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# Comparative study of Reinforced Cement Concrete Structure and Concrewall Structure

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**Abstract**

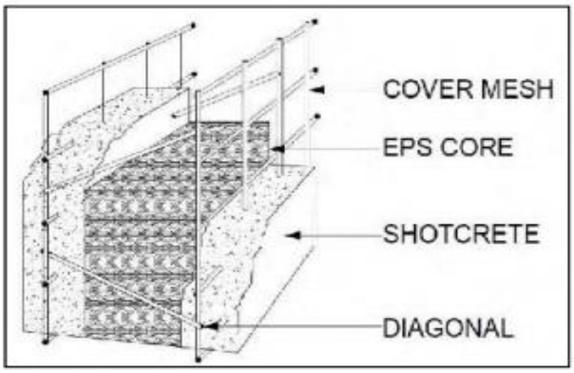
In constantly developing countries especially South East Asia(India), there is increase in population, which leads to growth of needs and increase in poverty. This is why there is a need of faster, lighter and affordable means of construction. This need has given birth to lot of new and innovative ideas. One such idea is Concrewall Panels. Concrewall is composed of a factory produced panel of undulated (wave shape) expanded polystyrene panel covered on both sides by an electro-welded zinc coated square mesh of galvanized steel and linked by 40 connectors per sq m made of high-elastic-limit 3mm dia wires and shotcreted on both sides. In this paper properties of expanded polysterene panels is explained. A G + 3 structure is designed by using both, conventional reinforced cement concrete method and concrewall method. A study is carried out comparing cost incurred in both the methods.

**Keywords;** *Concrewall system, Cost comparison, Expanded polystyrene panels, Low cost housing, Reinforced cement concrete structures.*

## I. INTRODUCTION

The Concrewall System is an industrial system for the construction of structural walls of reinforced concrete for building in single panel.The system is composed of a factory produced panel of undulated (wave shape) polystyrene covered on both sides by an electro-welded zinc coated square mesh of galvanized steel and linked by 40 connectors per sq m made of high-elastic-limit 3mm diawires.The panels are assembled on site and in-situ concrete (double panels, floors, stairs) and shotcrete concrete poured (single panel) to realize the following different elements of the system:

1. Vertical structural walls
2. Horizontal structural elements
3. Cladding element
4. Internal walls.




## II. LITERATURE REVIEW

For finding more information on concrewall and get more clear knowledge few papers were studied and are mentioned below:

**Rohan D More and Dr. Y.S Patil (2016)[1]** has point out the various aspects of construction of structure using brickwork or various type of brick & using concrewall to reduce the cost of construction and making low cost houses which is basic need of middle class people in our India. They concludes that use of Concrewall sheets or different panels in the construction of building is very economical. By adopting this methodology the construction work is fast and saves construction time.

**KAIRASNEHA AND T.P.TEZESWI (2016)[2]**has utilize time study method to determine the time taken by manpower and equipment to perform each task and show advances in technology that are making management of productivity, resource utility, cost, time which are more predictable.Their study indicates that expanded polystyrene wall and slab panels are cost effective and efficient enough as a construction technology to be used as a replacement for the traditional RCC frame with brick infill buildings.

**Sheikh Abdul Qadir, Atul Singh, Amit Dhaka and Sagar Singh (2018)[3]** has proposed the study of a method to implement a new technique regarding using polystyrene in construction of structure wall for housing which includes not only construction of bungalow but also building upto four floors as well as row houses whichever is necessary.

**Rohan D More and Dr. Y.S Patil (2016)[4]** points out the various aspects of construction of structure using mivian or any other formwork & using concrewall reduce the cost of construction and making low cost houses it is basic need of middle class people in our India. They conclude that the use of Concrewall sheets or different panels in the construction of building compared to mivian formwork is very economical. By adopting this methodology the construction work is fast and save in construction time.

**Rohit Raj, Manoj Kumar Nayak, MdAsifAkbari and P. Saha (2014)[5]** makes an attempt to review the various aspects of expanded polystyrene sheet (EPS) imbedded in the reinforced concrete and its prospective design & implementation in the building to make it energy efficient.This review does not touch on every available option. Instead, it includes the most common and readily available material options currently used in the EPSCSR industry and highlights the material options focused upon in this research.

