 25 sq. m. or 269 sq. ft. plinth area, (or whatever the housing size fixed by the Ministry of Rural Development), were included in Chapter 6. A few design variants are shown below.

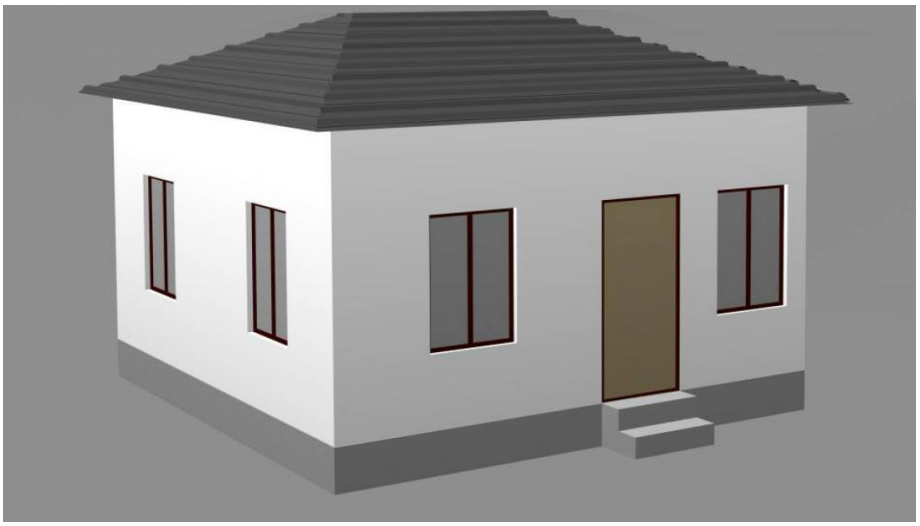


Figure A14.1 Housing for rural poor with sloped roof (Aluminium / suitable roofing sheet / tile)

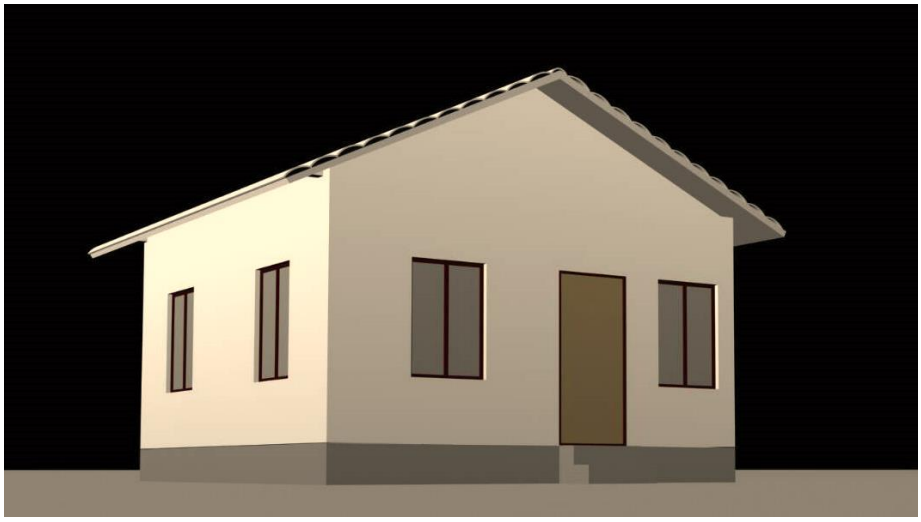


Figure A14.2 Housing for rural poor with sloped roof (Aluminium / suitable roofing sheet / tile)

Figure A14.3 Housing suitable for rural poor in the suburban parts of rural areas

ANNEXURE 15

GFRG SUNSHADE SYSTEM

Sunshades are provided on external doors / windows / ventilators, as protection against rain and sunlight. Providing sunshades for buildings is very important in a country with monsoon seasons and tropical hot climate. In the construction of GFRG buildings, one of the options is to provide RC lintel cum sunshade, which is to be constructed in-situ, during the infill of concrete after erection of wall panel. The other option is to provide GFRG sunshade. In addition to the details on use of cut panels of window / door openings for sunshades, given in section 4.2.1, the following drawings gives more information on the same. Type-1 system in this section refers to GFRG sunshade system provided for single windows. Type-2 system mentioned in this section refers to the GFRG sunshade system provided for door and adjoining window or two adjoining windows.

Type-1 system: For sunshades adjoining a door or window, of span less than or equal to 1200mm.

Panel cavities, 270mm high and 124mm wide, of required length, shall be inserted into adjoining cavities on either sides of window openings by cutting the external skin. These panel cavities stands as cantilever (normally, 450mm clear span is provided), and are called fins. A 44mm wide groove shall be provided at the end of panel such that the vertical rebar inside the cavity does not hinder the placement of the fin, with a bearing of 109mm into wall panel. Reinforcement, as specified, shall be provided inside the fins.

After infilling concrete upto a height of 2.1m into the wall cavities, GFRG sunshade panel (top part) shall be kept on the fins. Bearing of this panel shall also be 109mm. Before concreting the sunshade, necessary cut shall be made on the top panel to form grooves. Required stirrups shall be inserted into the grooves for connecting the fins and the sunshade. Conreting shall be done both from the top and from the cantilever sides.

