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Government of India
Ministry of Housing & Urban Affairs
Central Public Works Department

सत्यमेव जयते

CPWD

Emerging & Innovative Technologies for Sustainable Development



Technical Session on 164th CPWD Day



Prabhakar Singh
Director General

भारत सरकार
Government of India

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FOREWORD

It gives me immense pleasure to note that a Booklet on '***Emerging & Innovative Technologies for Sustainable Development***' is being brought out for circulation during Technical Session to be held on the occasion of 164th CPWD Annual Day.

The topic '***Emerging & Innovative Technologies for Sustainable Development***' chosen for the Technical Session is very apt taking into account rapid industrial and technological development, urbanization and injudicious planning without due regard to sustainable development, inducing changes in the environment and disrupting the ecological balance, which is a growing threat to the entire life support system.

Being a Principal Engineering Organization, CPWD has always encouraged use of locally available materials and Energy Efficient Sustainable Technologies. CPWD has been a pioneer in construction industry with regards to sustainable approach as being the first to prohibit use of wood in construction work and playing a lead role in use of fly ash. CPWD is committed to execute all its projects conforming to minimum three star rating thus reinforcing its outlook to environment friendly green construction.

CPWD is adopting sustainable, energy efficient and new emerging green and clean technologies in its construction to create sustainable built environment. We have exhibited our deep commitment in implementing energy efficiency measures and installation of solar power plants on roof-tops in the Central Government Buildings. We are already using new emerging technologies such as monolithic and pre-cast construction to ensure neat and tidy execution with minimal environmental pollution in our works.

The booklet contains the write ups of various buildings and other infrastructure works constructed by CPWD by using innovative materials and new clean, green and efficient technologies. I am confident that the booklet shall be well received by the readers.

I wish to acknowledge the sincere efforts and valuable technical write ups provided by Dr. K.M. Soni, CE WZ-I, Mumbai, Sh. D. C. Goel, CE, SZ-I, Chennai, Sh. N. S. S. Rao, CE, SZ-II, Hyderabad, Sh. B.B. Makkar, CPM, Supreme Court Project, Sh. Manu Amitabh, CPM (Housing), PWD, Delhi, Sh. C.K. Varma, CE(E)(CSQ), Sh. T. Tiwari, PM, Development Project Circle, Sh. R. K. Sao, SE,CCEC, Chandigarh and Sh. Awadhesh Kumar, SE, DCEC- I in preparation of the booklet.

I also congratulate Smt. Usha Batra, ADG (Arch), Sh. D. K. Garg, CE (D&DM) and his team of officers for taking pains in publishing this booklet in a very short time.

(Prabhakar Singh)

CPWD

Monolithic Construction Technology - Tunnel Formwork

Er. D.C. Goel, *CE SZ-I, Chennai*

Introduction :

(Adapted verbatim from https://theconstructor.org/concrete/tunnel-form-construction-technique/8574/ being in public domain and is thankfully acknowledged)

Tunnel Form Construction Technique was invented over 50 years ago. The use of tunnel-form produces high quality monolithic structures. It eliminates the use of any subsequent wet trades (Plastering etc). It is basically an operation to cast walls and slabs in one operation in a daily cycle. This technique is highly systematic, earthquake proven and provides an ideal solution to the critical problem of sound transmission. It gives a sound reduction of 50 decibels.

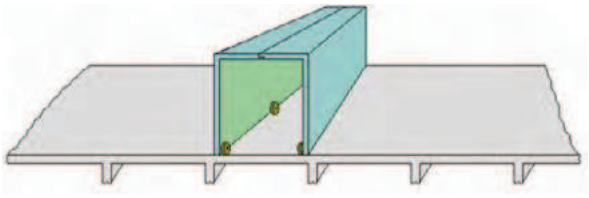
Tunnel form is widely used in the construction of cellular structures with high degree of repetition such as:

- Prisons
- Hotels
- Student Accommodation (Hostels)
- Housings
- Commercial Developments

It reduces the heating costs by providing "Thermal Mass" and speeds up the building process. However, specialist contractors with tunnel-form experience are highly recommended in order to tailor the design to suit best construction method.

Tunnel formwork comes in half units and in the form of an inverted "L" which are bolted together at the top to form each tunnel. The inbuilt wheels and the jacks help the formwork move in and out of the position and adjusted to the final height.

The factory-made steel formwork can be reused up to 500 times and it can suit a variety



of module sizes. This makes the method of construction very versatile and extremely economical.

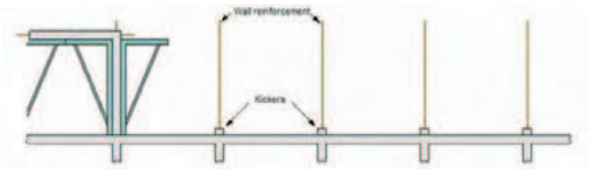
Tunnel-formwork allows a 24-hour construction cycle to be achieved and thus the buildability of in-situ concrete is improved by choosing this type of formwork.

In practice, when the two halves are bolted together, the tunnel formwork will appear like the following figure.

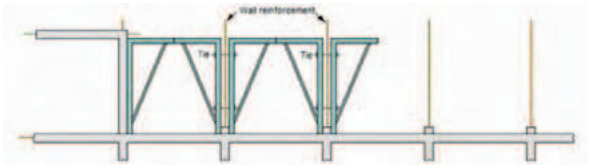


The Casting Process of Tunnel Formwork :

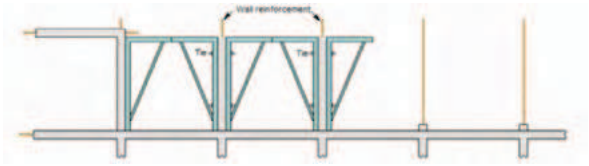
Stage 1 : Prefabricated/Tied in place Wall reinforcement is placed by crane along the entire wing prior to casting the kickers (used to position wall formwork). Service lines and connected requirements are laid along with.



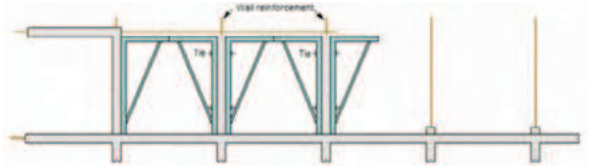
Stage 2 : Two and a half tunnel is craned into place, bolted together and ties are added.



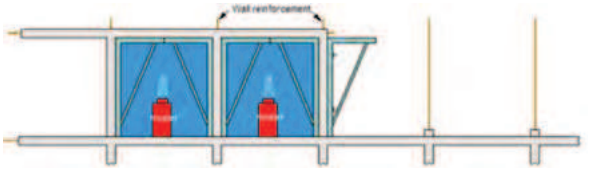
Stage 3 : The slab reinforcements are placed either as prefabricated or assembled at site.



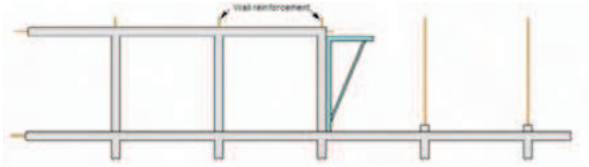
Stage 4 : Pipes for services such as electrical, fire-fighting and fire alarms are laid along with.



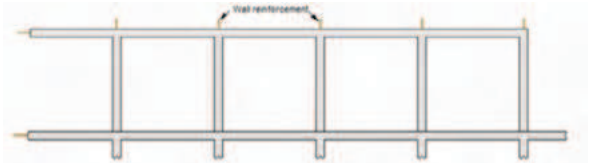
Stage 5 : The slab concrete is placed. The formwork system provides for a pour to be wrapped in tarpaulins and for the use of butane heaters to maintain a sufficiently high temperature for the concrete to reach its striking strength overnight.



Stage 6 : The tunnel-forms are removed next day.



Stage 7 : The process is repeated for the next two bays.



Tunnel form can produce strong and durable in-situ cellular structures. This method of construction can achieve time savings up to 25% with cost savings of 15%. Since the concrete finish is very good, the requirement for post construction trades such as plasterers and electricians are greatly reduced.

Scope :

Consequent to accord of A/A and E/S for Rs. 208.95 Crores for construction of 532 Nos Quarters for Income Tax at Anna Nagar, Chennai, CPWD invited technology neutral contract. Construction technologies with precast concrete and / or monolithic concrete were emphasised.

In the initial stages, the project had teething problems related with clients and local bodies.

Each issue was escalated to appropriate hierarchy and were resolved which saw the light of the day for the project. While these unavoidable hindrances were being dealt, parallel efforts were being made to identify a technology which could be safe, speedier and yet satisfying the requirements of technology prescribed by Ministry of Urban Development now Ministry of Housing and Urban Affairs.

The configuration of the proposed construction is as hereunder -

	Type 2 (G+18)	**Type 3 (G+18)**	**Type 4 (G+18)**
Number of Towers	1	2	1
Units per floor	8	8	4
Total Number of Units	152	304	75
Plinth Area/ tower/ floor (sqm)	767.18	855.15	661.63
Plinth Area/ DU (sqm)	67.60	78.57	120.13

Total Plinth Area: 57706 Sqm

The scope of work includes –

- Dismantling of existing dilapidated old quarters.
- Pile Foundation of length varying from 25 to 30m depth.
- Execution on design & built mode with rates quoted on plinth area basis as per Architectural drawings prepared by Senior Architect of CPWD properly finished complete as per schedule of finishes incorporated in tender.

Design Challenges :

A. Architectural

1. Due to high cost of customized form work, it was essential to allow sufficient numbers of repetition, slight modifications in architectural drawings were carried out to achieve symmetry.
2. Wall projections minimized to facilitate removal of tunnels after stripping.
3. Doors, windows and other opening were finalized beforehand as they had to be provided in the fabrication of the form work.
4. Front face of the structure has to be kept open for removal of tunnels.
5. Sun shades were avoided.
6. Building orientation done in a manner (Shorter length in E&W) to achieve thermal comfort.
7. Clearstory windows are oriented in N & S directions to get North light and air circulation without direct sun light.

B. Structural

1. Front portion of RCC tunnels was required to be kept open for taking out formwork.
2. This posed challenges in seismic / wind design.
3. Many iterations were carried out to satisfy design requirements

C. Services (MEP)

1. All services have to be designed beforehand as it would not be possible to create openings in future.
2. Openings were provided not only for present requirements but considering future requirements also.
3. 3-D modelling using REVIT was carried out and all services were planned and conflicts resolved.
4. All services including Rain water Pipes can be accessed from floor.
5. Necessary pre planning of future provision of Electrical appliances are taken care.

Present Status:

The Tunnel form work for this work was received in India from Turkey on 30.03.2018. Assembly of tunnels and trials were completed by April 2018.1st casting was carried out on 2nd May 2018.

