आत्मनिर्भर भारत

सत्यमेव जयते

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एक कदम स्वच्छता की ओर

COMPILATION OF TECHNICAL SEMINAR

July 12, 2021

CPWD

Director General, CPWD, New Delhi

CPWD : Sustainable Development for Atmanirbhar Bharat

COMPILATION OF TECHNICAL SEMINAR
Held on
July 12, 2021

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Director General
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Vinit Kumar Jayaswal
Director General

सत्यमेव जयते

भारत सरकार
Government of India

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Message

Construction sector has played a vital role in the growth and development of our country. There is an increased focus on adopting sustainable construction technologies to mitigate detrimental environmental impacts of the built assets. Knowledge sharing through technical seminars is an important tool to improve synergy, enhance productivity and promote best practices.

I am happy to note that a Technical Seminar is being organized on 12th July, 2021 at Nirman Bhawan, New Delhi on the occasion of 167th Annual Day of CPWD. The topics include the diversity of projects, unique challenges encountered during planning and execution, and evolution of sustainable technical solutions. I am confident that the compilation will provide an opportunity of knowledge sharing and experiential learning.

I congratulate Shri Dharmesh Chandra Goel, ADG (Tech) and his team for organizing the Technical Seminar and bringing out this compilation.

(Vinit Kumar Jayaswal)



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भारत सरकार
Government of India

Dharmesh Chandra Goel
Additional Director General (Technical)

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PREFACE

It is a matter of great pride for me to be associated with organising technical seminar on the occasion of 167th Annual Day of CPWD.

"**CPWD : Sustainable Development for Atmanirbhar Bharat**" is theme of this year to reiterate our commitment for safe, green and clean development in all our projects.

In the seminar proceedings, 13 papers are included on various topics which portray the organisational commitment towards sustainable development even under extremes with locally nurtured technologies. Challenges in construction of roads at high altitudes in Himalayan regions on one hand and marshy lands of Rann of Kutch on the other, along with restoration of Gorton Castle at Shimla, highlight the diversity. Use of Building Information Modelling (BIM) for managing projects at IIT Bhilai and IIT Palakkad projects, with strong bonding with the academia of these institutes, display the urge of the CPWD engineers to have hands on learning even while on work for newer technologies. Resilience to requirement of time is evident from redesigning of built environment post covid-19 along with modern trends in hospital architecture and Bio-safety levels. Use of Fly ash in construction works not only converts waste to opportunity but also reduces cost and carbon footprints. Last but not the least, legal framework governing damages in contracts and comparative study of project management are aimed to keep the organization afloat in competitive world. SETU rating of infrastructures provides a novel, easy and interactive coding of developed infrastructure.

I am thankful to my colleague Shri Rabindra Kumar, Chief Engineer (Design and Disaster Mitigation), Shri Devendra Kumar Sachan, Director (Technical & Public Relations), Shri Satish Kumar Agarwal, Superintending Engineer (Parliamentary Matters) and Shri Vijay Prakash Sahu, Superintending Engineer (Contracts & Manual) in bringing out this publication.

(Dharmesh Chandra Goel)

Central Public Works Department

167th CPWD DAY – 12th July, 2021

Technical Session - I



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2

Digital Transformation on Public Project Delivery Using Common Data Environment and Building Information Modelling by Dr.V. Senthilkumar and Er. C.S. Abineesh, EE, IIT Palakkad



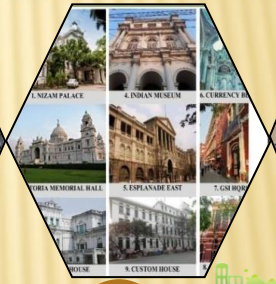
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Challenges in construction of high altitude roads by Er. Pradeep Gupta, CPM, ICBRPZ, Leh



4

Gorton Castle Building – Rehabilitation by Er. Devendra Prakash, SE, Shimla



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Revisiting Architectural Heritage of Kolkata by Shibashis Chaudhuri & Mrs Debarati Chakraborty, Architect, ADG(Kolkata)



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Infrastructure Development a Challenge in Rann of Kutch By Er. B P Singh, C E, Border Fencing Zone

CPWD: SUSTAINABLE DEVELOPMENT FOR ATMANIRBHAR BHARAT

Central Public Works Department

167th CPWD DAY – 12th July, 2021

Technical Session - II



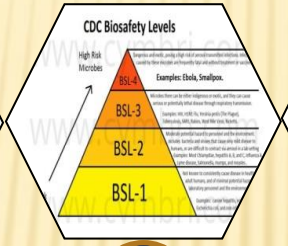
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Emerging Technologies in healthcare infrastructure by Monika Gupta, Architect , M/s Siika Associates



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Biosafety Levels (BSL) by Er. Sandeep Mehta, CE, Trivandrum



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Flyash in construction works by Er. Gopal Varshnay, CE, Central Vista Avenue

"Legal framework governing damages in contracts"

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CPWD: SUSTAINABLE DEVELOPMENT FOR ATMANIRBHAR BHARAT

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PERMANENT CAMPUS OF IIT BHILAI AT KUTELABHATA, DURG, CHHATTISGARH.PHASE-1 (STAGE-1)

Anurag Kumar, Superintending Engineer

Indian Institute of Technology (IIT) Bhilai was established in the state of Chhattisgarh by Ministry of Human Resource and Development in the year 2016 in a temporary campus. The campus is expected to grow eventually to accommodate 12,000 students along with the desired faculty members, staff members and their dependents over a period of 20 years in multiple Phases. The work of first Phase i.e. Phase 1 Stage 1 of Permanent Campus construction was entrusted to CPWD in 2018, which will cater to 1200 students, 120 faculty members, 132 staff members and dependents of students, faculty and staff members.

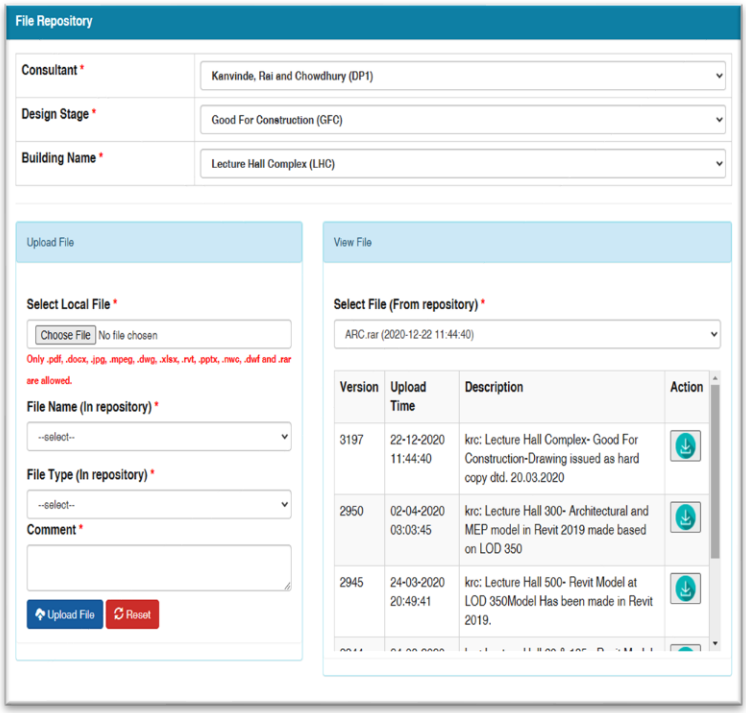


Construction of Permanent campus of IIT Bhilai started in July 2020 at Kutelabhata Village area of Durg district, Chhattisgarh after M/s Larsen and Toubro Ltd emerged as the lowest bidder amounting to Rs 719.20 Crore on the e-tendering platform.

The scope of work includes construction of 21 buildings in academic, hostel & residential areas, access corridor, ancillary buildings, boundary wall, internal and external services and external development. The work of first phase is targeted to be completed by Oct 2022, with all necessary buildings and utilities.

New Construction Technologies Implemented

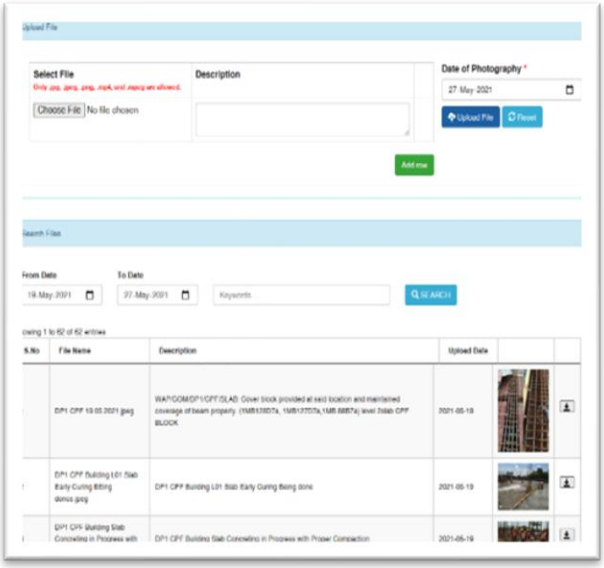
1. Drawing Document Management System



This project required tremendous coordination among the client, consultants, CPWD and executing agency. This required handling of thousands of multidisciplinary drawings, being circulated and reviewed. To reduce the circulation time and improve coordination, an innovative cloud based drawing document management system for uploading all the documents related to Planning and execution was developed by IIT Bhilai, named as Drawing Document Management System (DDMS) and implemented by CPWD in this project.

Consultants upload all the GFC drawings related to Architecture, Structure, MEP, Landscape etc. on the DDMS portal which sends a notification through email to all the concerned (Authorized) persons and the drawings are available for review of all, at a glance. During construction, one can always login the portal and can refer the latest drawing for construction. Furthermore, all the drawings are documented with date which can be referred in future construction also and having very good control on Revisions and Versions of Drawings. Even during tendering all the tender drawings are downloaded by various bidders from this website.

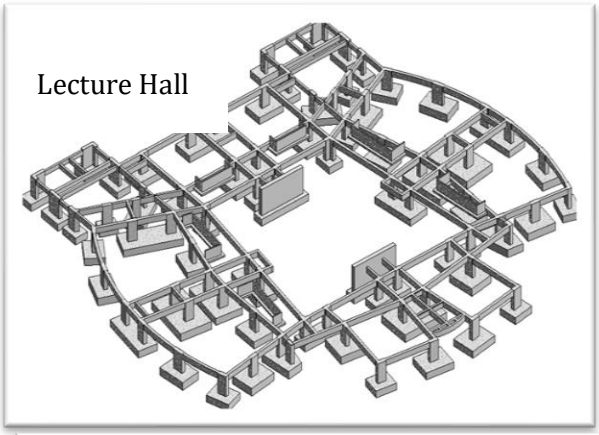
2. Construction Images Documentation System

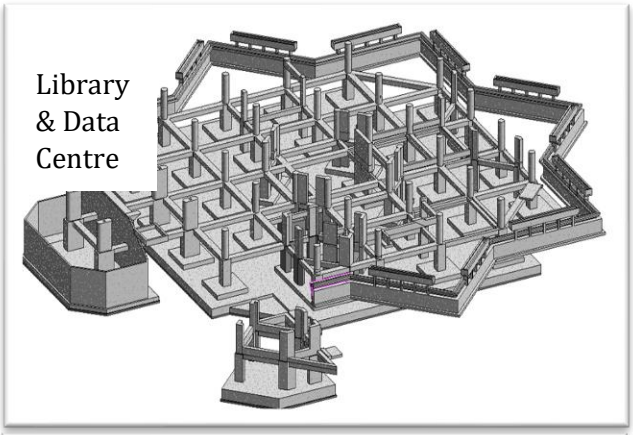


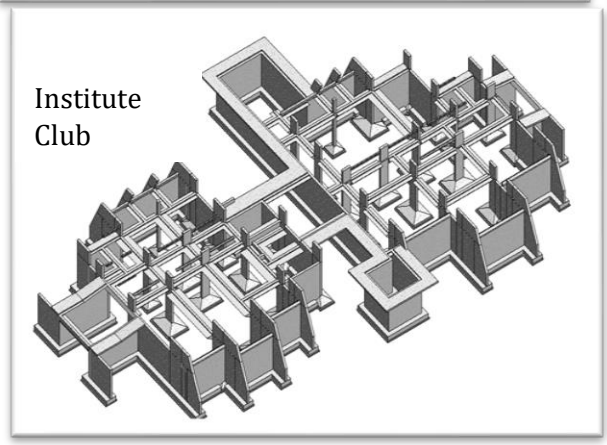
Cloud based system for daily monitoring of construction works at the site is implemented at IIT Bhilai project. Sites have been provided with IP Based cameras and daily photos are captured from site. These photos are uploaded on the portal on daily basis for effective monitoring of construction works. All Third party Quality control issues raised over this platform and rectification done are also uploaded besides regular site activities.

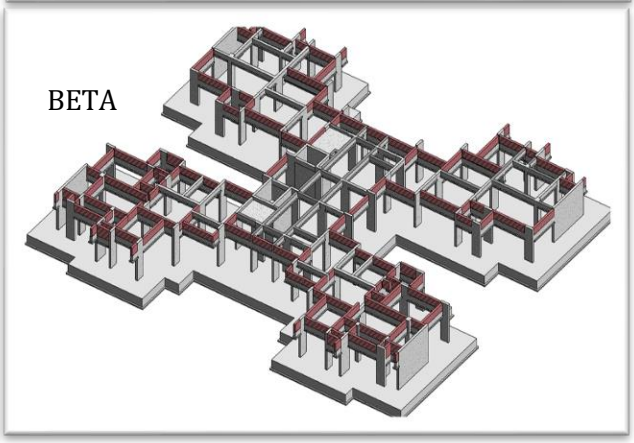
3. USE OF BUILDING INFORMATION MODELING (BIM)

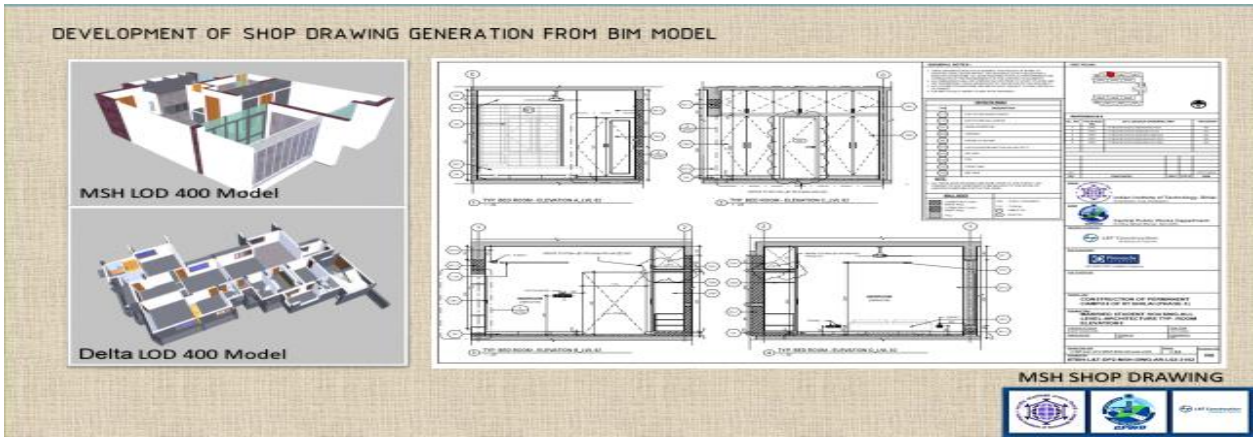
The project envisaged construction of more than 21 buildings having Multi- Disciplinary services. The buildings have services like HVAC, Firefighting, MEP etc along with interconnected sewer & storm water network. Though conceptualized by the consultants on 2 D drawings but clashes among the services and structure can only be visualized in a 3 D view. Hence the concept of Building Information Model (BIM) was introduced in the project for avoiding clashes at a later stage and saving cost and time. It also facilitates in development of shop drawings, Review by various stakeholders on BIM 360 platform, quantity confirmation of the BOQ during billing, Progress Monitoring,development of as built drawings and completion drawings.











4. Provision of Cavity Walls



Temperature in Bhilai rises up to 48 deg Celsius during summers which can increase the energy demand required for cooling the space inside the building. The academic and residential areas of IIT Bhilai have cavity wall construction to ease out the inhabitable space. Cavity walls have rock wool insulation in residential areas and XPS (Extruded Polystyrene Sheet board in academic area.