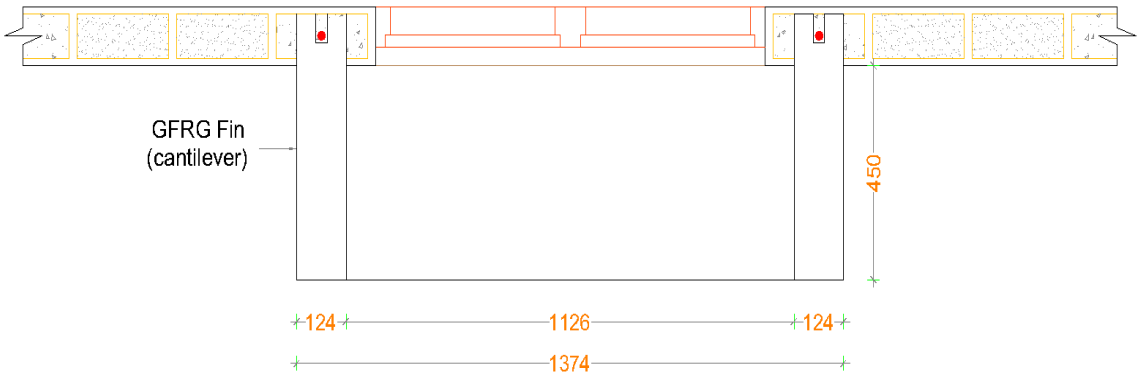


Figure A15.1 GFRG sunshade system - Plan

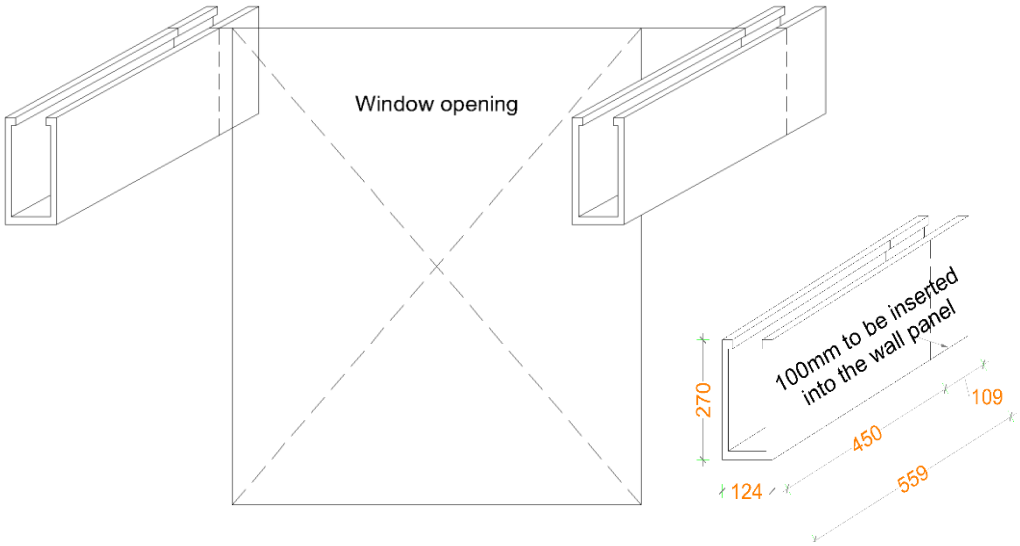


Figure A15.2 GFRG fins being inserted into wall

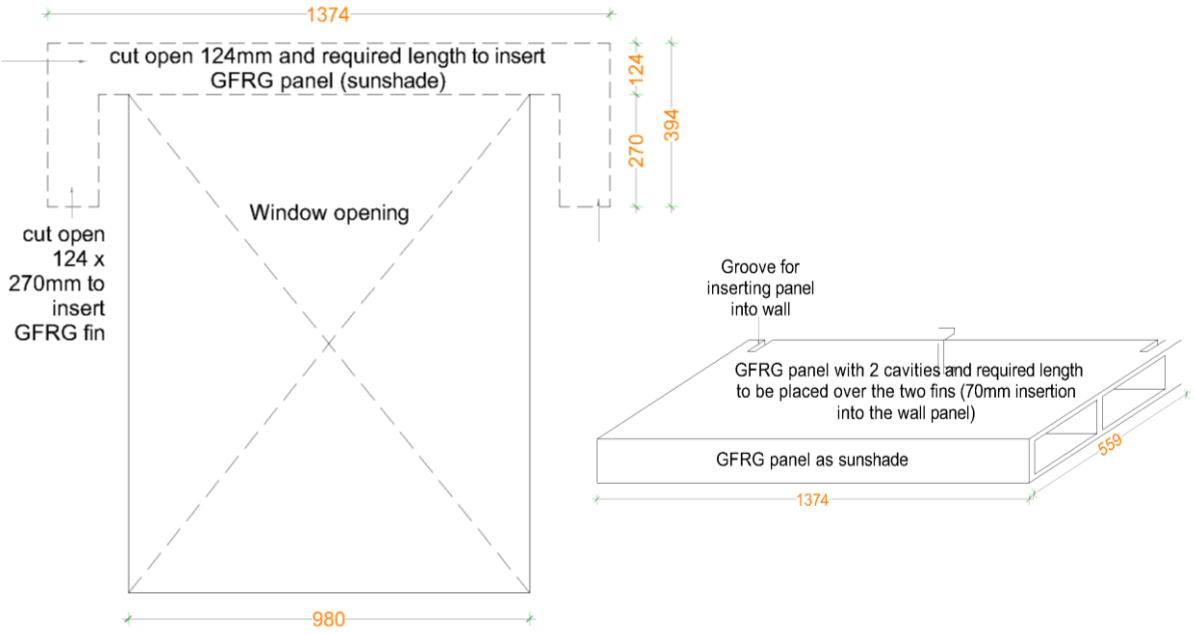


Figure A15.3 GFRG fins and sunshade panel, inserted into wall

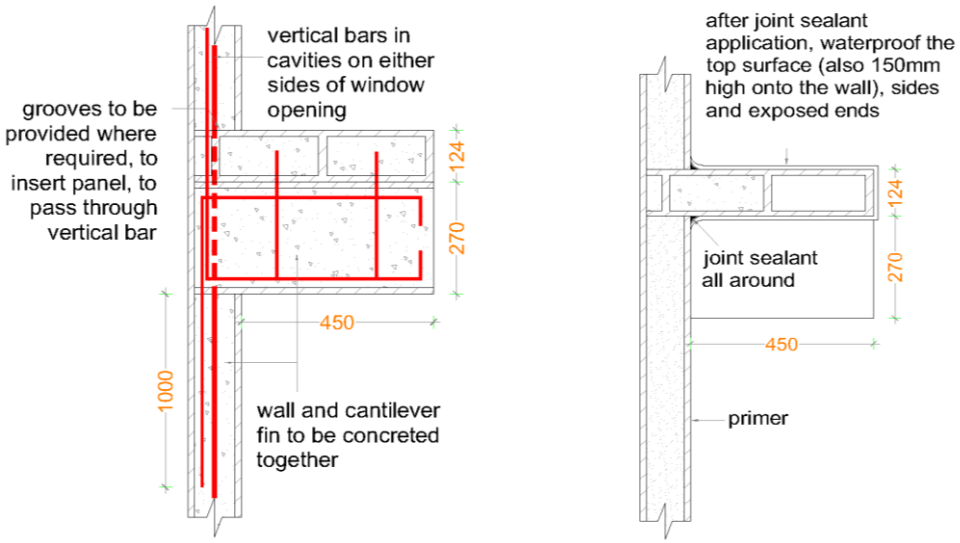


Figure A15.4 Details of cantilever reinforcement for GFRG fins

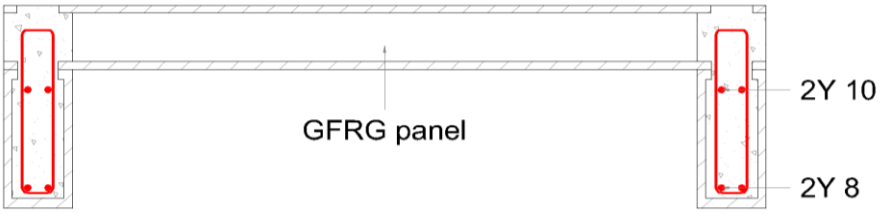


Figure A15.5 Reinforcement detail for integrating sunshade panels with GFRG vertical fin