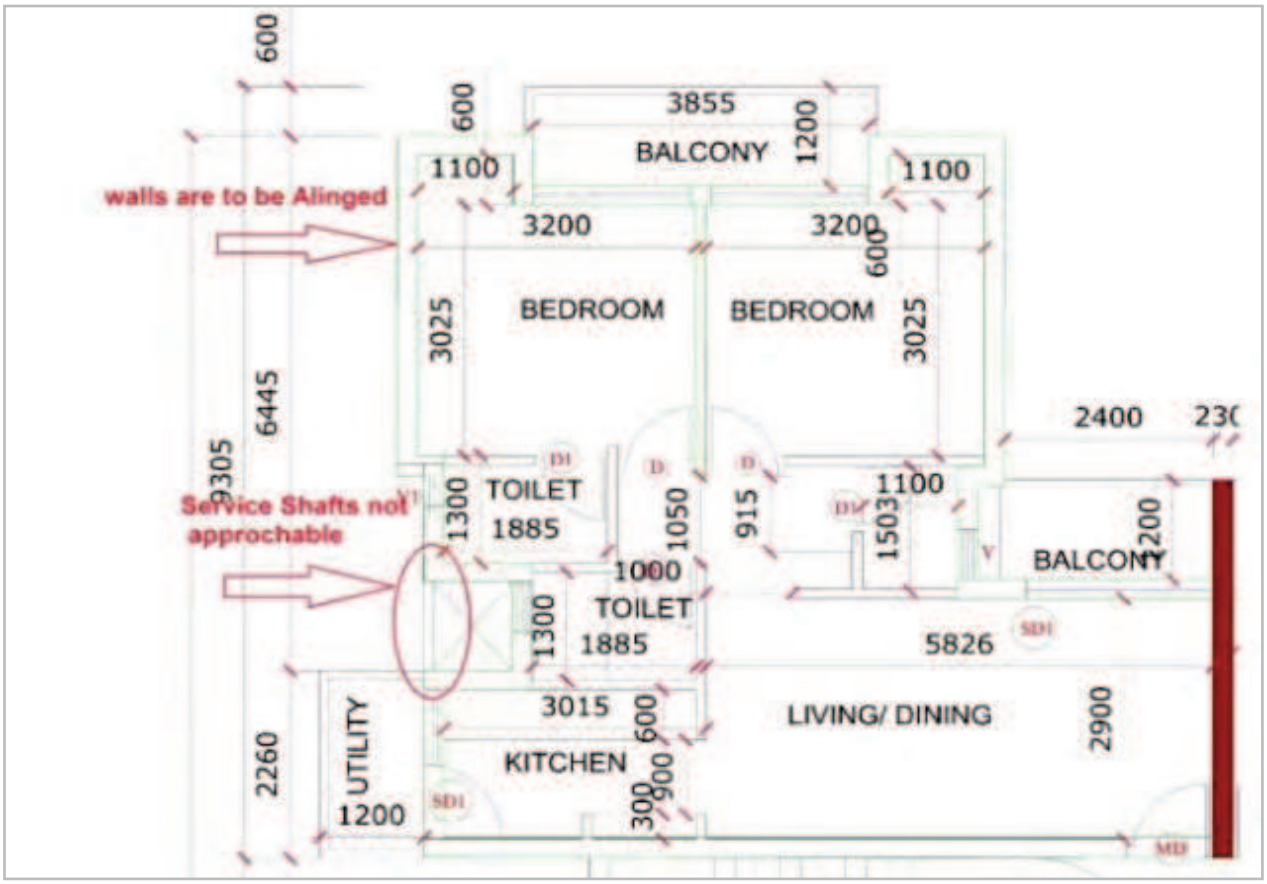
In the month of May 2018 itself, casting of total of three floors was done thereby completing 24 Dwelling units of Type II in the 3 floors.

The pace of execution has increased in June 2018 with another set of Form work being used for casting of Type-III block. Our target for June 2018 is 40 DUs – 20 each for Type II and III

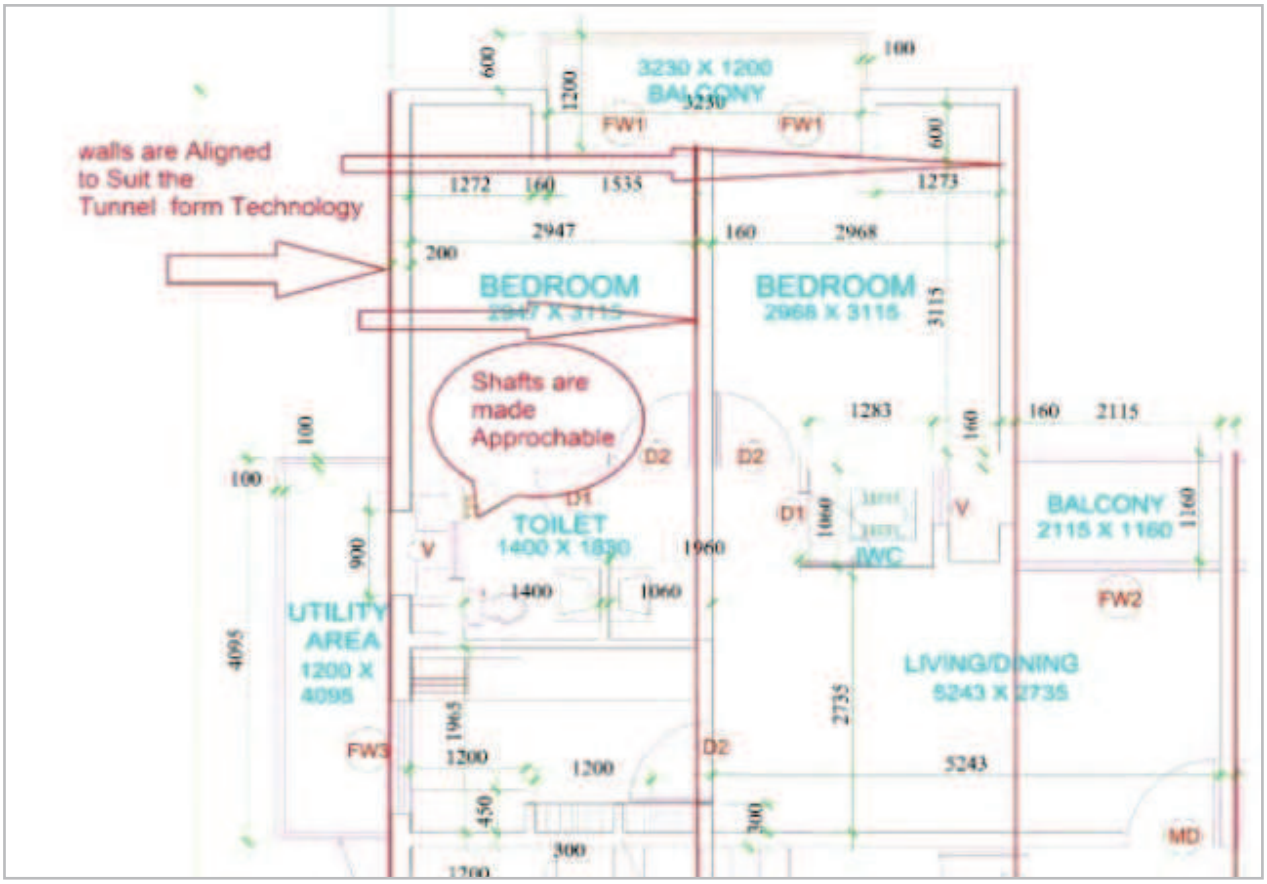
Mission - A flat a day

Vision - Technology adaption

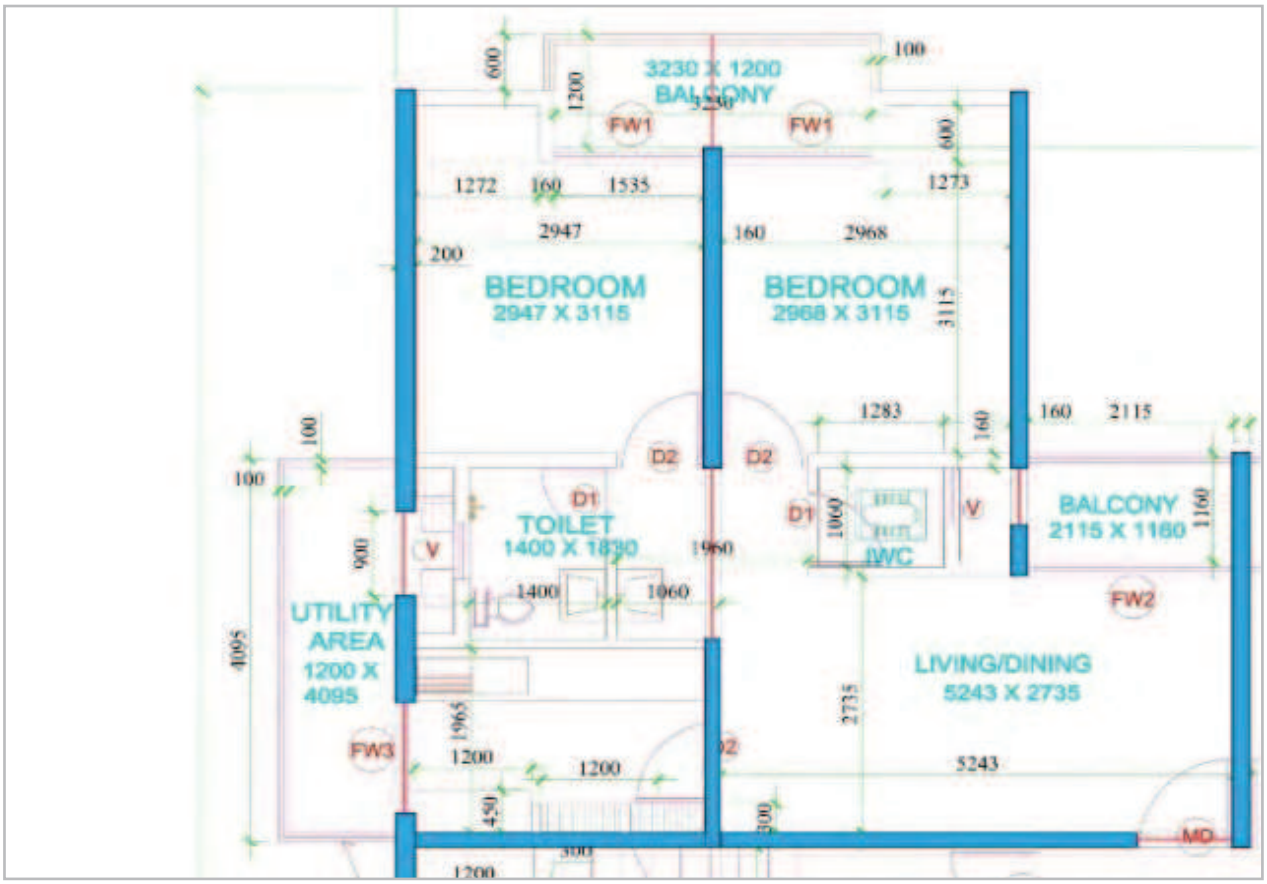
Plan - Complete 532 flats structurally by 30.04.2019 and finish them by 30.09.2019.