5. BLDC (Brush Less Direct Current) ceiling fan:

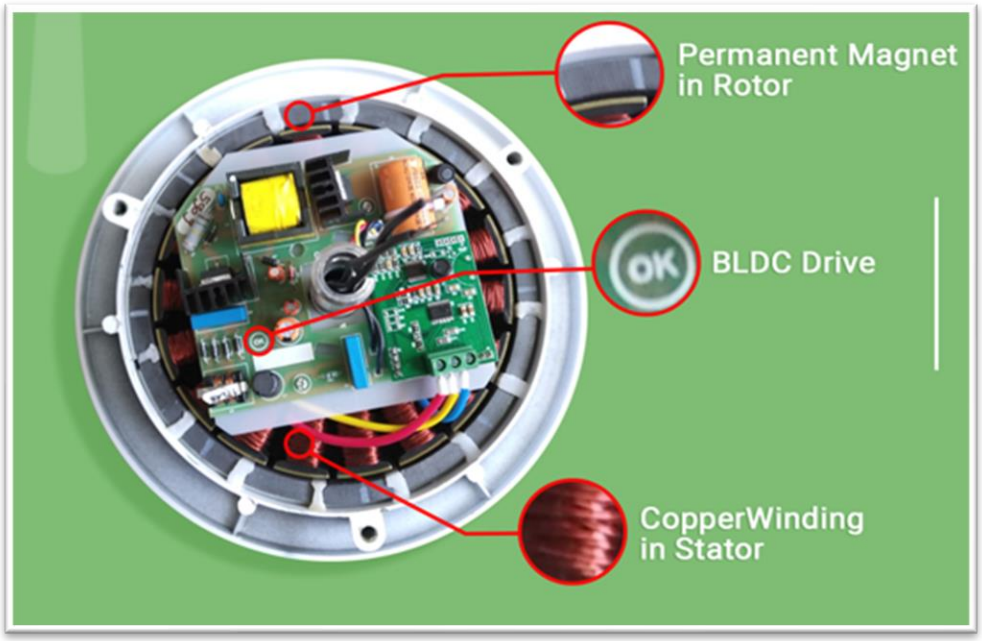
Nearly 3500 AC Ceiling fans to be provided in various buildings therefore to minimize /save the electrical energy, BLDC fan has been used in this project. Also as Per IS 374:2019 and the New Star Rating Plan of BEE, the Service Value of 5-Star rated Ceiling Fans should be greater than 6.0 (for fans having sweep ≥ 6.0, which is possible only in BLDC Fans.

For BLDC motor there is no brush use between rotor and stator for transferring electricity supply so it's called brushless dc motor.

BLDC fan means, a BLDC motor use in BLDC ceiling fan compare to induction motor in normal ceiling fan. With the use of BLDC motor in ceiling fan we can save 60% electricity in the ceiling fan.

BLDC fan lifespan is more than a normal ceiling fan because there is no heat generated in BLDC Motor hence its increases lifespan of ceiling fan bearings, also there are fewer chances for the winding failure due to the use of high thickness copper wire in the winding.

BLDC
TECHNOLOGY



The major parts use in BLDC ceiling fan is

I. Rotor: In BLDC ceiling fan permanent magnet is used in the rotor.
II. Stator: Copper wound stator is used, which produces magnetic flux after supply of electricity.

III. BLDC Drive: The BLDC Drive comprises of SMPS and Microcontroller. SMPS is use to convert ac supply into dc supply, and Microcontroller is used for receiving the input data from remote control and give output data accordingly to inverter

The DC brushless drive can also operate at unity power factor, whereas the best power factor for the induction drive is about 85 percent. This means that the peak point energy efficiency for a DC brushless drive will typically be a few percentage points higher than for an induction drive.

In summary BLDC ceiling fan can save up to 60% energy and have longer life. Users can take advantage of reduced maintenance, improved efficiency, reduced heat and noise.

DIGITAL TRANSFORMATION ON PUBLIC PROJECT DELIVERY USING COMMON DATA ENVIRONMENT AND BUILDING INFORMATION MODELING-EXPERIENCE FROM IIT PALAKKAD PHASE 1A (PACKAGE 1)

Dr. V Senthilkumar, Chairman, works Division, IIT Palakkad
Er. C S Abineesh, Executive Engineer Engineering and
Senior Manager, CPWD, IIT Palakkad Projects

Development and Management of Project information is vital for the projects such as campus development, as the lead time of the development is longer. Different agencies will be responsible for creating and managing certain aspects or elements of the built environment of the project. To manage, coordinate and ascertain that appropriate information is created and managed in an organized way. Hence, IIT Palakkad (IITPKD) envisaged embracing the digital way of modeling the information of its physical and infrastructure assets and managing it through Building Information Modeling (BIM) as a natural choice to achieve the same. BIM is an assembly of different project information digitally stored in a relational database called the Common Data Environment (CDE). This includes "geometry", or graphical data, structured digital properties or attributes of information, or non-graphical data & relevant "documentation" (stored as files). Deployment of BIM is widespread in developed world, but it's utilization in Indian public project delivery is minimal. BIM is proved for its efficient project delivery benefits which extend to the asset's whole lifecycle phases and is mandated by many governments around the globe. With this background, IITPKD and CPWD Team envisaged to be an example to the society and determined to deploy the said digital transformation, execute the project with minimal rework and lead time. Since this project has many stakeholders with varying responsibilities, hence need arises for web based CDE to administer and manage all the project information such as documentations, communications, updates etc. BIM360 was decided as CDE for this campus development project for seamless information flow among the stakeholders and to avert the delays. Being part of implementation all stakeholders including the CPWD team was given training by IITPKD. Data retrieval and data archive is automated; hence the version control and tracking are warranted. Further, the data collected can be utilized for the efficient deployment of the Building Management Systems (BMS) with enhanced interoperability.

With the assistance of CPWD team, the project execution workflow was captured and the CDE workflow protocol developed as shown in Figure 1. It was included in the Contractor's BIM Execution Plan also. Quality of the work at the site is monitored by CPWD beside Third-Party Quality Assurance Agency (TPQA) using BIM360 Mobile app for recording and monitoring the quality aspects of the site activities through checklists. So far around 3000 checklists have been generated and around 300 site-based Quality related RFI's have been proactively identified and resolved through the system. Site safety culture is paramount hence stringent safety norms insisted with the help of the RFI's and Checklists.

IITPKD is using CDE called BIM360 docs for timely seamless communication among stakeholders, ensuring continuous information flow among the stakeholders without delays. Data retrieval and data archive are automated; hence version control and tracking are warranted. Further, the data collected can be utilized for the efficient deployment of the BMS with enhanced interoperability. CDE further extends the insight about the project RFI's and Quality Issues as shown in Figure 2, which will be used to analyze and perform the timely interventions.

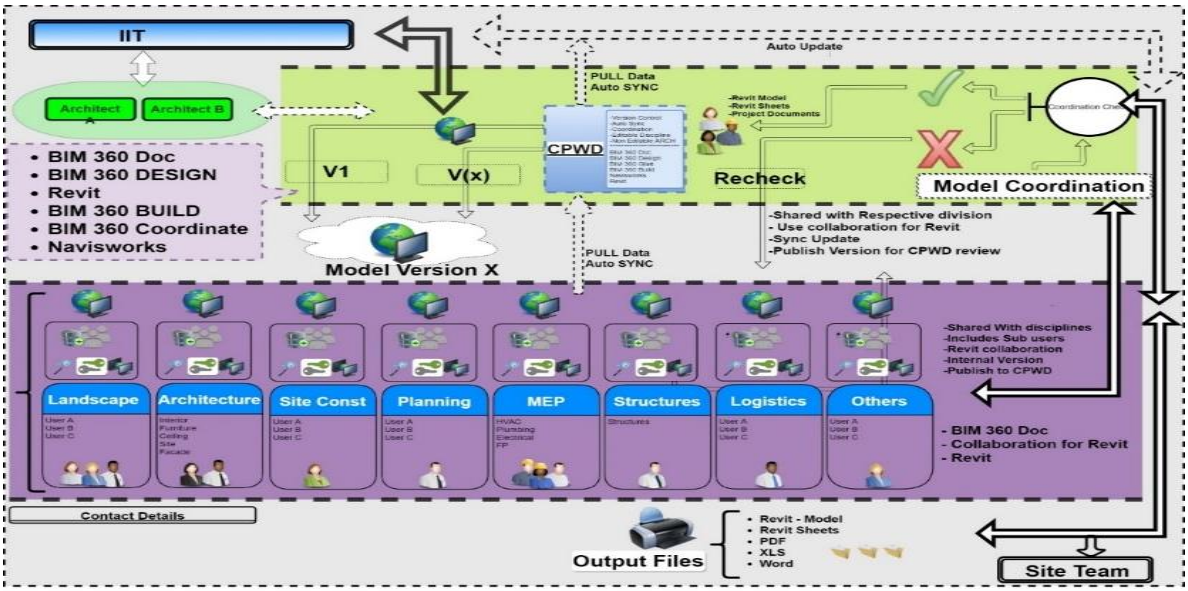


Figure 1. CDE Implementation Workflow Architecture

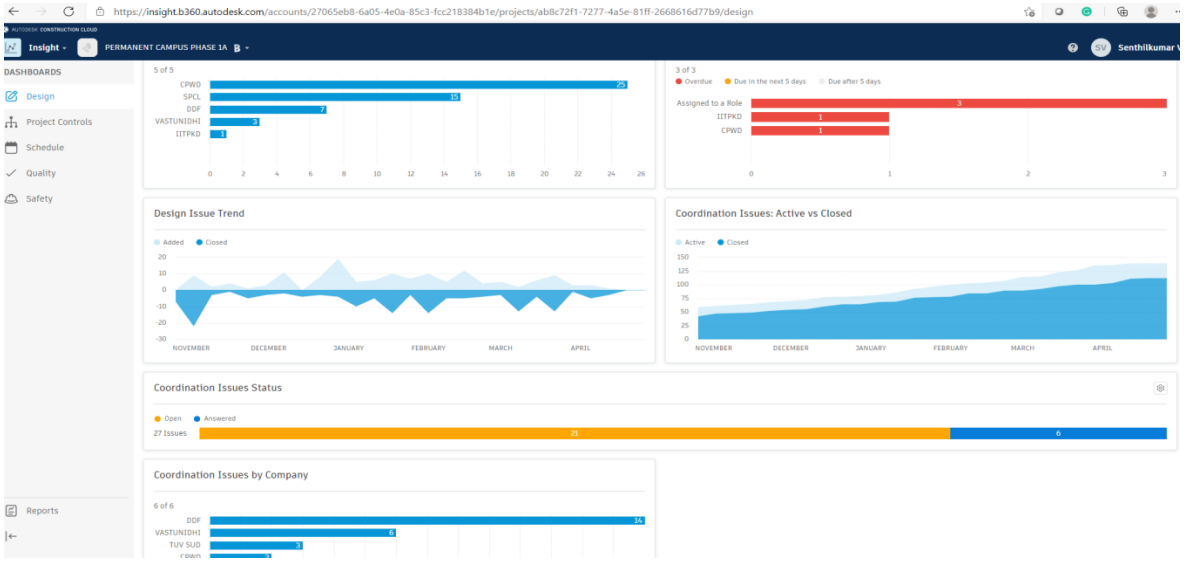


Figure 2. Snapshot of the Project Insight in CDE “BIM 360 Docs”

Deployment of Building Information Modelling (BIM)

IIT Palakkad included BIM model development for all buildings in the notice inviting tender (NIT) for capturing its asset data for the Permanent Campus Phase 1A project. The contractor is asked to develop the Clash Free coordinated BIM model of LOD350/400 before the commencement of construction of each building in this project. However, there are delays encountered in the development and submission of the federated BIM models of the buildings. Further, the developed models will be integrated with the scheduling tool to demonstrate the 4D simulation periodically to better understand the project progress and make timely activity execution decisions. The adoption of BIM greatly reduced the physical clashes, around 675 RFI’s are identified during the BIM model development and the same are resolved and clarified using the BIM360 CDE. Developed model will be a lifecycle Asset Data repository for IITPKD, who aims to reduce the whole lifecycle cost of its assets through an appropriate BMS system. The developed BIM models will be integrated to the BMS. Following are the some of the developed BIM models of work in progress buildings.

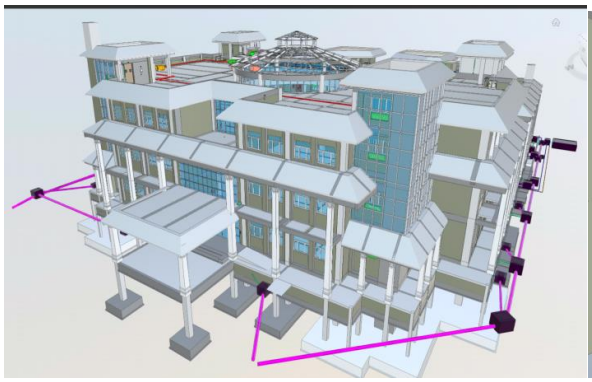


Figure 3. Federated BIM Model of the Classroom Complex A1



Figure 4. Interior View of the Classroom Complex A1 in the BIM Model



Figure 5. Federated BIM model of Central Fabrication Lab in the CDE

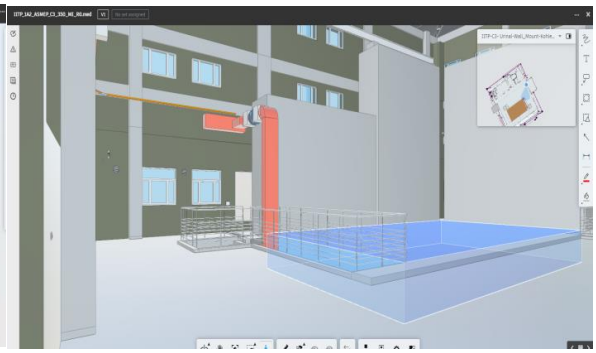


Figure 6. Interior of Large Infrastructure Testing Facility BIM model

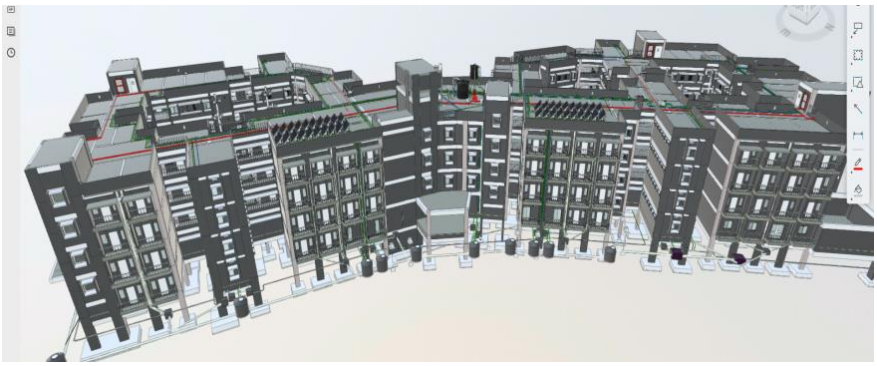


Figure 7. Federated BIM model of the Hostel Block K1



Figure 8. Snapshot of MEP coordination in federated BIM model of the Hostel Block K1



Figure 9. Snapshot of Type V Faculty Quarters BIM model of the Hostel Block K1

Summary

The deployed CDE provide various functionality in the IITPKD project. It gives licenses to access the project data on 24 X 7 basis through a secure login system among stakeholders (presently around 55) belonging to 7 agencies. Further, project related metadata are recorded using the document management's powerful relational database. Complete details of project i.e. who made the information contribution, when it was made (date/time stamp), revision and suitability/status code for each file exchanged etc. It also allows project participants to review the current and all previous revisions, which can be viewed and downloaded on requirement (historical record). CDE used has various level of access permissions including view, edit, upload, download etc., for example a viewer may not have design authoring tools or capability (such as BIM software installed on their system) allow them to review and comment on federated BIM model is possible through the CDE, as well as if he is privileged to have the edit and other authoring permissions on the project information. The metadata stored in this web-based platform will be enough to provide audit trail for files to determine the identity of the project actor and the activity performed during the project. CDE allowed the project team to resolve the RFI's with more details such as photographs, annotated markups etc to convey with ease content and get it resolved quickly. The automated version control plays a major role for the team members to always access the latest drawings, models etc. BIM model is also utilized for clash detection before physical execution of the project. Quality control and documentation at site is improved due to the 3D model access by the executing engineers at site from contractor and CPWD. The implementation also left with challenges as the standard work procedures adopted in CPWD sometimes is in conflict with the digital transformation workflow. Since awareness and willingness to adopt new technologies are low, on realizing benefits adoption had become easier. Potential of much more benefits exists by using BIM along with CDE, present project realized benefits limited to few areas. Additional research, project procurement guidelines and standard operating procedures etc meant for BIM and CDE for projects of CPWD is the need of the hour to benefit most of these initiatives.