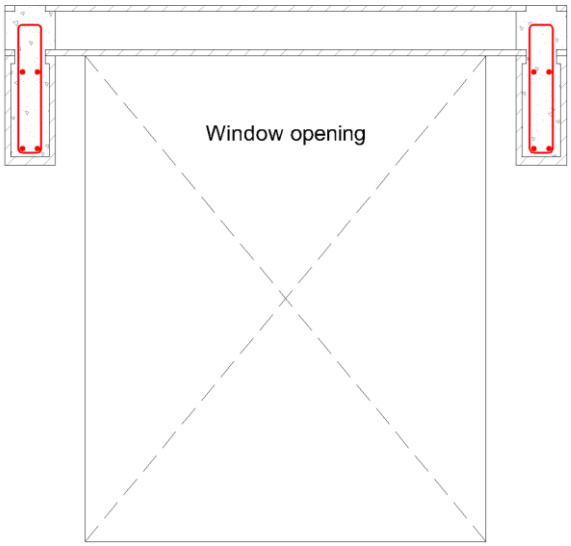


Figure A15.6 GFRG sunshade system – cross-section

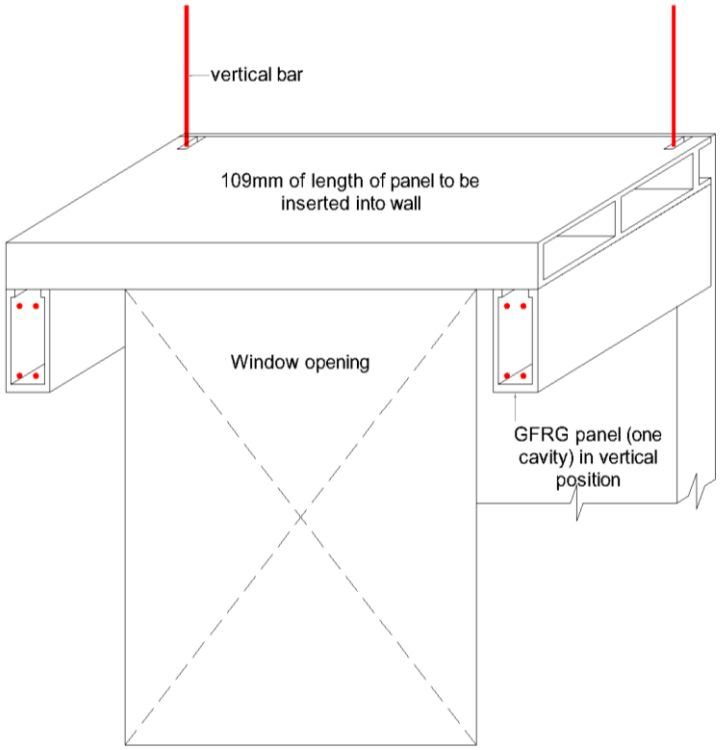


Figure A15.7 GFRG sunshade system, after placement of sunshade panel

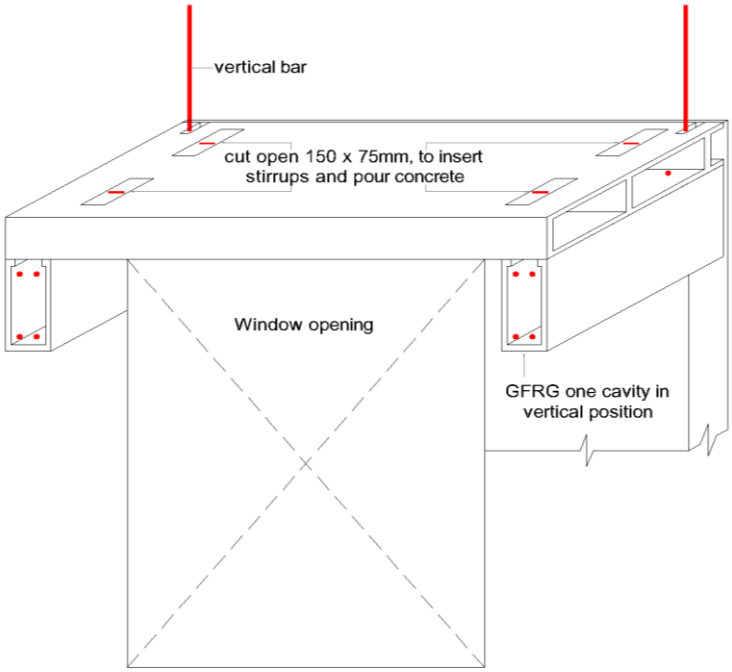


Figure A15.8 GFRG sunshade system, after cutting the top flange of sunshade panel

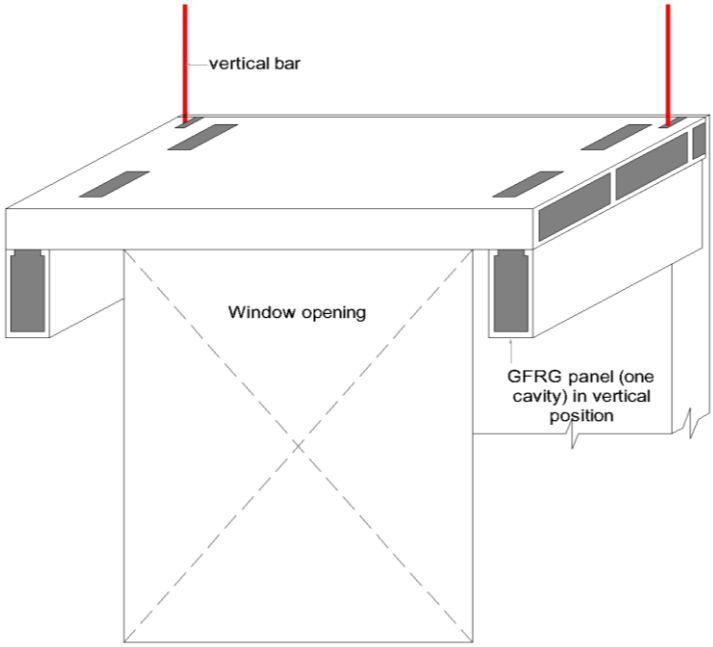


Figure A15.9 GFRG sunshade system, after concreting

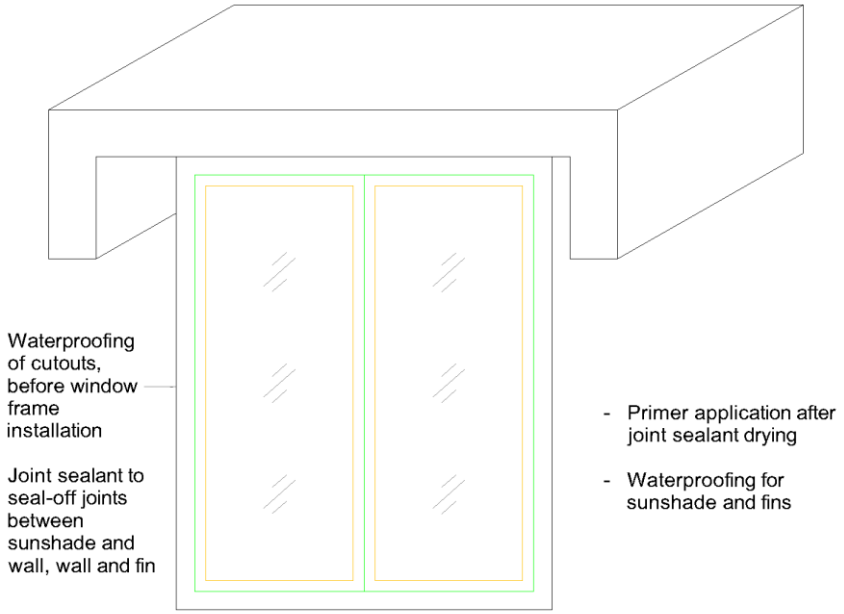


Figure A15.10 GFRG sunshade system, after completion of finishing works

Type-2 system: For long sunshades (more than 1200mm span), adjoining two windows or a window and door.