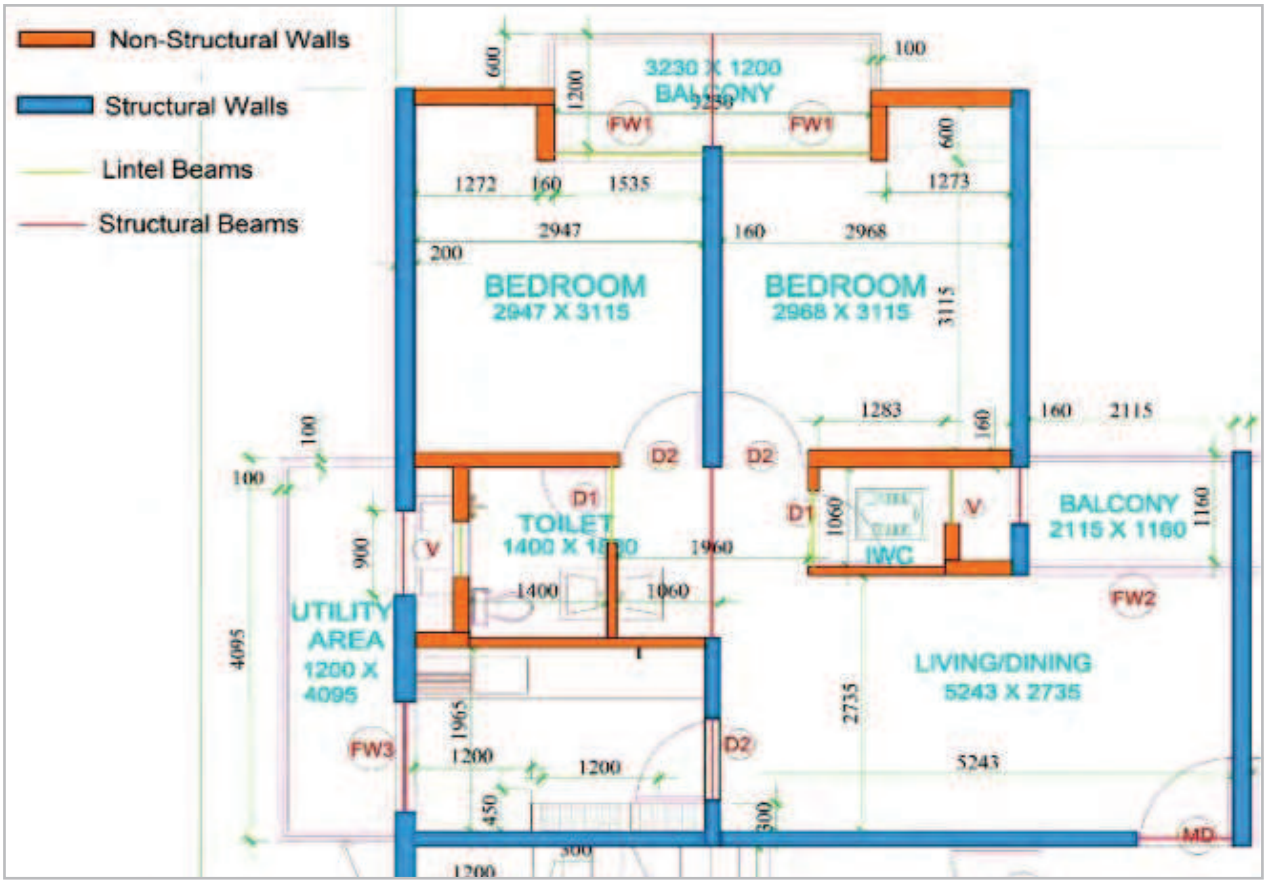
As per conventional conception



As per tunnel form conception

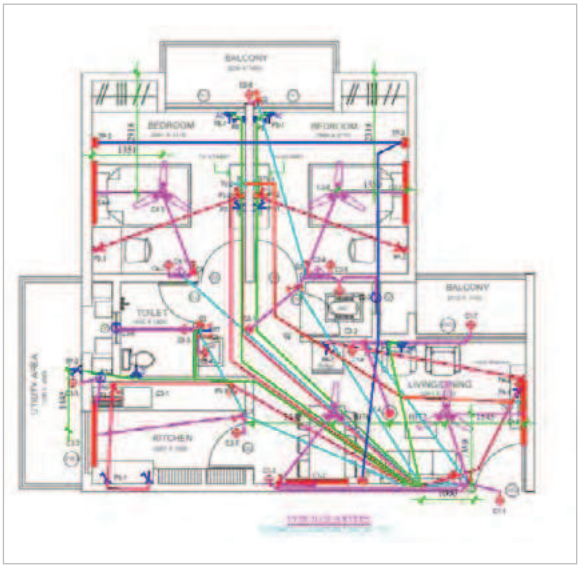


Structural wall configuration



Structural and non-structural wall configuration

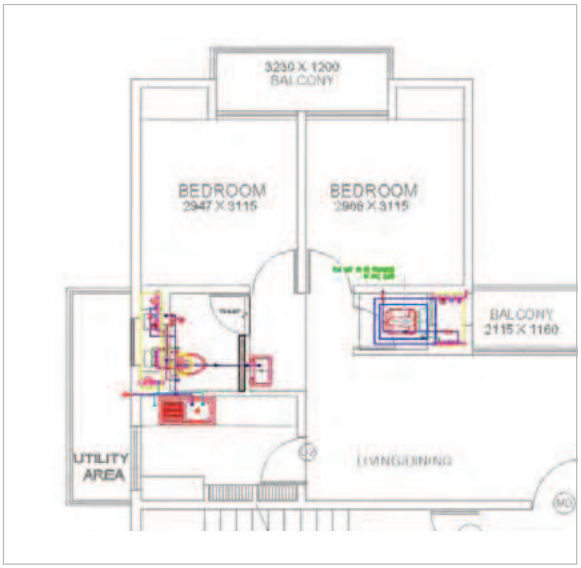
Services :



Electrical layout



Sanitary layout



Plumbing layout

Start of Work at Site:



Demolition of existing old blocks

Construction after Demolition for Re-Development :



Type II – 20 DUs as on 31st May 2018
(one month's progress of superstructure)



Secretary MoHUA & DG CPWD inspecting the work on 07.06.2018

Multi Level Car Parking Block for SBI DATA Centre at Hyderabad – Precast Construction Technology

Er. N.S.S. Rao, *CE SZ-II, Hyderabad*

Name of Work	:	Design & Construction of G+3 Storeyed Multi Level Car Parking Block with Precast Technology including Internal Water Supply, Sanitary Installation, Drainage, Internal Electrical Installation & Fans, Telephone Conduits, Automatic Fire Alarm System, Fire Fighting with Wet Riser and Sprinkler System, Passenger Lifts and Car Lift for SBI DATA Centre at Gachibowli, Hyderabad.
Name of Client	:	State Bank of India, Ministry of Finance.
Technology adopted	:	Precast Technology.
Total Built up Area	:	7595 sqm
A/A & E/S	:	Rs.19,70,70,000/- including 3% contingencies.
Tendered Amount	:	Civil & Electrical = Rs.14,14,23,429/- (Composite Tender)

Time Allowed for Completion of Work : 180 Days, Stipulated Date of Start : 30.05.2017.

Stipulated Date of Completion : 25.11.2017, Actual Date of Completion 30.05.2018.

Nature of Construction: The proposed building is designed and constructed as cast-in-situ up to foundation and precast / pre-stressed in super structure involving columns, beams, hollow core slabs, ramp, staircases, external / internal walls and lift core walls and other precast elements as per design requirements.

The main structural members like beams, slabs, ramps etc are precast pre-stressed members. The car parking block is G+3 storey structure having 7595 sqm plinth area and housing for 244 nos. cars and 185 nos. two wheelers.

The Architectural drawings were prepared in house. The agency M/s. Preca Solutions designed it and got approved from IIT Madras.





Detailed Scope of Work :

RCC Work in Foundation & Plinth: Foundation work including pedestals and pocket for columns are cast in-situ RCC work in M25 Concrete.

RCC in superstructure in Column, Beams, Stairs, Walls & Slabs - All Precast Members:

i. Precast external & internal wall panels, 200mm thick with M40 concrete & Fe 500D.

ii. Precast parapet wall panels, 200mm thick with M40 concrete & Fe 500D.

iii. Precast pre-stressed beam with M60 concrete & pre-stress steel Fe P1860.

iv. Precast pre-stressed hollow core slabs, 200mm thick with M50 concrete & pre-stressed steel Fe P1860.

v. Precast staircase (150mm riser and 300mm tread width) M40 concrete & Fe 500D.

vi. Precast solid slabs for ramps landing, 200mm thick with M40 concrete & Fe 500D.

vii. Precast columns with M40 concrete & Fe 500D.









Flooring :

Car parking and ramp portion flooring is provided with screed concrete grade M30 including temperature reinforcement provided over and above the precast beam and slab to make the complete slab as monolithic structure. FOSROC Polyurethane based flooring finish in car parking area including ramps is provided for skid resistance surface including Lane & Bay markings for parking.

The two passenger lifts and one car lift are provided as per the specific requirement of the Client.

The ramp has been taken up to the terrace to facilitate the terrace as car parking.

RR Masonry provided up to plinth level. Granite, Wood Work, Steel Work etc. is provided as per the regular Specifications of the CPWD.

Cost Comparison :

Cost of Precast/Pre-Stressed work in superstructure : Rs.10,957/- per Sq.m.

Cost of RCC Work in Superstructure for ongoing works : Rs. 6,568/- per Sq.m.

The cost of completed building is Rs. 21,066/- per sq. m. approximately.





Reasons for selection of Precast Technology :

1. The campus is functional campus. In and around all the buildings are occupied and in use. In particular the DATA Center for SBI which is working adjoining to Car Parking is to be free from external dust.
2. No free space was available to stack material and machinery for making green concrete at site.
3. The pollution levels can be controlled / minimized at site.
4. Minimum / optimum usage of water at site.
5. Since the elements are manufactured / cast under controlled condition, the quantity of concrete is better.
6. Before erection, the elements are subjected to physical testing.

The fabricating yard is located at approximately 30 km. from the construction site. Total 10 nos. precast / pre-stressed elements and 1 no. bed hollow core slab of 150m / 180 sqm were casted at casting yard per day. The precast / pre-stressed beam curing was done with steam curing for 3 days and curing of other members were done by manual curing method for 10 days at factory. The members / elements transported after getting 75% of 28 days strength i.e., the member could be transported after three days with steam curing and 10 days with normal water curing. The quality of the precast / pre-stressed members as per structural drawing were ensured by deploying one engineer at fabricating yard. Due to restricted space available at site, the various precast elements were transported from fabrication yard in the trailers during the night time and the same were erected in day time on next day. Although, the time assigned for the work was 6 months however, due to revision of the Architectural and Structural design and changes offered by the client, the work could be completed in 12 months.

Creating Sustainable Urban Elevated Road Corridors in Delhi - A Case Study

Er. Sarvagya Srivastava, *E-in-C(Retd.), PWD, Delhi*
Er. Manu Amitabh, *CPM, PWD, Delhi*
Er. Manoj Kumar, *PM, Flyover Project Circle, PWD, Delhi*

Introduction :

Delhi has maximum number of vehicles on its roads, more than the number of vehicles in other metropolitan cities, i.e., Kolkata, Mumbai and Chennai put together. There are 7.5 million registered vehicles in the city, which is the highest in the world among all cities, most of which do not follow any pollution emission norm (within municipal limits), while the National Capital Region Delhi (NCR Delhi) has 11.2 million vehicles. It is estimated that Delhi and NCR lose nearly 42 crore (420 million) man-hours every month while commuting between home and office through public transport, due to the traffic congestion.

The city planners and departments entrusted with creation of public transport infrastructure face the relentless challenge of allocating the rapidly shrinking scarce land resources for creation of assets like flyovers and underpasses.

The Ring Road, with a 6 to 8 lane divided carriageway has some of the highest traffic density stretches in Delhi, with average daily traffic of over 1,75,000 PCUs and peak hourly traffic touching 10,000 PCUs, requiring immediate solutions of additional lanes. The ring road passes through highly congested and densely populated areas of Delhi, with no scope for addition of extra lanes at-grade. The only solution left is constructing elevated corridors over the existing carriageways one of the access-controlled solutions.

However, the challenge to find space for pillars for the 6 additional elevated lanes still remains. In this endeavor, The Public Works Department (PWD) Delhi has used the segmental construction technology for creating an elevated corridor over the Ring Road in Delhi. PWD has found a structural design and construction methodology solution in a design concept for a six lane divided carriageway of 24.2 m width, supported on a single pier on the space of the central verge. The structural system consists of a longitudinally post-tensioned spine beam superstructure, with transversely post-tensioned wings put in place by an elaborate launching system, and later stitched.

Structural System :

A structural system on single central verge piers, consisting of a longitudinally post-tensioned spine beam superstructure, with transversely post-tensioned wings put in place by an elaborate launching system, and later stitched, was devised, as shown in the Fig.-1.

The super-structure consists of the flyover deck of width 24.20m. The whole box girder is supported on single column. Since, transportation, erection of full box girder is not feasible without heavy launching girder and cranes, the superstructure is divided into three parts namely two cantilever slabs and two cell Box girder. The loads on cantilever slabs shall be transferred essentially to box girder from there to bearing thus to pier and foundations. For all longitudinal actions (longitudinal bending/shear force/torsion etc), are through central box girder only, thus it is called as Spine Beam.

