BMTPC
PACS
PERFORMANCE APPRAISAL CERTIFICATION

Structural Stay-in-Place Formwork System

User should check the validity of the Certificate by contacting Member Secretary, BMBA at BMTPC or the Holder of this Certificate.

Name and Address of Certificate Holder:
M/s Coffor Construction Technology Pvt. Ltd.,
Chandan Metal Products Compound, Near Gorwa BIDC, Gorwa Road, Vadodara-390016 (Gujarat)
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Performance Appraisal Certificate

PAC No.:**1035-S/2018**
Issue No. **01**

Date of Issue: **12-03-2018**

bmtpc

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Government of India
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PERFORMANCE APPRAISAL CERTIFICATE

FOR

Structural Stay-in-Place Formwork System

ISSUED TO

M/s Coffor Construction Technology Pvt. Ltd., Vadodra

STATUS OF PAC NO.: 1035-S/2018

S.No	Issue No.	Date of Issue	Date of renewal	Amendment		Valid up to (Date)	Remarks	Signature of authorized signatory
				No.	Date			
1.	2.	3.	4.	5.	6.	7.	8.	9.
1	01	12-03-2018	12-03-2020	–	–	11-03-2020	–	
2.			12.03.2020			11.03.2021		
3			12-03-2021			11-03-2022		
4			12.03.2022			11.03.2024		

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PART 1 CERTIFICATION

1.1 Certificate Holder:

M/s Coffor Construction Technology Pvt. Ltd.
Chandan Metal Products Compound
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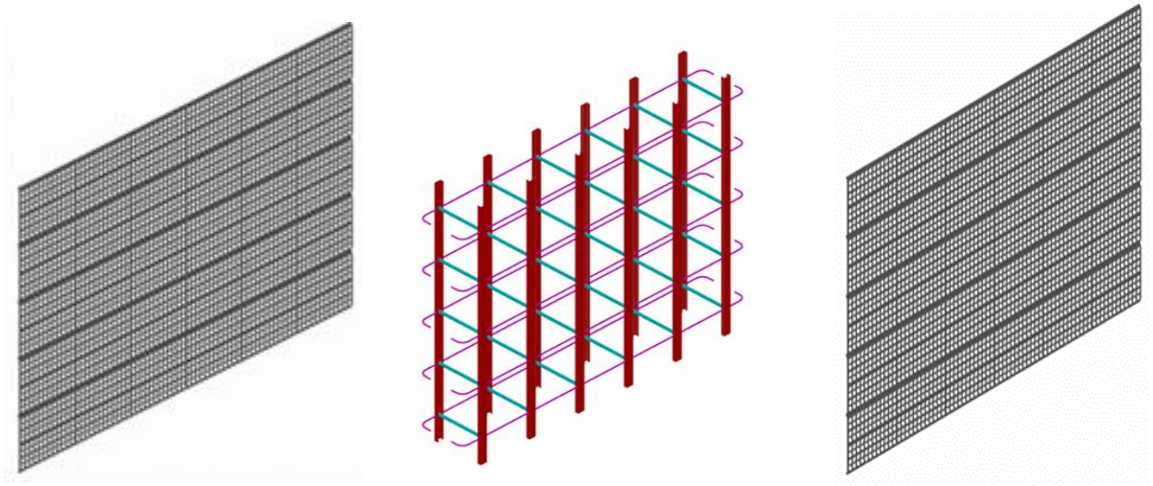
Tel: 0265-2290718, 0972772453
Email: info@cofforindia.com

1.2 Description of System

1.2.1 *Name of the System:* Structural Stay-in-Place Formwork System

1.2.2 *Brief Description:* The formwork system comprises of two filtering grids made of rib mesh reinforced by vertical stiffeners called 'C' channel. The grids are connected by rebar which act as horizontal stiffeners and connector which act as a shear link. The grids on both faces act as sacrificial formwork in which concrete is poured in-situ. The vertical steel channels and horizontal steel bars act as steel reinforcement for load bearing wall. The connectors help to fold the formwork for easy transportation. (Fig. 1)
Details of these components are given in Clause 1.3.
The panels are prefabricated which when arrive on the construction site are installed and ready for concreting.
The technology used for this system was originally developed by Coffor Services S. A., Switzerland.



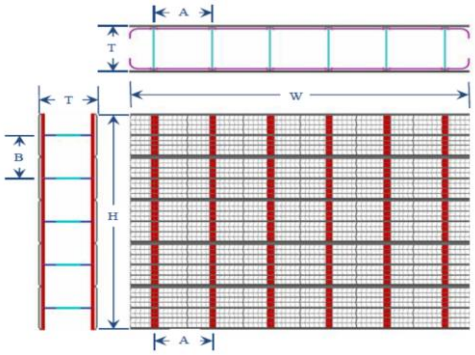
Rib Mesh **'C' Profile, Rebar & Connector** **Rib Mesh**

Fig. 1

1.2.3 *Size and Types of Panels*

1.2.3.1 Panels are normally produced in sizes as given below (See Fig. 2):

Width (W): 300mm, 500mm, 700mm, 900mm & 1100mm
Height (H): 500mm to 5000mm in multiples of 100 mm.
Thickness (T): 110mm, 140mm, 160mm, 200mm & 250mm.
However, customized sizes also be available on demand.



Panel Type	T mm	A mm	B mm	W mm	H mm
C10	100	200	100,200	300, 500, 700, 900, 1100	Min. 500 then in multiples of 100
C14	140	200	100,200		
C16	160	200	100,200		
C20	200	200	100,200		
C25	250	200	100,200		

Fig. 2

1.2.3.2 Types of panels are given below:

i. Standard single panels – These panels shall be used for slab shuttering but may also be used as shuttering option for RCC wall having thickness of more than 350mm. (Fig. 3)

ii. Double panels – Double panels shall have inbuilt steel and not require extra reinforcement. In double panels, the grids shall be connected by articulated rebar loops and connectors that fold. These panels are of two types:

(a) Standard double panels shall be of fixed size and need to be cut on site for openings etc.

(b) Customized double panels from the factory shall have required cutting for openings as per drawing and no need to cut on site.

(c) These panels create a monolithic structure as it allows pouring of walls and slab together.

These panels shall be used for load bearing walls, retaining walls and shear walls. (Fig. 4)

iii. Insulated Double panel – These panels shall have an integrated insulation on the exterior side. The insulated material shall be of polystyrene or polyurethane of required thickness as per design. (Fig. 5)

iv. Fiber Cement Double panel – These panels shall have its interior face as fibre cement board which has smooth surface and avoid plastering of walls. (Fig. 6)
These panels may be used for water retaining structures.

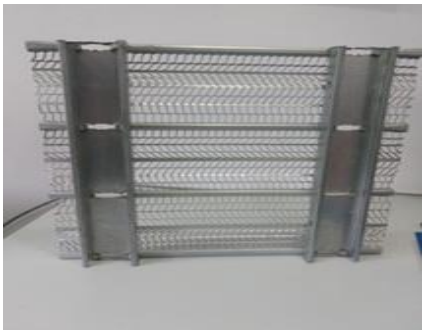


Fig. 3 Standard Single Panel

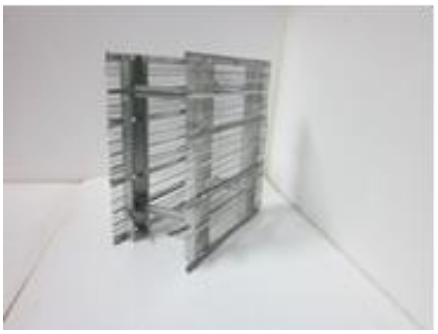


Fig. 4 Standard Double Panel

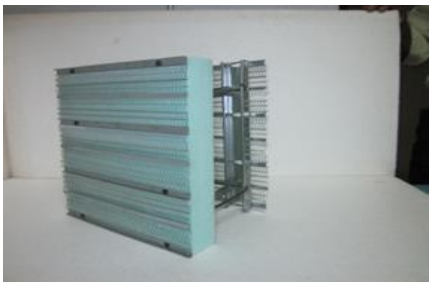


Fig. 5 Insulated Panel

Fig. 6 Fiber Cement Panel

1.3 Elements and Panel Assembly

1.3.1 *'C' Channel or Vertical Stiffeners*

- These are vertical stiffeners which work as vertical steel in RCC wall.
- These shall be made up of 0.6mm thick high galvanized sheet having 180gm/m^2/275gm/m^2 zinc coating which shall be used as per geological location to prevent rusting of steel.
- Area of profile is 60.6mm^2 (i.e. > 8 mm Ø bar)
- These shall be placed at every 200mm along the width. (Fig. 7)
- 'C' Channel acts as equivalent to 8mm bar.