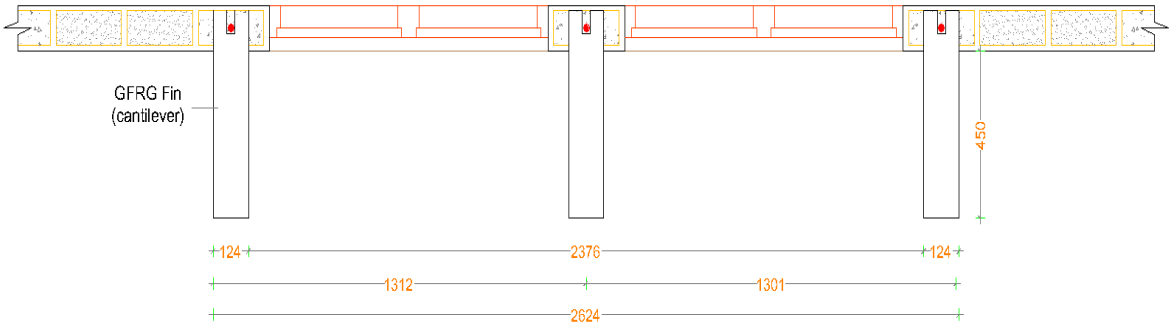


Figure A15.11 GFRG sunshade system - Plan

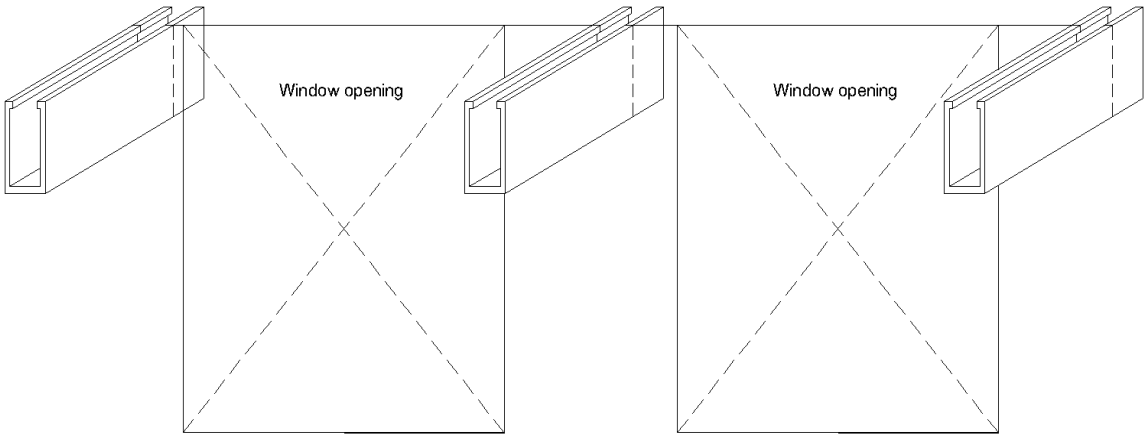


Figure A15.12 GFRG fins inserted into walls

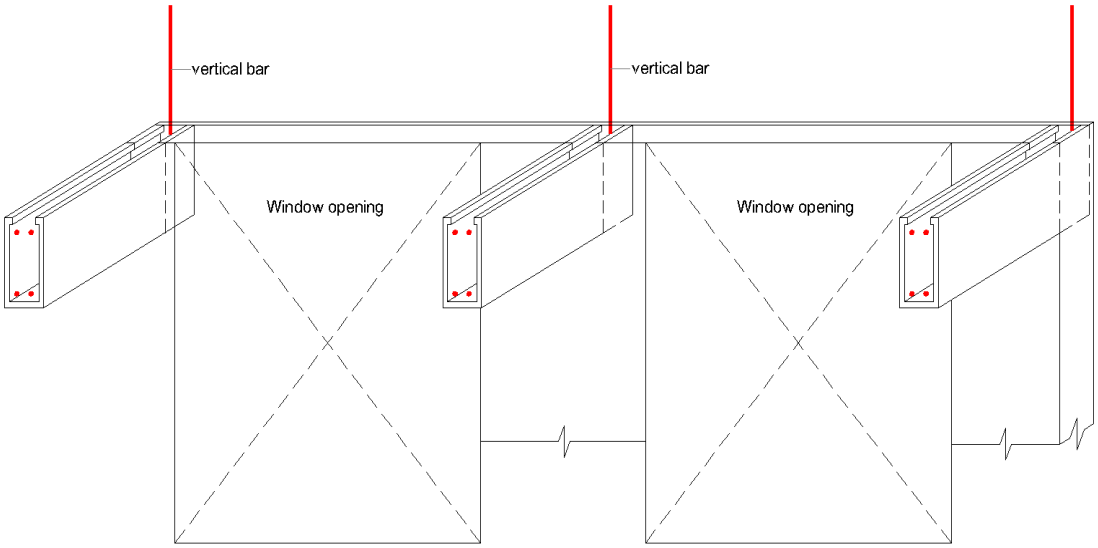


Figure A15.13 Vertical rebars inserted into wall panels

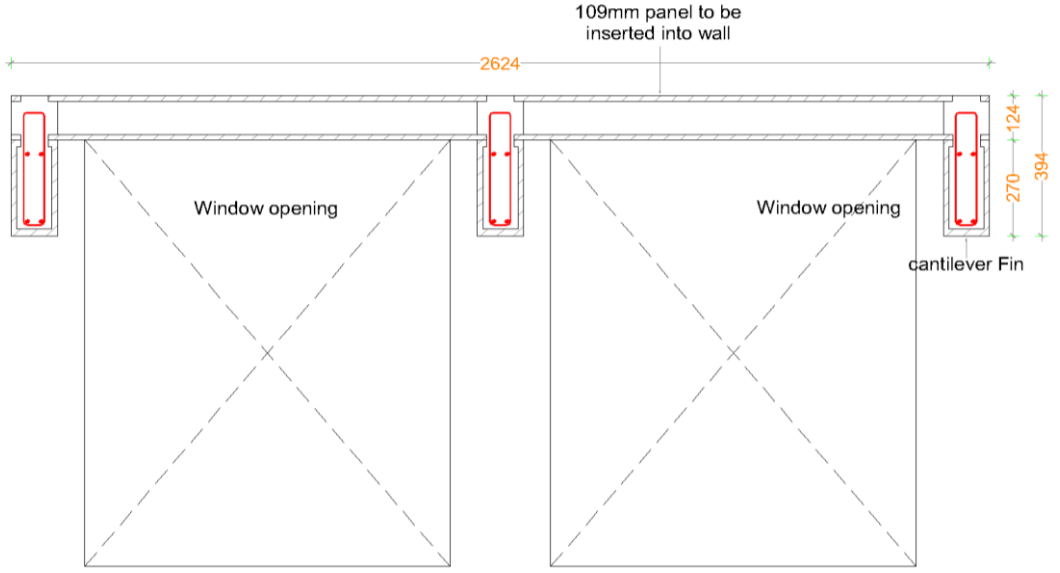


Figure A15.14 Reinforcement for the fins, to be provided as detailed in type-1

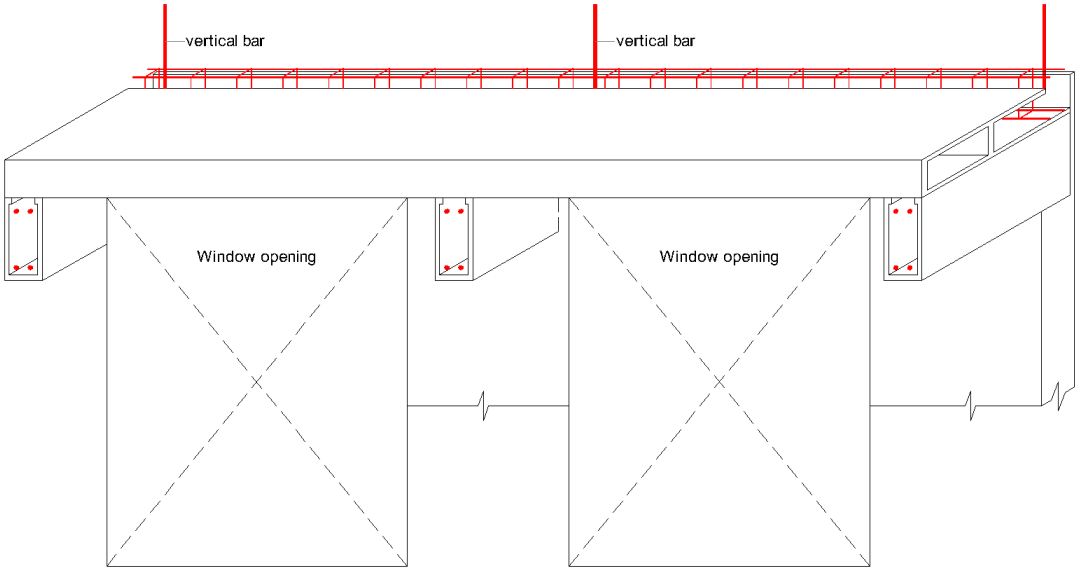