After studying all this papers one thing can be is evident that concrewall structure is more cost and time efficient than other structures.

From this study the objective of this paper is:

1. Design a reinforced cement concrete structure and a concrewall structure and compare them.

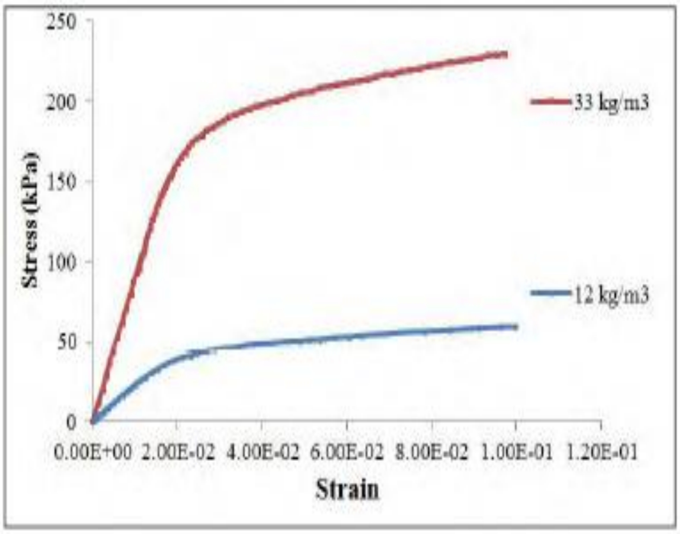
2. Compare the cost required in both the projects.

## III. PROPERTIES OF EXPANDED POLYSTYRENE PANEL

Extended Polystyrene, regularly alluded to as EPS, is a type of unbending, shut mobile foamplastic. EPS houses have a low warmth conductivity, excessive compressive fine, is mild weight, latent. It thoroughly may be implemented as a form fabric or a plan component, and may be customary into severa shapes for various circle of relatives makes use of too.

1. Density: Density of EPS can be 15, 20, 25, 30 or 35 kg/m3 as consistent with IS 4671: 1984[6].

2. Compressive Strength and Stress-Strain Characteristics: Negussey and Elragi , 2000[14]



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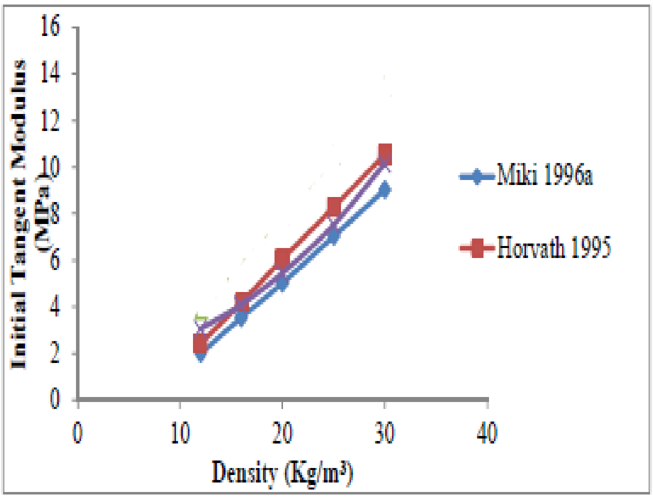
3. *Initial Elastic Modulus:* Horvath, 1995b[15] and Miki, H., 1996[16]




4. *Poisson's Ratio:* Sanders 1996[17]

| Reference | Yamanaka, et al. (1991) | Negussey and Sun (1996) | GeoTech (1999a) | Duskov et al. (1998) | Ooe, et al. (1996) | Sanders (1996) | Momoi and Kokusyo (1996) |
|---|---|---|---|---|---|---|---|
| Poisson's Ratio | 0.075 | 0.09 and 0.33 | 0.05 | 0.1 | 0.08 | 0.05 up to 0.2 | 0.5 |

5. Water Absorption: van Dorp 1988[18]

| Density, kg/m³ | After 7 Days | After 1 Year |
|---|---|---|
| 15 | 3.0 | 5.0 |
| 20 | 2.3 | 4.0 |
| 25 | 2.2 | 3.8 |
| 30 | 2.0 | 3.5 |
| 35 | 1.9 | 3.3 |

6. Durability: No inadequacy impacts aren't out of the ordinary from EPS fills for a normal existence pattern of one hundred years [Aabøe, R. (2000)][19]