Fig. 7 'C' Channel

1.3.2 *ReBar*

- These are horizontal stiffeners placed at every 200/100mm center to center
- These are 5mm Ø MS or galvanized bars and used as distribution bars.
- These shall be made from Fe 415 grade steel. (Fig. 8)

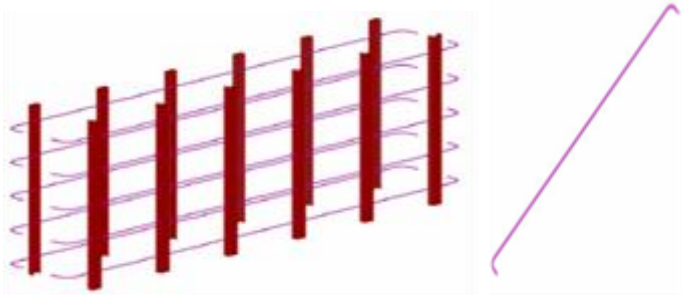


Fig. 8 Rebar

1.3.3 *Connector*

- Connectors connect C profile and Rebar
- These shall be made up of 1.6mm thick Cold Rolled Cold Annealed (CRCA) plate of 120 gm/m^2 zinc coated sheet to prevent rusting
- These work as shear link to connect steel on both faces of formwork.
- These also help to avoid bulging of formwork during concrete pouring. (Fig. 9)

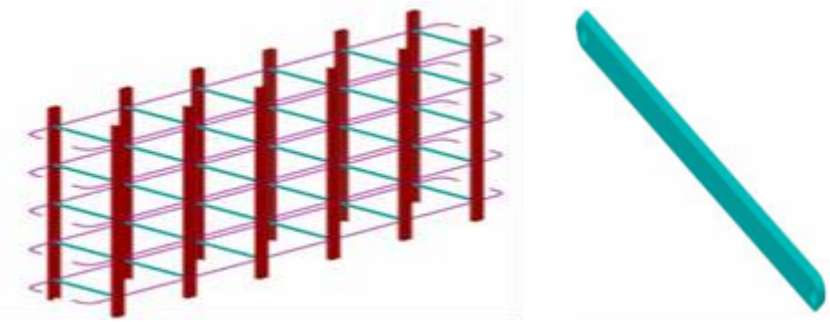


Fig. 9 Connector

1.3.4 *Rib Mesh*

- Rib meshes are filtering grids.
- These shall be made up of 0.42mm thick high galvanized sheet having 275gm/m^2 zinc coating which shall be used as per geological location to prevent rusting of steel.
- These work as reinforcement to plaster to prevent crack generated due to contraction and expansion.
- These also provide good bonding to plaster. (Fig. 10)

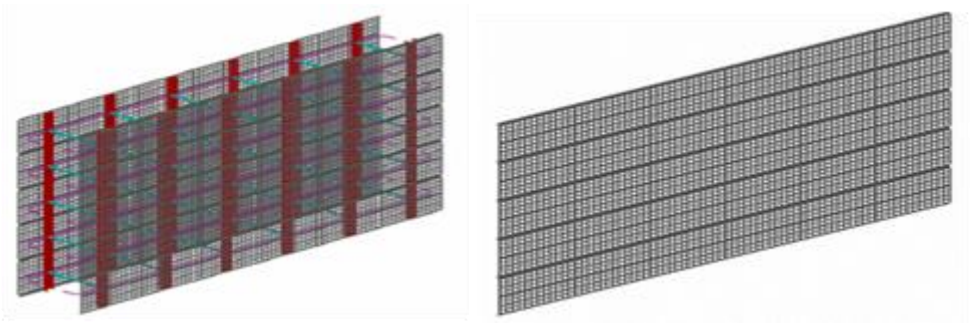


Fig. 10 Rib Mesh

1.3.5 *Constitution of the Formwork*

The following factors shall be considered for construction of buildings with this Formwork:

1.3.5.1 *Geometry of the structure*

The formwork is composed of elements given in Clause 1.3 above, positioned one next to the other so as to constitute, on the two facings a continuous unit. Standard panels are available in 90cm and 110cm wide so as to adapt to the geometry. When the wall length does not exactly correspond to these dimensions or to the one of their compositions, these are cut to size on site with a rotary cutter.

The angles shall be left open to make it possible to introduce local reinforcements (angle posts). Afterwards, these shall be closed by wall height angle pieces. In the same way, to build a bearing partition wall, panels shall be juxtaposed so as to enable easy insertion of the reinforcement bars. Vertically, the formwork is adapted to the wall height and if necessary to the thickness of flooring slab. (Fig. 11)

Lap length should be provided as per Clause 26.2.1 & 26.2.5.1 of IS 456:2000. For reinforcement in flexural tension shall be greater of Ld or 30 times the diameter of bar. (Ld = development length) and for bars in direct tension shall be greater of 2Ld or 30 times the diameter.

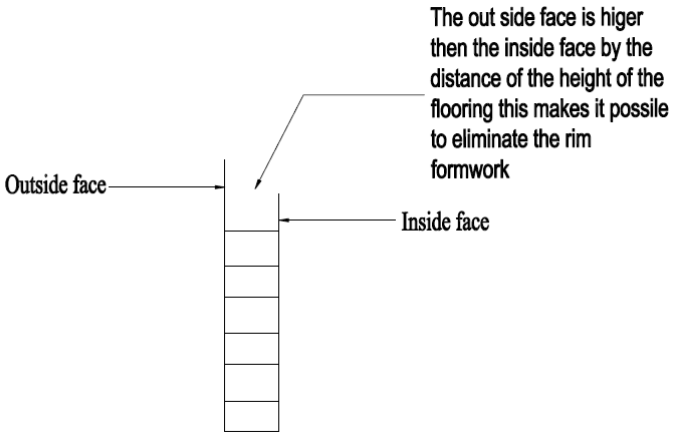


Fig. 11 Adopting the formwork to the wall height

1.3.5.2 *Type of wall*

The height of walls made with the Formwork vary according to the requirement. The two formwork faces are the same. The connectors make it possible to fold the panel for transportation.

1.3.5.3 *Association of components for openings with the Formwork*

One advantageous alternative can be the incorporation, during installation of the panels, of more or less complete opening components. These shall be compatible with the formwork, in particular, as follows:

- continue and extend their structural arrangements (assumption of thrust from concrete)
- remain homogeneous with the characteristics of installation of the Formwork
- be compatible with the dimensional tolerances and assumption of the concreting clearances of the Formwork
- tolerate the installation restrictions of the Formwork related, in particular to the draining capacity of the formwork faces.

The incorporation of the openings make it possible to better fix the joinery to the structure (the joinery is fixed with the aid of reinforced lugs or braces, with lengths such that the anchoring in

the concrete extend beyond the vertical stiffening sections of the contiguous panel rim).

1.4 Design Considerations

1.4.1 *Design Philosophy*

1.4.1.1 *Strategy*

The design strategy is to utilize concrete and formwork steel to the ultimate and to provide standard solutions for minimum reinforcement to be used, wherever required, depending on the application and will be determined by structural calculations performed according to the IS 456:2000. In seismic prone areas requiring seismic resistant construction, relevant provisions of IS 875 (Part 1, 2, 4 & 5):1987, IS 875 (Part 3):2015, IS 1893 (Part 1):2016, IS 4326:2013 and IS 13920:2016 shall apply.

1.4.1.2 ***Basic principles of designing plain concrete****:*

Design analysis of the Structural formwork walls, panels, floor slabs etc. shall be done using Staad Pro Software or equivalent.

i. The Optimal result is obtained when walls shall be designed as braced construction elements whose horizontal loads are supported by other bracing elements belonging to the same construction e.g. shear walls.

ii. The panels with concrete shall act as “lightly reinforced RCC walls” as per clause 32 of IS 456:2000 and as “prefabricated concrete load bearing walls” as per IS 15916:2010 & IS 15917: 2010 & amp; IS 15971:2010.