HIGH ALTITUDE ROADSIN LADAKH
ENGINEERING CHALLENGES AND WAY AHEAD

Pradeep Gupta, Chief Engineer

1. Introduction

1.1 A high-altitude hill road is the road that passes through a steep or mountainous terrain (with slope more than 25% or more) and located at an altitude of 8,000 ft. or more above the Mean Sea Level (MSL). High altitude hill road construction and maintenance is a very specialized and evolving field of civil engineering. The remoteness of location, restricted working windows and extreme temperature variation as well as low oxygen environment poses a great challenge for working in these areas. These roads are mostly constructed for last mile connectivity and security of the borders with neighboring countries. Usually constructed in highly ecologically sensitive areas, sustainability in construction and maintenance of these roads is of prime concern. CPWD has been proudly engaged in construction and maintenance of high-altitude hill roads for more than 50 years now. The Indo-China Border Roads Project Zone (ICBRPZ) of CPWD located at Leh, UT of Ladakh is engaged in the construction and rehabilitation of high-altitude roads in Ladakh.

1.2 During military standoff in the eastern sector of Ladakh, CPWD was called upon by Ministry of Home Affairs, Govt. of India to restore the protection structures of its high-altitude strategic road along Pangong Lake leading to Line of Actual Control (LAC)in Ladakh. This road is highly critical and of huge military importance for providing last mile connectivity to LAC.

1.3 The road leading to LAC was almost on the verge of collapse into the lake at several places when the work began in July 2020. In case the rehabilitation would not have been done immediately, the road stretch at two critical locations would have been collapsed in the lake in the oncoming winter season resulting in cut-off of the mobility of security agencies towards the LAC. CPWD took up this uphill task when COVID-19 was also at peak and security forces needed it the most to protect the borders of our country. Our priority was to make the road operational on war footing within a month’s time.

2. Challenges in Road Construction at high altitudes

Many operational challenges are faced while constructing roads in high altitude.

2.1. Due to freezing temperatures and low oxygen content in the environment, the efficiency of labour force is greatly reduced. Labour gets sick often and needs to be replaced frequently.

2.2. The machinery also operates at its sub optimal levels in this environment owing to the freezing temperatures and low oxygen content which are general features of high-altitude climate. The POL doesn’t burn completely leading to inefficient performance.

2.3. Maintenance of the machinery has its challenges in the logistics as any component if to be replaced has to be brought from plains to the site resulting in wastage of too much resources.

2.4. The working window in high altitudes is limited only to the summer months of May to October. This limited working window too is often disrupted due to the unpredictable weather conditions in these areas.

2.5. Cement concrete laying is also difficult as the setting time is greatly reduced due to extremely cold environment. Different techniques like adding of admixtures, heating of aggregates, heating of formwork has to be undertaken so as to ensure proper placement and setting of concrete.

2.6. Similar difficulties are also faced while construction of bituminous course of the road. Different admixtures are added in the mix in order to ensure requisite temperature of bitumen while laying, rolling and compacting. .

3. Case Study: Rehabilitation of the protection structures of strategic road along Pangong Tso (14,000 ft.) by CPWD.

3.1. The Pangong Tso is the world's highest saltwater lake (at an altitude of 14,000 ft.) situated in Ladakh region. The lake runs across the LAC in both India and China. This lake is so huge in size that almost sea like turbulent waves can be seen on its shores. The temperatures in the area fall as low as minus (-) 35degrees Celsius. The temperature variation that any structure here goes through is of the order of almost 55degrees Celsius. The oxygen levels are low and require two stage acclimatization for the supervising staff and labour to work at site. The embankment of the road running along the lake is constantly subjected to erosion by the waves.

3.2. RCC retaining wall had earlier been constructed for protection of the road embankment. The wave action of the lake had already eroded the soil below the stem of the retaining wall resulting in loss of fines from the adjacent embankment. This left the existing RCC retaining wall virtually hanging at multiple locations or has failed by overturning and sliding in to the lake. (Fig 1.1 & 1.2 below).



Fig.1.1 Washing away of foundation of RCC wall by wave



Fig.1.2. RCC retaining wall failure by overturning and sliding in

3.3. RCC plates like structures have been deployed on slopes for protection of road slightly away from the lake. These have cracked at various places and are peeling off the soil surface (Fig.1.3).

3.4. **Challenges in carrying out protection works in the area are depicted below (Fig. 1.4).**



Fig. 1.4 Challenges for Protection

3.4.1. **Salinity of Lake**
3.4.2. **Collision with ice chunks of the lake**
3.4.3. **Huge Temperature variation**
3.4.4. **Wave Action**
3.4.5. **Improper selection of existing protection structures**

4. Solution adopted by CPWD - Polymer Coated Gabion with Geo-textile

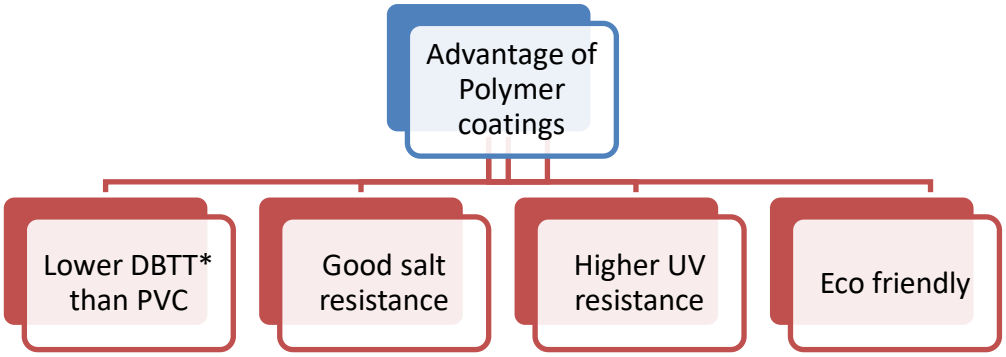
4.1. An ecologically friendly as well as economical solution using the locally available material was needed for arresting the wave action of the lake as well as for protection of the soil in the embankment from losing fines into the lake through wave action.

4.2. **Gabions**

It was decided to put gabion structure adjacent (towards lake side) to the partially hanging retaining wall and cutting off the wave action.So mechanically woven, double twisted, hexagonal shaped wire-mesh gabion boxes filled with locally available boulders was erected along the existing retaining wall towards the lake side.

4.3. **Polymer coated Gabion wire: a new technology to the rescue.**

Polymer coated (organic coating) Gabions were used for countering the above challenges of salinity and temperature variation. This new coating on gabion wire is introduced in IS 16014:2018. Polymer coated gabions are made out of low carbon mild steel wires with heavy duty coating of zinc. The polymer coating is done above the zinc coated wire as per IS 16014:2018. This coating confirms to EN 10245-5:2011.



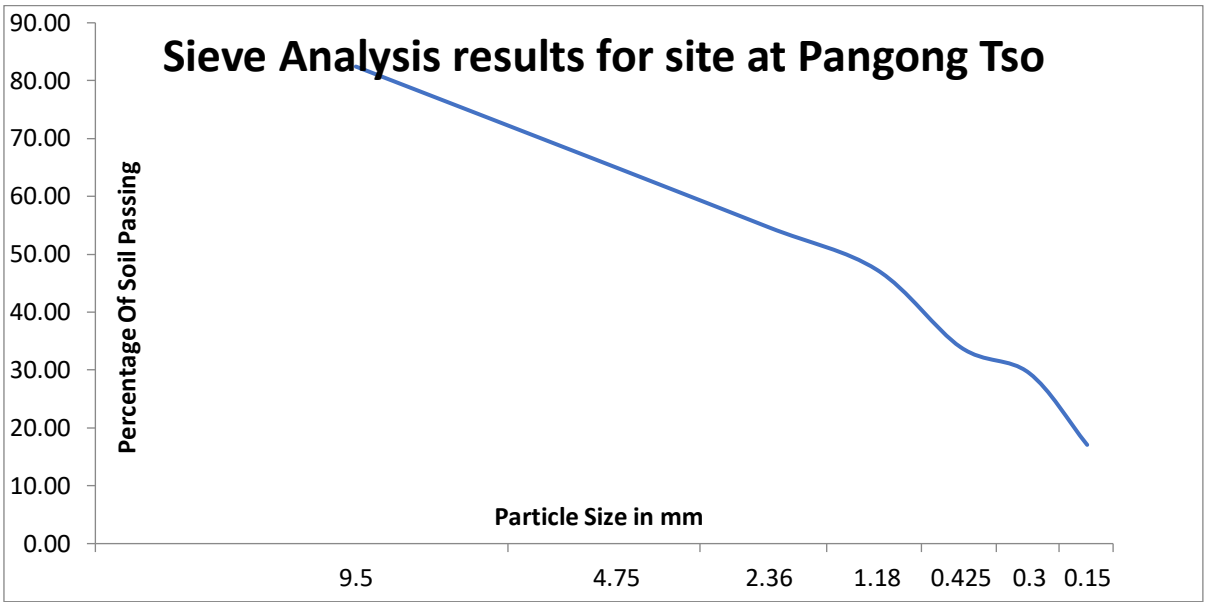
DBTT – Ductile Brittle Transition Temperature

4.4. **Geotextile**

4.4.1. The geotextile was decided to be used as it was needed to avoid loss of fines of the embankment. The geotextile clothing acts as a filter and separating media as the water that still manages to percolate into the embankment gets out through the voids of this media without taking the fines with it. Also, the surface runoff generated by ice melting in the winter season also requires a filter layer to allow the flow of water and at the same time prevent the loss of soil.

4.4.2. The Gabion structure and Geo-textile filter media act in synchronization to prevent the road embankment from erosion. The design of geotextile is required to be done based on the soil characteristics at site of work. The apparent opening size and permittivity of geotextile was selected as per sieve analysis of filled up soil and its resistance against UV radiation.

4.4.3. The sieve analysis of the soil mix boulder to be used in the backfilling behind the retaining structure was carried out at site. Most of the backfill material (>50%) was retained on the 0.075mm sieve.



4.4.4 MoRTH specifications for Roads and Bridges Works (5th Revision), Section 700 and Table 700-6defines the geotextile requirements for sub-surface drainage as given below:

In-situ Passing 0.075 mm Sieve (%)	Permittivity,per sec as per ASTM D4491	Maximum Apparent opening size,mm ASTM D-4751
<15 (ADOPTED)	0.7	0.43
15 to 50	0.2	0.25
>50	0.1	0.22

On the basis of the sample collected and the above table, as well as on the basis of the manufacturer's specification,non-woven geotextile was selected. The selected geotextile at site conforms to the MoRTH specifications as the apparent opening size is as per Table 700-6. The percentage of backfill material passing through 0.075 mm sieve is less than 15%. Hence as per the above table, the permittivity of the geotextile required at site is 0.7 per second and maximum Apparent Opening Size (AOS) shall be 0.43 mm. The AOS for the material used at site is 0.21 mm which is smaller than the maximum AOS required as per MoRTH specifications. The permittivity is more than the required permittivity of 0.7 per sec.The condition for installation is taken as moderate Type-II.

4.4.4. Geotextile selected for the project conforms to the moderate installation condition as per the manufacturers test certificate. The parameters for strength (i.e., grab,tear and puncture) become significant due to the fact that the geotextile has to bear the weight of the soil backfill. The pressure created due to movement of heavy vehicles (Army/ITBP trucks and artillery) also becomes a guiding factor in deciding the type and specifications of the geotextile.

4.4.5. The function of filter material is also performed by the geotextile as it filters out any ice melt /surface runoff.

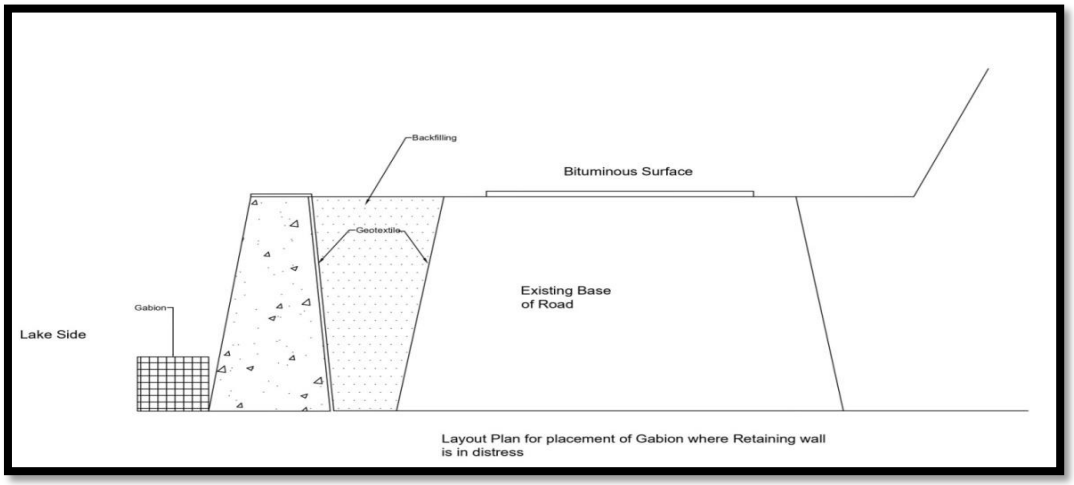


Fig.1.7 Schematic of gabion placement where retaining wall is already .



Fig. 1.8. Actualon-site image in December 2020.

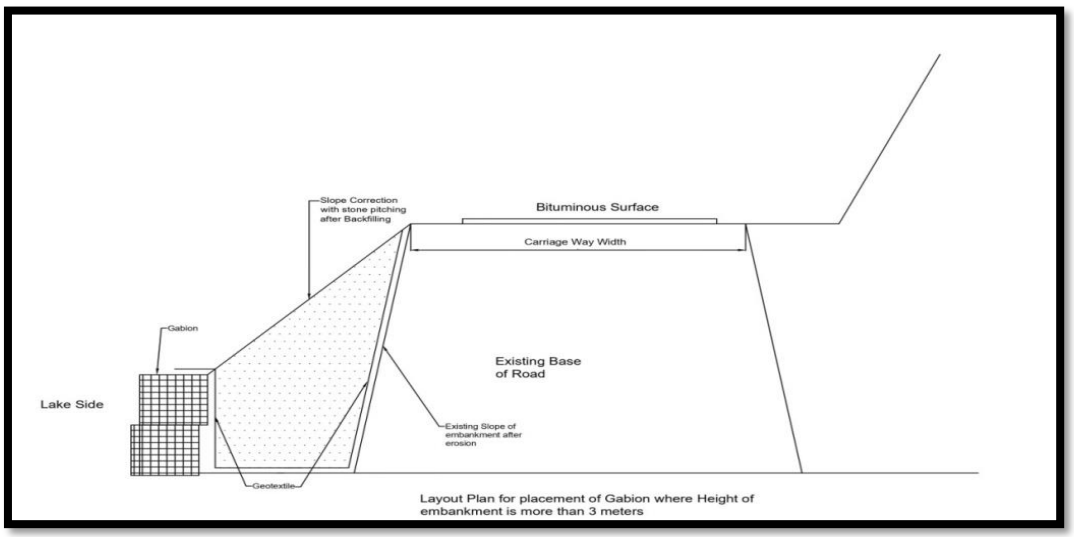


Fig. 1.9. Schematic of protection work where there is no retaining wall and road is away from the lake.



Fig. 2.0. Actual onsite image in December 2020.



Fig. 2.1.Existing condition of road in July 2018.



Fig. 2.2.Road after rehabilitation by CPWD in December 2020.

5. Conclusion

So far CPWD has been able to restore protection works for 1.5 km length (approx.) covering all major critical points. The remaining portion of work is now being taken up in full as the lake is now unfreeze and weather has become mild. There is a very unique situation prevailing at site where any conventional ready to use solution could not be deployed. Polymer coated gabionsis a latest innovation which came to the rescue in this particular condition. Further, the conventional geotextile also had to be used in a new innovative way to tailor the need of the project. We can draw a conclusion now that bad engineering in the initial phase of the project during construction of road always leads to additional expenditure for rehabilitation &maintenance, besides lowering the service life of the road and associated structures as a whole.