7. Thermal Conductivity: The heat conductivity at zero°C and 10°C, one by way of one of the fabric will not surpass the tendencies given below as indicated through IS:4671-1984[6], decided as consistent with the method recommended in IS : 3346-1980[13]

| Bulk Density (kg/m³) | Thermal conductivity mW/cm °C | |
|---|---|---|
| | 0°C | 10°C |
| 15 | 0.34 | 0.37 |
| 20 | 0.32 | 0.35 |
| 25 | 0.30 | 0.33 |
| 30 | 0.29 | 0.32 |
| 35 | 0.28 | 0.31 |

6. Acoustical Properties: EPS has the advantage of being light-weight and powerful in thicknesses as low as 0.625 cm it is able to supplant thicker, heavier substances.

## IV. DESIGN PHILOSOPHY

The plan limits given in these guidelines depend on restrict united states of america shape strategies thinking about a definitive point of confinement country for first rate shape, treating the 1.2m huge and 3m immoderate EPS constructing board due to the fact the unit building material.

## V. METHODOLOGY

A G + three form is considered and deliberate forr every concrewall technique and fashionable RCC approach. Right now configuration is regarded. RCC configuration is completed via using Buildmaster and appeared in postulation file.

Plan Calclation:

Plan the Concrewall load bearing divider board walking for following –

Dead burden - 2.015kN/m2 (Calculation regarded in later content material fabric)

Divider Load - 2.015kN/m2 (Calculation appeared in later content)

Live burden - 2kN/m2 (consistent with IS 875-2: 1987)

Rooftop stay burden - 1.5kN/m2 (in line with IS 875-2: 1987)

Plan the out of doors divider board and take a look at for its fitness for the above stacking.

Presumption

On the off hazard that the structure is located in a seismically dynamic district. The ground is predicted to head approximately as a belly, disseminating the seismic powers to the heap



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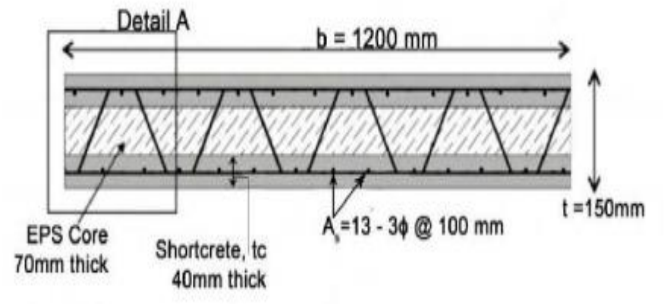
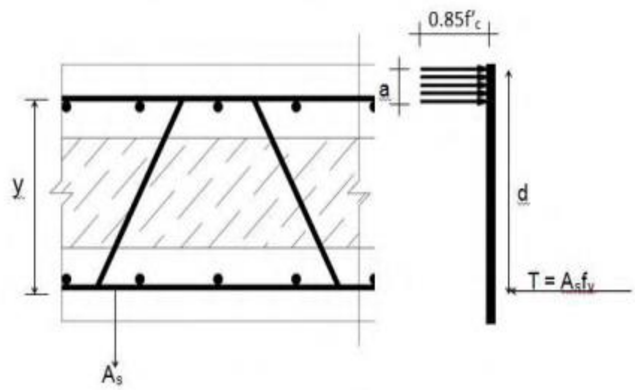
bearing dividers. Check the properly being of the divider boards for in-plane shear powers.

Divider board:

Consider a divider board of following measurements as seemed




**Cross-section of Concrewall Wall Panel**




**Detail A**

| | |
|---|---|
| B (Width of the Panel) | 1200mm |
| T (Total Panel thickness) | 180mm |
| Tc(Depth of the Shotcrete on one component) | 40mm |
| y (Distance amongst Compression and Tension Reinforcement) | 140mm |
| t (Thickness of EPS center) | 100mm |
| fy(Yield Strength of Steel Wires) | 415MPa |
| Es(Elastic Modulus of Steel) | 200000 MPa |
| $\beta$1 Factor for fc ≤ 30 MPa | 0.85 |
| d Distance from the outrageous pressure fiber to the centroid of stress fortification [T-(Tc/2)] | 160mm |
| d' Distance from the outrageous stress fiber to the centroid of stress help [Tc/2] | 20mm |
| d" Distance from the plastic centroid to the centroid of the stress steel of the divider board at the same time as unconventionally loaded.[(T-Tc)/2] | 70mm |
| belly muscle Depth of the identical rectangular stable stress square | 80.39mm |
| Thickness of Shotcrete | 25kN/m3 |
| Thickness of EPS | 0.15kN/m3 |
| Thickness of the Slab | 180mm |
| Territory of pressure and pressure Steel | 13-3 ϕ@100mm |