The Structural Form work, vertical reinforcement shall act as 8mm dia. @200 C to C and horizontal mild steel bar of 5mm dia. shall act as distribution steel, shall be taken for design as per National Building Code of India.

Walls subjected to bending or axial load and for the rest subjected to wind load parallel or perpendicular to the plane of the wall shall be designed considering formwork in built steel but without additional steel reinforcement, provided following condition is met:

md + *mt* < *mu*
where
md = the design value for the limit state of collapse, of the max. bending moment per unit length, due to the loads liable to act on the structure. **(Live load, Dead load of wall, support reaction and moment from slab)**

mt = the design value for the limit state of collapse, of the accidental restraint moment. **(Moment developed at the junction of wall and slab generated due to lateral force)**
mu = the ultimate bending moment per unit length occurring with the design value of the axial load applied to the center of gravity of the cross section. (**Moment capacity of the wall made with structural stay in place system)** (Fig. 12)

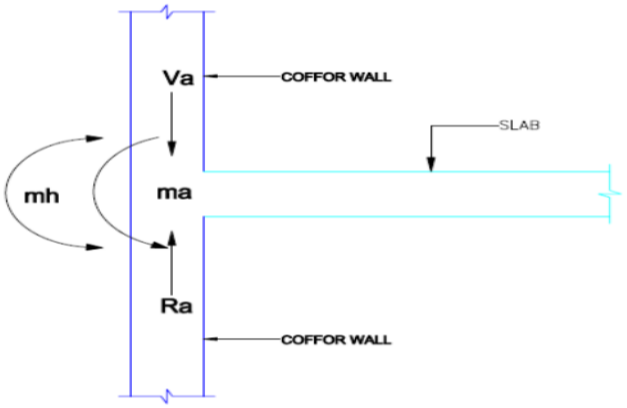


Fig. 12

where:
md = ma+Va x (emin)
mt = mh (moment due to lateral load)
mu – Ultimate bending capacity of the wall
ma –Support moment for slab
Va- vertical axial load.
Ra – Slab reaction part of vertical axial load calculation Va.
mh – moment due to lateral load.
emin – Minimum eccentricity.

iii. Wall- to –floor/slab tie reinforcement: When mt,i is too high to meet the above condition and it may be proved that position equilibrium is possible for the limit state of serviceability, reinforcement shall not be required if accepted as per IS 456:2000. This equilibrium exists if the rotational capacity of the wall near to the wall-floor connection shall be sufficient to follow the rotation

of the floor slab. If this equilibrium doesn't exist, wall to floor tie reinforcement shall be required. (Figs. 13, 14, 15 & 16).

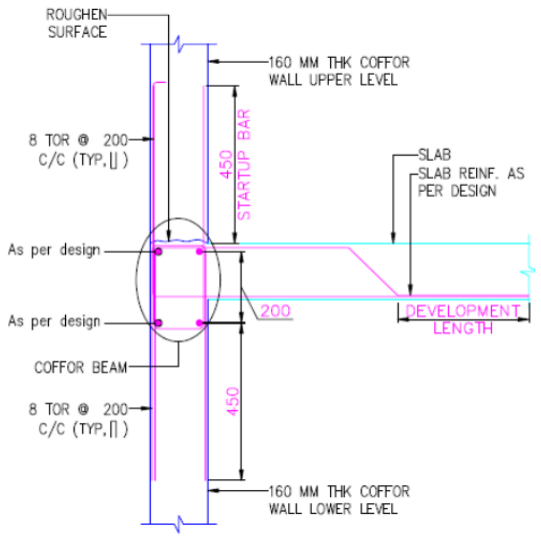


Fig. 13 Slab & outer wall connection

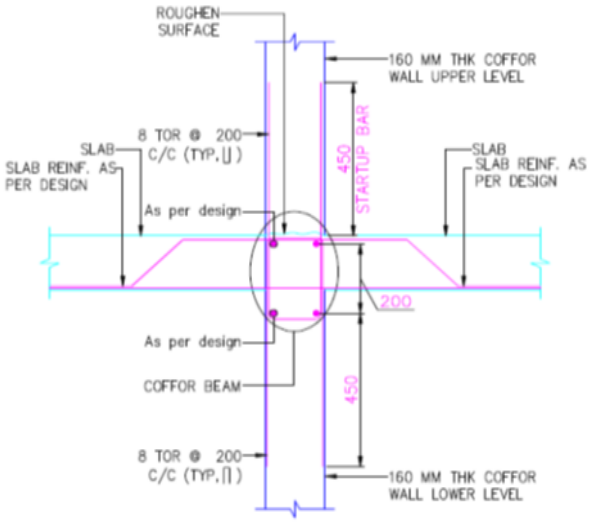


Fig. 14 Slab & Inner wall connection

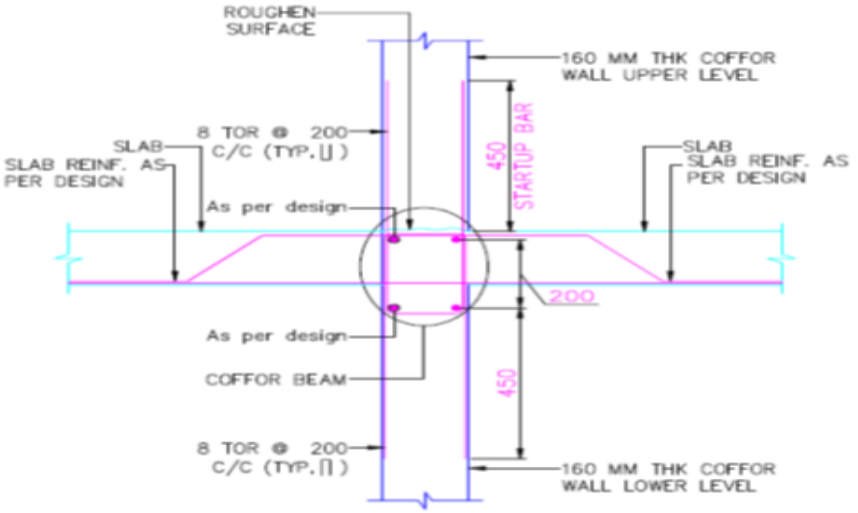


Fig. 15 Roof Slab & outer wall connection

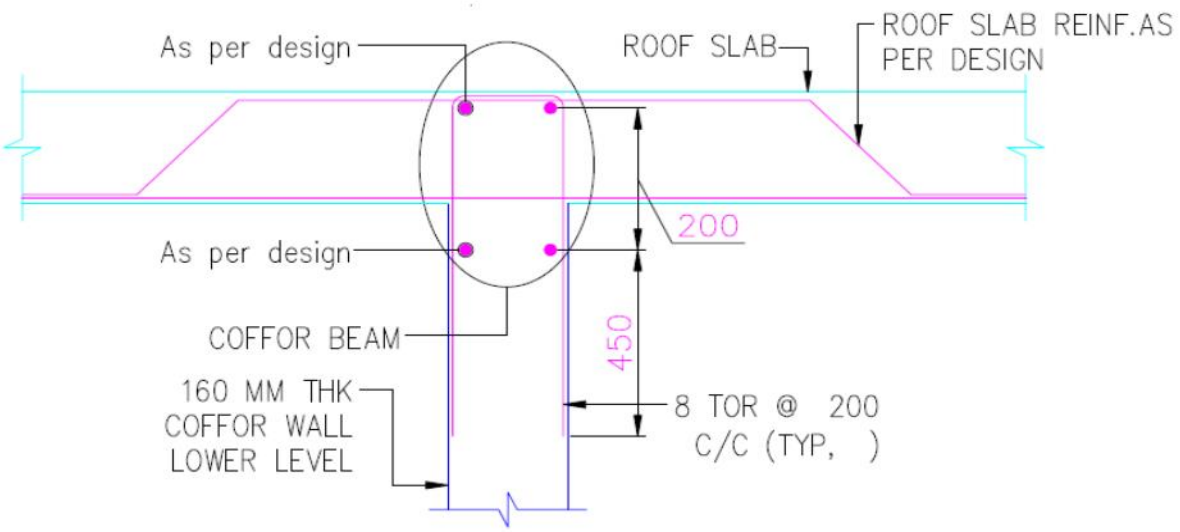


Fig. 16 Roof Slab & Inner wall connection

iv. Wall-to-wall tie reinforcement: In bearing walls of houses and buildings where no special loads are to be considered. There shall be continuous horizontal tie-reinforcement on every floor level. If not otherwise specified by IS 456:2000, the tie-reinforcement shall be omitted when the difference between the upper floor level and the terrace doesn't exceed 6.5meter. (Figs. 17, 18)