CASE STUDY OF REPAIR, RESTORATION & RETROFITTING OF FIRE DAMAGEDGORTON CASTLE BUILDING

Devendra Prakash Superintending Engineer, Shimla

Historical Background



The site of 'Gorton Castle' Shimla originally belonged to Mr. Gorton, I.C.S. during the year 1840. Then it felled into the hands of a Banker, Sir James Walker, for making it a hospital, in 1890. However, the proposal was later rejected due to non-suitability of site. The Imperial Government of India then purchased the site in 1900 to build the office of Civil Secretariat at a cost of 1.20 lakh. The original design of current building was conceptualized by Sir Swinton Jacob in 1900 and it was built under supervision of Major H.F. Chesney, R.E. The construction works commenced during November, 1901 and completed during May, 1904 and this building was named as "Government of India Civil Secretariat". The building was got constructed for a cost of Rs. 11 lakhs. The structure of this building is three to four storeyed structures with load bearing stone masonry walls in lime-surkhi mortar of varying thickness (width reducing from 90cm at Ground Floor to 45cm at Top Floor) with GI Sheet in Nainital pattern, artistic roof with provision of various features such as spires, canopies, flag-post, attic floors, jack arch ceiling, etc. Presently, Gorton Castle Building houses the office of Pr. Accountant General (A&E) and Pr. Accountant General (Audit) of Himachal Pradesh.

Fire Incidence





In the night of 27th-28th January, 2014, a major fire broke. Due to this unfortunate incidence, top two floors of Gorton Castle Building gutted into fire causing massive damage to the top two floors of building including structural damages. CPWD took the challenge of repair, restoration & retrofitting of fire damaged Gorton Castle building. A comprehensive inspection and study of the building was made by the Senior Scientists of CBRI and CPWD officials. As per recommendations of CBRI, retrofitting of this building was taken in two phases. The repair, restoration & retrofitting of this building for phase-I is already completed and handed over. Since top two floors were massively damaged, therefore need of time was to first clear burnt materials from these two floors. With dedicated involvement of CPWD Work-Charged staff and CPWD officials & on war footing works, removal of burnt materials were done successfully within very short time-frame. Additional office space was created using prefabricated structure and official functioning was normalized in two-third portion of building. Rest one third portion of building was selected for commencing restoration works. The big challenge in front of CPWD team was to carry out typical restoration works in methodological way and maintain safety of occupants during official hours. The Restoration Works were basically categorized in two parts:

(A) Strengthening of Ground Floor and First Floor which were intact and not affected by Fire.

(B) Re-construction of Second and Third Floor which were heavily damaged due to fire

(A) Strengthening of Ground Floor and First Floor

1. **Strengthening of stone masonry walls using bond stones:** Pre-cast bond stones were used to strengthen masonry walls. Various sub-activities undertaken under this operation are elaborated as under:

(a) Dismantling of existing lime plaster using pneumatic hammer.

(b) Use of steel formworks for Pre-casting of bond (through) stones of 135mm dia in M25 design mix concrete with 10mm dia TMT bar at centre.

(c) Making holes of 150mm diameter in stone masonry walls using Core cutting machine and repairing inlet face using cement mortar 1:3(1 cement:3 Coarse sand).

(d) Insertion and placement of bond stones at spacing of 1.5 mtrs center to center both horizontally and vertically in staggered pattern.

(e) Pressure grouting of peripheral gap around bond stone using lime-cement-sand grout (1 lime: 1 cement: 1 Quartz sand) admixed with cebex 100 (plasticized expanding grout) of Fosroc.



2. **Strengthening Using Pressure Grouting**

Weak spots in stone masonry walls having loose mortar joints/ hollow joints/ cracked stones were marked and following sub-activities were undertaken:

(a) Raking of joints using pneumatic hammer/chase cutting machine and cleaning of stone masonry walls using water pressure jet.

(b) Pressure grouting using lime-cement-sand grout (1 lime: 1 cement: 1 Quartz sand) admixed with cebex 100 (plasticized expanding grout) of Fosroc at these weak spots.



3. **Strengthening of Corners of stone masonry walls:** The corners of stone masonry wall were strengthened using epoxy coated TMT bars. Various sub-activities undertaken under this operation are as follows:

(a) Excavating pit for pedestal of size 600 x 600 x 600 mm and erection of epoxy (Nitozinc primer) coated 12 mm diameter TMT steel bar from pedestal at corner of stone masonry wall & clamping the bar at mid heights to keep it intact in corner.

(b) Casting pedestal in M25 design mix concrete.

(c) Making champhered corners of 75 x 75 mm using micro-concrete.



4. Strengthening of openings and walls using Galvanized Welded Wire Mesh

The door and window openings were strengthened by wrapping & pneumatic nailing of 300 wide galvanized wire mesh around door/ window openings and also wrapping it at sill and lintel level all around.




5. Strengthening Using Ferro Cement Plaster

Ferro cement plaster was done on stone masonry walls to further strengthen it. The sub-activities performed under this operation are mentioned as below:

(a) Application of layer of Nitobond AR of Fosroc (bonding agent between old and new layers).

(b) Leveling course of cement plaster of varying thickness to bridge uneven protrusions of stones in cement mortar (1 cement: 3 coarse sand) admixed with Conplast WL (Integral waterproofing agent) and SBR Latex (mortar and screed modifier cum bonding aid).

(c) Wrapping and pneumatic nailing of galvanized woven wire mesh on the entire surface of leveling course.

(d) Two layers of ferro-cement plaster of 10mm thickness each in cement mortar (1 cement: 3 coarse sand) admixed with Conplast WL (Integral waterproofing agent) and SBR Latex (mortar and screed modifier cum bonding aid) with application of layer of Nitobond between layers & galvanized woven wire mesh between layers.





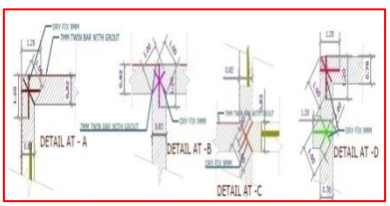

6. Seismic Retrofitting Using SS Helical Bars

Dry fix helical bars have been used to stitch L&T joints of stone masonry. Wet fix helical bars have been used for seismic retrofitting of structure. Helical bars have been used at sill level & lintel level of each storey of building. Following Sub-activities undertaken under this operation:

Dry stitching at L&T joints of stone masonry walls

(a) Making pilot hole of 7mm dia & 15mm more long than the length of helical bars.

(b) Driving 9mm dia SS helical bars at sill & lintel level of each storey using drilling machine and plugging the top of hole.




Wet stitching in external periphery of stone masonry walls:

(a) Making 30mm deep chase at sill & lintel level using chase cutting machine.





(b) Placement of 7mm dia SS helical bars at sill & lintel level of each storey.

(c) Covering the gap using thixotropic grout using pressure gun and finishing the joints with proper raking.

(B) Re-construction Second Floor and Third Floor

The second and third floor was completely burnt & damaged due to fire. Therefore it's dismantling & removal of malba was main challenges which were successfully completed by dedicated efforts of entire work-charged staff of CPWD Shimla in a very short time frame. The sub-activities in re-construction works included followings operations:













(a) New stone masonry walls in cement-lime mortar (1 cement : 1 lime : 3 coarse sand) matching with shade of parent stone.

(b) Re-construction of fire places for fire chimney in brick masonry and facia of decorative wood work in teakwood.

(c) Provision of MS belting arrangement of epoxy coated MS flat both longitudinally and laterally inside the stone masonry wall at lintel level (second and third floor) in order to tie the structure and provide lateral & ductile strength to structure against seismic forces.

(d) Casting of 150 mm thick RCC bands in M25 design mix concrete above lintel level and creating pedestal with gusset plate top for supporting structure members of deck slab roofing at second floor and truss roofing at third floor.

(e) Deck sheet slab supported on MS girders & secondary members were placed. After that shear studs were welded near the both the supports and nominal steel bar (8mm dia @ 250 mm c/c) were placed and casting of 120mm thick RCC slabs in M25 design mix concrete was done.

(f) Erection of pre-engineered tubular trusses and purlins coated with primer, fire retardant paint and enamel paint at third floor.

(g) Covering structural members of trusses with 300mm wide pine wood planks (coated with fire retardant paint & bitumen paint) & jointed with tongue and groove joint, laying of APP water proofing membrane (3 mm thick and 5 layered), laying of polynum sheets (4 mm thick) as moisture/ vapour barrier over APP sheets & final fixing of postal red 0.8mm thick CRC sheets in Nainital pattern.

(j) Cleaning of external facade using antifungal wash treatment chemicals, re-pointing of the joints of stone masonry walls and applying chemical for restoration of stone and final coat of water repellent.

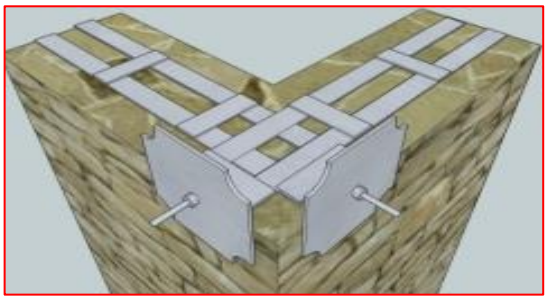
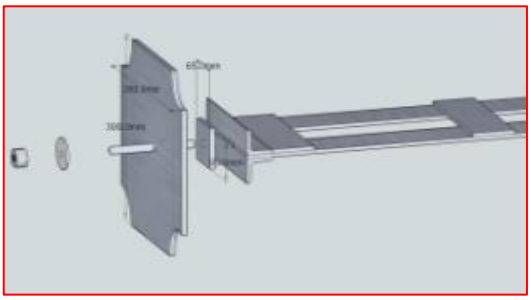













(C) Internal Finishing Works

The internal finishing work include following sub-activities:

(a) Ornamental teak wood wall lining with melamine polish.

(b) Ornamental door fittings like brass sliding door bolts, handles & long tower bolts in doors and windows.

(c) Ornamental precast cast iron spiral staircases.

(d) Ornamental electrical fittings like gold plated electrical switches & sockets

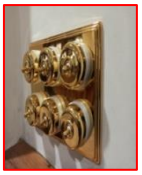
(e) Dhajji wall internal partitions basically include stone pieces/ stone chips masonry wall in mud–phaska mortar reinforced with pine wood batten and frames to provide thermal insulation and also to economies the cost of construction.

(f) Cast iron rectangular drainage pipes with arrangement of funnel at top.







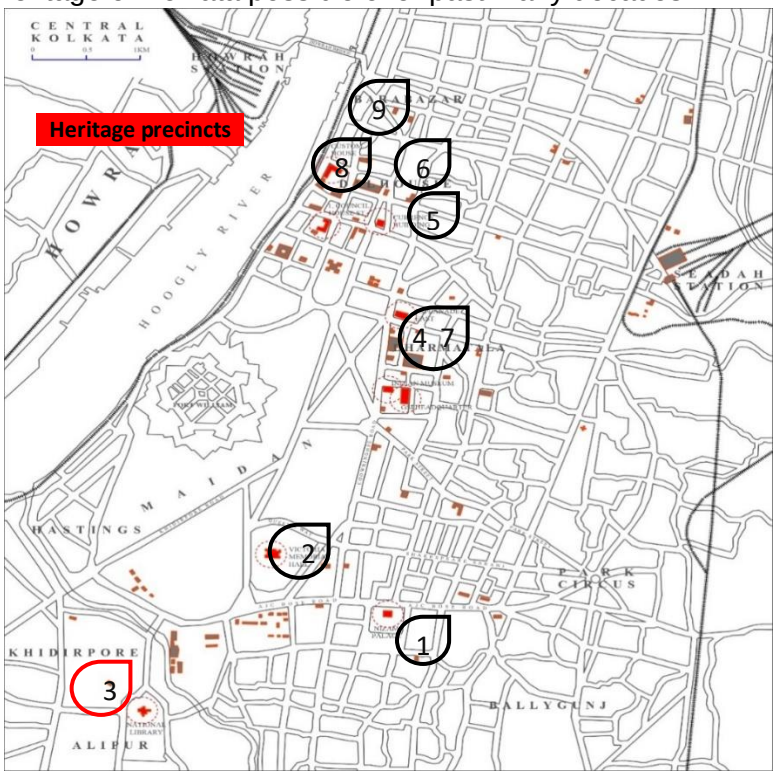





REVISITING THE ARCHITECTURAL HERITAGE OF KOLKATA WITH CPWD - A CASE STUDY OF BELVEDERE HOUSE (NATIONAL LIBRARY)

Shibashis Chaudhuri, Architect, Chief Architect (Region Kolkata)
Debarati Chakraborty, Architect,Chief Architect (Region Kolkata)

Introduction: Kolkata- once the 'City of Palaces' is now the City of Joy – an epithet that hardly carries any meaning expect in the fertile imaginations of the poetic mind. Kolkata once standing as the second city of the empire is now a decaying urban slum, but still carries the legacy of being the capital of British ruled India with its monuments and hidden built heritage gems. CPWD on the other hand as an esteemed institution since its inception in 1854 is entirely dedicated in building this Nations capacity in the world-wide platform and since the formation of its eastern zonal headquarter in Kolkata around mid-twentieth century, CPWD has not only set the mark with creating new landmark buildings / projects & adding up values to city skyline but also has been very active in protecting the built heritage in the once 'City of Palaces'. From time immemorial to 2021 CPWD in Kolkata has been entrusted with works related to conservation & restoration, upgradation, maintenance of numerous numbers of Grade I, Grade II, Grade III categories (as in the Heritage category of Buildings enlisted by Kolkata Municipal Corporation) of Heritage buildings in Kolkata. Some of the Buildings worth mentioning in this piece are (a) Indian Museum, (b) Victoria Memorial Hall, (c) Belvedere House (national Library), (d) Currency Building, (e) Nizam Palace, (f) Customs' House, (g) 1No. Council House Street, (h) GSI Headquarters, (i) Esplanade East. CPWD Kolkata with its own team of remarkably able Architects, Engineers & Horticulturists is devoted and relentlessly working towards making better and meaningful existence of such prestigious built heritage of Kolkata possible over past many decades.





8. 1, COUNCIL HOUSE



9. CUSTOM HOUSE



6. CURRENCY BUILDING



7. GSI HEADQUARTERS



5. ESPLANADE EAST



1. NIZAM PALACE



2. VICTORIA MEMORIAL HALL



3. NATIONAL LIBRARY



4. INDIAN MUSEUM

ABOUT BELVEDERE HOUSE: The **Belvedere Estate** consists of Belvedere House and 30-acre (12 ha) grounds surrounding it, in which the National Library of India was housed, since 1948[1][2] . It is located in Alipore, near the zoo in Kolkata. Belvedere House earlier was the former palace for the Viceroy of India and later the Governor of Bengal. The Governor of Bengal resided in Belvedere House, Kolkata till year 1948, when Government House (present Raj Bhavan) was constructed; the Governor of Bengal shifted there and Belvedere Houses was handed over to National Library of India. There is talk of unconfirmed supernatural sightings in the house as well as the grounds, with rumours of the ballroom being lit up and carriages drawing up in the driveway. The complex now includes within it, two housing colonies built by the government, one being for National Library of India employees and other for central government employees. The main building is under the coustody of the Archaeological Survey of India.[1] Presently the major portion of the Belvedere Estate comprises the old belvedere house, and houses National Library of India in the newly constructed Bhasha Bhawan in the campus. While a small portion of Belvedere Estate is being used as residential complex for fairly senior Central Government employees and is known as '1, Belvedere Estate, Alipore Road', consists of 24 Type VI houses and 77 Type V houses, is under the control and maintenance by the CPWD (Central Public Works Department) and provides very quiet and pollution free housing, with plenty of old trees and walking area, to the Central Government Employees.[3]

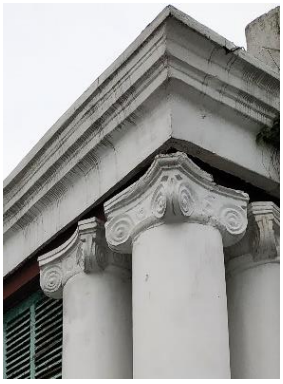


Illustration of Belvedere House, 1838, by the Anglo-Indian merchant and artist William Princep.



Panorama taken from the same angle on 31st May, 2021.