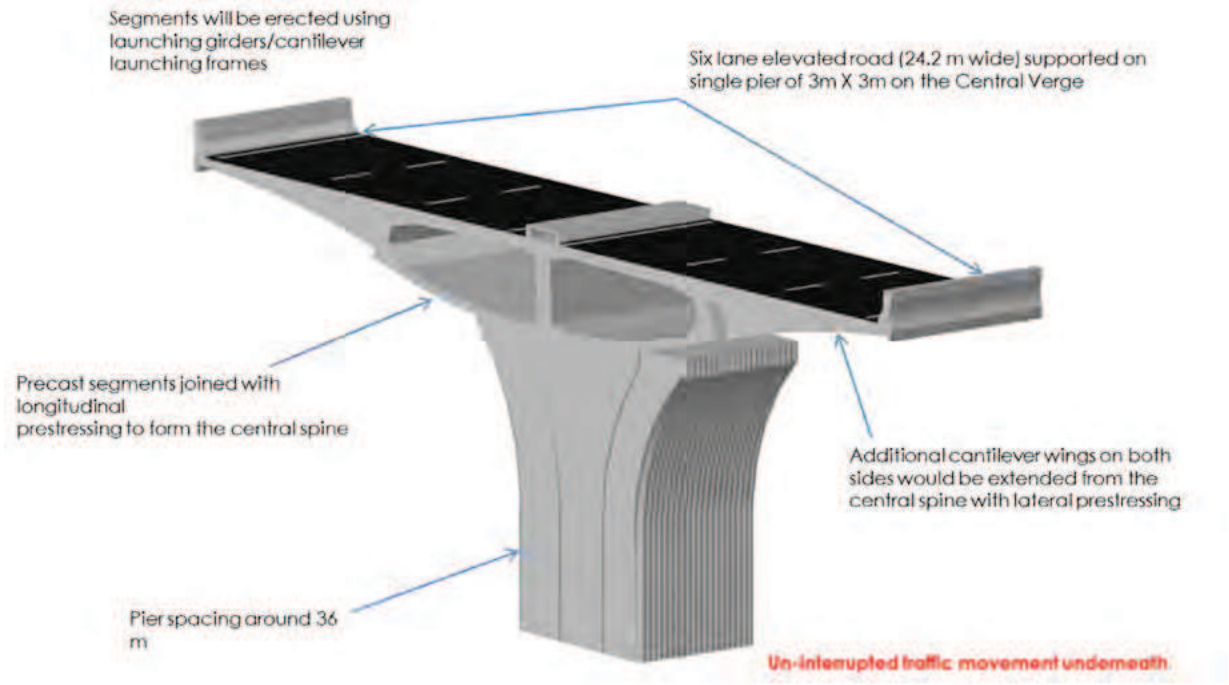


Fig. 1 : The Structural System

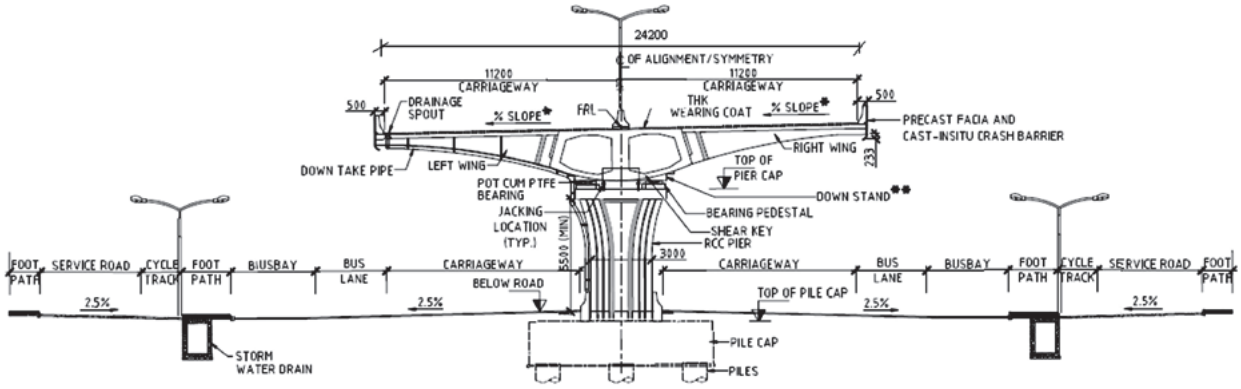


Fig. 2 : Cross-section of Elevated Corridor

The Spine Beam Superstructure is two cell box girders with inclined webs. The overall width of the spine beam is 6.0m at top. Cantilever Slabs (Wings) on either side are 9.10m each. The cantilever slab portion is provided with Ribs which are abutting to Spine beam Webs. The diaphragms are proposed at bearing location only; its thickness is 700mm.

The transverse spacing of bearing is 3.250m and the distance between the bearings in longitudinal direction is 1000mm from centre of the pier. The clear spacing between the diaphragms works out to be 1000m.

The sub-structure consists of Single column with "Dumble" shape in cross section with varying width is proposed from aesthetics point of view. Grooves of 25mm deep are provided on the surface to improve the aesthetics of the pier. The top width of the pier is restricted to 4.50m (H) and 3.20m (L) in longitudinal direction. The Vertical Clearance of 5.5m is measured on roadside beyond vertical plane drawn on outer face of crash barrier, i.e., with horizontal clearance of 0.5m from outer face of pier.

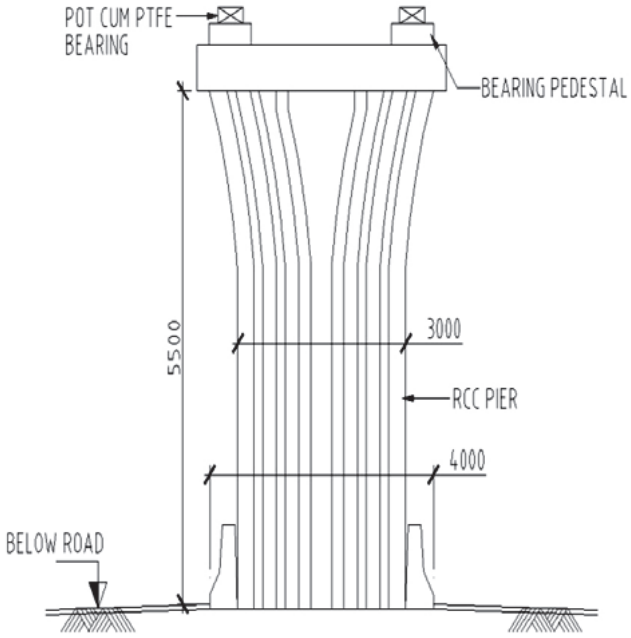


Fig. 3: Typical Pier for Viaduct Portion of Flyover

The Foundation System consists of pile foundations with 1200mm diameter piles. As per the geotechnical investigation and load analysis, the length of the piles is kept around 36.0m. The minimum thickness of the pile cap is 1800mm to give adequate rigidity for pile group. Since structure is simple supported with deck continuity, differential settlement of the foundation does not affect the performance of the superstructure and substructure.

Expansion joints have been planned for typical span at spacing of 108m. Each deck is supported by four POT/PTFE bearings as shown in the Fig. 4. The bearing articulations have been arranged to allow the bridge deck to contract and expand longitudinally about its centre while minimizing the strain on the substructure caused by the deck movement. To arrest the dislodgement of superstructure, the deck is fixed to substructure through seismic arrester/Shear Key. Shear Key arrangement is the primary defense followed by pin bearing at Fixed Pier location. Shear key is designed to take full seismic force and longitudinal forces as derived in the load combination.

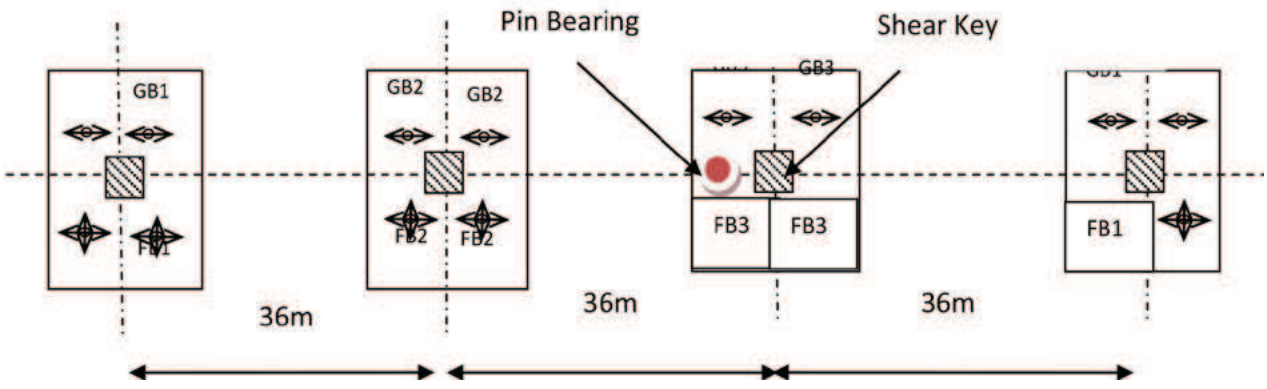


Fig. 4 : Arrangement of Bearings

Construction Methodology :

The Construction Methodology is governed by site constraints, where there is a lack of availability of land for diversion of traffic. Therefore, stage construction is adopted for obligatory and viaduct spans.

The concreting for piles is being carried out by means of Batching Plant / Ready Mixed Concrete and delivered by transport mixed and placed by tremie.



Fig. 5 : Transportation of Spine Segments

The superstructure is being constructed by Precast Segmental Construction in two parts i.e, Spine Beam and Cantilever Slab with Ribs. Further, Spine beam is also being constructed by Segmental Construction. The maximum length of the segment is restricted to 3.0m for running section and 2.0m for diaphragm segments. The restriction of segment length is based on the assumption that the weight of the segment maintained is less than 50MT and easily transportable on low bed trailers. The precast segment are erected with overhead Launching Girder (L.G) with suspenders. All the segments of a single span are suspended from L.G, aligned and joints glued. For this glue to be effective, temporary external pre-stressing is applied by Macalloy/Dywidag bars. Once the pre-stressing operation is completed the superstructure is lowered on temporary packing to support the spine beam. The L.G moves forward for erection of next span as shown in Fig. 6.



Fig. 6 : Erection of Spine Segments

In the next stage, the precast cantilever wings are erected by using a steel frame / portal structure supported on the already erected spine beam for lifting and aligning the precast cantilever segments. In case of curved span, cantilever slab is lifted on inner curve side first before erection of outer curve cantilever wing.



Fig. 7 : Wing Segments

Once the cantilever segments are erected, longitudinal and vertical stitch joints between the cantilever slab and spine beam are carried out. This activity can be carried out for the entire cantilever wings (always a pair of wings) before application of transverse pre-stressing. Pre-stressing is also carried out individually as a pair of cantilever wings, once the in-situ stitch concrete attains minimum strength of 35Mpa. The cantilever segments are held in position using the steel frame structure till transverse pre-stressing operation is carried out. After completion of the transverse pre-stressing, the transverse joint between the cantilever wings is done.

Due to the curved natures of the soffit of the spine segments, the stacking of these segments is done in suitable designed saddles to maintain the stability of the segments. The segments are lifted from the bed, loaded on to the trailer and off loaded at the stacking area by means of a 100 Ton capacity mobile crane moving in the hoarded area of the construction.

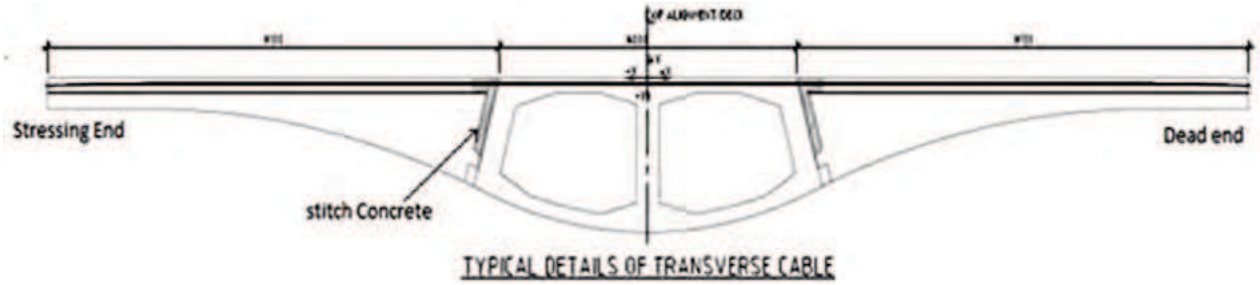


Fig. 8 : Details of Transverse Wings

Cost-Benefit Study & Analysis

A cost-benefit analysis was done for all these elevated corridors under construction.

The summary of the findings of the study, for one of the elevated corridor projects i.e. Prembari Pul to Azadpur is presented below. It was found that the cost of the 1.32 Km elevated corridor (total length of corridor improvement is 2.5 Km.) would be recovered in 3 years.