Computation of burdens following up on the out of doors divider board

Wind Load through IS:875-3 1987[9]

Essential Wind Speed at Roorkee, Vb= 39 m/s

Hazard Factor, k1 = 1

Building tallness landscape issue (Class A, Category III), k2 = zero.91

Geographical Factor, k3 = 1

Configuration Wind Speed, Vz = Vb x k1 x k2 x k3 = 39 x 1 x 0.91 x 1 = 35.Forty nine m/s

Configuration wind strain, Pz = 0.6 Vz2 = 0.6 x (35.49)2/1000= zero.76 kN/m2

Estimation of Dead Load and Wall Load in keeping with IS:875-1 1987[7]

All out Dead Load = 58.04kN

Live burden consistent with board in step with IS:875-2 1987[8]

All out Live Load = 27 kN

Pivotal Force because of Total Dead and Total Live Load,

Pu = 1.4□Total Dead load□ □1.7□Total Live Load□ =127.16 kN

On the off threat that the flightiness of 25.4 mm is usual.

Offbeat Moment because of Pu, Mu = Pu x 0.0254 =three.22 kNm

Minute because of wind, Mw = 0.Seventy six x 32/eight = 0.85 kNm

Hub Force for joined D+L+W

Pf □ zero.75 □ 1.4D + 1.7L + 1.7W □

Pf = 95.37 kN

Minute for unpredictable pivotal burden and wind load,

Mf = zero.Seventy five(Mu + 1.7 Mu )



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Mf = 3.Forty nine kNm

**Slenderness:**

$$\beta d = \frac{Factored\ Dead\ Load}{Factored\ Total\ Load} = \frac{1.4\ x\ 58.04}{127.16} = 0.64$$

(Note: βd does not apply to wind load moments)

Gross Moment of Inertia, Ig = (Width of the panel × Thickness of the shotcrete at one side × (Distance between Compression and Tension Reinforcement)2 )/2

Gross Moment of Inertia, Ig $= \frac{1200\ x\ 40\ x\ 140^2}{2\ x\ 1000^4} =$ $4.70\ x\ 10^{-4} m^4$

$$Ec = 5000\sqrt{fck}\ x\ 10^3 kN/m^2$$

$$Ec = 5000\sqrt{20}\ x\ 10^3 kN/m^2$$

$$Ec = 22360.68\ x\ 10^3 kN/m^2$$

$$EI = \frac{\frac{EcIg}{5}}{1+\beta d} = \frac{22360.68\ x\ 10^3\ x\ 4.70\ x \frac{10^{-4}}{5}}{1+0.64} = 1281.65$$

$$Pc = \frac{\pi^2 EI}{{l_u}^2} = \frac{\pi^2\ x\ 1281.65}{3^2} = 1404.06\ kN$$

$$\delta = \frac{1}{1-\frac{P_f}{\Phi P_c}} = \frac{1}{1-\frac{127.16}{0.85\ x\ 1404.06}} = 1.12$$

Modified Moments due to slenderness,

D + L, Mf = 3.22 x 1.12 = 3.61 kNm

D + L + W, Mf = 3.49 x 1.12 = 3.91 kNm

**In-Plane Shear**

Count of Seismic Weight

Count of Dead Load and Wall Load

Dead Load in line with m2 and Wall Load in step with m2 (For 180mm Exterior Wall) = (Density of Concrete × Thickness of cement in the divider board) + (Density of EPS × Thickness of EPS in the divider board) = 2.Half kN/m2

Dead Load in line with m2& Wall Load in step with m2 (For 120mm thick Interior Wall) = (Density of Concrete × Thickness of cement inside the divider board) + (Density of EPS × Thickness of EPS in the divider board) =1.757 kN/m2

Dead burden

Floor Load = (Dead Load consistent with m2 ) × (Area of Slab) × (Number of tale) = 1353.7 kN