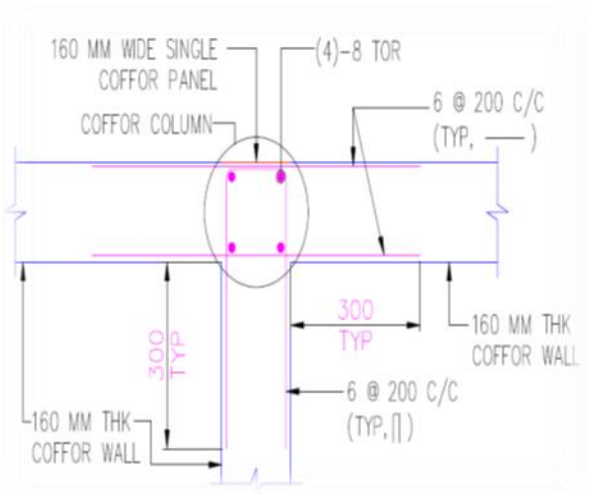


Fig. 17 Wall "T" junction

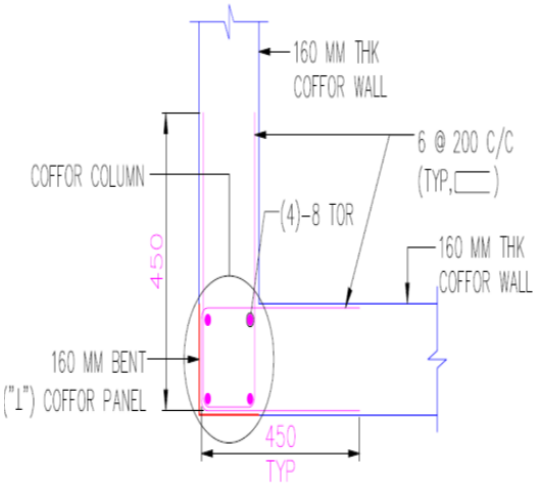


Fig. 18 Wall "L" junction

v. Edge reinforcement in walls: vertical reinforcement shall be provided at the edges of bearing walls for houses and buildings where no special loads are to be considered. Reinforcement shall be provided around all doors & window openings. If not otherwise specified by IS 456:2000, edge reinforcement in walls shall be omitted when the difference between the upper floor level and the terrace doesn't exceed 12.5meter. (Fig. 19)

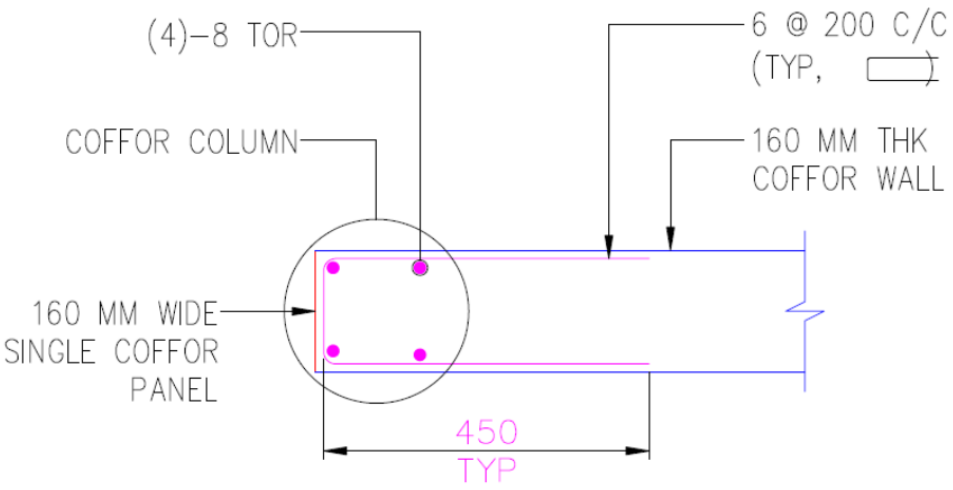


Fig. 19 Wall Edge junction

vi. Splitting reinforcement at beams: Splitting reinforcement shall be required when the design value of bearing stress due to the concentrated load exceeds the design value of the concrete strength**.**

Splitting reinforcement is the steel which binds two layers of reinforcement mesh on the either face of the wall, which has been provided in the system as connectors at 400mm c/c in both the directions.

1.4.2 Structural design and analysis of the formwork shall be based on relevant Indian and International standards. The panel construction assembly shall be used for free standing walls when designed and anchored as cantilever walls. Panels shall be reinforced and tied at vertical joints to maintain alignment. Additional reinforcement and cement plaster shall be provided as required by the design.

1.4.3 The technology is intended for use where Architectural drawings are available. The Architect and Engineer designer team of the concerned developer/owner (client) is responsible for the drawings and overall building design to comply with the various regulatory requirements applicable to the area.

1.4.4 The design assumptions, detailed calculations, references to necessary and detailed design drawings shall be made available on demand from the PAC holder, if required by the Client. The structural design calculations should clearly demonstrate structural integrity and stability including connection details.

1.4.5 Foundation shall be specifically designed in accordance with provisions given in IS 1904:2005. All foundations should be designed by structural engineer with appropriate reference.

1.4.6 In addition, any other requirement regarding safety against earthquake need to be ensured by the designer as per prevailing codal requirements.

Proof checking of Design of G+2 building of BMTPC being constructed at Bihar using Wall Panels carried out by IIT Bombay is available with the PAC Holder and can be seen, on demand.

1.5 Manufacturing/Installing Machinery/Equipment

Sr No	Month & Year of installation	Name of Machine	Make	Capacity/ Capability	Nos.
1.	12/2008	Riblathe	Minister, USA	60 Tons	1
2.	12/2008	'C" Profileline	--	--	1
3.	12/2008	Wire Straightnert Line	--	--	1
4.	12/2008	Connector line	--	--	1
5.	12/2008	Crimping Machine	--	--	1
6.	12/2008	Assembly machine standard	--	--	1
7.	12/2008	Assembly Machine Long	--	--	1
8.	12/2008	Corner forming Machine	CP Tools Inc. Taiwan	--	1
9.	12/2008	Ubar Forming Machine	--	--	1
10.	12/2008	Vertical Mill	Lagun Machine Tools, USA	--	1
11.	12/2008	Turning Lathe	Lagun Liberty	--	1
12.	12/2008	Hydraulic Shear Machine	--	--	1
13.	12/2008	Vertical Saw	Safety Speed Cut Mfg. Co., USA	--	1
14.	12/2008	Surface grinder	Harig Production Inc.	--	1
15.	12/2008	Rollaway toolbox with tool	Craft Master	--	1

1.6 Manufacturing of the Elements

1.6.1 *The production of the rib mesh shall comprise of the following operations:*

- After loading the strip, the press shall incise the metal continuously.
- The ribs that reinforce the expanded metal shall be formed
- The metal shall be expanded

- At the end of the production line, the section shall be cut to the desired length.

1.6.2 *The production of the stiffening sections shall comprise of the following operations:*

- After loading the strip, the press shall incise the metal continuously.
- The ribs that reinforce the expanded metal shall be formed
- The metal shall be expanded
- At the end of the production line, the section shall be cut to the desired length.

1.6.3 *The production of the connectors shall comprise of the following operations:*

- The steel strip shall be drilled and ribbed
- It shall be cut to the desired length and fall into a receptacle that will be transported to the assembly tables.

1.6.4 *The production of the horizontal reinforcement shall comprise of the following operations:*

- The rods shall be straightened continuously and shall be cut to length as per the manufacturer's drawing
- Once straightened, the rods shall be inserted into a machine that will form them and cut them as per the requirement.
- The formed rods shall be placed on a work table that will be transported to the assembly tables.