Figure A15.15 GFRG sunshade panel of 559mm width and required length to be provided

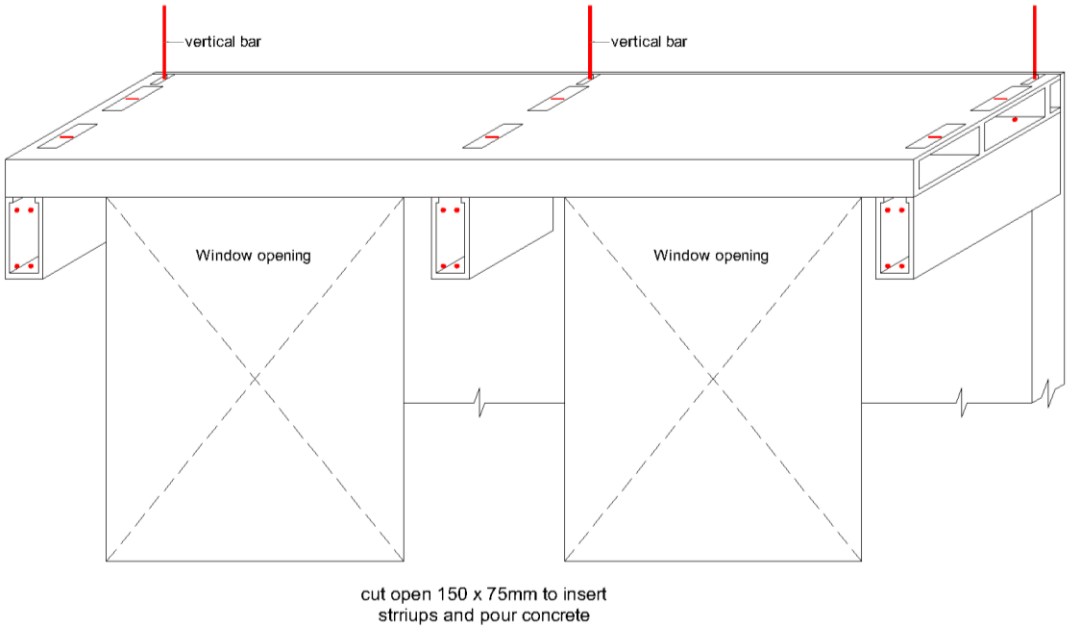
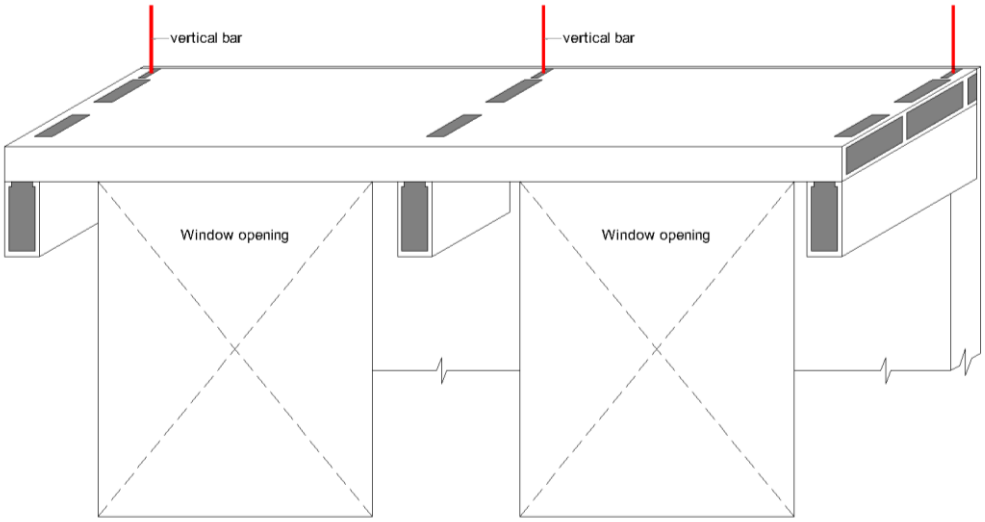


Figure A15.16 Cut-open 150 × 75mm to insert stirrups and pour concrete



Note: For spans more than 1200mm (clear span), a third fin to be provided as shown above

Figure A15.17 Reinforcement detail for GFRG fin and sunshade system, to be provided as detailed in type-1