Outside Wall Load = (Wall Load in line with m2 ) × (Height of the divider) × (Total Length of the outdoor divider according to tale) × (Number of tale) = 1701.50 kN

Inside Wall Load= (Wall Load in line with m2 ) × (Height of the divider) × (Total Length of the outdoor divider in step with tale) × (Number of story) = 445.34 kN

All out Dead Load= 3500.54 kN

Live burden

Think about the divider at corridor,

Floor Load at Corridor= (Live Load constant with m2 ) × (Area of Slab) × (Number of story's - 1) = 1007.Seventy six kN

Rooftop Load = (Roof Live Load in line with m2 ) × (Area of the piece) = 251.Ninety four kN

Absolute Live Load= 1007.Seventy six + 251.Ninety four= 1259.7 kN

Seismic Weight = DL + 0.25LL = 3815.Forty six kN

Computation of structure seismic base shear as in line with IS 1893:2002[10]

Vb = Ah× W

Where, Vb is absolutely the shape sidelong electricity or plan seismic base shear.

Ok is the, Design even increasing pace range an incentive consistent with 6.Four.2 IS 1893

W = Seismic load of the shape regular with 7.4.2\$A_h = \frac{ZIS_a}{2Rg}$

Vb = 2.5 × (1/3) × (0.24/2) ×3815.46

Vb = 381.55kN

Shear Strength of the Assumed Concrewall Panel:

According to ACI 11.1 318R-08[11] design of cross sections subject to shear are based on

ϕVn≥ Vu

Where Vu is the factored force at the section considered and Vn is the nominal shear strength computed by

Vn = Vc + Vs [ACI 11.1.1 318R-08][11]

Vc is nominal shear strength provided by concrete and Vs is nominal shear strength provided by shear reinforcement



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Vc $= 2\sqrt{f'_c}\, hd$ [ACI 11.2.1 318R-08] [11]

h = 2 × (40) = 80mm (h is the thickness of shotcrete used in the wall)

d = 0.8 × lw = 0.8 × 6.3 = 5.04m = 5040mm

Use Imperial unit system

1MPa = 145.038 psi

1inch = 25.4mm

1kN = 0.2248 kips

h = 80mm = 3.15inch

d = 4000mm = 198.42inch

fck= 20MPa = 2900.75psi

$$V_c = \frac{2\ x\ \sqrt{2900.75}\ x\ 3.15\ x\ 198.42}{1000} = 67.32\ kips$$

Vc = 299.49 kN

Area of wire = 77.715mm2 in a 1000mm width of a panel,

Av = 2 x (77.715) = 155.43 mm2 , s = 1000mm

$$V_s = \frac{A_v f_y d}{s} = \frac{155.43\ x\ 415\ x\ 5040}{1000\ x\ 1000}$$

$= 3525.09\ kN$ [ACI 11.9.9.1 318R $-$ 08]

$$\Phi V_n = \Phi(V_c + V_s) = 0.85(325.09 + 299.49) = 530.89\ kN > 381.55\ kN$$

**Floor Panel Design**

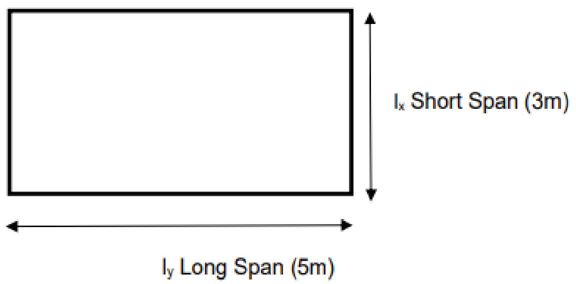
**Structure a Concrewall ground board for a room estimating 3m x 5msize. The floor board is to be based as an internal board as constant with IS 456:2000[12]. The stacking on the board is as referenced below:**