1.6.5 *The crimping of the sections* with the expanded metal shall be done by a crimping machine comprising two work tables. The components shall be loaded on one work table while the crimping table moves on guides to crimp the sections and the expanded metal. The crimping table shall produce single panels. The single panels shall be subjected to quality assurance operations for verifying proper crimping. In case of need, screws shall be added to any crimping which might seem fragile.

1.6.6 *The double formwork assembly shall comprise of the following:*

- Positioning of the connectors to the guides
- Positioning of the single panels

- Insertion of the horizontal reinforcement and their press-forming.
- The assembled panels shall be subjected to a second set of quality assurance operations.

Production Flow Chart is given in Annex II.

1.7 Basis of Assessment

1.7.1 Scope of Assessment

Scope of assessment includes conformance of manufactured wall and floor/roof panels to the specified requirements for use in the building construction.

1.7.2 Basis of Assessment

Assessment of the suitability of the Panels is based on:

i) Inspection of the under construction/constructed buildings during visit of some of TAC members and Officers of BMTPC at Vadodra.
ii) Technical Assessment No. 16/10-607 of Structural Formwork by CSTB, Paris, France
iii) Proof checking of Design of G+2 building of BMTPC being constructed at Bihar using Structural stay in place Wall Panels carried out by IIT Bombay
iv) Structural Evaluation of Prefabricated Concrete Wall System made of structural formwork Steel panels comprising tests of Lateral load, Flexural strength and Axial load of the Panels by IIT Bombay
v) Checking of Design of G+3 Telangana Project by Maulana Azad National Institute of Technology, Bhopal
vi) Project Report of Flexural, Compression, Shear & Deflection tests by Geo Test House, Vadodra
vii) Test results of tensile and Vicker's Hardness Measurement, tests of samples of Strip by TCR Advanced Engg. Pvt. Ltd., Vadodra
viii) Test results of Mass of Zinc Coating test of samples of GI Sheet by Met-Heat Engg. Pvt. Ltd., Vadodra
ix) Test report of Deflection test on Panels by CSTB, Paris, France
x) Operating Manual giving details of Installation and Execution of the panels

xi) Quality Assurance Procedure Manual followed by the Certificate Holder for quality control of the system as per the Quality Assurance Plan enclosed at Annex II.

1.8 Use and Limitations of the Panels

1.8.1 The Formwork System shall be used for load bearing walls/ retaining walls/shear walls for residential buildings upto G+4 storey, Industrial buildings, Underground Tanks, Water retaining structures, Storm water drains, Compound walls etc. and as shuttering material for slabs.

1.8.2 *Limitations of Use*

- For construction of high rise buildings beyond G+4 storey, extra steel in walls shall be required.

1. 9 C**onditions of Certification**

1.9.1 *Technical Conditions*

1.9.1.1 Raw materials and the finished panels shall conform to the requirements of the prescribed specifications.

1.9.1.2 The building to be constructed using the Panels shall be designed by competent structural engineers in accordance with the specifications, following relevant codal requirements, manufactured as per the details worked out in design and constructed by trained persons only with technical support or supervision by qualified engineers and builders, based on structural designs and seismic evaluation & wind forces as per the details given and this PAC.

The structural engineers and building designers associated with such type of construction should be thoroughly familiar with the various structural aspects. It is also recommended that Architects and Construction Engineers who undertake such building design and construction gain familiarity with the properties and materials, characteristics of Formwork panels and its applications.

The design assumptions, detailed calculations, references to necessary and detailed design drawings shall be made available on demand, if required. The structural design calculations should clearly demonstrate structural integrity and stability including connection details.

1.9.2 *Quality Assurance*

The Certificate Holder shall implement & maintain a quality assurance system in accordance with Scheme of Quality Assurance (SQA) given in the Annex I attached with this Certificate.

1.9.3 D*urability*

The Certificate Holder shall provide necessary structural warranty ensuring durability of the system to the user, on demand. Durability shall be as per Clause 8 of IS456:2000.

1.9.4 *Handling of User Complaints*

1.9.4.1 The Certificate holder shall provide quick redressal to consumer/ user complaints proved reasonable & genuine and within the conditions of warranty provided by it to customer/purchaser.

1.9.4.2 The Certificate holder shall implement the procedure included in the SQA. As part of PACS Certification he shall maintain data on such complaints with a view to assess the complaint satisfaction and suitable preventive measures taken.

1.10 Certification

On the basis of assessment given in Part 3 of this Certificate & subject to the conditions of certification, use & limitations set out in this Certificate and if selected, installed & maintained as set out in Part 1 & 2 of this Certificate, the system covered by this Certificate is fit for use set out in the Scope of Assessment.

PART 2 CERTIFICATE HOLDER'S TECHNICAL SPECIFICATIONS

2.1 General

The PAC holder shall manufacture the panels in accordance with the requirements specified.

2.2 S**pecifications of Raw Materials**

i. Rib mesh: Hot dip galvanized steel in coil shall be as per IS 277:2003/ASTM A653/ASTM A653 M-00 and as per following details:

Thickness: 0.42mm and tolerance: ± 0.04mm
Wdth: 342mm and tolerance ±0.5mm
Galvanization: 275gm/m^2 ±40 gsm/m^2
Specification of steel: Tensile strength—305 MPa to 415 MPa, Yield point—215MPa to 450MPa, Elongation – 31% (min.), Steel hardness – 50 to 60HRB on Rockwell hardness scale, Lock forming steel – zero spangle.

ii. "C" Channel: Hot dip galvanized steel in coil shall be as per IS 277:2003/ASTM A653/ASTM A653 M-00 and as per following details:
Thickness: 0.6mm and tolerance: ± 0.04mm,
Width: 101mm & tolerance ±0.5mm
Galvanization: 275gm/m^2 ±40 gsm/m^2
Specification of steel: Tensile strength—305 MPa to 415 MPa, Yield point—250 MPa to 450 MPa, Elongation – 31% (min.), Steel hardness – 50 to 60 HRB on Rockwell hardness scale, Lock forming steel – zero spangle.

iii. Connector: Cold galvanized steel or Cold Rolled Cold Annealed (CRCA) in coil shall be as per IS 277:2003 and as per following details:
Thickness: 1.60mm and tolerance ±0.1mm
Width: 19 mm and tolerance ±0.5mm
Galvanization: 120gm/m^2 or plain CRCA.

iv. Rebar: Fe 415 shall be as per IS 7887:1992 and as per following details:
Dia of wire: 5mm ± 1mm, Wire shall be rust free MS or galvanized with zinc coating 70 to 120gm/m^2.

v. Fibre Cement Board: Shall be 100% asbestos free and of Grade A, Category 4 as per IS 14862:2000 and as per following details:
Thickness: 9.00 mm and nominal tolerance: ± 10%
Density: 1350 kg/m^3 (min.)

vi. Insulated Panel: Shall be extruded Polystyrene Foam and as per following details:
Thickness: 50mm, and tolerance ± 2 as per ASTM D1622, Compression strength: 10% difilation ≥ 300 kg/m^2 as per ASTM D1621
Thermal conductivity at 25ºC: 0.028W/mK as per ASTM C518.

vii. Screws: Shall be S.S. 304 CSK Philips head of size 8 x 19mm and type of surface treatment as Nitric Acid passivation as per ASTM A967.

viii. Cement: Shall be of OPC 53 grade as per IS 12269:2013.

ix. Glue: Shall have smooth thyrotrophic paste having tack free time of 6 to 12 hours and Hardness shore: approx. 30

2.3 Construction of the Panels

2.3.1 *Layout and Blocking*

The alignment shall be traced with chalk on the two sides. Boards/battens shall be nailed on the ground to indicate the positioning of one face of the panels. Though, it may not be necessary to do a second alignment of other face of the panel, but it might facilitate the positioning.

2.3.2 *Positioning the Panels – Provisional Support*

The Structural formwork panels shall be fitted over projecting vertical reinforcing rods which first of all need to be checked to make sure that these are vertical and then straightened, if necessary. On a provisional basis, each panel shall be held vertically with wood pieces (boards/battens) or metal pieces (L-sections/tubes). The minimum length of these bracing elements shall not be less than 1.80m. The panels shall preferably be positioned beginning from the angles and from the doors. Whenever length of the wall does not correspond to a multiple of width of the panels, the last panel shall be cut with a rotary saw to adjust to length of the wall.