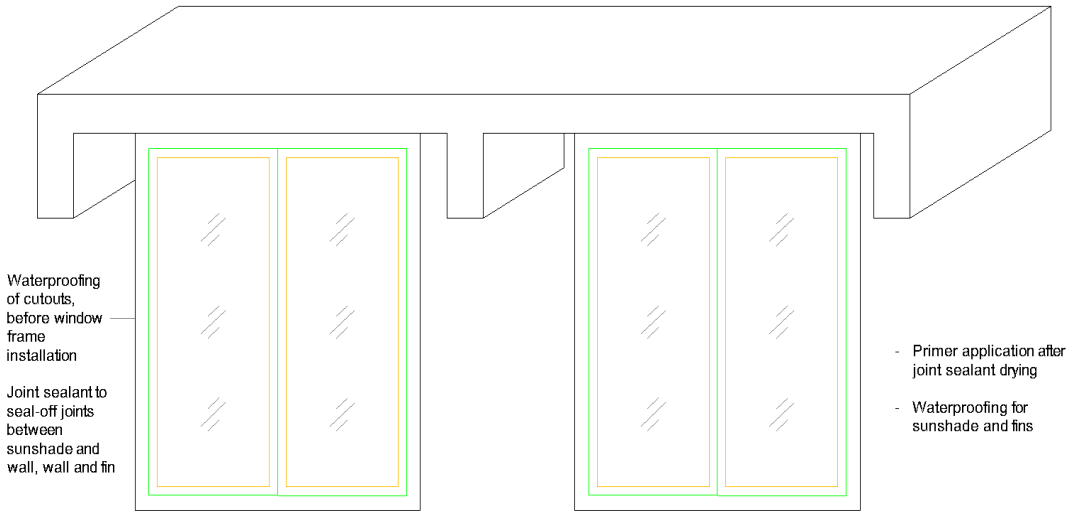


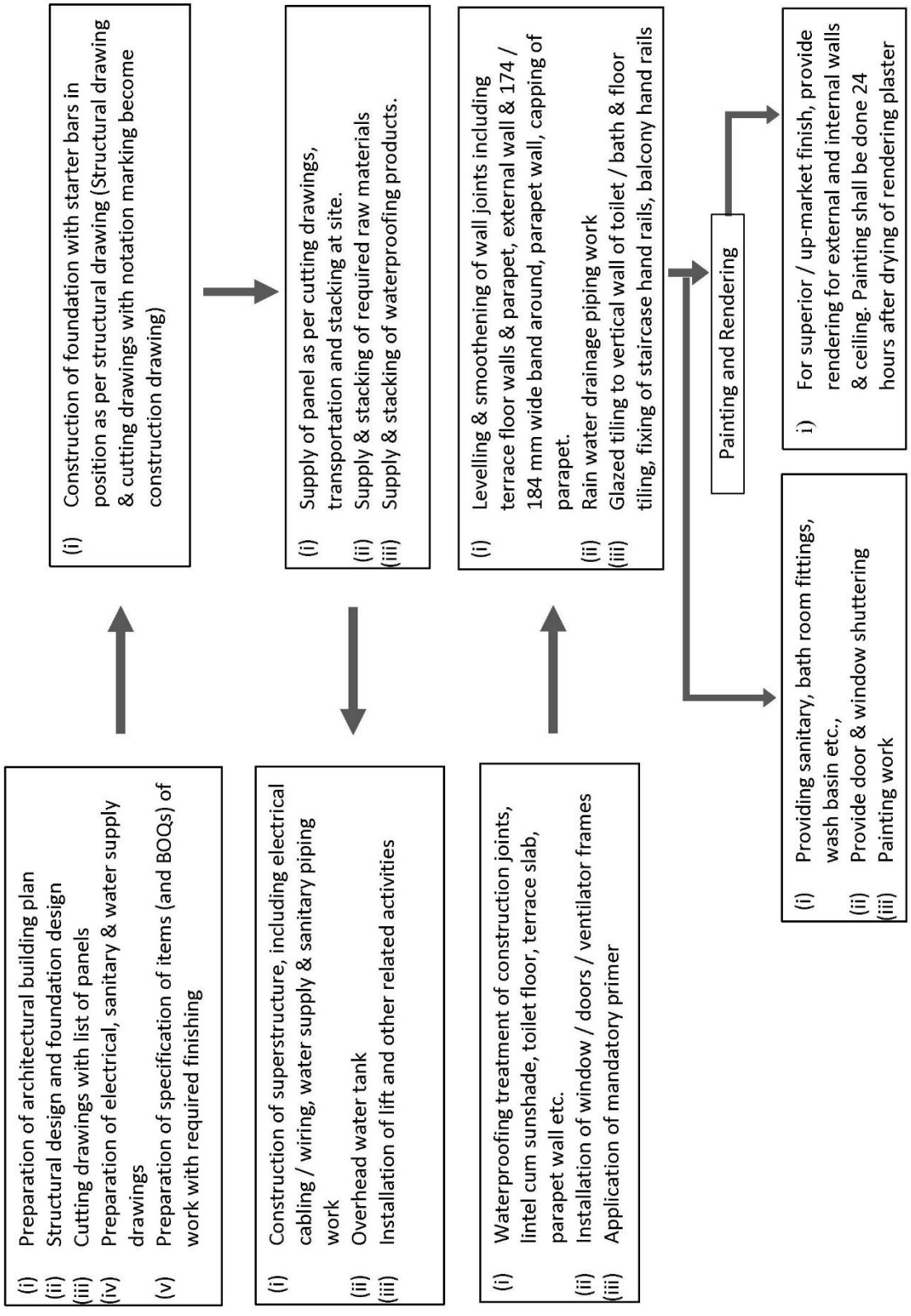
Figure A15.18 GFRG sunshade system, after completion of finishing works

Notes:

1. Both ends of sunshade slab panel shall be sooth finished by concrete fill and plastered.
2. Exposed end of cantilever cavity shall be smooth finished by concrete plastering.
3. Joints all around the sunshade and cantilever fins shall be sealed-off with joint sealant.
4. After drying, the sealed joints shall be waterproofed (Refer “Manual of Watewrproofing of GFRG / Rapidwall Buldings”)
5. If the clearspan of sunshade (between the two fins) is more than 1.2m, a third fin shall be provided at the middle.

ANNEXURE 16

ACTIVITIES AND SEQUENCE OF CONSTRUCTION OF GFRG BUILDINGS



ANNEXURE 17

THREE LEVEL TRAINING FOR GFRG CONSTRUCTION

There is a need to provide short-term training to Architects, Structural Engineers and Construction (Civil) Engineers on the design and construction of GFRG / Rapidwall buildings. The methodology of waterproofing, electrification, plumbing and other allied works have also been included for the training. Training also need to be given to construction / technical supervisors, ITI tradesmen and waterproofing applicators, with hands-on training at site.

A17.1. Three day short term training to Architects / Structural Engineers / Civil Engineers or Construction Engineers on GFRG / Rapidwall Design & Construction There is need and demand for short term (3-day) training for professionals like Architects, Structural Engineers, Construction Engineers of Government agencies, urban local bodies, private sector agencies and professional consultants on design & construction of GFRG buildings.

Proposed training module for 3-day training is for qualified and practicing Architects, Structural Engineers, Civil or Construction Engineers and other interested professionals and consultants from building construction industries from private sector, faculty from Engineering colleges or technological institutions across the country.

Short-term Course on *Design and Construction of GFRG / Rapidwall Building Systems*

Day – 1

- *Brief Introduction to GFRG (Rapidwall) Building Systems*
- *Video on GFRG Demo Building at IIT Madras*
- *Visit to GFRG / Rapidwall manufacturing plant - to see manufacturing of panel and handling wet panel, drying of panel in drying chamber*
- *Visit to GFRG / Rapidwall manufacturing plant - cutting of panel by automised cutting saw, loading into stillages, loading of stillages into truck & visit to calciner plant and plaster plant to see wall plaster production*

Day – 2

- *Design of GFRG Buildings - Gravity Loads*
- *Structural Analysis and Modelling of GFRG Building Systems*
- *Behaviour of GFRG Wall Panel under Lateral Loading*
- *GFRG / Rapidwall Building System (Integrated & composite building System combined with GFRG prefab panel & RCC monolithic cast in situ construction)*

Day – 3

- *Method of Construction of GFRG Building: (Foundation & RC plinth beam, erection of wall panel, concrete infill, laying of slab panel, embedded RC concealed beams & screed, staircase, erection of upper floor of wall panel)*
- *Waterproofing Treatment of Construction Joints & Wet Areas: (Foundation, Basement & plinth, Flooring of Ground floor, Joint treatment of external & internal sides of External wall, Window sides, RC Lintel cum sunshade, Vertical wall corner joints, joint between parapet wall and terrace slab, coping of parapet top, bathroom / toilet / sunken floor or normal floor, terrace slab, joints of embedded pipes through wall panel or embedded concealed beams)*
- *Special primer for GFRG panels - significance or why special primer for GFRG panel, rendering / thin layer of plastering for external wall surface, rendering of internal wall surface, fixing of wall tiles / glazed tiles, painting)*
- *Electrification, Water Supply, Sanitary works & Fire Fighting system for High Rise Buildings above 4 floors*

Note: Training can be organized by other IITs, NITs or Engineering colleges who have tie-up with IIT Madras for training their academicians / faculty who can give training.