Ionic Columns & Wooden Louvers in 2nd floor Balcony



Doric Column, archways, detailed stucco relief work



Doric Column, archways, detailed stucco relief work



Corinthian column, Dentils, trabeated , stucco work, matka baluster and face relief in balcony support

ARCHITECTURAL STYLE OF BELVEDERE HOUSE: C. E. Buckland describes it as follows; “in the middle of a park studded with groups of trees stands Belvedere house. Its architecture is of a **free Italian renaissance style developed of an ordinary Anglo-Indian building.” [4]Amalgamation of various architectural styles** prevailing in the pre-independence era can be found in & out of the structure adapted as per the requirement of the users over the timeline of its existence. No real discernable pattern or style can be found as the building has been extended and modified number of times. The entire building is raised on a high plinth forming a basement floor. Broad flight of steps on the north and south leading up to the building can be seen. All the columns on the ground floor level have Ionic capitals; those on the upper level have Corinthian capitals. Segmented Arch, full archways can be found over doorways or windows in external or internal part of the building. Extensive surface decoration as festoons in stucco, Plaster decoration dentils in the cornice, earthen pot balusters or cast iron railing in balcony of parapet, carved wooden ornamentation and traces of wooden louvers / jalies in balconies can be seen throughout the building.



Exposed RWP inside the structure causing seepage



Failure of structural support systems



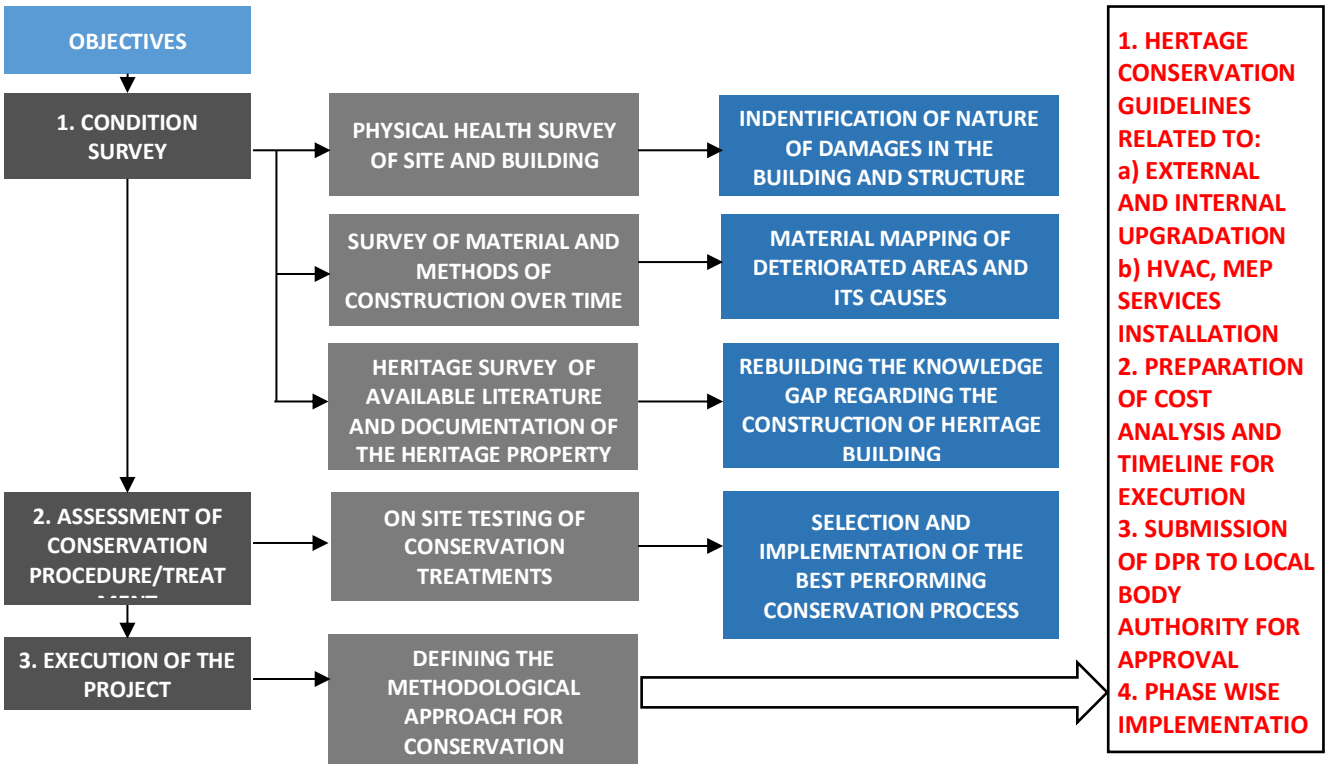
Roof failure, piled-up debris



Open drainage channel in floor

CONDITION SURVEY: The **Belvedere House** once standing as a glorified & luxurious stay for its residents from time late as 1700, further transformed into National Library in the post Independent era, is now suffering from severe damages within the structure, from the modification done from time to time by its previous owners. From the high plinth transformed into the part of National Library with functional uses put therein as reading hall, stores or galleries for books and various other departments, to its first and second floor with additions and alterations done with the entire structural systems to make it suitable for the use as a library, has made some detrimental characteristics changes in the entire structure, resulting in vertical / horizontal cracks in the wall, rupture in the roofing systems, failure of wooden beam and purling supports, damaged internal and external plumbing and drainage system (seepage in roof, wall), pillage of plaster etc. .Although the 1st floor and a part of 2nd floor was restored in 2019, none of the actions taken could suffice the purpose of restoring back the structure in entirety to its almost original form, or catering to the need of safety point of views as important as the fire-fighting systems or disaster management

METHODOLOGICAL APPROACH FOR CONSERVATION & RESTORATION OF BELVEDERE HOUSE:



CONCLUSION

The dire need of a comprehensive and sustainable conservation and restoration procedure and a future vision report with proper HR management and day to day maintenance is evident from the condition survey done during 2021. Any structure becomes prone to decay once left unused. Proposal formation based on a tri partite model as coined in general conference of ICOM(1971) is in process.Proposal preparation combining display galleries, display reserve (part/whole), temporary exhibition.Proposal for preparation of transformation of museum as a forum (from research to socio-cultural aspect shift). Hosting exhibition/publications/educational programs& events/light and sound show shall generate public interest and facilitate revenue generation is a part of the proposal. A strong and competent team comprised of heritage experts, Architects, Engineers, Horticulturists from CPWD is working persistently to make this dream come true.

Brief note on Infrastructure Development
A- Challenge in Rann of Kachchh

B P Singh, Chief Engineer

Abstract

Rann of Kachchh is known for its hardship not for the public but also a challenge for the Engineers to find an acceptable solution to the technical hardships due to the climatic & environmental severity and aggressive engineering parameters. Experienced professional body consultation and detailed study has helped in negotiating the difficult ground condition of corrosion, erosion, marshy water-logged area and wave action of both way movement of the tidal water for the development of various infrastructure such as road work, fence & building structures. There is no substitute for use of new technology and industries trend.

1.0 Background

Border Fencing Zone of CPWD is involved in developing infrastructure works in state of hilly terrain of Uttarakhand, riverine belt of Punjab, desert land of Rajasthan and Rann of Kachchh in Gujrat. Each state is known for its uniqueness in terms of climatic conditions, environmental severity, soil condition and other construction associated problems. Here, the focus has been kept on deliberating to the problems related with the Rann of Kachchh area only. The Construction of new border road & link road, strengthening of existing border road and link road, Construction of new fence and replacement of existing damaged fence and construction of New Border out post including maintenance of Border and link roads in area of Rann of Kachhh along the Indo-Pak border up to Sir Creek region are the new tasks assigned in the area **(figure – 1).** The area is unique in terms of its land features, environmental issues and harsh climatic condition which poses a great Challenge for an Engineering fraternity.

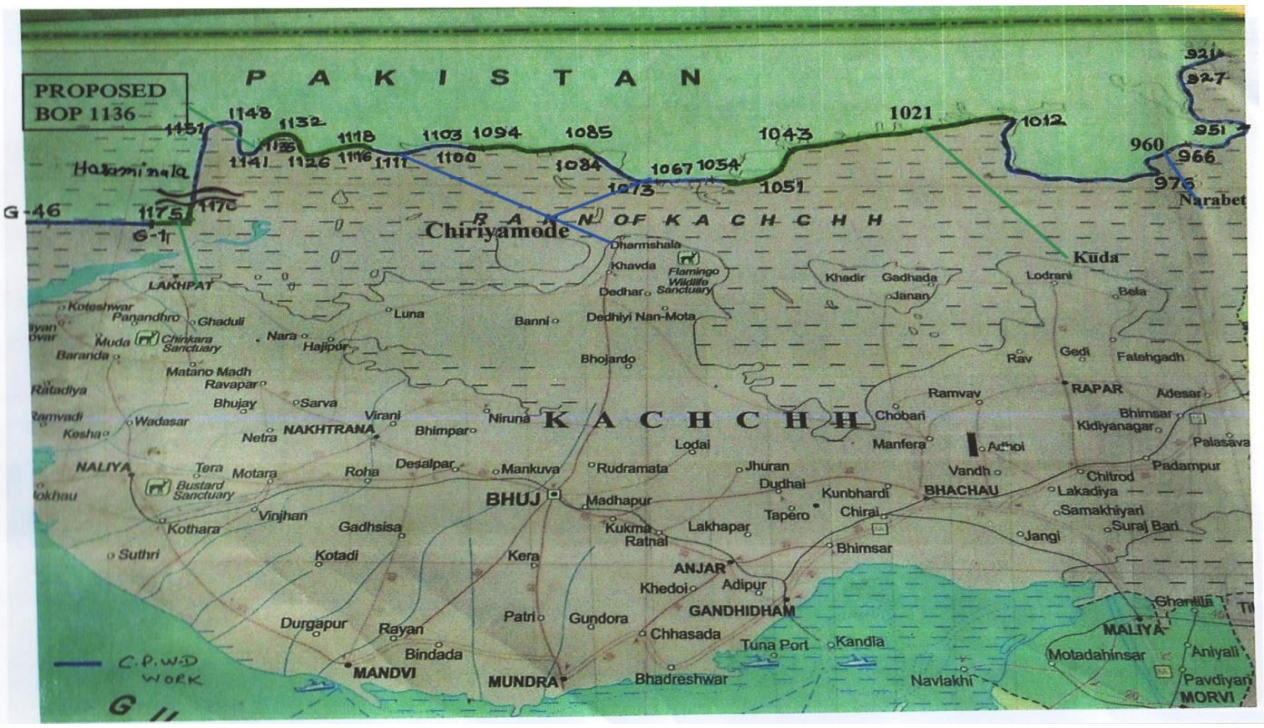


Figure 1 General ground features and area jurisdiction along border line

2.0 Kachchha at a glance

Kachchh is an ancient land with history since antiquity and deriving its name from geographical characteristics and topographical features resembling a Tortoise 'kachchh'. Latitude 22º44'11"- 24º 41'25" N, Longitude 68º09'46"-71º54'47" E, Coast line 406 Km, Temperature 0-50º C, Rainfall Annual average 382 mm. Total annual of rainfall varies from 2 mm to maximum of 840 mm. Even though rainfall is scanty sometimes heavy rain 100 mm to 250 mm in a day are recorded. Short rainy season, frequent failures of monsoon, high rate of evaporation (2400 mm annual) Freak cyclone storm with high local winds are the typical features of the area.

3.0 Climate

It falls within great tropical desert belt stretching from Sahara to Thar. Summer sun is vertical and intensively hot. Winters are comparatively cool and particularly following failure of monsoon rains, the dry land becomes extremely cold. No vegetation cover but high radiation. A strong wind during cool months blows N-E. Basic Wind speed is as higher as 50 m/s with that Topography Flat. Sea water ingress and regress due to tidal variations land area remains marshy. The depth of tidal water varies from 1.8 m to 2.1 m. Seismological it lies in a very active Zone-V.

4.0 Field observations / investigations

Lot of damages in the existing Building structures (BOPs), Barbed wire fences, border roads and link roads have been reported in the past. The extent of damages can be seen in the following photographs **(figure – 2, 3, 4 & 5)**



Figure 2 Damage in existing link road



Figure 3 Overtopping of border road



Figure 4 Corrosion in fence



Figure 5 Damage in building

5.0 Summarizing the challenges

These damages have been credited to poor soil conditions, quality of soil and water (high Chlorides and Sulphide Contents), movement of rain and tidal water (both ways), poor drainage, water logging, harsh weather conditions, soil erosion and excessive corrosion etc.

6.0 Professional Body involvement

The professional bodies like CRRI (New Delhi), CECRI (Korikudi), Sri Ram Institute of Industrial research (Delhi) and SVNIT (Surat) were involved for providing professional expertise.

7.0 Physical and chemical analysis of Soil and Bore water

Sub Soil Engineering Properties

Subsoil properties		Location	
		BP 1135 – BP 1154	BP 1175 – G17
SPT N – Value at 1.5 m depth		4 – 13	2 – 7
In-situ Moisture Content (%)		22.10	30.5
Salt Content (%)		13.81	16.91
Liquid Limit (%)		33	36
Plastic Limit (%)		NP	19
Plasticity Index (%)		NP	17
Grain size Analysis	Gravel (%)	0	0
	Sand (%)	80	71
	Clay (%)	16	29
Ground water table		0.85 – 4.0	0.45 - 1.50
High Flood Level		1.80 – 2.00	2.00 – 2.10

Chemical analysis

A - Soil

BP	Depth (m)	pH	Chlorides (%)	Sulphate (g/l)
1135-1142	3.0	7.87	0.45	2.9
	6.0	8.11	0.78	2.4
1175-G17	1.5	8.03	0.35	5.6
	3.0	8.07	0.28	5.2

B – Bore water

BP	pH (>6.00)	Chlorides (as Cl) Max allowed 500 mg/l	Sulphate as (SO3) Max allowed 400 mg/l
1135 - 1142	7.12	10000	3010
1175 – G17	7.55	16650	4650

8.0 Engineering Solution

8.1 Road work

8.1.1 Providing Gabions and Geotextiles

The embankment soil obtained from Rann area is having excessive salt content. This very high salt content makes soil highly friable and prone to erosion due to wind and water. Detailed specifications Gabion and Geotextiles used are enclosed in the Annexure.

8.1.2 Stone pitching for embankment erosion control

The side slopes are very much prone for erosion due to rainfall and wind. The embankment side slopes need protection irrespective of HFL. Gabion toe wall of sufficient dimensions on both sides of the embankment are provided for damage control due to Tidal wave.

8.1.3 Improvement of soil

Out of the available ground improvement techniques the uses of Bi-Axial Geogrid and Geotextile have been preferred due to the existing soil characteristics. Detailed specification of Bi-axial Geogrid and Geotextile has been provided in the Annexure. The typical road sections are shown in **figure –6.**

Location	Height of embankment
1135 - 1149	3.5m
1149 - 1154	3.7m
1175 - G10	3.5m
G10 - G17	3.8m

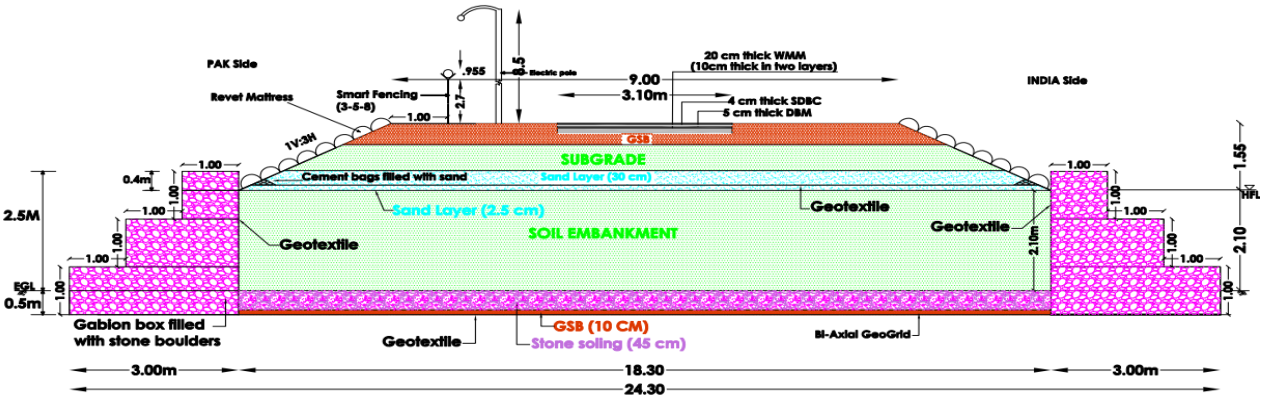


Figure 6 Proposed new road typical section

8.1.4 Provision of balancing Culverts for Drainage Measures

Based on the discharged assessment it was felt to provide more number of culverts (at every 250 m intervals) on border roads to act as balancing culverts and to ensure unhindered movement of flood waters from upstream side to downstream side. **(Figure – 7)**



Figure 7 Precast RCC Box Culvert 2.5 m X 2.5 m

8.1.5 Minimising the adverse effect of Chlorides and Sulphate

It was achieved by the use of Richer grade of concrete(M40),restricting the C3A content of 5-8% in OPC cement, Limiting the total Sulphate and Chloride content in wet concrete, self-compacting concrete for making dense concrete to reduce the Rapid Chloride penetration value(600 Coulomb) and water permeability value of 10 mm. Use of high corrosion resistant (HCR) steel in conformity to IS 1786:2008 Amendment 2017 were resorted. Over and above two coats of water repellent acrylic-based paint have been used to increase the durability further.