2.3.3 *Consolidating the Panels*

When all the panels are installed, these shall be consolidated with wood pieces (boards/battens) or metal pieces (L-sections/tubes), spaced from each other at approx. 1m to 1.50m. Then these shall be fixed horizontally with galvanized steel wire. An alignment board shall preferably be placed at top of the panels. The adjacent panels shall be bonded to each other at every 60cm to 80cm with steel wire. The horizontal battens shall be installed on a single side, with a steel wire that is bounded around one of the two stiffening sections of the neighboring panels. In this way, on a wall of 4.0m,

there will be four rows of consolidating pieces, including the batten at the bottom of the panels.

2.3.4 *Final Adjustment of the Panels*

When all the wall panels, in this way, have been erected and consolidated to each other, a final adjustment shall be performed with wood pieces (boards/battens) or metal pieces (L-sections / tubes) which shall be used as bracing. The provisional restraining pieces shall be removed and replaced by final stays positioned approx. every 2m. The verticality shall be checked using a plumb line or level.

2.3.5 *Closing the Rims of Doors and Windows*

The opening for windows shall be done using a rotary saw. Rims of doors and windows shall be closed preferably with wood pieces, the width of which shall be equal to thickness of the panel. In case several doors made to save time.

2.3.6 *Installing the Reinforcement Bars*

Once the panels are correctly stabilized, reinforcement bars, complimentary to the Formwork shall be installed in the following way:

2.3.6.1 *Reinforcement bars in regular part of the wall*

In case the cross-section of the vertical reinforcement bars is less than 1 cm^2/m, as per the design, the vertical sections of the Formwork shall act as reinforcements. If it is necessary to add complimentary horizontal reinforcement bars, these shall be slid in and rest of the connectors. If it is necessary to add complimentary vertical reinforcement bars, such bars shall be prepared in advance and delivered to the worksite by the supplier or these can be cut on the worksite. The vertical reinforcement bars shall be grouped in pairs, connected to each other by 2 horizontal rods (3 or 4 according to the wall height) welded or bounded to the vertical reinforcement bars.

2.3.6.2 *Reinforcement bars at the extremities and next to the openings*

Details of the reinforcement elements in the angles and around the openings shall be the same as for traditional walls of reinforced concrete.
After positioning the regular reinforcement bars of the walls, vertical bars and horizontal bars in U-shape, shall be placed in the angles and openings and bound together.

2.3.7 *Closing the Angles*

The angles shall be closed with Formwork angle panels delivered from the factory. In the absence of angle panels delivered from the factory, panels of expanded metal shall be press-formed on the site.

The angle panels shall preferably be fixed as follows:

- On the inside with a batten placed vertically all the way up the angle. This batten shall be bounded around the stiffening sections of Formwork panels of the angle.
- On the outside with braces spaced about one meter apart and bound around the stiffening sections. If there are no Formwork angle panels, timber boards shall be used to close the angles.

2.3.8 *Electric and Plumbing Ducts*

The electric and plumbing ducts etc. shall be placed inside the ducts. For connectors, small openings shall be made in the expanded metal.

2.3.9 *Checking before Concrete Pouring*

The following points shall be verified before pouring the concrete:

- Alignment of the Formwork
- Correct positioning of the stays (knee braces) for stability of the Formwork
- Closing of angles, doors and windows
- Positioning of reinforcement bars
- Subsequent work of the electric and plumbing ducts
- Cleaning of surfaces where fresh concrete joins the old concreting

2.3.10 *Pouring the Concrete*

The concreting shall be done with suitable grade of OPC as per IS 456:2000. The pouring shall be monitored at the jointing points, reveals and zones containing reinforcement bars. The expanded metal walls of the Formwork system makes it possible to drain off the excess water when pouring.

2.3.11 *Finishing the Wall*

On the outside, traditional hydraulic or sprayed façade coating shall be used, the bond of which is also facilitated by the expanded metal's rough surface. The composition of coating, number of coats and its thickness shall be as per general practice.
On the inside, normal plaster, panels of wood, tile, marble etc. shall be used.
On the outside, plaster shall confirm to Table 2 of Clauses 7.2, 7.3, 7.4 & 7.5 of IS1661:1972.
The ideal number of coats is two, namely the undercoat followed by a finishing coat.
The total thickness of two coat plaster shall not normally exceed 20mm.
The thickness of an individual coat shall generally be as recommended in Table 2 of Clauses 7.3.3 & 7.4.1 of IS 1661:1972:
i) Back coat, both for internal and external shall be 10 to 12 mm thick,
ii) Finishing coat shall be 3 to 8 mm thick.

2.3.12 *Facings and Coverings*

2.3.12.1 *Inside facings*

Given the rough surface of concrete, the inside face shall be finished either with a panel of plaster or other material bonded by dabs, either using a sprayed coating of cement mortar or of plaster.

2.3.12.2 *Outside coverings*

Outside coverings shall be the same as for coatings or insulated cladding elements or traditional walls.

2.4 Installation of the System

For detailed installation procedure of the System, reference may be made to the Operating Manual available with the PAC Holder.

2.5 Inspections & Testing

Inspections & testing shall be done at appropriate stages of manufacturing process of all the elements. The inspected panels shall be stored & packed to ensure that no damage occurs during transportation. As part of quality assurance, regular in process inspections shall be carried out by the trained personnel of the PAC holder.

2.6 Good Practices for Installation & Maintenance

Good practice as per requirement of the panels of the manufacturer shall be followed for erection and maintenance of these sections.

2.7 Maintenance Requirements

The PAC holder shall provide repair or replacement parts, provided the panels are damaged due to sole fault of the manufacturer for condition and time mentioned in Clause 2.9.

2.8 Skilled /Training Needed for Installation

The PAC holder shall provide supervision for use and implementation of the panels on site during training period. The manufacturer shall provide onsite training to client by qualified technical team. Training package includes:

- Technical presentation on installation of panels, foundation preparation, concrete pouring of wall and slab through Video
- Training by practical demo on site and monitor the entire process till one slab cast
- Technical manual for installation process.

2.9 Guarantees/Warranties Provided by the PAC Holder

PAC holder shall provide necessary warranty of the system for manufacturing defects for a period of 6 months or before concreting whichever is earlier to the client.

2.10 Responsibility

- Specific design using Stay-in-Place Formwork System is the responsibility of the designer with the instructions, supervision and guidance of the PAC holder.
- Quality of installation/construction of the system on site is the responsibility of the trade persons engaged by the building owner under the guidance of the manufacturer.
- Quality of maintenance of the building is the responsibility of the building owner under the guidance of the manufacturer.
- Providing necessary facilities and space for movement of cranes and vehicles is the responsibility of the building owner.

PART 3 BASIS OF ASSESSMENT AND BRIEF DESCRIPTION OF ASSESSMENT PROCEDURE

3.1 Assessment

3.1.1 The technical assessment was done as per provisions of the Standards listed in Part 5 of this Certificate.

3.2 Mock Exercise and Site Inspection

The TAC members and IOs observed a mock exercise of erecting the panels and pouring the concrete walls and roofs during the inspection. The exercise demonstrated the convenience of erection of panels, placement of reinforcement, pouring of concrete and use of traditional scaffolding. The entire operation was found to be satisfactory and with minimum training of manpower.

The TAC members and IOs also visited a G+4 storey residential building constructed at Vadodara**.** The work was generally found to be satisfactory.

3.3 Tests Performed

3.3.1 *By IIT Mumbai*

3.3.1.1 *Test 1: Lateral capacity of the panels with concrete*

Details of Test:

- Size of panels: 2.2 m x 3.0 m, thickness : 160 mm and no. of panels used = 2
- Grade of concrete: M20

Test result;

- Breaking load: 8.512 MT
- Maximum deflection: 6.2 mm.