A17.2 Training to mid-level professionals like Construction Engineers & Site Engineers / Construction Supervisors / Technical Supervisors for water proofing application

A17.2.1 Technical qualification

Graduate Civil Engineers with a minimum experience of 1 to 2 years, Diploma holders in Civil Engineering with a minimum of 3 to 5 years of experience and ITI in Civil Engineering certificate course with a minimum experience of 10 years, in conventional building construction.

(Trained Graduate Construction Engineer with experience on GFRG / Rapidwall building construction for one year is mandatory. Initial training for Architect / Structural Engineer will be necessary for theoretical classes or expertise in GFRG / Rapidwall technology and construction at IIT Madras).

Duration of Training: 2 days theoretical classes & 4 days of training in construction site (total one week with 6 working days).

Day – 1

- *Brief Introduction to GFRG / Rapidwall technology*

- *Video film on "Construction of GFRG Demo Building at IIT Madras in 29 days"*
- *Presentation on "GFRG / Rapidwall Building Systems" - GFRG / Rapidwall building plan, structural / construction drawing, cutting drawing, notation marking, list of panels, panels in stillages, stillages in trucks, unloading of panels in stillages at site, stacking stillages at site, etc.*
- *"Method of Construction of GFG Building" - (Foundation & RC plinth beam with starter bars in position, Erection of wall panel, Concrete infill, network of embedded tie beam on top of wall panel , construction of stair case, support system for laying of slab panel, laying of floor / roof panel , side shuttering, embedded RC concealed beams & screed. Erection of upper floor wall panel and related work.)*
- *Introduction to Tools and tackle, equipment for handling of the panels, lifting of wall panel by crane, lifting of floor slab/ roof slab by crane. Identifying cavities for fixing lifting jaws, tying to crane using spreader bar etc. marking of points for drilling to make holes to insert soft sling to tie under panel spreader bar/bars for lifting panel keeping in perfect balance to float panel in the air horizontally: Safety parameters involved and Consequences of carelessness and improper work*

Day – 2

- *Preparation of various waterproofing products like Zycosil Solution, joint sealing compound, packing compound, coving compound like Grout RW in slurry & in paste form (in white or grey colour) and Mix RW, preparation of plaster mix with elastobar for rendering of external wall surface & wet areas like bath / toilet walls etc.*
- *Waterproofing treatment of construction Joints and wet areas (basement footing above GL , network of RC plinth beam , filling up of basement , concreting of ground floor of ground floor, Joint treatment of joint between RC plinth beam and walls , external & internal wall corner joints, window sides, RC lintel cum sunshade and joints, joint between upper floor slab and walls, joint between parapet wall and terrace slab, terrace slab and stair case / lift well head room walls , coping of parapet top, bathroom / toilet / sunken floor or normal floor, water proofing treatment of terrace, joints of piping through wall panel and its packing with sealants). Significance of technical supervision for all this work.*
- *Significance of Construction supervision and water proofing application and consequences of improper work / improper water proofing treatment and all related work without supervision.*
- *Special Primer for GFRG panels (preparation of Primer) Significance of special primer for GFRG panels, rendering / thin layer of plastering (by trained PoP Plasters) for external wall surface, bath / toilet wall ,rendering of internal wall surface, ceiling, fixing of wall tiling / glazed tiles, painting*
- *Fixing of lateral props with top fixing plate and base plate, cutting of panel at site or in wall position, support system before laying of floor slab panel, cutting of top skin of*

panel for providing concealed beam, providing reinforcement, conduits for electrification, fan hooks etc., side shuttering, staircase construction, preparation of panel cavities as beam shuttering, use of drilling machine, use of electrical chain saw, use of laser levelling machine, use of plumb to fix panel on proper level and line etc., mixing of plaster for rendering and use of tools for perfect finish.

- *Electrification, Water Supply, Sanitary works and Terrace Drainage; Firefighting systems for high rise buildings*

3rd, 4th, 5th & 6th days (4 days): Training in GFRG construction site

For giving training in GFRG construction site, it is necessary to have a trained & experienced (for at least one year in GFRG construction) GFRG Construction Engineer / Site Engineer / Supervisor.

Note: For training in construction site for erection / installation of wall panels and roof panel for medium or high rise GFRG buildings (above 4 storeys to 10 storeys), it is necessary to get the training from an installer / expert on GFRG construction from Australia. Those who got such training and worked in such high rise GFRG structures for at least 6 months can in turn give the training to site Engineers / supervisors, who in-turn can give training to erection crew or construction crew. For handling of panel lifting for construction above 3 floors, it is necessary to have trained riggers.

A17.3 Training for suitable construction workers & ITI tradesmen / technicians on GFRG / Rapidwall construction (2 days theoretical classes and 10 days hands on work at site)

Hands on work experience based training to building construction workers / ITI technicians on handling and erection of GFRG / Rapidwall panel and to certify as GFRG / Rapidwall installation / construction crew members.

Selecting suitable building construction workers of 20 to 35 years of age preferably from carpenters, masons, plumbers, electrical wiremen, bar benders, PoP plasterers, skilled concrete workers with at least elementary schooling, ITI technicians on carpentry, civil / mechanical or electrical engineering or draftsmen, fitter, mechanic, wiremen, plumbing and sanitary courses, etc., are preferred for hands on work experience covering the following areas of GFRG / Rapidwall building construction.

Once experienced in the actual building construction, under a trained construction / site Engineer, these trained and experienced persons can choose to work in any special area. They can also work as an installation team consisting of 6 to 7 crew members. Each member of the crew will have to know each and every aspect of GFRG / Rapidwall construction, including, handling, operating and use of right tools and equipment and proper construction.

It is important that a consulting office or builder or construction company should have a trained Architect / Structural Engineer, Civil / Construction Engineer, who have undergone 3-day training prescribed by IIT Madras on design and construction of GFRG / Rapidwall buildings.

Thereafter, through tie up with an experienced GFRG builder or construction company or construction of GFRG / Rapidwall building construction can deploy selected existing construction workers / ITI technicians to get hands on training on actual construction at site.

The erection team can work along with experienced erection team. For example, 2 to 3 new persons in an erection team along with 3-4 experienced workers can work together to get trained.

Hands on work experience as detailed in later part has to be followed up.