Overall, for all the four stretches combined, lot of benefits will accrue to the citizens of Delhi in terms of savings of time, fuel and a huge reduction in pollution. As per the study for all the stretches, around 24,000 man days will be saved daily which it is equivalent to saving of Rs. 330 crore per year. In terms of fuel saving, approximately 31,500/- litre of fuel will be saved per day which is equivalent to 70 crore saving per year. With regard to reduction in pollution, it has been estimated that Co2 emission would be more than 12 tons during peak hours which is equivalent to 12 carbon credit per hour and there were earning of 6.95 crore per year. For construction of all the four stretches of the project, around 1500 trees are being cut but 1.53 crore trees are required to absorb the Co2 emission being reduced by this project. This project therefore, alone, is equivalent to the benefits of 1.53 Crore full grown trees.

Conclusions :

This case study finds that not only do such segmental structural design and construction methodologies can solve the various vexed and conflicting goals of creating elevated corridors in congested metropolises, where land is not available, but they also offer a sustainable solution on the balanced score-card of social, economic and environmental costs.



Fig. 9 : View of completed Elevated Road



Fig. 10 : View of completed Elevated Road

Supreme Court Additional Office Complex, N. Delhi - Innovative Technologies Intervention

Er. B. B. Makkar
CPM, Supreme Court Project, CPWD



Various emerging and innovative technologies have been adopted in the construction of additional office complex for Supreme Court. Some of the emerging / new and innovative technologies adopted are as under:

- Soil Nailing
- Soil Anchoring
- C&D Block Masonry
- Erection of SS Space Frame
- Largest Roof Top Solar Power Grid of 1400 KWp capacity.
- All LED based and energy efficient light fixtures.
- Day Light Sensor and Occupancy Sensor for optimization of power consumption.
- Integrated Building Management System for management of incoming power supply, HVAC system, Fire Alarm and Fire Fighting System.
- Sewage Treatment Plant with facility for used water recycling. No sewage disposal in municipal sewage system.
- Automatic Sprinkler irrigation system with STP recycled water.
- Centralized Parking Management System in three basement with 1800 car capacity.
- HVAC System -
  a. Pre Insulated (factory Insulated) Chilled Water pipe used for central air conditioning system.
  b. Free Cooling and Night Purging System in Air Conditioning Areas for reducing the heat load at the start of chilling unit system which shall be automatically control through IBMS system.
  c. Fresh Air Supply and Smoke Extraction System in Tower Air Conditioned area in case of fire.

d. VFD control Ventilation System for ventilation of basement in case of normal ventilation and in case of fire ventilation.

- Grooved Flexible Couplings used for jointing M.S. pipe meant for fire fighting. This coupling provides dependable method of joining pipe, allowing for angular and linear deflection, thermal expansion and contraction.
- IP based EPABX System with 3000 nodes capacity.

Soil Anchors :

The building has three basements and being near the bed of river Yamuna, the water table of the area is very highi.e. at 2m below the ground. To protect the raft which is placed at 15.2 m below the ground against floating under high up thrust, Soil Anchors has been used. There are 3500 soil anchors used for raft area of 30000 sqm. In each anchor, 4 nos. high Tensile Strands of dia. 15.2 mm were grouted in bore which is 20 meter deep below raft level. Out of 20 m,10 m is fixed length and 10 m is free length for post tensioning. The anchors were tested at a tensile stress of 78 T (1.5 times the required stress of 52 T as per design). These anchors so installed in grid provide downward force on raft protecting it from the ground water up thrust.

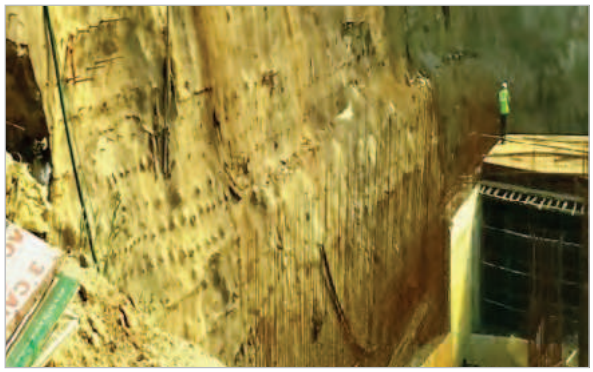


Soil Anchor


Drilling Rig

Soil Nailing :

The space available after excavation was too short to cut soil in natural self supporting slope, it was decided to retain the vertical cut surface of soil through soil Nailing. Soil nailing is a temporary earth retaining structure






Soil Nailing

used for supporting vertical soil during excavation with limited setback conditions. This technique uses the pull out strength of the reinforcement which should be more than the weight of slip surface of the earth. Soil is reinforced with closely spaced steel nails (TMT bars) and surface is shot-creted using steel wire mesh.The nailing is done at an angle as per design. Drainage pipes are also provided to act as weep holes.

C&D Block Masonry :

Construction and Demolition Waste is used to manufacture these blocks. These blocks have compressive strength higher than Class I red brick (10 Mpa) due to which these can be used in external walls, toilet walls and lift well walls. The blocks of size 100x200x400 has been used at this site. Pull out strength for fastener is found satisfactory. As a green measure, no red brick has been used on this project. About 17.50 lac of C&D waste blocks has been consumed on this project.





C&D Block Masonry used in the project

Waterproofing :

Self adhesive HDPE flexible membrane of 1.2 mm has been used for horizontal waterproofing.The membrane develops a continuousadhesive bond with the concrete poured on it. This prevents water migration between structure and the membrane, substantially reducing the risk of leakage. The membrane along with preprufe tape and LM has been used to seal the bore created for soil anchors





Water proofing

Thermal insulation System for building envelope :

The building complex has adopted cavity wall insulation system wherein fiberglass wool insulation board of 30 mm has been fixed between the outer wall made of C&D block masonry and inner wall of autoclaved aerated concrete blocks. The thickness of insulation has been considered optimally to satisfy thethermal transmittance value as per energy conservation building code (ECBC-2007).

Similarly for the roof, the underside area has been insulated with fiberglass insulation boards of 60 mm thickness. The lightweight fiber glasswool insulation board has been adopted with factory applied aluminum based vapor barrier & tissue based mechanical barrier on opposite faces. The board has been fixed with polyamide based fasteners. The material has helped in reduction of heat load and hence will help to reduce energy consumption in building.



Thermal insulation System

Free Cooling and Night Purging System in Air Conditioning Areas :

Fresh Air is being inducted in the Air Conditioned area at the time when outside temperature is comfortable like early morning in summer season. This is also called Air Purging. Air Purging is by operation of motorized damper and fire smoke dampers installed in AHU, thereby initial attic heat load on AC plant is reduced. Fresh air is inducted in common areas through shafts by the fans which are installed at terrace of the building This whole system will be operated through IBMS system automatically at per the pre-defined programme.

In case of fire signal received from particular area, same set of operation shall be operated by signal received from addressable fire detection system and this shall supersede the IBMS command.

VFD Control Ventilation System for ventilation of basement :

At the time of preparation of NIT, as per NBC, air charge rate was 30 ACPH in case of fire and 15 ACPH in normal ventilation in basement. As per amended NBC, air change rate is revised from 30 to 12 ACPH.

As per design, same ducting was to be used during normal and fire mode ventilation. As the same fan and same ducting is to be used for normal operation and fire operation, pressure drop across the duct increases by 3- fold during fire mode operation. Therefore, fans have to run at different speed and Variable Frequency Drives (VFD) have to be used.

Based on Fan curves, it was decided that all the fans will run at lower speed during normal ventilation to achieve 8 ACPH and at full speed during fire mode to achieve 12 ACPH. As a result, the power consumption during normal mode will drastically reduce.

In normal case, the CO sensors shall give the signal to axial fans to meet the ventilation demand. In case of fire, the fire panel will give the signal to axial fans overriding the signal of CO sensors.

National Institute of Securities Markets – A New Approach of Modernity

Dr. K. M. Soni, *Chief Engineer, WZ-I, Mumbai*

National Institute of Securities Markets (NISM) is an educational initiative of SEBI (Securities Exchange Board of India) India. In securities markets, NISM is already recognised all over the world. The institute entrusted the work of project management consultancy to CPWD. M/s Hiten Sethi & Associates were appointed as consultants of the project.

The institute was allotted 70 acres land by MIDC (Maharashtra Industrial Development Corporation) at Patalganga, Rasayani in Raigarh district located at about 75 kms from Mumbai international airport on Mumbai-Pune expressway. The land was in three plots, measuring 53 acres, 10 acres and 7 acres. The institutional buildings and hostels were designed in the plot of 53 acres while residential buildings in 10 acres plot. Plot of 7 acres area has been reserved for future expansion.



NISM Campus

Architectural Concept :

The architectural concept of main campus is based on an axis passing through orientation block, centre of academic blocks and library. All the infrastructure facilities are planned on both sides of this axis. There are two gates, main gate near orientation block and rear gate near hostels. The recreation block and library are planned in such a way that they are close to the hostels. The hostels are connected through a corridor to amphitheatre, dining hall, and academic blocks. Main entry to the campus for the visitors is through orientation block in front of which two water bodies are created. The orientation block, academic cum administrative blocks (4 Nos.), library, amphitheatre, auditorium, dining hall, recreation block, hostels (3 Nos. Students hostel and 1 MDP executive hostel for about 1000 pax) and utility block are designed in 53 acre plot while residential block (42 flats) for the faculty and director's bungalow in 10 acres plot. To avoid large cutting, levels of various buildings have been adopted as per the topography of the area. For

better maintainability during life cycle of the buildings, all the services like external water supply, fire and electric cables except sewer lines were taken through trenches.

The buildings are planned as four star green GRIHA rated buildings. Total sanctioned cost of the project is Rs 315 crores which includes cost of interiors, furniture and furnishing and agency charges.

Structural Concept :

All the buildings are designed as RCC structures with required earthquake resistant design. The hostels and residential block are G+7 storeyed structures while academic blocks and orientation block as G+2 storeyed structures. Dining hall is designed below open air theatre to utilise the space. Some portions of the slabs of the academic blocks have been designed as post tensioned slab to get the advantage of higher headroom required for air conditioning.

All the buildings except utility block are designed as air conditioned buildings.



Hostels

New Building Materials :

Speciality of the project was use of large numbers of new and innovative materials in the project, both in construction and interiors. Some of them are discussed below:

Autoclaved Aerated Concrete (AAC) Blocks :

Factory made eco-friendly AAC blocks having low density (@ 550 kg/m^3) have been used in all masonry work. Apart from the light weight, they have good acoustic and insulation properties. The blocks reduce the weight of structure and also produce quality construction.

Glass Fibre Reinforced Concrete (GFRC) Panels :

GFRC panels have been used in the façade of orientation block having curvilinear surface to avoid use of natural stone thus qualifying for a green material. These panels are also weather proof and durable. Another advantage of such panels is that they can be manufactured in any shape. The panels consisted of glass fibers of @ 3.5 to 5% by weight, silica, white cement and admixtures. Water repellant coating was applied on the panels by dipping panels in required solution to withstand atmospheric conditions.



Orientation Block

Hot dipped galvanized M.S framework and brackets were used for supporting the GFRC panels. Minimum thickness of GFRC panels was adopted as 15 mm whereas thicknesses at return flange/embedded location was kept as 50 mm. The panels were strengthened by providing sufficient nos. of horizontal and vertical stiffeners of stainless steel grade 316 of required shape and size as per design requirement.

Post Tensioned Slabs :

Post tensioned (PT) slabs were used in some portions of academic blocks. This provided additional headroom for the services. Such construction also has the advantages of higher clear spans, thinner slabs, lighter structure, higher loading performance, reduced cracking and deflections, and leads to reduction in storey height resulting into more storeys in same height. The technique also results into rapid, quality and skilled construction.

After placement of steel and tendons, concreting is first done except at the end from where stressing is done, excess length cut and grouting carried out around the tendons. Precaution is that it has to be ensured that the slab is not drilled during lifetime of the structure as it may damage pre-stressing and lead to failure.

False Ceiling and Wall Panelling :

Large numbers of patterns have been used for false ceiling and wall panelling in the project providing elegant looks. Some of the special false ceilings used are Anutone Salon Slats Plus false ceiling and panelling in selected lecture halls, recreation block etc. Cloud false ceiling has been used in the dining hall. In the auditorium, not only false ceiling and acoustic arrangement but interior provides an elegant look.