3.3.1.2 *Test 2: Axial and Buckling capacity of the panels with concrete*

Details of Test:

- Size of panels: 0.5 m x 3.0 m, thickness : 160 mm and no. of panels used = 2
- Concrete grade : M20

Test Result:

- Maximum load per cylinder given: 26.3 MT
- Total load applied per cylinder: 105.2 MT
- Maximum deflection observed: 1.87 mm
- Failure of slab-beam observed at maximum load
- No structural change observed in the panel

3.3.2 *By Geo Test House, Vadodra (Gujarat)*

3.3.2.1 *Test 1: Compressive Strength on Hardened Concrete Cubes*

Details of Test:

- Material description: Concrete cube (150 x 150 x 150mm)
- Concrete grade: M20 for 28 days strength
- Concrete grade: M25 for 7 days & 28 days strength
- Concrete grade: M30 for 28 days strength

3.3.2.2 *Test 2: Compressive strength of Concrete cubes & Concrete panel (after 7 days & 28 days), Flexural strength of Concrete beam & concrete panel (after 7 days & 28 days), Shear strength of panel (after 28 days), Deflection of panel (after 28 days), Water absorption (after 28 days) and Modulus of Elasticity of Cylinder (after 28 days)*

Details of Test:

- M10 grade concrete with 20mm max. size of coarse aggregate and OPC 53
- M20 grade concrete with 20mm max. size of coarse aggregate and OPC 53
- M30 grade concrete with 20mm max. size of coarse aggregate and OPC 53

3.3.3 *By Laboratory of the Scientific & Technical Centre for Building Construction (CSTB), Paris, France*

Details of test:

- Sample of size 200cm x 122cm x 15cm with no rebar reinforcement was used for test.

Test result:

- Under centered deflection, the panel broke under a weight of 48 KN. (4.8 T)
- In addition, the panel demonstrated high ductility.

3.4 Execution of Projects

The manufacturer and its foreign collaborator Coffor France SNC, France, as reported, has executed the following major projects in India and abroad as per the details given below: (These have not been inspected by BMTPC)

S. No.	Name & location of the Client	Total Area (sqm) approx.	Period of supply
1.	Firmenich Aromatics Production (I) Pvt. Ltd., Dahej, Gujarat for laying of Storm water drain line	2000	2010-11
2.	West Coast Contractors Pvt. Ltd., Vadodra, Gujarat for construction of P+4 apartments	1596	2012-13
3.	Phoenix Infra estate Int. Pvt. Ltd., Nasik, Maharashtra for construction of Compound wall	1480	2010-11
4.	Sandeep Shah & Associates, Surendranagar, Gujarat for construction of G+4 structure	1251	2013-14
5.	Lubi Pump Pvt. Ltd., Ahmedabad, Gujarat for construction of Retaining wall	1400	2013-14
6.	Coffor France SNC, France for construction of various projects	17839	2008 -15
7.	Coffor France SNC, Kenya for construction of G+1 & G+3 structures	3045	2013-14
8.	Coffor France SNC, France for construction of Swimming pools	22770	2008-15
9.	Coffor France SNC, Cameron for construction of Villa projects	19374	2012-15
10.	Coffor France SNC, Haiti for construction of Villa projects	3646	2010-13
11.	Coffor France SNC (Lafarge), Brazil for construction of various projects	7660	2012-14

12.	Thomas & Pirion, Kenya for construction of Villa projects	2417	2013-14
13.	Loft Wood for construction of various projects at France	998	2014-15
14.	Coffor France SNC (sales) for construction of Swimming pool	8324	2015-16
15.	Coffor France SNC for construction of Swimming pool at France/Canada	10574	2016-17
16.	H_2O Distribution for construction of Swimming pool at France/Canada	28314	2016-17

PART 4 STANDARD CONDITIONS

This certificate holder shall satisfy the following conditions:

4.1 The certificate holder shall continue to have the product reviewed by BMBA.

4.2 The product shall be continued to be manufactured according to and in compliance with the manufacturing specifications and quality assurance measures which applied at the time of issue or revalidation of this certificate. The Scheme of Quality Assurance separately approved shall be followed.

4.3 The quality of the product shall be maintained by the certificate holder. Complete testing facilities shall be installed for in-process control.

4.4 The product user should install, use and maintain the product in accordance with the provisions in this Certificate.

4.5 This certificate does not cover uses of the product outside the scope of this appraisal.

4.6 The product is appraised against performance provisions contained in the standards listed in Part-V. Provisions of any subsequent revisions or provisions introduced after the date of the certificate do not apply.

4.7 Where reference is made in this Certificate to any Act of Parliament of India, Rules and Regulations made there under, statutes, specifications, codes of practice, standards etc. of the Bureau of Indian Standards or any other national standards body and the International Organization for Standardization (ISO), manufacturer's company standards, instruction/manual etc., it shall be construed as reference to such publications in the form in which they were in force on the date of grant of this Certificate (and indicated in Part V to this Certificate)

4.8 The certificate holder agrees to inform BMBA of their clients with details of construction on six monthly basis.

4.9 The certificate holder agrees to provide to BMBA feedback on the complaints received, the redressal provided, and the time taken to provide redressal on complaint to complaint basis as soon as redressal is provided. BMBA agrees to provide the certificate holder the user feedback received by it, if any.

4.10 If at any time during the validity period, PACH is unable to fulfill the conditions in his PAC, he should on his own initiative suspend using the PAC and notify Chairman, PAC the date from which he has suspended its use, the reason for suspension and the period by which he will be able to resume. He shall not resume without the prior permission of BMBA. He shall also inform, simultaneously, his agents, licensees, distributors, institutional, government,

4.11 In granting this Certificate, BMBA takes no position as to:

(a) The presence or absence of patent or similar rights relating to the product;
(b) The legal right of the Certificate holder to market, install or maintain the product;
(c) The nature of individual installations of the product, including methods of workmanship.

4.12 BMTPC and the Board of Agreement of BMTPC (BMBA) take no position relating to the holder of the Performance Appraisal Certificate (PACH) and the users of the Performance Appraisal Certificate (PAC) respecting the patent rights / copy rights asserted relating to the product / system / design / method of installation etc. covered by this PAC. Considerations relating to patent / copy rights are beyond the scope of the Performance Appraisal Certification Scheme (PACS) under which this PAC has been issued. PACH and users of this PAC are expressly advised that determination of the Claim / validity of any such patent rights / copy rights and the risk of infringement of such rights are entirely the responsibility of PACH on the one hand and that of the users on the other.

4.13 It should be noted that any recommendations relating to the safe use of the product which are contained or referred to in this Certificate are the minimum standards required to be met with when the product is installed, used and maintained. They do not purport in any way to restate or cover all the requirements of related Acts such as the Factory Act, or of any other statutory or Common Law duties of care, or of any duty of care which exist at the date of this Certificate or in the future, nor is conformity with the provisions of this Certificate to be taken as satisfying the requirements of related Acts.

4.14 In granting this Certificate, BMTPC and BMBA does not accept responsibility to any person or body for any loss or damage, including personal injury, arising as a direct or indirect result of the use of this product.

4.15 The certificate holder indemnifies BMBA, its officers and officials involved in this assessment against any consequences of actions taken in good faith including contents of this certificate. The responsibility fully rests with the certificate holder and user of the product.

4.16 The responsibility for conformity to conditions specified in this PAC lies with the manufacturer who is granted this PAC. The Board (BMBA) will only consider requests for modification or withdrawal of the PAC.

4.17 The PAC holder shall not use this certificate for legal defense in cases against him or for legal claims he may make from others.

Place: New Delhi
Date of issue_____

Chairman TAC &
Member Secretary, BMBA

for and on behalf of

Dr. Shailesh Kr. Agarwal
Chairman, TAC
& Member Secretary, BMBA
Building Materials and Technology Promotion Council
Ministry of Housing & Urban Poverty Alleviation, (Govt. of India)
Core 5A, Ist Floor, India Habitat Centre, Lodhi Road,
New Delhi-110 003

PART 5 LIST OF STANDARDS & CODES USED IN ASSESSMENT

5.1 Standards - These Standards are referred for carrying out particular tests only and do not specify the requirement for the whole product as such.