8.1.6 Fence work

The damaged fence to be replaced with single line new modular fence system which is anti-cut, anti-rust and anti-climb having resistance of C 5M grade of corrosivity.
The level of precast concrete foundation block will be raised at least 150 mm above HFL. To avoid contact of soil with the fence, a provision of precast RCC beam of 150X 100 mm between the foundation block has been used.
The sample of new design fence installed at site is shown in **figure – 8**.



Figure 8New design single line fence (3-5-8)

9.0 Conclusion

The challenges posed by the Environmental severity can be dealt by treating the every element of a structure suitably. The adverse effect of Sulphates and Chlorides in the soil and water can be effectively countered by the use of dense and durable concrete by controlling the vital parameters of water permeability and RCPT test. Use of new technology and materials available the soil capacity can be improved. Soil erosion and tidal wave action of water have also been dealt suitably by use of Gabions, Geogrid and Geotextile. Present industry trend and practice is helpful in finding the feasible solutions. Codal recommendation needs to be carefully studied before field implementation. Sometimes only indications are given in the code to tackle a specific problem which requires further study. Use of New Technology and as much as possible local available material has been helpful in reducing the carbon foot print.

Revisiting the Built Environment in Post Covid Era

C K Varma, Additional Director General (Region Chennai)

Introduction:

The corona virus has left us amid a serious health crisis. Not only that, it has also been appeared and construed as a design problem. The built environment therefore needs serious design thinking in the aftermath of Covid 19.



World over, architects and engineers are seriously considering as how to deal with this life threatening disease in the building design. In CPWD also, building design has to be revisited to identify the points of infection and their elimination so that such type of crisis can be overcome by taking simple steps.

While the already built environment needs suitable adaptations, the to-be built environment requires further planning to suit the future situations. So to say, the built environment has undergone different spatial definitions & dimensions since the beginning of covid-19 world over. Lot of people are now thinking about spatial life in the Covid era. Extending this to post-covid era, the built environment should necessarily include more open spaces, touchless services, sanitisation sprinklers, automatic doors with thermal imaging etc.

Especially, the second wave has triggered many permanent changes we look towards our living and working spaces. These changes in a nutshell include social distancing norms, separate entry and exit points, proper shielding between people etc.



If social distancing, frequent sanitisation and covering face with mask are the neo norms of the society, then these norms should also be in-built in our living spaces where we work, rest or socialise.






This can be achieved by making flexible changes in our built spaces by suitable furniture layout, incorporating sanitisation chamber at the entrance to the building and by proper shielding between individuals as depicted below:





The countering of the Corona crisis in the built environment has mainly two types of controls namely Architectural and Engineering controls.

Architectural controls:

- Separate entry and exit Gates
- Wall near to entry with built in thermal scanner & Space provisions for sanitisation chamber at the entrance
- Furniture Layout to avoid direct facing of each other by people
- Interior Fabrics for avoiding sitting of pathogens
- Building Materials: Easy to clean building materials with non-porous surfaces and
  Antimicrobial Technology, Wall Treatment by using microbicide wall paints, Floor treatment by avoiding Granite and other natural stone countertop surfaces which allow for moisture, food particles, and microbial spores to accumulate. In place Cork, Epoxy, Terrazzo, Linoleum and Bamboo flooring can be considered. Lead free Copper will be the new material trend for Kitchen & Bathroom fixtures as it does not allow free surface for pathogens
- Work from Home is the new trend- A space with enough daylight, ventilation and comfortable sitting should be the new norm for dwelling units.
- Health care design needs an upgrade too. “The biggest thing to come to light during this period is the inability for hospitals to accommodate the large number of sick people. So from design perspective, a normal patient room should be more flexible to increase capacity or be easily converted into an ICU.
- Concerns about future viruses might encourage architects to provide more open spaces for enabling people to spread out. This will be helpful to people within to maintain social distance.
- Even Parking spaces should have the flexibility to turn into critical care units / quarantine spaces- Large parking spaces in every public utility building can turn into covid hospital as the need arises.

Engineering controls

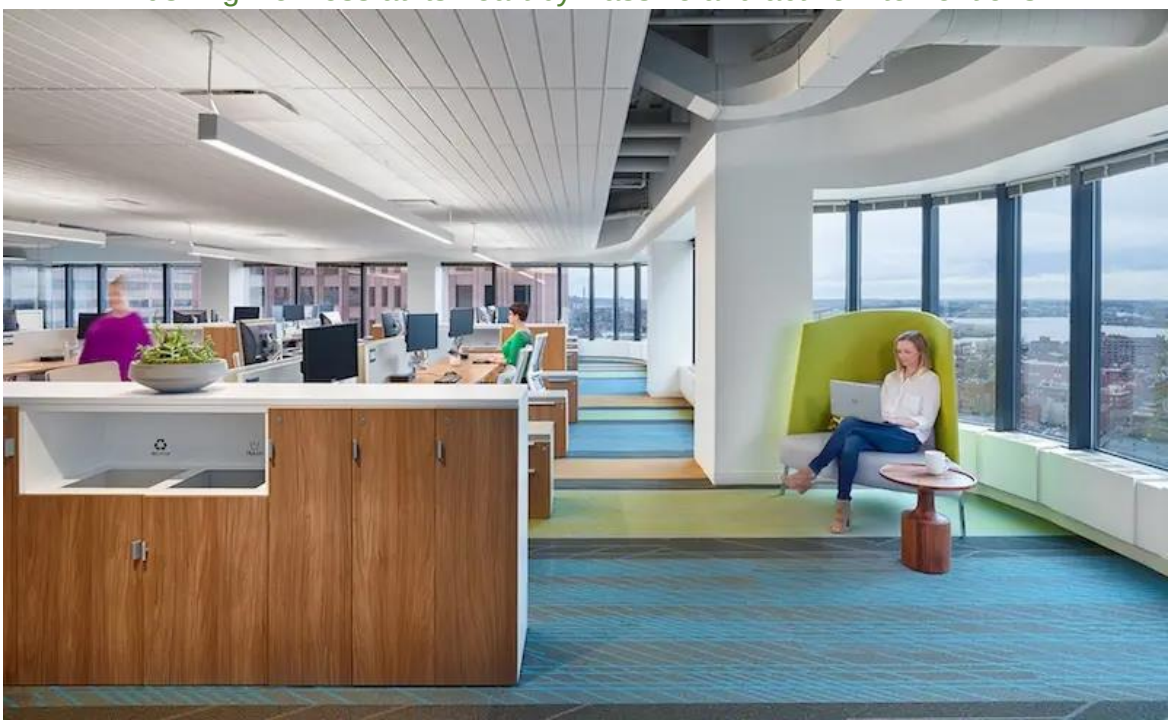
- Doors can be automatic to avoid any surface touching

- Touchless/App Based Elevators
- Remote/voice operated switches for room lights & Fan
- UV Lights need be used for sanitisation in offices and homes- At least one UV Light can be installed in every space to provide disinfection of usable surfaces.
- UVGI system in Air conditioning will sanitise the air in the AHU itself- Air flow when gets sanitised through Ultra violet rays will provide people safe air with requisite comfort.
- The need for fresh air and more air changes in the closed spaces has compelled us to look to our present system of comfort with air conditioning and air circulatory system.
- Mixing of return air should be totally eliminated. 100% Fresh air intake and exhaust should be the new norms in HVAC Design to avoid any infection through air draft.
- Use of AI in density Management within built space- Density Management within built space can be controlled by suitable Algorithm based on Artificial Intelligence.
- Waste Converters- Different types of Converters will be required to be installed in large numbers in built spaces to convert large amount of waste generated especially medical and other non biodegradable waste.
- Food transfer window- Its applicability is felt more in housing societies as well as office gates.

Conclusion

Motto of building design should therefore be

Pushing wellness at its heart by Passive and active interventions!



This will strive to keep humans Safe, Healthy& Pathogens Negative in a built environment.

Emerging Technologies in Healthcare Infrastructure

Ar. Monika Gupta, Sr Associate Architect, M/s Sikka Associates, New Delhi

The world of pandemic has clearly brought out the importance of “resilience” in healthcare facilities. While designing a crucial facility like “hospital”; one must understand that minute details of the building could be lifesaving factor for millions of people.

Backbone of hospital planning is the smooth flow of 4 movements – identified as FF (Four Flows) –namely patient, caregivers, supplies and services. But what actually makes it fully successful is the RIGHT planning of the services which complete this cycle.

Hence, to deliver a successful resilient hospital building, it is important that futuristic trends and technologies must be adopted for important areas which is not just the need of the hour but also something we owe to the humanity at large.

A. Pneumatic Waste and Laundry Collection System (PWLCS)

PWLCS is an ideal way to transfer soiled linen and solid waste from the source of generation to the centralized collection centre. It is a network of tubes which connects all the discharge points to one collection area. This collection centre can be anywhere in the campus and is capable of connecting all the buildings.

Once the dustbin is filled with the garbage, a sensor activates and the garbage is transported via this network of tubes to a central collection point; thus removing all manual practices of emptying and cleaning the dustbins.

What is also does is; it makes sure no waste is exposed in the public areas thereby improving health & hygiene.



Waste Inlet Points - Hospital

It also enables in segregation of waste right at the source of generation as different tubes can be connected to different collection chambers in the same room. This enables in segregating dry, wet and recyclable waste easily.



Waste Inlet Points - Outside

B. Pneumatic Tubular Transport System (PTTS)

PTTS is the most aggressive technology coming into limelight in making hospital function smoothly when it comes to the transport of samples and materials from one point to another.



In





hospitals, transport of samples to the laboratory right from the nurse station adjacent to the patient ward bed; receiving medicines directly at nurse station from the central pharmacy and transportation of reports can be easily benefitted with this system. Small tubes of 160mm dia spread out across multiple floors which are further connected with multiple loading stations.

Structure of PTTS consists of Blower (for suction and movement of carriers), Stations (Loading & Receiving), Carriers (reusable plastic containers containing materials), Diverters (enabling

multiple receiving stations connected to single loading station in a zone), Tubing (piping system preferably of PVC) and a Central Control Centre.It can transport up-to about 16-18kgs of material @ the speed of 8m/sec.

Result of one such cast at Kasturba Hospital, Manipal indicated that a saving of manpower and time of 94.6 minutes for the total completion of process of sample transportation and results being put online were remarkable observed.

Drawing of Sample from Patients	Slips and arrangement by Lab Staff to send to Clinical Lab	Packing and arranging manpower	Handing over samples to the GD worker with dispatch slip	Transportation to Clinical Lab and taking receipt slip	Reporting of Results after tests	Total Hrs. for the patient to get after sample collection
2.0 Min	5.0 Min.	25.0Min	10.0 Min	60.0 Min	35.0Min	137.0 Min
			PTS Transporting Time Taken after Installation of PTS in June 13th 2011			
2.0 Min	5.0 Min	Nil	.66 Min		35.0 Min	42.6 Min
			Difference/Savings of Time			**94.6 Min**

C. Advanced Nurse Call System (ANCS)

It comes with the basic motto not just to help the patients in emergency but also for calling additional help if required. This system must run independently on its own electrical supply and communication network.

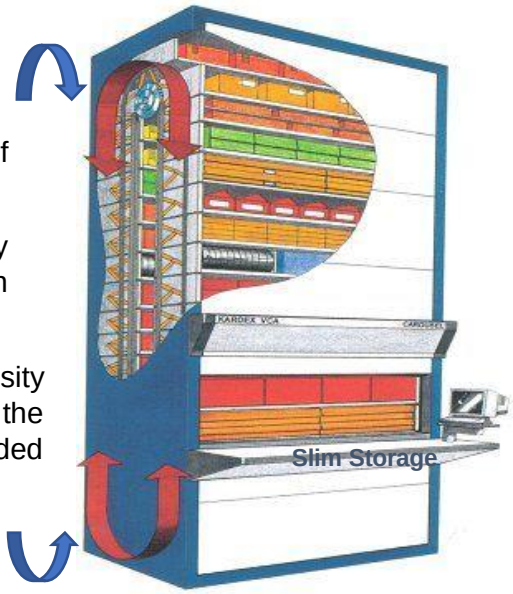
Currently, FDA lists NCS as a Medical Device, Class II, in Medical Device Data Systems. This requires that like other Hospital Call Systems, NCS must be an independent system and possess its own electrical supply and communication network. It must be controlled and monitored by the NCS itself.

It requires that in addition to call annunciation at the responsible Nursing Station, the call generation must also light up a defined system of Primary Corridor Dome Lights, Secondary Corridor Lights (Intersection Lights), Zonal Lights, etc., which, then guide the Nursing Staff to reach the point of call generation quickly.

All NCSs are designed to provide “follow-the-light” concept for Call service Compliance.Lavatory emergency, staff emergency, code blue, and room auxiliary calls as available in Advanced NCS, placed by the patient or staff shall function as listed above but all lights shall continue to flash, and the tone shall continue to sound until the call is cancelled. However, basic NCS must comply with the minimum requirement of DIN VDE 0834.

After closure of nurse call system works at a facility, the NCS must always be verified by the OEM component suppliers as well as validated by a third party and this validation must be witnessed by a hospital representative. Proper markings of NCS and test reports must form the part of closure submittals.

D. Automated Storage & Retrieval System (ASRS)



Storage has always been considered as a chaotic affair especially in hospitals; but imaging if storage and retrieval is managed by robot aided system which not only reduces 60% storage footprint but also gives us multiple combination of loading and retrieval stations.

It primarily consists of steel rack structures, driven by machine, which circulates small storage modules between various pickup and deposit stations.

Advantages can be summarised as space saving, high density storage column which has reduced human efforts to the minimum. Better efficiency can be ensured through its added feature of both clockwise and anticlockwise movements.

E. Hospital Information System (HIS)



Digitalization is the key technology in almost field. If we talk about hospitals, IT networking has taken a next leap in converting hospital into SMART Building when integrated with Hospital Information System.

Few emerging smart solutions for hospitals right from entrance to discharge of patient includes Healthcare Kiosks, Smart ID cards, Mobile apps for Doctors, Patient Portals, Dashboards and Wearable Gadgets.

Smart gadgets help in registering the patients themselves, book appointments online, pay bills online, collect reports online – all of which has played major role in raising the customer satisfaction level considerably.

Human errors have been reduced to minimum in case patient misses out in mentioning important point the doctor from his medical history. These interfaces generate as well as maintain Electronic Medical Records (EMR) of the patients which can be accessed by the caregiver at any point of time. It ensures accurate and reliable interaction between doctors and patients.

This data networking system which constitutes of computer hardware, software, telecommunication, database and human resources altogether.

Conclusion: There is no debate about the importance of technology in healthcare. With the advancements of technologies, healthcare practitioners across the globe are in a much better place to manage their patient's in-hospitalization and post-hospitalization care. These technologies have significantly refined the processes. From predictive to preventive healthcare management, the objective is now to offer the best possible care, give enough and more information in the hands of the patients so that they can feel empowered about their health.

BIOSAFETY LEVELS (BSL)

Sandeep Mehta, Chief Engineer

INTRODUCTION

"BSL" (BIO SAFETY LEVEL), acronym assumed significance since, origin of Covid-19 in Wuhan (China), a BSL4 certified lab. CPWD has recently been entrusted with the construction of BSL labs (including BSL4) across the country. An attempt has been made to introduce the concepts of BSL labs through this article.

WHO Laboratory Safety Manual 2004 have classified laboratories that handle hazardous biological agents into four bio-safety categories that correspond to a four-tiered classification of infectious agents that increase in hazard from 1 to 4 for microbiological laboratories and for the animal research laboratories.

A ***Biosafety Level 1*** **(BSL-1)** lab is suitable for work involving well-characterized agents not known to consistently cause disease in healthy adults and that are of minimal potential hazard to laboratory personnel and the environment.