Auditorium



Dining Hall

Floorings :

Various types of new and innovative floorings have been used in the project including traditional flooring like vitrified tiles and granite floorings. Special flooring includes squash court flooring, wood plastic composite flooring, wooden flooring, pattern of polished, flamed and leather finish granite flooring, and Italian marble flooring etc.

Stamping finish concrete was used in open areas to have desired patterns.

Stamping Finish Concrete in front of Library



Stamping Finish Concrete in front of Library

Expanded Polystyrene (EPS) Geofoam Blocks :

Such blocks have been used in lecture halls on first and second floors of the academic blocks for construction of steps. The blocks are very light and thus help in weight reduction. Due to light weight, their handling and placing is also easy. In the present case density of the blocks used was 21.6 kg per cum. Moreover, despite their light weight, compressive resistance ranges from about 15,178 to 128,223 Pa at a one percent strain.

When used in the steps, the thickness of the blocks should be as per the requirements of the riser and laid accordingly so that riser of the step is sum of thickness of the block, wire mess and screed concrete including thickness of flooring if any or carpet as proposed. Over the blocks, wire mesh is used to tie them, to keep in position and also for better bonding with the concrete being laid over the blocks. Small thickness of concrete is used for protection and flooring to be laid as per the architectural requirements.

Glass :

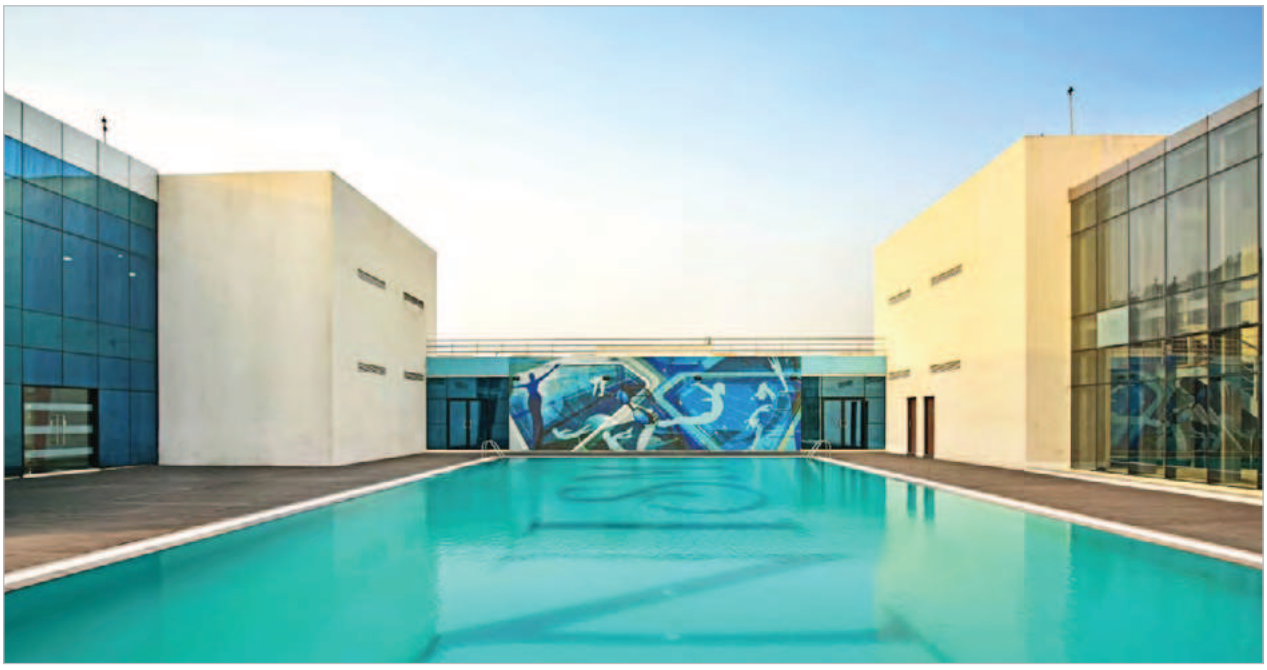
Though glass is a traditional material but its special use in various allocations makes it innovative. Glass has been used in structural glazing, staircase of the library, sky light windows of connecting corridor of the hostels near dining hall, faculty rooms, balcony railings of the hostels, partitions in toilets and other places, doors, etc. Glass mosaic tiles have been used in a wall of the swimming pool.



Academic Blocks

Other New Materials :

Apart from the above, PVC drain covers in the overflow drain of swimming pool, acoustic boards in library, steel staircase with glass balustrade in staircase of the library, Wi-Fi enabled class rooms, aluminium louvers in academic blocks and dining hall etc have been adopted in the project.



Swimming Pool of Recreation Block

Apart from the above, PVC drain covers in the overflow drain of swimming pool, acoustic boards in library, steel staircase with glass balustrade in staircase of the library, Wi-Fi enabled class rooms, aluminium louvers in academic blocks and dining hall etc have been adopted in the project.

Namaste furniture manufactured by M/s Godrej Interio has been provided in all the lecture theatres. The furniture has the speciality of having all the facilities like for laptops, foldable chairs and desks occupying fewer footprints while not in use. Interactive learning and broadcasting facilities have also been provided in the lecture theatres.

Green Building Features :

All green building features have been provided required for qualifying as 4 star and the project registered for 4-star GRIHA rating. Some of the green features include LED fittings, AAC blocks, green building materials, sewage treatment plants, rain water harvesting system, solar water heating and solar PV panels systems, water recycling, and energy efficient air-conditioning system etc.

Inauguration :

The project was completed on 24th December 2016 and inaugurated by Hon'ble Prime Minister in presence of Hon'ble Finance Minister, His Excellency Governor of Maharashtra and Hon'ble Chief Minister of Maharashtra. At present, the campus is fully functional.





Incubation and Data Centre, STPI, Mohali - A Green & Smart Building

Er. R. K. Sao
PM, PGIMER, CPWD, Chandigarh

The construction of Incubation centre for Software Technology Park of India (STPI) at Mohali, Punjab was entrusted to Central Public Works Department, Government of India on turnkey basis.

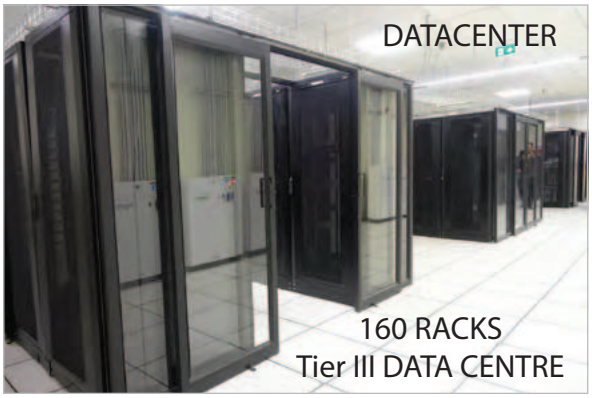
The building is located on a prime plot measuring 4965 sq. yards in Industrial area, Mohali. Total built up area is 14500 sqm and the construction cost is appx. Rs 55 Crore. This is a Ground plus seven storied building with one basement.



This building houses Tier III DATA CENTRE (as per uptime standards) with 160 Racks on the first floor. In row cooling with cold aisle containment has been provided to prevent hot spots and for energy saving. Ultra high efficiency UPS and IP based power distribution rack with the facility to monitor and control 34 different parameters has been provided. 138 inches video wall has been provided in the network operation centre for 24 X 7 monitoring of the data centre.

On the second floor 100 seater plug & play Incubation has been provided which can accommodate up to 20 budding entrepreneurs.

3rd to 6th floor is meant for warm shell wherein SME companies and medium budding Entrepreneurs (30 - 40 companies and 600 software professionals) can be accommodated.



160 Racks Tier III Data Centre


Incubatees Area

Facade is curtain wall system with high performance DGU and aluminum composite panel cladding, designed to allow natural light and to reduce heat load.

Interior of the building has been designed to provide sophisticated & contemporary look by using combination of selective natural stones, glass, natural wood veneers, wall paper and fabric panels.

7th Floor which has Auditorium, Conference Rooms, Meeting Rooms, Cafeteria and other state of the art facilities will be used for skill development wherein all relevant training and seminars useful for the budding entrepreneurs will be scheduled.

Auditorium & Conference Rooms are fully equipped with professional sound system, conferencing system, electrically operated


100 seater Plug & Play Incubation



IP Based PDC Monitor

professional projector, motorized screen, LED display panels, stage lighting video walls, video & audio conferencing systems etc.

Air conditioning System comprises of highly efficient 3 nos. of 315 TR water cooled screw chillers with VFDs. Energy saving devices like VFDs, VAV boxes, heat recovery wheel has been used to reduce the energy consumption.

Fire & Life Safety Measures : Iintelligent addressable fire alarm, Wet Riser & sprinkler system, gas suppression system, addressable emergency lighting system with super capacitors as backup, digital PA & emergency announcement system & fire resistant doors has been provided.

Electrical Power Distribution comprising of 2 X 2500 KVA DRY type transformers, 2X 1500 KVA DG sets. Type tested assembly panels with hot swappable & smart features have been provided.











Interiors of Building

Smart Features: All the systems are IP based and are scheduled, monitored and controlled through highly advanced BMS system. Each ACB & MCCBs of the building can be controlled as well as monitored for energy management and power quality. For indoor air quality CO2 & CO sensors have been installed. BTU meters, water meters, smart meters has been installed at every place to monitor energy consumption of the incubates.



138" Video Wall



State of Art A/V System in Conference Room



Access Control

Security System comprising of IP based CCTV System, Access control system, X- ray baggage system, Popup Bollards and Flap barriers has been provided.

Lighting : Highly efficient dimmable LED fixtures along with occupancy & Light sensors (for daylight harvesting) has been judiciously used. Lighting of the building is 60 % more efficient then what ECBC prescribes. All the lights of the building can be dimmed, controlled, monitored, scheduled through IPAD/Smart phones. Tunable/ Dimmable LED Fixtures have been used for human circadian centric lighting.

Other Services/Works : 60 KW grid interactive Rooftop solar system, Double stack mechanised car parking**,** Hydro pneumatic pumping, Centralized RO, Water leakage detection, Rodent repellent system, Furniture etc. have been used.

Other Green Building measures : 25 KLD STP for recycling of waste water, Rain water Harvesting, Use of AAC block with insulation between the two layers, use of Low flow fixtures, High SRI tiles etc. 100% energy requirements for indoor and outdoor lighting is being met through solar power.

Disabled Friendly Features : Ramp, Braille and audio in LIFT, Handicap toilets etc.

Awards & Recognitions :

- Adjudged best project in the country by the GRIHA Council for demonstrating exemplary performance in Energy Management.
- The project was adjudged smartest building in the country in its category by Honeywell- Network 18 in Dec 2017. Was also given platinum rating.
- Project is registered with GRIHA and is Expected to get 5 star rating based on the current scores.



TTA Panel with Hot Swappable Switches

Dr. B.R. Ambedkar National Memorial, Delhi - Innovative Technologies Intervention

Er. Tarkeshwar Tiwary
PM, Dev. Proj. Circle, CPWD

Background :

Dr. B.R. Ambedkar popularly known as an Architect of the Indian Constitution, breathed his last at 26, Alipur Road and attained Mahaprinirvaan on 6th December, 1956. This place was declared as a memorial by the then Hon'ble PM Shri Atal Bihari Vajpayee in 2003. A high level committee for planning the development of Dr. B.R. Ambedkar Memorial at 26, Alipur Road, Delhi was formed by the M/o Social Justice & Empowerment (MoSJ&E), Govt. of India on 29.11.2011. The committee submitted its report on 14.06.2012 and MoSJ&E assigned the construction work of Dr. B.R. Ambedkar Memorial to CPWD in the year 2013. Architectural planning of the building was entrusted to Consultant. A/A & E/S amounting to Rs. 99.64 Crore was issued on 02.07.2015 with completion period of 30 months. Hon'ble Prime Minister Sh. Narendra Modi laid the foundation of the Memorial on 21.03.2016 and the work actually started at site on 21.04.16. The work completed in March, 2018 and Hon'ble Prime Minister inaugurated the memorial and dedicated it to nation on 13.04.2018.