5.1.1 IS 277:2003 – Specifications for Galvanized steel sheets

5.1.2 IS 456:2000 -- Code of practice for plain and reinforced concrete

5.1.3 IS 875 (Part 1):1987 -- Code of Practice for Design Loads (other than earthquake) for Buildings & Structures: Part 1 -- Dead Loads - Unit Weights of Building Material & Stored Materials

5.1.4 IS 875 (Part 2):1987 -- Imposed Loads

5.1.5 IS 875 (Part 3):2016 – Wind Loads

5.1.6 IS 875 (Part 4):1987 – Snow Loads

5.1.7 IS 875 (Part 5):1987 – Special Loads and Combinations

5.1.8 IS 1501:2013 –Method for Vicker's Hardness Test from metallic materials

5.1.9 IS 1608:2005 -- Metallic Materials - Tensile Testing at ambient temperature

5.1.10 IS 1893 (Part 1):16 -- Criteria for Earthquake resistant design of structures

5.1.11 IS 1904: 2005 – Code of practice for design and construction of foundations in soils: General requirements

5.1.12 IS 2062:2011 – Hot Rolled Medium and High Tensile structural steel

5.1.13 IS 4326:2013 -- Code of Practice for earthquake resistant design and construction of buildings

5.1.14 IS 4759:2016 – Hot Dip Zinc Coating on structural steel products

5.1.15 IS 7887:2012 -- Specification for Mild Steel Wire Rods for general engineering purposes

5.1.16 IS 12269:2013 – Specifications for 53 grade cement

5.1.17 IS 13920:2016 – Code of practice for ductile detailing of RCC structures subjected to seismic forces.

5.1.18 IS 14862:2000 – Specifications for Fibre Cement Flat Sheets

5.1.19 ASTM A 653/ A 653-00 – Specifications for steel sheet, zinc coated galvanized by Hot-dip process

5.1.20 ASTM C518-17--Standard test method for steady static thermal transmission properties

5.1.21 ASTM D1622-08 -- Standard test method for core density of rigid cellular plastics

Part 5.2 Company Standards of the PAC holder – The branded design & specifications of the raw materials and finished product are as submitted by the manufacturer. The PAC holder has to make available the company standards to the consumers according to which testing have been done.

5.1.3 References

1. Technical Assessment No. 16/10-607 of Coffor Structural Formwork by CSTB, Paris, France
2. Proof checking of Design of G+2 building of BMTPC being
3. constructed at Bihar using Coffor Wall Panels carried out by IIT Bombay
4. Structural Evaluation of Prefabricated Concrete Wall System made of Coffor Steel panels comprising tests of Lateral load, Flexural strength and Axial load of the Panels by IIT Bombay
5. Checking of Design of G+3 Telangana Project by Maulana Azad National Institute of Technology, Bhopal
6. Project Report of Flexural, Compression, Shear & Deflection tests by Geo Test House, Vadodra
7. Test results of tensile and Vicker's Hardness Measurement, tests of samples of Strip by TCR Advanced Engg. Pvt. Ltd., Vadodra
8. Test results of Mass of Zinc Coating test of samples of GI Sheet by Met-Heat Engg. Pvt. Ltd., Vadodra
9. Test report of Deflection test on Panels by CSTB, Paris, France
10. Operating Manual giving details of Installation and Execution of the panels
11. Quality Assurance Procedure Manual

CERTIFICATION

In the opinion of Building Materials & Technology Promotion Council's Board of Agreement (BMBA), **Structural Stay-in-place Formwork System** bearing the mark manufactured by M/s Coffor Construction Technology Pvt. Ltd., Vadodra is satisfactory if used as set out above in the text of the Certificate. This Certificate **PAC No. 1035-S/2018** is awarded to **M/s Coffor Construction Technology Pvt. Ltd., Vadodra.**

The period of validity of this Certificate is for a period of one year i.e. from **12.03.2022** to **11.03.2024** as shown on Page 1 of the PAC.

This Certificate consists of a cover page and pages 1 to 36.

Embossing Seal of BMBA

On behalf of BMTPC Board of Agreement, Chairman, Technical Assessment Committee (TAC) of BMBA & Member Secretary, BMTPC Board of Agreement (BMBA) Under Ministry of Housing and Urban Affairs, Government of India

Place: New Delhi, India

Date: 12-03-2022

PART 6 ABBREVIATIONS

Abbreviations

BMBA	Board of Agreement of BMTPC
BMTPC	Building Materials and Technology Promotion Council
CPWD	Central Public Works Department
ED	Executive Director of BMTPC
IO	Inspecting Officer
MS	Member Secretary of BBA
PAC	Performance Appraisal Certificate
PACH	PAC Holder
PACS	Performance Appraisal Certification Scheme
SQA	Scheme of Quality Assurance
TAC	Technical Assessment Committee (of BMBA)

PERFORMANCE APPRAISAL CERTIFICATION SCHEME - A BRIEF

Building Materials & Technology Promotion Council (BMTPC) was set up by the Government of India as a body under the Ministry of Housing &Urban Poverty Alleviation to serve as an apex body to provide inter-disciplinary platform to promote development and use of innovative building materials and technologies laying special emphasis on sustainable growth, environmental friendliness and protection, use of industrial, agricultural, mining and mineral wastes, cost saving, energy saving etc. without diminishing needs of safety, durability and comfort to the occupants of buildings using newly developed materials and technologies.

During the years, government, public and private sector organizations independently or under the aegis of BMTPC have developed several new materials and technologies. With liberalization of the economy several such materials and technologies are being imported.

However, benefits of such developments have not been realized in full measure as understandably the ultimate users are reluctant to put them to full use for want of information and data to enable them to make informed choice.

In order to help the user in this regard and derive the envisaged social and economic benefits the Ministry of Housing &Urban Poverty Alleviation has instituted a scheme called Performance Appraisal Certification Scheme (PACS) under which a Performance Appraisal Certificate (PAC) is issued covering new materials and technologies. PAC provides after due investigation, tests and assessments, amongst other things information to the user to make informed choice.

To make the PACS transparent and authentic it is administered through a Technical Assessment Committee
(TAC) and the BMTPC Board of Agreement (BMBA) in which scientific, technological, academic, professional organizations and industry interests are represented.

The Government of India has vested the authority for the operation of the Scheme with BMTPC through Gazette Notification No. 1-16011/5/99 H-II in the Gazette of India No. 49 dated 4th December, 1999.

Builders and construction agencies in the Government, public and private sectors can help serve the economic, development and environmental causes for which the people and Government stand committed by giving preference to materials and technologies which have earned Performance Appraisal Certificates.

Further information on PACS can be obtained from the website: www.bmtpc.org

ANNEX I

(Clause 1.9.2)

Quality Assurance Plan for Structural Stay-in-Place Formwork System

S.No	Parameters to be inspected	Requirement Specified	Test Method	Frequency Of Testing
I.	**Raw Material**			
A.	*Rib Mesh/ 'C' Profile*			
1.	Material thickness	Reqd. thickness	Micro meter	Every new lot
2.	Tensile strength	305 to 415 MPa	IS 1608:2005	Every new lot
3.	Yield strength	215 to 450 MPa	IS 1608:2005	Every new lot
4.	Elongation	31 % min.	IS 1608:2005	Every new lot
5.	Hardness	50 to 60 HRB	IS 1501:2013	Every new lot
6.	Zinc Coating	275 gm/m^2 both sides	IS 6745:2016	Every new lot
B.	*Connector*			
1.	Material thickness	Reqd. thickness	Micro meter	Every new lot
2.	Tensile strength	305 to 415 MPa	IS 1608:2005	Every new lot
3.	Yield strength	215 to 450 MPa	IS 1608:2005	Every new lot
4.	Elongation	31 % min.	IS 1608:2005	Every new lot
5.	Hardness	50 to 60 HRB	IS 1501:2013	Every new lot
6.	Zinc Coating	120 gm/m^2 both sides	IS 6745:2016	Every new lot
C.	*Rebar*			
1.	Material thickness	Reqd. thickness	Micro meter	Every new lot
2.	Tensile strength (N/mm^2)	450 MPa	ASTM E8:15a	Every new lot
3.	Yield strength (N/mm^2)	400 MPa	ASTM E8:15a	Every new lot
4.	Elongation (%)	6 % min.	ASTM E8:15a	Every new lot
5.	Hardness (HRB)	70 to 80 HRB	ASTM E384 :2011a	Every new lot
II.	**Finished panels**			
1.	Panel length & width	As specified in project schedule	Measuring tape	Every batch
2.	Panel thickness	As specified in project schedule	Micro meter	Every batch

ANNEX II

(Clause 1.6.6)

Manufacturing Process Flow Chart