Note: For providing theoretical classes to the installation/ construction team, a trained Graduate Construction Engineer with experience in GFRG / Rapidwall building construction for one year or more, or Diploma in Civil Engineering with 2 to 3 years of experience or Architect or Structural Engineer with experience on GFRG design & construction are necessary.

Day – 1

- *Brief Introduction to GFRG / Rapidwall technology*
- *Video film on "Construction of GFRG Demo Building at IIT Madras in 29 days"*
- *Presentation on "GFRG / Rapidwall Building Systems" GFRG / Rapidwall building plan, Structural / Construction drawing, cutting drawing, notation marking, list of panels, panels in stillages, stillages in trucks, unloading of panels in stillages at site, stacking stillages at site, etc.*
- *"Method of Construction of GFG Building" (Foundation & RC plinth beam with starter bars in position, Erection of wall panel, Concrete infill, network of embedded tie beam on top of wall panel, construction stair case, support system for laying of slab panel,*

laying of floor / roof panel, side shuttering, embedded RC concealed beams & screed. Erection of Upper floor wall panel and related work)

- *Introduction to Tools and tackle, equipment for handling of the panels, lifting of wall panel by crane, lifting of floor slab / roof slab by crane. Identifying cavities for fixing lifting jaws, tying to crane using spreader bar etc. marking of points for drilling to make holes to insert soft sling to tie under panel spreader bar / bars for lifting panel keeping in perfect balance to float panel in the air horizontally: Safety parameters involved and Consequences of carelessness and improper work.*

Day – 2

- *Preparation of various waterproofing products like Zycosil Solution, joint sealing compound, packing compound, coving compound like Grout RW in slurry & in paste form (in white or grey colour) and Mix RW, preparation of plaster mix with elastobar for rendering of external wall surface & wet areas like bath / toilet walls etc.*
- *Waterproofing treatment of construction Joints and wet areas (basement footing above GL , network of RC plinth beam , filling up of basement , concreting of ground floor of ground floor, Joint treatment of joint between RC plinth beam and walls , external & internal wall corner joints, window sides, RC lintel cum sunshade and joints, joint between upper floor slab and walls, joint between parapet wall and terrace slab, terrace slab and stair case / lift well head room walls , coping of parapet top, bathroom / toilet / sunken floor or normal floor, water proofing treatment of terrace, joints of piping through wall panel and its packing with sealants. Significance of technical supervision for all this work.*
- *Significance of Construction supervision and water proofing application and consequences of improper work / improper water proofing treatment and all related work without supervision.*
- *Special Primer for GFRG panels (preparation of Primer) Significance of special primer for GFRG panels, rendering / thin layer of plastering (by trained PoP Plasters) for external wall surface, bath / toilet wall ,rendering of internal wall surface, ceiling, fixing of wall tiling / glazed tiles, painting*
- *Fixing of lateral props with top fixing plate and base plate, cutting of panel at site or in wall position, support system before laying of floor slab panel, cutting of top skin of panel for providing concealed beam, providing reinforcement, conduits for electrification, fan hooks etc., side shuttering, staircase construction, preparation of panel cavities as beam shuttering, use of drilling machine, use of electrical chain saw, use of laser levelling machine, use of plumb to fix panel on proper level and line etc., mixing of plaster for rendering and use of tools for perfect finish.*
- *Electrification, Water Supply, Sanitary works and Terrace Drainage; Firefighting systems for high rise buildings*

Note: Following hands on work experience, after above theoretical classes, in GFRG building construction is required to get the accreditation or certification as a GFRG / Rapidwall installer or skilled GFRG construction worker.

Hands on Work Experience:

Handling of Wall Panel: 1 day

- *This involves identifying panels from stillages or stock by seeing the notation mark in cutting drawing linked to building plan and notation mark written on the panel in factory.*
- *Checking of starter bars in position and checking the levels of RC plinth beam, etc., application of damp proof course on RC plinth beam top and sides, etc.*
- *Use of tools or equipment like lifting jaws and their fixtures to panels, tying to spreader bar and connecting to crane, proper placement of panel, if any cutting or proceeding is required for lifting panel by crane to install the panel*
- *Same way lifting of panel in horizontal position using under panel spreader bars and tying to soft sling and marking of holes to lift at balanced position to lift the panel safely on crane*

Wall panel erection: 1 day

- *It involve all aspects of erection of wall panel and checking plumb and level, fixing of lateral props in position, inserting vertical rods, tying of vertical rod with starter bars, identifying spot on wall panel for fixing lateral props and drilling of holes and fixing top fixing plate and fixing of base plate etc., joint sealing with Grout RW , infilling of concrete (using 6mm to 10mm metal, M20) in stages and all associated work, including RC lintel cum sun shade, Stair case construction, embedded horizontal tie beam etc.*

Floor slab laying and concreting: 2 days

- *Support system with runners, vertical prop in position, lifting of panel in horizontal position and laying in position, cutting of top skin or flange, concealed beam reinforcement in position, electrical cabling / conduits, fan points, side shuttering with 6mm grove, piping work and all related work, Panel joint treatment with mini concealed beams, concreting(M25), use of concealed beams, laying of weld mesh with concrete blocks (30 x 30 x 30mm size) to hold the weld mesh in level etc. and concreting to zero-zero level.*

Electrification, Plumbing & Water supply: 1 day

Water proofing treatment including bath room & terrace: 2 days

Fixing of glazed tiles & Installation of window / door frames: 1 day

Primer application & rendering, painting work etc. number of ITI technicians can gain work experience: 2 days

Total 12 working days*: (2 days theoretical & 10 days in construction site)*

Notes:

1. Daily wages (apart from food and refreshment to be given to the workers during the whole training period by the concerned company). If fresh ITI technicians are participating, agreed payment are to be given, apart from food and refreshments.
2. If the trained workers are intended to be taken for employment in Construction Companies, the company or the builder has to meet the cost of training and wages.
3. If such training is sponsored by Government or other agencies, the cost of training shall include the daily wages.

Training to construction workers to be given only after supervisors, site Engineers, and construction Engineers are trained, as construction in Rapidwall can be done only under technical supervision.

8. REFERENCES

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6. SP 7 : 2005, National Building Code of India, Bureau of Indian Standards, New Delhi.
7. IS 456 : 2000, Plain and reinforced concrete – Code of practice (fourth revision), Bureau of Indian Standards, New Delhi.

About BMTPC

The Building Materials & Technology Promotion Council (BMTPC) under the aegis of the Ministry of Housing & Urban Affairs strives to propagate cost effective, energy efficient, eco-friendly and disaster resistant construction technologies for field level applications. Over the years, BMTPC has successfully transferred many alternate building materials & construction systems, developed standards & specifications and brought out meaningful publications, brochures, guidelines for better advocacy and outreach. However, in the recent years in the backdrop of acute housing shortage, it has been realised that potential emerging technologies for social mass housing is the need of the hour and therefore, BMTPC is making concerted efforts so as to identify, study and propagate new technologies. In the process, BMTPC has successfully identified number of technologies and the same are being studied for implementation in Indian conditions through Performance Appraisal Certification Scheme (PACS) being operated by BMTPC. These emerging technologies are being studied so as to bring speed, quality, economy and safety against natural hazards over the conventional way of construction. With fast depleting natural resources; need for environment protection to protect greenhouse effect; need for bringing more speed, durability and quality in construction; it is prudent to bring alternate technologies from within and outside the country.