Uniqueness :

The iconic open book shape of the building is unique in India as it represent the constitution of India. The memorial building has been diagonally placed at site to enhance its visibility appeal. The outdoor has been designed and divided into different activities zones beautifully complimenting the building like Ashoka Stambh (Bronze) on the entrance plaza, the stepped green lawn on the left of the main entrance to provide seating space for the audience, the steps going down to cafeteria leads to wall of mudras representing Buddhist meditation postures. Bodhi tree on the right side of the entrance plaza and musical fountain along the theme garden enhance its beauty. In fact everything have been planned systematically in the campus. Level difference on the front and back side of the roads of the existing campus is approximately 850mm and building level and land escape was made accordingly to suite both the levels.

The shape of entrance door of the memorial building has been derived from Chaitya arch. The height restriction of the building and other features were limited to 11 metre by the statutory authority which led to planning of three basements to fulfill the parking and services requirements. Two nos. Toran Gates are the excellent piece of architectural design and gives classical look to the memorial whereas the Bust under the canopy is a place of tribute to Dr. Ambedkar.

Basement-1 and Ground floor space has been utilized for museum and meditation hall & Basment-2 & 3 have been made as the parking space.

The Meditation Hall in the first basement is under Stupa Dome where a provision for the natural light has been made through holes in the dome. The sanctity of the Stupa form has been retained and it has been so planned to get natural light in the Meditation Hall.



Dr. Ambedkar National Memorial, Delhi - Front View



LED walls , Mannequins & Holographic Projection in the Museum

Main Building :

Plot area of the building is 7274 sqm and built up area is 6758 sqm. Building having 3 basements and Ground Floor has been designed as R.C.C. framed structure with a floor height of 4.5m except the Ground Floor, where the floor height is varying from 9m to 11m.

- Raft foundation is in M-35 grade concrete. The site is nearly 1 km away from the bank of Yamuna River. The depth of foundation excavation was 13.55m. The open raft was designed and extended beyond the retaining wall (450mm & 250mm) along the periphery to the extent of 1000mm considering the earth load to counter water uplift.
- There were many space constraints at site and the adjoining area, being a residential one, controlled excavation for 3 basements was done.
- Considering the quality and time schedule, water proofing below the raft, around the retaining wall and on roof was done with EPDM membrane.
- Superstructure : RCC framed structure (Beam slab arrangement) with circular (900mm dia) and rectangular columns (450mm x 225mm) has grid spans varying from 8m to 12m. RCC roof is in double curvature to depict open book shape.
- Stainless Steel Fins : Hollow S.S fins of size (thickness 234mm) with cantilever S.S. frame & sheets supported on vertical MS frames are fixed to RCC structure at top and bottom. S.S cladding in curvature and its precise positioning to get open book shape facade was a mammoth challenging task.
- Hollow space between the two successive fins is filled up with DGU unit glass of 24mm thickness (6mm+12mm+12mm) in facade for effective air-conditioning and saving in electricity.
- Floor finishing : 18mm thick leather finish steel grey granite in ground floor and 1st basement, export quality 18mm thick white marble in meditation hall, 18mm leather finish Sadar Ali on staircase area and 75mm thick tremix flooring in basement 2 and 3 (Parking area).
- Other finishes : Stainless steel railing, external stone cladding & acrylic finish inside the building.
- False ceiling : Open metal (aluminium) false ceiling of cell size 50mmx50mm covered on top with ROCKINSUL Acoustic Thermal Insulation Board (ATIB) at ground floor and S-4 Hook on rectangular metal ceiling of suitable size with perforations at basement-1 (Museum area).
- Chaitya Door : Main entrance door in the shape of Chaitya door with hammered copper sheet clad on teak wood joint frame on pivot support.
- Lifts : 02 nos. 10 passengers lift (machine room less) with glass door both sides and differently abled persons friendly.
- D.G. Set : 02 nos. DG set (500 KVA & 180 KVA) with sound proof box & stack height 4.5m above the building height and as per CPCB Norms.

Museum :

- State of the art technology to create both static and dynamic effects. 6 nos. indoor LED walls of various sizes (10m x 3.5m, 7m x 5m & 2.5m x 2.5m), projection

mapping and edge blending with 7 nos. projectors, holographic, artistic and museum light effects are some of the key features in the museum.

- Animatronics : It is a robotic device, hyper realistic animatronics of Dr. Ambedkar where actions are programmed to provide the realism, blinking eye lids, hand movement, mouth movement while speaking, eyeball movements etc. Speech and expressions sync and operated through proximity sensors.
- Interactive Table : 16 nos. work stations and 55 inch interactive screens for browsing the variety of information relating to constitution and Dr. Ambedkar. It also includes related speeches of Dr. Ambedkar and other dignitaries.
- Hyper realistic Mannequins displaying the reality and creating life like ambience. In hyper realistic mannequins exposed parts are made of silicon which gives real look and body part made of FRP. Hand crafted hair on the head, mustaches, eyebrows and eyelids making the mannequins more realistic.
- 12 Feet high Bronze Statue of Dr. Ambedkar at the entry of the museum.
- 7 feet high Statue of Buddha in sitting posture in spotless single piece Vietnamese marble.
- Mural work in FRP.

Outdoor Activities :

- Toran Dwar - 2 Nos. Toran Dwars are erected alongside linear musical fountain. CNC Machine carvings on Jaisalmer stone finished in Ahmadabad, transported to Delhi & fixed securely with RCC frame work.
- Ashoka Pillar - 11m high bronze pillar was prepared in Jaipur & transported to Delhi & installed.
- Buddhist Mudras:- 12 nos. made in FRP and secured in curved wall near cafeteria.
- Bodhi Tree and Garden – Outdoor meditation area surrounded by flowers and ground covers depicting peace, purity and tranquility.
- Façade lighting:- Direct illumination with strip of LED nodes put in the tracks fixed to S.S. fins and programmed to depict the various display on the façade. Luminaries work on Ethernet based network using VSM (Video System Manager) controller.
- Musical Fountain:- 100mm length of linear musical fountain along the theme garden where colourful fountain with music and proper programming has been installed. It is modern, digitally controlled with the advantage of plumbing less technology and DMX control system.
- Canopy: Dr. Ambedkar bust in bronze. Visitors pay homage to Dr. Ambedkar under the canopy.



Dr. Ambedkar National Memorial - Mannequins in Museum



Statue of Dr. B.R. Ambedkar in the Memorial

Green Features :

- Use of fly ash bricks and fly ash admixed cement concrete.
- Waste water recycling through sewage treatment plant (MBBR) of 25 KLD.
- Renewable energy as roof top solar power generation 50 KW installed on the curved roof and connected to grid & only energy efficient LED lights used.
- Rain water harvesting pits.
- Low VOC paint/adhesive.
- Rockwool products in false ceiling.
- HVAC System:- 100% zero ODP insulating. HCFC & CFC free HVAC system.
- VRV (Variable Refrigerant Volume) (346 HP):- Saving in energy more than 20%.
- Solar Power Generation is 50 kw while the internal light load for general lighting is 15 kw.
- Innovations - DMX (Data Mixing Extension) control facade lighting, musical fountain with frequency controlled pumps & DMX operated lights.

Dr. Ambedkar National Memorial Project assigned to CPWD was successfully completed on time. The Hon'ble Prime Minister inaugurated in on 13.04.2018 and dedicated to the nation. The Memorial building is fully functional and approximately ten thousand people visited the Memorial on 14.04.2018. On an average six hundred people visit the Memorial on daily basis. This Memorial has become an iconic building constructed by CPWD.



Inauguration of Dr. B.R. National Memorial & Visit of Hon'ble P.M on 13/04/18

Dynamic Facade Lighting System at Rashtrapati Bhawan, North Block, South Block and India Gate

Er. Awadhesh Kumar, *SE DCEC-I*
Er. Rahul Kamble, *EE ED-I, N. Delhi*

Genesis of Dynamic Facade Lighting at Central Vista :

Rashtrapati Bhawan, North Block, South Block & India Gate are the living monumental heritage buildings/structures of national/ international importance in the Central Vista of New Delhi having attractive architectural features. A large number of VIPs, foreign dignitaries, domestic and foreign tourists visit this area throughout the year.

North Block and south Block being important Heritage building and housing Central Secretariat, it was decided to enhance its look by providing with state of art technology available for Dynamic Facade Lighting System globally. Considering the current trends in facade lighting globally, initially it was decided to provide such facade lighting to the North Block and South Block only. Having faced all sorts of difficulties right from stage of concept, preparation of estimates based on all together new items, new technical specifications, getting clearance from committees, the work could be awarded at very competitive rates. No sooner than the work was awarded, it was the directive of the authorities to complete the work within 70 days. The campus of North Block and South Block being the VIP area and highly secured zone, completing the work within 70 days was very challenging job. Crossing all the hurdles, the work could be completed on target date which was finally formally lighted on 11-10-17 in the presence of Hon'ble PM.

It was announced on the day of lighting ON ceremony at North Block that such lighting system shall also be provided at Rashtrapati Bhawan and India Gate and was to be completed before 31st Dec.' 2017. After getting the direction from President's Secretariat, the work was taken up at Rashtrapati Bhawan on war footing. And in spite of all challenges of time constraints and restricted site due to VVIP movements, the work could be completed within set timelines. The evergreen beauty of Rashtrapati Bhawan forecourt during night time was enhanced multi-fold after lighting with this new technology. The new lighting on the building was inaugurated by Hon'ble President of India on 19-01-2018 which was well appreciated and applauded by all present dignitaries and public.

Being part of the Central Vista and one of the most attractive tourist spot, the facade lighting was also taken up on India Gate and completed before Republic Day 2018 which was inaugurated by Hon'ble LG of Delhi.

After providing dynamic facade lighting at Rashtrapati Bhawan, North Block, South Block and India Gate, the following objectives have been achieved:

- Night view of Central Vista improved significantly in line with global standard.
- There has been value addition by improving the standard of facade lighting.
- There is saving in electrical energy consumption per unit facade area.
- Different lighting themes specific to different occasions have been made possible.
- There has been significant increase in numbers of tourists visiting Central Vista area.
- Temporary lighting which was done on these buildings on various occasions was done away with.

Technical Details of the Project for North Block and South Block:

1. Previously temporary lighting arrangements were being made during National festivals for a total period of 8 days (5 days during Republic Day ceremony and 3 days during Independence Day ceremony) by providing 3 watt capacity LED bulbs and appx. 350 conventional security lights for regular security & facade lighting purpose.

2. Dynamic façade lighting is capable of providing volume lighting as well as focus lighting having 16 million colour combinations to highlight architectural features of the building. The light fittings have external lenses to facilitate change of beam angles as per site requirement and ease of cleaning. About 800 light fittings have been used in this project which involves about 40 km long cable laying (Electrical cables & Data cables). All light fittings have dust, vermin, moisture and outdoor weather protection of the highest order (IP-66) with robust design. The entire network of dynamic façade lighting system has central computerized programmable control. Complete light system conforms to the most stringent international regulatory and technicalities complying to international standards viz. RoHS, UL and CE.

3. Administrative Approval and Expenditure Sanction amounting to Rs.19.3 Crore was received on 03.05.2017 for taking up this project. The work was awarded for Rs.10.78 Cr. for construction cost and Rs.4.62 Cr. for comprehensive maintenance. The date of start of the project was 24.07.2017 with stipulated time of completion as 70 days ending on 02.10.2017. The project was completed within time period including increased scope of work as per requirements.

4. It has around 100000 (1 Lac) burning hours whereas earlier light fixtures were having around 10000 (10 thousand) burning hours.