A ***Biosafety Level 2*** **(BSL-2)** lab is similar to BSL-1 and is "suitable for work involving agents of moderate potential hazard to personnel and the environment.

The ***Biosafety Level 3*** **(BSL-3)** lab is "applicable to clinical, diagnostic, teaching, research, or production facilities in which work is done with indigenous or exotic agents with a potential for respiratory transmission and which may cause serious or potentially lethal disease as a result of exposure by inhalation route.

The ***Biosafety level-4*** **(BSL-4)** lab is "applicable for the work with dangerous and exotic agents that pose a high individual risk of life-threatening disease, which may be transmitted via the aerosol route and for which there is no available vaccine or therapy." The laboratory worker's complete isolation from aerosolized infectious materials is accomplished primarily by working in a Class III BSC (Bio safety cabinet) or in a full-body, air-supplied and positive-pressure personnel suit.

THE INDIAN ACTS/REGULATION/GUIDELINES PERTAINING TO BSL are listed below.

1. Manufacture, Use/ Import/ Export and Storage of Hazardous Microorganisms/ Genetically Engineered Organisms or Cells, Rules, 1989 under the Environment (Protection) Act, 1986.

2. The Regulation & Guidelines for Recombinant DNA research and Bio containment, 2017.

3. Guidelines for the Establishment of Containment Facilities: Bio safety Level 2 (BSL-2) & 3 (BSL-3) and certification of BSL-3 facility, 2020.

PRINCIPLE OF CONTAINMENT

Protection may be required from the following organisms: risk inherent GE (Genetically engineered) and non-GE micro-organisms, Animals, Plants, Arthropods, Aquatic animals etc. during use in a lab. This can be achieved by

a) Identification of elements to be protected Eg. Workers (primary), Outsiders and environment (secondary)

b) Identification of Potential Risk associated with the organisms. (Risk group classification as adopted from WHO Lab Biosafety Manual 2004)

Risk Group (RG)	Description
RG 1 (no or low individual and community risk)	Micro-organisms that are unlikely to cause human / animal / plant disease.
RG 2 (moderate individual risk, low community risk)	Microorganisms that can cause disease in human /animal/ plant.
RG 3 (high individual risk, low community risk)	A microorganism that usually causes serious or lethal human/ animal/ plant disease but does not ordinarily spread from one infected individual to another.
RG 4 (high individual and community risk)	A microorganism that usually causes serious human or animal disease and that can be readily transmitted from one individual to another, directly or indirectly. Effective treatment and preventive measures are not usually available.

c) Determination of bio safety level facility for handling of organisms.

Strategy: Selection of appropriate containment strategy to ensure safety of lab workers, outside people and environment from hazardous microorganisms by,

1. Reducing exposure 2. Preventing Escape and 3. establishment in a natural environment

FACTORS IN CONTAINMENT

1. Physical containment
   a) Procedure to be followed by workers
   b) Safety equipment
   c) **Facility design**
2. Biological containment
3. Decontamination and Disposal
4. Laboratory Monitoring, Medical surveillance and emergency procedures.
5. Training
6. Certification

Role of CPWD would be to primarily focus on the Facility design which is covered in some detail below:

FACILITY DESIGN

As per WHO 2020 Biosafety Manual the facility design features listed below are the Core Requirements for biosafety for all laboratories handling biological agents.

1. Ample space must be provided for the safe conduct of laboratory work and for cleaning and maintenance.
2. Designated hand-washing basins operated by a hands-free mechanism must be provided in each laboratory room, preferably close to the exit door.
3. The laboratory must be a restricted-access area. Laboratory entrance doors should have vision panels (to avoid accidents during opening), appropriate fire ratings and preferably be self-closing.
4. Doors must be appropriately labeled with the international biohazard warning symbols wherever bio hazardous materials are handled and stored.
5. Laboratory walls, floors and furniture must be smooth, easy to clean, impermeable to liquids and resistant to the chemicals and disinfectants normally used in the laboratory.

6 . Laboratory bench tops must be impervious to water and resistant to disinfectants, acids, alkalis, organic solvents and moderate heat.

7 . Laboratory furniture must be fit for purpose. Open spaces between and under benches, cabinets and equipment must be accessible for cleaning.

8 . Laboratory lighting (illumination) must be adequate for all activities. Daylight should be utilized effectively to save energy. Undesirable reflections and glare should be avoided. Emergency lighting must be sufficient to permit safe stopping of work as well as safe exit from the laboratory.

9 . Laboratory ventilation where provided (including heating/cooling systems, especially fans/local cooling split-system air conditioning units – specifically when retrofitted) should ensure airflows do not compromise safe working. Consideration must be given to resultant airflow speeds and directions, and turbulent airflows should be avoided; this applies also to natural ventilation.

10 . Laboratory storage space must be adequate to hold supplies for immediate use to prevent clutter on bench tops and in aisles. Additional long-term storage space, conveniently located outside of the laboratory room/space, should be considered.

11 . Space and facilities must be provided for the safe handling and storage of chemicals and solvents, radioactive materials, and compressed and liquefied gases if used.

12 . Facilities for storing food and drink, personal items, jackets and outerwear must be provided outside the laboratory.

13 . Facilities for eating and drinking must be provided outside the laboratory.

14 . First-aid facilities must be readily accessible and suitably equipped/stocked.

15 . Appropriate methods for decontamination of waste, for example, disinfectants and autoclaves, must be available in proximity to the laboratory.

16 . The management of waste must be considered in the design. Safety systems must cover fire, electrical emergencies and emergency/incident response facilities based on risk assessment.

17 . There must be a reliable and adequate electricity supply and lighting to permit safe exit.

18 . Emergency situations must be considered in the design as indicated in the local risk assessment and should include the geographical/meteorological context.

19 . Fire security and flood risk must be considered.

A CHECKLIST OF FACTORS AND FEATURES FOR BIOSAFETY LEVEL LABORATORIES

Sourced from "Guidelines for Laboratory design: Health, Safety, and Environmental considerations" (John Wiley & Sons publication) is given below for ready reference.

	Infectious Agent	BSL-1	BSL-2	BSL-3	Cabinet BSL-4	Suit Bsl-4
Hazard	Not harmful to humans or environment, work possible on open bench work	Y				
	Moderate hazard to people, environment vaccine and treatment known;		Y			
	Potential for aerosol transmission			Y		
	Serious or lethal hazard to people; vaccine and treatment known			Y		
	Serious, lethal, or unknown hazard to people; no vaccine or treatment available.				Y	Y
Electric	Emergency power generation system			Y	Y	Y
Plumbing	Liquid effluent kill-tank			O	Y	Y
Fire Protection	Class A FP system and wet sprinklers Safety Equipment	Y	Y	Y	Y	Y
Sterilizer	Autoclave available in building		Y			
	Autoclave, 1-door in suite			Y		
	Autoclave, 2-door in suite				Y	Y
	Dunk tank for item transfers out of containment lab			O	O	O
Certified BSC	Biosafety Cabinet II Type A	O	Y	Y		
	Biosafety Cabinet II Type B			Y		Y
	Biosafety Cabinet III				Y	
Splash	Emergency deluge shower	Y	Y	Y		
Protectio n	Emergency eyewash fountain	Y	Y	Y	Y	
Personal	Handwash sink	Y	Y	Y	Y	Y
Hygiene	Laboratory coat		Y	Y	Y	
	Personal protective equipment (PPE)		Y	Y	Y	
	Positive pressure-air sealed full-body suit					Y
Life safety	Self-contained breathing air				Y	Y
Sharps	Needles/sharp containers	Y	Y	Y	Y	Y
Material Transfer	Pass-through box with interlocking doors facility features		O	Y		
Doors	Automatic door closer	O	Y	Y	Y	Y
	Door locks	O	Y			
	Door locks with access control system	O	O	Y	Y	Y
Surfaces	Cleanable floors	Y				
	Cleanable floors, ceilings, walls	O	Y	Y	Y	Y
	Cleanable lab furniture	O	Y	Y	Y	Y
	Cleanable work countertops	Y	Y	Y	Y	Y
	All penetrations in lab sealed			Y		
	All penetrations in lab sealed gastight				Y	Y
	Water-resistant floors	Y	Y			
	Water-resistant floors and walls			Y	Y	Y
	Water-resistant work counters	O	Y	Y	Y	Y
Air-Lock	Provide air-lock(s)			Y	Y	Y
	Provide airlock with gowning			Y		

Anteroom	Provide ante room with gowning and/or changing			**O**	**Y**	**Y**
	Provide anteroom for gowning and shower-into lab				**Y**	**Y**
	Provide anteroom for clothes change and shower-out lab				**Y**	**Y**
	Provide anteroom for suit decontamination shower-out					**Y**
Equip Decon	Provide a gastight room for equipment and furniture gaseous sterilization			**O**	**Y**	**Y**
Windows	Exterior windows	**O**	**O**	**O**	**N**	**N**
	Exterior windows - operable with insect screens	**Y**	**Y**	**N**	**N**	**N**
	Interior windows view into lab Ventilation Features	**O**	**O**	**O**	**Y**	**Y**
Airflow	Airflows into lab, negative pressure	**O**	**Y**	**Y**	**Y**	**Y**
Exhaust	Natural ventilation possible	**O**	**O**	**N**	**N**	**N**
	Mechanical exhaust	**O**	**Y**	**Y**	**Y**	**Y**
	Mechanical exhaust with HEPA filters			**Y**		
	Mechanical exhaust independent of general building exhaust with 2 HEPAs in series			**O**	**Y**	**Y**
	In-place filter-testing facilities			**O**	**Y**	**Y**
	Vacuum line require HEPA filter			**Y**	**Y**	**Y**
Supply Air	Natural ventilation possible	**O**	**O**	**N**	**N**	**N**
	HVAC supply required		**Y**	**Y**	**Y**	**Y**
	HVAC supply independent of general building supply			**Y**		
	HVAC supply independent of general building supply with HEPA filters				**Y**	**Y**
	HVAC supply automatic shutdown interlocked with exhaust			**Y**	**Y**	**Y**
	Supply backflow prevention with dampers.			**Y**	**Y**	**Y**
	Breathing air system- protected, separate				**O**	**Y**

Symbol key
O – Optional according to agent, volume of agent, and jurisdiction having authority
Y – Recommended or Required
N - Not permitted

COST COMPARISON OF VARIOUS BIO SAFETY LABORATORIES
(Sourced from the John Wiley & Sons publication) is furnished below:

	BSL-1	**BSL-2**	**BSL-3**	**BSL-4 Cabinet**	**BSL-4 Suit**
Net area to gross area ratio	0.65	0.6	0.5	0.38	0.33
Relative cost factor	1	1.25	2	4	6

USE OF FLY ASH IN CONSTRUCTION INDUSTRY –case study
Filling within the plinth and road embankments – IIT Ropar

Gopal Varshney, Chief Engineer, Central Vista Avenue

Production

Fly ash is produced from the combustion of coal in electric utility or industrial boilers. There are four basic types of coal-fired boilers: pulverized coal (PC), stoker-fired or traveling grate, cyclone, and fluidized-bed combustion (FBC) boilers. The PC boiler is the most widely used, especially for large electric generating units. The other boilers are more common at industrial or cogeneration facilities. Fly ash is captured from the flue gases using electrostatic precipitators (ESP) or in filter fabric collectors, commonly referred to as baghouses. The physical and chemical characteristics of fly ash vary among combustion methods, coal source, and particle shape.

Thermal Power Plants (coal + lignite) account for 54.7% of total power generation in India. On burning of pulverized coal in the furnace of the power stations, about 80% of ash produced is very fine in nature, which gets carried along with flue gases and is collected by using electro-static precipitator. This is called as Fly ash and is used for making Portland Pozzolana Cement (PPC), having pozzolanic properties. Fly ash constitutes of Silica (SiO_2), Lime (CaO), Iron (Fe_2O_3), Alumina (Al_2O_3) and certain other toxic chemicals. The remaining ash i.e. bottom /pond ash sinters and falls down at the bottom of the furnace, is not having pozzolanic properties and can be used only for purposes such as embankment filling or non pozzolanic uses.

Fly Ash uses

In India, Annual Fly ash generation was about 226.13 MT in 2020 whereas only 187.81 MT (83%) of this Fly ash is being utilised presently. The following are the some of the areas where fly ash can be used in construction industry:

- Concrete production, as a substitute material for Portland cement, sand.
- Corrosion control in RC structures.
- Fly-ash pellets which can replace normal aggregate in concrete mixture.
- Embankments and other structural fills (usually for road construction).
- Grout and Flowable fill production.
- Waste stabilization and solidification.
- Cement clinker production – (as a substitute material for clay).
- Mine reclamation.
- Stabilization of soft soils.
- Road sub base construction.
- As aggregate substitute material (e.g. for brick production).
- Mineral filler in asphaltic concrete.
- Agricultural uses: soil amendment, fertilizer, cattle feeders, soil stabilization in stock feed yards, and agricultural stakes.

Of this, cement & concrete accounts for almost 60%, fills accounts for 20%, road base or sub base accounts for 4%, waste stabilization or modification accounts for 6% and soil stabilization accounts for 4% among other uses.

Quality of fly ash available In India:

The thermal power plants in India are primarily dependent on the combustion of high-ash bituminous coal in pulverized fuel fired systems and low-lime fly ash (similar to Class F of

ASTM C 618) is the prime variety generated in India, although smaller volumes of high-lime fly ash (comparable to ASTM Class C) is available in the country.

Research has shown that the quality of fly ash produced at NTPC's power stations is extremely good with respect to fineness, low unburnt carbon and has high pozzolanic activity and conforms to the requirements of IS 3812 - 2003-Pulverized Fuel Ash for use as Pozzolana in cement, cement mortar and concrete.

Accordingly, the fly ash available from NTPC is of class F. Though Indian codes allow the 35% replacement of OPC with fly ash. International standards specify only 25% replacement of cement using class F fly ash whereas replacement of OPC with fly ash of class C can go up to 35%, as class C fly ash contains self-cementing properties along with pozzolanic properties and class F fly ash contains only pozzolanic properties which requires CSH released by OPC during heat of hydration for its binding properties.

However, various studies show that best results can be achieved with 25% cement replacement with fly ash.

Environmental Risks posed by unutilized fly

Unutilized fly ash contributes to environmental pollution. Fly ash can cause environmental risks in all three ways:

1. Air – Direct emission of toxic chemicals from power plants and windblown fly ash dust from mounds
2. Water – Wet system of disposal from power plant directly into nearby surface water systems
3. Ground – Long storage of fly ash can contaminate underlying soil and ground water

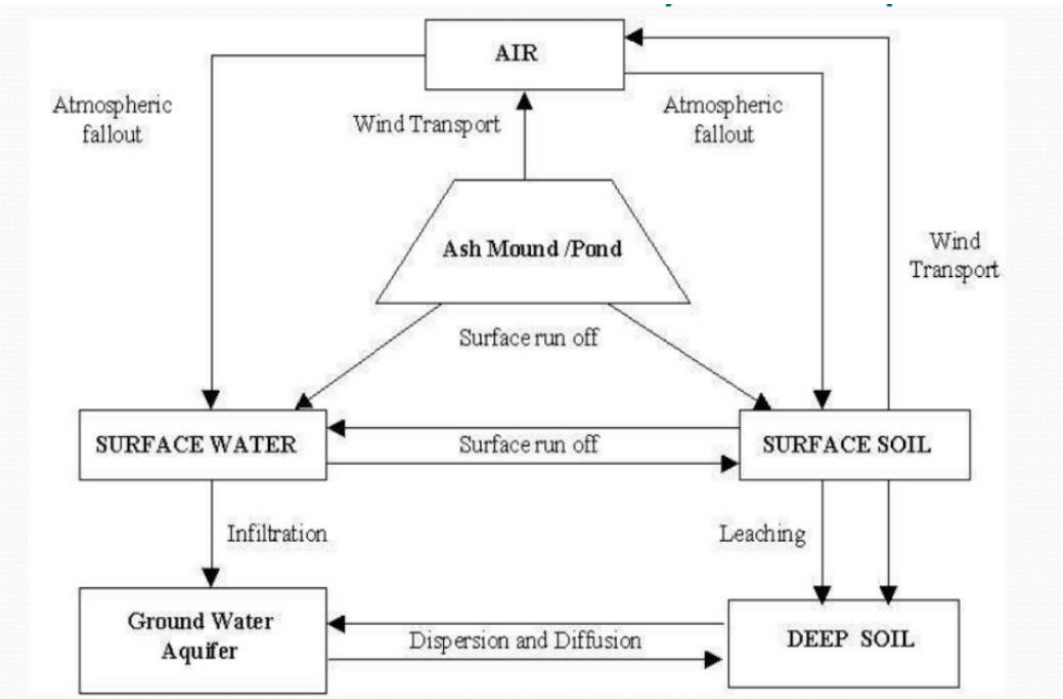


Fig 1: Pollution cycle of fly ash

A vast area of land, 65000 acres in 2020 was occupied for storing fly ash which is an environmental hazard. Moreover, Fly ash generation is anticipated to increase to about 900 MT in 2030. This necessitates proper utilization of fly ash in construction activities.