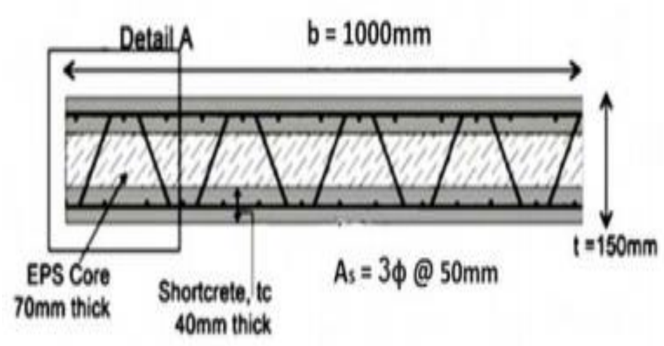
**Dead burden: 2.Zero.5 kN/m2**

**Live burden: Typical - 3kN/m2**

**Floor finish: 1.5kN/m2**

**Plan the ground board and test for its security for the above stacking**.




**Stacking on chunk:**

**Computation of Dead Load**

**Dead Load of Floor Panel in line with m2 = (Density of Concrete × Thickness of cement in the divider board) + (Density of EPS × Thickness of EPS inside the divider board = 2.1/2 kN/m2**

**Live Load = 2 kN/m2**

**Floor Finish = 1.Five kN/m2**

**Absolute Load = 5.51 kN/m2**

**Calculated Load = 1.5 x five.Fifty one = eight.265 kN/m2**

**As in step with IS 456:2000 Table 26 Bending Moment Coefficients for Rectangular Panels Supported on Four Sides with Provision for Torsion at Corners.**

**Bowing Moment Coefficients,**$\alpha_x^+ = 0.0474$

$\alpha_x^- = 0.063$

$\alpha_y^+ = 0.032$

$\alpha_y^- = 0.024$

$$M_{ux}^+ = \alpha_x^+ W_u l_x^2 = 0.0474\ x\ 8.265\ x\ 3.15^2 = 3.88\ kNm M_{ux}^- = \alpha_x^- W_u l_x^2 = 0.063\ x\ 8.265\ x\ 3.15^2 = 5.17\ kNm$$

$$M_{uy}^+ = \alpha_y^+ W_u l_x^2 = 0.032\ x\ 8.265\ x\ 3.15^2 = 2.62\ kNm$$

$$M_{uy}^- = \alpha_y^- W_u l_x^2 = 0.024\ x\ 8.265\ x\ 3.15^2 = 1.97\ kNm$$

Minimum Area of Steel Wire Mesh is 3ϕ-50mm c/c

$$\text{Area of Steel} = \frac{1000\ x\ Area\ of\ steel\ wire\ x\ 2}{Spacing\ between\ steel\ wires} = \frac{1000\ x\ 7.1\ x\ 2}{100} = 142\ mm^2/m$$

Moment of Resistance, $M_{res} = 0.87\ x\ f_y\ x\ A_n\ x\ Lever\ Arm$



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$$Lever\ Arm = d - \frac{0.5d}{2}$$

$$M_{res} = 0.87\ x\ 415\ x\ 142\ x\ \left(160 - \frac{0.5\ x\ 160}{2}\right)$$
$$= 6.15\ kNm/m$$

## VI. RESULTS AND DISCUSSIONS

For above design take off sheet is prepared for quantity estimation and cost is calculated for both the structures. Complete calculation is given in thesis report. Below given is the table for comparison of cost of both the structures.

| Component | Cost in Rs. | |
|---|---|---|
| | RCC | Concrewall |
| External walls | 881809.7 | 1198800 |
| Internal walls | 221085.5 | 425658.8 |
| Extra at joints | - | 418217.4 |
| Extra at openings | - | 74688 |
| RCC Column | | |
| Concrete | 196968.56 | - |
| Centering / Shuttering | 169734.24 | - |
| Reinforcement | 300222.94 | - |
| RCC Beams | | |
| Concrete | 247824.05 | - |
| Centering / Shuttering | 129239.57 | - |
| Reinforcement | 283296 | - |
| Slabs | | |
| Concrete / EPS panels | 407158.15 | 702869.76 |
| Centering / Shuttering | 211942.67 | 105973.97 |
| Reinforcement | 310270.41 | - |
| **Total** | 3359551.79 | 2926207.93 |

## VII. CONCLUSION

From This paper we can infer that Concrewall framework is a cutting location, gifted, covered and financial improvement framework for the improvement of structures.

1. It is a couple of times quicker than everyday RCC improvement

2. 12 – 14 % lots less highly-priced than ordinary RCC improvement.

3. It has low carbon impact, as the fabric utilized inside the improvement is wise in nature.

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