5. Cost Savings are as under:

Conventional Lighting (Being used for 16,750 sq. m.)	Dynamic Façade Lighting (Being used for 21,450 sq. m.)
1. National festival : (15 August and 26th January - Total 8 days) 50000 (No. of bulbs) x 0.003 (KW per bulb) x 5 (Hours) x 8 (Days) x 8.5 (Unit price) = Rs. 51,000/- per year. 2. Security lighting during year : 72 (No. of fittings) x 0.2(KW per fitting) x 11 (Hours) x 8.5 (Unit price) x 365 (days) = Rs. 4, 91,436/- per year. 3. Conventional Facade lighting : 50(KW) x 5(Hours) x 8.5(Unit price) x 365(days) = Rs. 7, 75,625/- per year.	Total Capacity 110 KW (100% load = 1 hour, 50% load 1.5 hours & 25% load = 7.5 hours) = Total unit per year 98000 KWh Annual bill = 98000 KWh x 8.5 (Unit price) = Rs. 8,33,000/-
Total annual bill = 51,000 + 7, 75,625 + 4, 91,436 = Rs. 13, 18,061/-	Total annual bill = Rs. 8,33,000/-
Energy Consumption per sq.m. of facade = Rs.78/-	Energy Consumption per sq. m. of facade = Rs. 39/-
Net saving in electricity consumption is to the tune of 50%	

Challenges to overcome during Execution:

Working in a time bound short duration project for two living monumental heritage buildings i.e. North Block and South Block was quite challenging job, Here it is mentioned some major difficulties faced during successful execution:

a. Both the buildings are of national/ international importance in the Central Vista of New Delhi having attractive architectural features. It was prime concern to execute all the work without disturbing original aesthetic look of monuments so most of the execution of work was done underground. Wherever it was necessary to carry out the work over ground (like stone foundations), it was executed in consultation with concerned officers with a view to improve the look.

b. Execution of lighting work within approx. 40 days was done in a manner that there should not be any disturbance to the VVIP occupants in the offices including P.M. Office, MHA office, Finance and Defence Ministry offices etc. Cutting & making good of pathways/roads etc was done in night, cable laying and all the cutting/ digging work was redone as original before office timing in the morning. Supervision of labour was quite challenging in such security prone area to carry out the work with maximum efficiency.

c. Planning for labour passes & material passes (as per shorter duration requirement) for night timing was done in best way to avoid unnecessary hindrance at site. Key feature for this task was to liaise with various security agencies such as SPG in PMO, H Block for South Block, CISF for North Bloc, Delhi Police and Traffic Police offices for other areas.

d. Procurement of various materials from abroad (i.e. from Netherland, Mexico, China and other countries) was quite tough job, as during the execution period Mexico was hit by severe earthquake. It was made possible well in time by efforts made at DG, SDG & ADG level along with higher officials of M/s Philips India Lighting Ltd.



Dynamic Facade Lighting - Rashtrapati Bhawan



Dynamic Facade Lighting - North Block / South Block

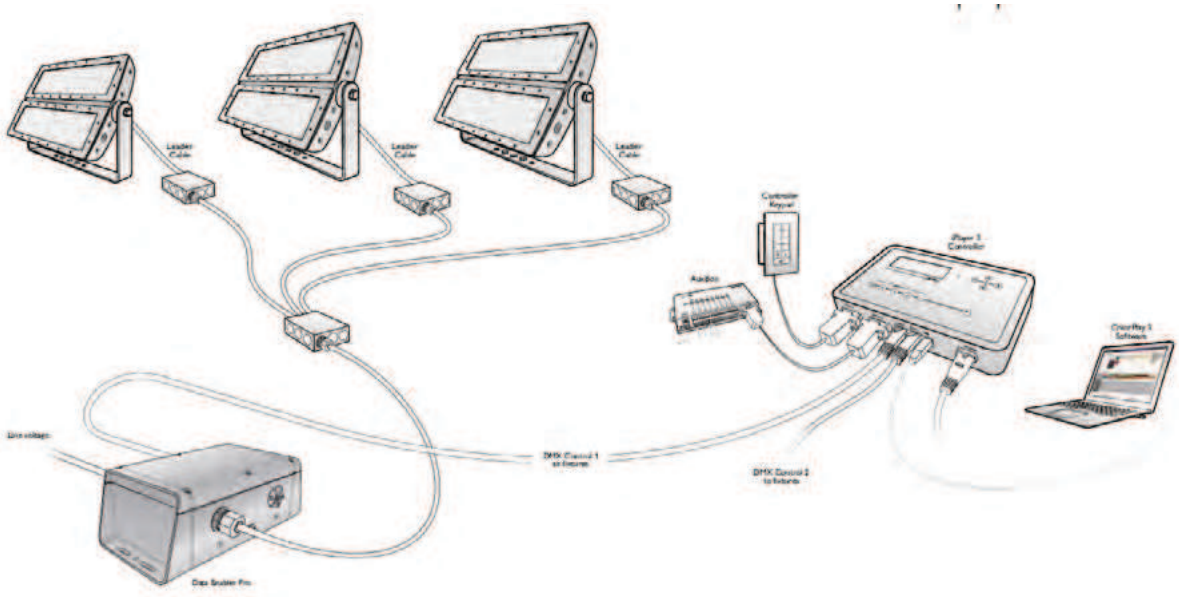
Technical Challenges:

Since the Dynamic facade lighting work was done first time in India at such a broad level, there were many technical challenges before the CPWD Team. Some major technical difficulties experienced during execution were as under:

a. Execution of Dynamic facade lighting work on such a huge facade area (approx. 21450 sq. m.) with so many aesthetic features, was quite complicated. So arrangements were done for various round of mock up from different agencies to explore the aesthetic and architectural features of building.

b. During preparation of NIT, it was considered to take care of technical specification of each item in such a way that all the agencies active in Dynamic Lighting field can participate.

c. As the Dynamic facade lighting work was first of its kind, maintenance of the fixtures, control panels and other accessories was a big issue. To counter this issue, provision of 5 years of routine preventive & comprehensive maintenance of whole system was included in the NIT.



Typical Powercore Installation Diagram

Aesthetics of Heritage Structure and Central Vista:

1. All care has been taken to avoid any type of damage to the heritage buildings as all installations are outdoor fittings. Most of the fittings are in lawns away from the building. All light fittings are of outdoor types which have been simply kept on the floor or rooftop of the buildings with suitable arrangements.

2. In order to have aesthetics of Central Vista intact, rigorous evaluation by Central Vista Committee was done and approval sought.

Energy Efficiency - GRIHA :

Although this Project completely does not comes in the purview of GRIHA, but as per criterion 6 in GRIHA manual for outdoor lighting, this project has 2 appraisal points out of 3.

Special Features & Innovation :

1. Luminaries having **RGB LED Technology** is capable of producing combination of **16 million colours** with countless themes & designs according to thoughts of mind. Every single architectural feature can be highlighted very beautifully with these programmable lightings.

2. Luminaries are capable of **programming with different audio tracks to produce Light & sound show.**

3. **Dimming Capability** is also possible in these fittings. This feature is quite useful for lowering the energy consumption as per requirement.

4. Lights fittings have **external lenses** to facilitate **unique feature to change of beam angle** as per location requirement.

Highlights :

- Lighting ON ceremony of North Block and South Block was done in the presence of Honourable PM on 11-10-17 and Inauguration of President Estate lighting by Hon'ble President of India on 19-01-18.

- Latest State of Art technology in the field of Facade lighting now being adopted world over.

- The project has been widely appreciated by Govt functionaries and public at large.

- This project has triggered adoption of this technology at other locations also.



Dynamic Facade Lighting - India Gate

CPWD Striving to Reduce Carbon Footprints

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The phenomenon of global warming is causing great environmental concern as it is leading towards significant climate changes worldwide. One of the prime reasons for this is increase of CO2 in the atmosphere. CO2 or Carbon Dioxide - a naturally occurring gas and a by-product of burning fossil fuels is also caused by building construction activities & has close connection with the change of the earth's temperature. Therefore CO2 gas has to be kept in control to reduce the effect of global warming.



Year on year, mankind is adding large number of buildings for habitation/commercial use, thereby contributing significantly in global warming. The Construction of buildings is primarily an energy intensive activity and remains so even after construction is over and the building is put into beneficial use. Thus every building is a major source of CO2 emission and in consequence a driver of climate-change in a direction which will affect all habitation adversely. The cure is to construct a climate friendly micro **climate surrounding a building.**



CPWD a premier construction agency of the Govt. of India in all its new constructions has understood this concern and is taking into account the environmental impacts right from the stage of concept to not only till the commissioning but until the life cycle of the building in a manner which is not only improving the surrounding micro climate but is also improving the energy security of the country.

In this regard, a study was conducted by CSQ (E) unit of CPWD Directorate of a few buildings at Delhi in which CPWD engineered environmental protection. Besides taking care of the embodied energy in the materials of construction and other sustainable provisions, all these buildings use energy efficient LED lights for internal lighting and for external lighting, solar street lights which have pole mounted solar PV Panels with LED Lights, Solar rooftops which utilize spare building roofs to harness green power which not only comes free of cost but also provides sufficient reduction in intake of grid power.

The increased energy efficiency into the lighting system as well as generation of solar power saves electrical energy resulting into less generation of conventional electricity which is based on burning of fossil fuels. This prevents significant release of CO2 emissions into the atmosphere. One KWh of energy saved is equivalent to 0.9 Kg of reduction of CO2 emission. Saving in energy due to use of LED lights has been calculated by reverse calculation methodology using average lumen output of conventional lamps as 65 lumen per watt and that of LED lamps as 100 lumen per watt.



Western Court Annexe Hostel Building, New Delhi

As a sample study, calculation of quantum of CO2 emission in only one of the buildings i.e. Western Court Annexe Hostel Building at Janpath, New Delhi is presented here :-

A. Energy Saving & Reduction in CO2 Emissions due to LEDs:

Total built up area	19470 sqm
Total Wattage due to LED lighting	38022 W (38.02 KW)
Total Wattage due to conventional lighting	66538.5 W (66.54 KW)
Power Saving in KWs	28.52 KW
Energy Saving per day in KWh	342.24 KWh
Energy saving during one year	124917.6 KWh
Savings in Electrical consumption charges	Rs. 1249176
Reduction in CO2 Emissions due to Energy saving	112425.84 Kg/year (112.43 Ton/year)

B. Energy Saving& Reduction in CO2 Emissions due to External Solar Lightings:

Total built up area	19470 sqm
Total Wattage due to LED lighting	1050 W (1.05 KW)
Total Wattage due conventional lighting	1837.5W(1.84 KW)
Power Saving in KWs	0.79 KW
Energy Saving per day in KWh	9.48 KWh
Energy saving during one year	3460.2 KWh
Saving in Electrical Consumption Charges @ Rs. 10/KWh	Rs. 34602
Reduction in CO_2 Emissions due to Energy Saving from External Solar Lighting	3114.18 Kg/year (3.11 Ton/year)

C. Energy Saving& Reduction in CO2 Emissions due to Energy Generation by Rooftop Solar Power Plant:

Total installed capacity of Rooftop Solar Power Plant	75 KWp
Average No. of units generated per day/KW	4.5 KWh
Energy generated by Solar Power Plant/day	337.5 KWh
Energy generated by Solar Power Plant/year	1,23,187.5 KWh
Savings/year in Electrical Consumption Charges @ Rs. 10/unit	Rs. 12,31,875
Reduction in CO_2 Emissions due to Energy Saving due to Rooftop Solar Power Plant	10868.75 Kg (110.86 Ton/year)

D. Total of Energy Saving due to all Measures (Per Year):

Energy Saving due to provision of LED light fittings instead of conventional light fittings	1,24,917.6 KWh
Energy Saving due to provision of LED light fittings on compound light poles	3,460.2 KWh
Energy Saving due to installation of 75 KWp rooftop solar power plant	1,23,187.5 KWh
Total Energy Saving per year	2,51,565.3 KWh
Total Savings in Electrical Consumption Charges per year (@ Rs. 10/KWh)	Rs. 25,15,653/-

E. Total Reduction in CO2 Emission due to all Measures (per year)

Reduction in CO_2 Emission due to Provision of LED light fittings instead of conventional light fittings	112.43 Ton
Reduction in CO_2 Emission due to provision of LED light fittings on compound light poles	3.11 Ton
Reduction in CO_2 Emission due to installation of 75 KWp rooftop solar power plant	110.86 Ton
Total reduction in CO_2 Emission per year	226.4 Ton

F. Total Reduction in CO2 Emission per year = 226.4 Ton

With this potential of reduction in CO2 emission in one building alone, the quantum of nationwide reduction in CO2 emission by CPWD is only a matter of great national assertion towards a green India.



Western Court Annexe Hostel Building, New Delhi