Advantages of Fly ash

1. It is environment friendly to use fly ash in construction.
2. Use of fly ash in construction industry is also cost effective. A 50 kg bag of fly ash cost only Rs. 85 whereas a 50 kg bag of cement costs around Rs. 240. GST on fly ash products is 5%.
3. Fine particles of fly ash lead to less permeability in concrete.
4. Use of fly ash in concrete makes is more resistant to acid and sulphate attacks.
5. Fly ash also reduces shrinkage of concrete.
6. It also provides good workability, durability and finish.
7. Less heat of hydration is produced by use of fly ash in concrete.
8. It also provide better thermal insulation.
9. A mobile APP named 'ASHTRACK' for tracking availability of fly ash has also been developed.

Government policy on Fly ash

In 1991, Government of India by notification mandated 100 % Fly ash utilization by the year 2009. Also, construction industries were required to mandatorily use fly ash if a thermal power plant falls within 50 km radius of site. Later this 50km radius was increased to 100 km in 2003. In 2009, 100% utilization of fly ash was to be achieved by 2014. In 2016, the radius was increased from 100 km to 300 km. Cost of transportation within 100 km was to be borne by thermal power plant and thereafter, equally by thermal power plant and user. Draft notification of 2020 focuses on pollutants i.e. thermal power plants rather than construction agencies. 100% utilization is to be achieved in next 3 years by thermal power plants. In case of non-compliance, fly ash is to be provided free of cost to construction agencies within 300km and fine of Rs. 1000 per ton to be imposed.

Case study on utilization fly ash under plinth & Foundation

IIT Ropar Project was sanctioned in February, 2014. The total project cost was around Rs. 1200 Crores having total plinth area of 2,32,000 Sqm. The whole project was divided in three phases. The 485 acres of plot is located on the bank of river Sutlej. The plinth level of the buildings was decided to be kept at two meters above the natural ground level to match the Highest Flood Level (HFL) of river Sutlej. This required large amount of earth filling in road embankment and in plinths. The rate of good earth filling in surrounding areas was around Rs. 400 per cum, which would have increased overall project cost. A cheaper alternative to good earth filling was Fly ash which was available free of cost at Ropar Thermal Power Plant about 10 km distance from IIT Ropar site.

Taking note of advantages of fly ash in construction, while preparing the tender document for IIT Ropar project, the road embankments were proposed to be filled with pond ash. *However the filling with in the buildings was planned to be filled with good earth due to the belief that the reinforcement gets corroded when it comes in contact with fly ash*. The other items where fly ash was proposed to be utilized were cavity-wall construction of AAC blocks and FALG Bricks and using Portland Pozzolana Cement (PPC). The use of common burnt clay bricks was restricted for wet areas and below ground level only.

The properties of fly ash vary depending upon type of coal, its pulverization and combustion technique, their collection and disposal systems etc. Ash from two different thermal power plants can have different properties. As the sulphate content of fly ash are mainly responsible for corrosion in concrete structures, the pond ash / bottom ash of Ropar Thermal Power Plant was got tested for sulphate contents which was found to be less than the values required as

per IRC: SP:58-2001. Contemplating that the plinth filling with in the buildings will also cost heavy, it was decided to use fly ash with in the plinth also.

In general, pond ash/bottom ash of density lower than 0.9 gm/cc may not be suitable for embankments construction and the earth used as intermediate layer and top cover should have maximum dry density not less than 1.52 gm/cc. To avoid sulphate attack, the GI, cast iron, Aluminium pipes buried in the fly ash should be protected by polythene sheeting or bituminous coating. As soon as the pond ash/ bottom ash is laid, it should be compacted as early as possible and slops should be benched if these are steeper than 1:4 (V:H).

The design of embankment is an iterative process. It involves developing conceptual plans, which satisfy site needs, design requirement pertaining to slope stability, bearing capacity, settlements and drainage. These conceptual designs were finalized based on the parameters mentioned in IRC: SP:58-2001.

Since the plinth beam was coming at around two meters above the natural ground level, the RCC column of buildings were casted till the bottom of the plinth beams before filling. The filling was done on natural ground level in layers of 15 cm with intermediate layer of compacted earth under OMC (Soil density of 98%) after every four layers of compacted 15 Cm depth of pond ash (Dry density of 95%) with sides and top layer of 30 cm compacted earth as shown in Fig-2.

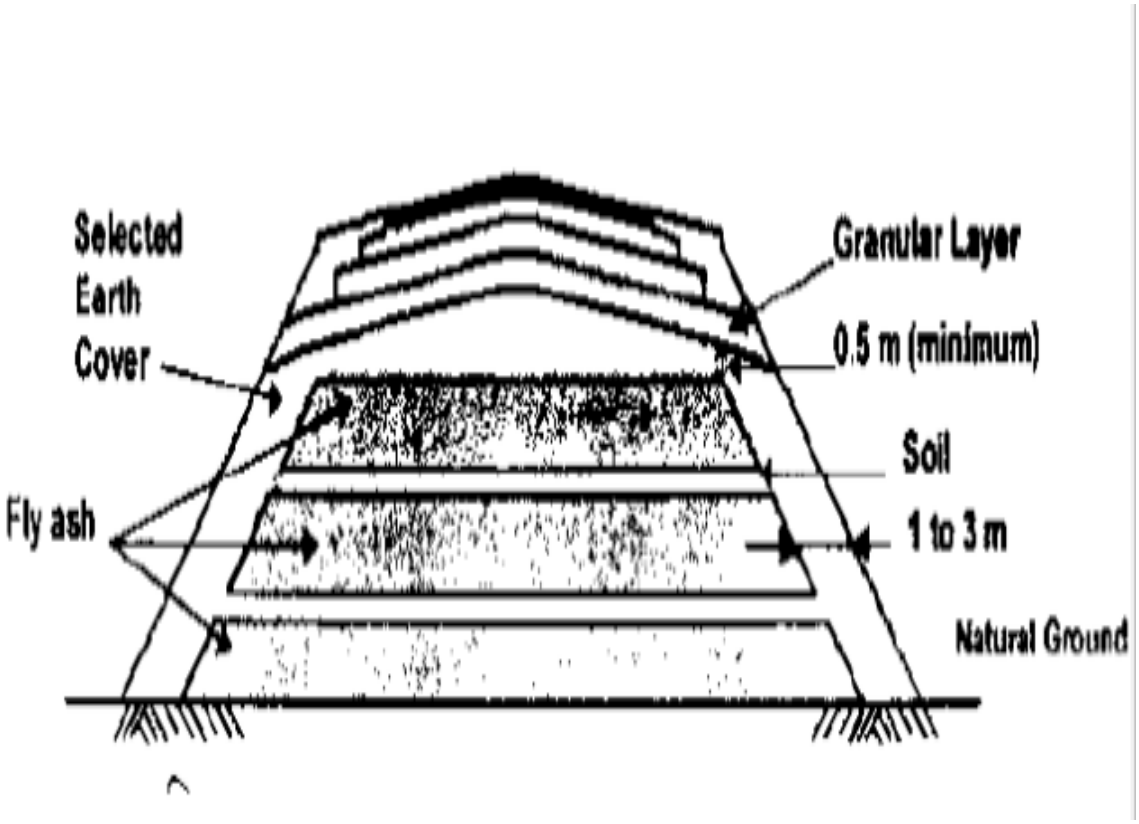


Fig-2

Within the column the compaction was done with one metre wide one-ton vibratory rollers as shown in the Fig-3 and Fig-4.



Fig-3: Compaction of layers by roller



Fig-4: Compaction of layers by roller

The filling was done till bottom of the PCC of RCC plinth beam and subsequently the filling was compacted with hand compactors within the plinth beams as shown in the Fig-5. In total seven Lakhs cum of pond ash/bottom ash was used in filling only, thereby achieving economic and environmental benefits.



Fig-5: Compaction within plinth with earth compactor

Conclusion

Fly ash is a viable alternative to cementitious material/good earth filling which is established. Judicious use of fly ash in construction industry undoubtedly serves both the purposes of bringing economy to the project as well as being environment friendly. There is a need to find other ways and means to utilize the fly ash where it is not thought of so far. However great caution needs to be exercised while doing so.

Legal framework governing damages in contracts

Nirmal Goel, Superintending Engineer-Cochin, CPWD

Delay is the most common type of breach in execution of construction contracts. Government contracts invariably incorporate some provision for handling this aspect. Such provisions tend to make contractor liable to pay liquidated damages (LD) for delay attributable to him. Usually a formula is included in tender documents for calculating the amount of liquid damages based on quantum of delay. In government contracts, an upper limit is usually put on the quantum of such damages recoverable from the contractors. These provisions aim to serve two functions i) to have a deterrent effect on contractor and to make him work diligently as per contract schedule; and ii) to recover monetary losses suffered by the employer for delay attributable to the contractor. However it is utmost necessary that the contract provisions and actual action for recovering liquidated damages from the contractor are in tune with the law of the land. The contractor also has right to be compensated for the damages occurred to him due to Employer's failure to fulfill its contractual obligation. This article tend to deal with the contract law provisions for damages due to such breach of contract. A proper understanding of these provisions may help both the contractor and the government party to understand their rights and liabilities in proper perspective and take preventive and remedial measures to protect their rights on this subject.

The relevant laws relating to liability to pay damages for breach of contract are primarily covered in section 55, 73 and 74 of the Indian contract Act (ICA). Before a discussion on these laws is attempted, it is necessary to distinguish liquidated damages from non-liquidated damages. The term Liquidated damages refers to pre-estimated damages or a sum named in the contract as damages, as distinct from non-liquidated damages which are not pre-specified in the contract and are ascertained in each case upon happening of the event considered as the breach of contract. Thus Liquidated damage is a pre-agreed sum of money payable as damage by the party who breaches the contract to the party who suffered such damage as a consequence of such breach. Section 74 deals with liquidated damages while section 73 deals with General (non-liquidated) damages. Section 55 deals with effect of failure to perform contractual obligation, notice requirement and extension of time for performance.

Section 74

Section 74 lays down that the party who breached the contract is liable to pay to the other party, reasonable compensation, not exceeding the sum named in the contract (liquidated damage or penalty) for such breach, whether or not actual damage or loss is proved to have been caused thereby. This section treats liquidated damages/penalty amount mentioned in the contract to be the upper limit of compensation payable in case of breach. Thus it restricts compensation amount to a reasonable figure only notwithstanding the higher amount which may be mentioned in the contract. An ordinary reading of this section, owing to the fact that it contains the phrase "whether or not actual damage or loss is proved to have been caused by the breach", gives an impression that actual loss or damages are not required to be proved by suffering party in order to be eligible to receive reasonable compensation from the breaching party. But this is not true. The section, as interpreted in some landmark court decisions, does not obviates the need of proof of damages completely. The ratio on law of liquidated damages as built in landmark case of Fateh Chand vs Bal kishan Das 1963 AIR 1405 was later enforced in other landmark cases like Maula Bux vs Union of India 1970 AIR 1955, Variety Body Builders versus the union of India 1973 Guj 256.

As per law pronounced in these landmark cases, the courts do not treat as justified the award of compensation, when in consequence of the breach, no legal injury has resulted. The award of compensation in such a case is held unreasonable/penal in nature and not upheld by courts. Therefore the phrase "whether or not actual damage or loss is proved to have been caused by the breach" used in section 74 should not be given excessive weight by employer/his engineer as this term has been qualified by courts in various rulings restricting its scope and intent. Therefore it is necessary for the government engineers and authorities deciding to levy liquidated damages on the contractor to put on record the details of loss or damages suffered due to delay attributable to the contractor along with the evidences of such loss/damage.

Otherwise, the compensation order issued by the contract authority will not be held reasonable and recovery of such compensation may be disallowed by the court.

Another important point in this law is to distinguish compensation from penalty. Compensation is meant to put the sufferer in the same position as he had been if there was no breach of the contract by the other party. Compensation is not meant to make profit (or unjust enrichment) out of the fault of the other party. On the other hand, Penalty is meant to act as deterrent and can be a figure in terrorem much higher than the actual damage. In order to make sure that the liquidated damages mentioned in the contract do not take the form of penalty, it is required that they are the reasonable sums. The purpose of putting a moderate upper limit on amount of liquidated damage also serves to fulfill this test of reasonableness so that the compensation is upheld as reasonable sum in law.

Section 55

Another important provision in the law of contractual damage is section 55 of the Indian contract act. Section 55 permits, in case of delay in performance by one party, the remaining unperformed contract to become void at the option of the suffering party. However this is permissible only when the time is an essence of the contract.

The question arises then what is essence of the contract and what is its significance. In a contract, there are many provisions. But all provisions do not carry the same weight. Some stipulations are treated as heart and soul of the contract. These are treated as non-compromisable provisions without which the contract may not be permitted to subsist (at the option of suffering party). The violation of such provisions by one party entitles other party to repudiate/cancel/determine/declare void the contract altogether. Time period of performance of the contract is mostly treated as one such provision in government contracts. The other provisions (say not so important provisions) are non-essential provisions, the violation of which, entitle a party to recover from the defaulting party, the damages occurred to him, as a result of such default. However violation of such provisions does not entitle a party to fully repudiate the contract

This section requires that in order to be eligible to receive damages, the party who suffers losses due to breach of contract, will give notice of his intention to claim compensation, to the party who is responsible for causing such damage at the earliest possible time when such damage is suffered or expected to be suffered. This section aims to alert the breaching party and give him an opportunity to contain or avoid such damage. It also affords an opportunity to breaching party to contest the claim of damage lodged by the party giving such a notice. This section is based on the principle of natural justice. It is therefore necessary that the notice is timely given to contractor, pinpointing in specific terms, the various acts/omission on his part which caused delay attributable solely to him and his liability to pay damages for such breach. This responsibility for delay has to be imposed on the contractor in irrefutable manner and should be duly supported with sufficient evidences. If this is not done at relevant time (when he is delaying and causing loss to the government), it is very much possible that the contractor walks away scot free at the end without having to pay liquidated damage.

Section 73

Last but not the least, section 73 of the Indian Contract Act enables a party to claim damages suffered by it as a result of default by the other party even when no such provision exist in the agreement. These damages are general damages and not quantified as such in the contract (and are thus non-liquidated damages) but their sufferance has to be proved by the party claiming it. Contractors can claim damages from their employers under section 73 of the contract though such damages (owing to the default of the employers) are not mentioned in the contract. Such damages, however, are limited to those damages which naturally arise in the usual course of things from such breach, or which the parties knew, when they made the contract, to be likely to result from the breach of it. Such compensation is not to be given for any remote and indirect loss or damage sustained by reason of the breach. Most of the time, such damages take the form of underutilized/idle labour, T&P and staff due to delays attributable to the employer. However in order to claim such damages, following conditions needs to be fulfilled by the contractor.

(i) Definite breach on the part of employer which caused loss to the contractor;

(ii) Notice under sec 55 to the employer at the appropriate time about sufferance of loss or damage;

(iii) Proof of sufferance of such damage and its quantum;

(iv) Efforts made by the contractor to mitigate such losses; and

(v) The loss arose naturally in the usual course of things from such breach or the party knew, when they made the contract, to be likely to result from the breach of it, meaning thereby that the losses are not indirect or remote.

A Comparative Study of Contract Management Systems in CPWD, DMRC & NHAI

O.P. Tripathi, Chief Engineer, Research Scholar, IIT Delhi
A.K. Jain, Professor and **Kumar Neeraj Jha**, Professor IIT Delhi

I Introduction

Development of any country is proportional to development of its infrastructure growth. The infrastructure growth, world over, face many issues like time, cost, quality, dispute, safety and environment. The ill effects of construction also include depletion of natural resources, consumption of energy, causing of pollution, generation of waste and emission of harmful gasses. Therefore, it is imperative that the infrastructure project avoids all these ill effect and at the same time remain successful in terms of time, cost, quality, safety and environment.

To achieve optimum result, a study has been conducted to understand the project management system of three organizations viz. CPWD, DMRC and NHAI and screen out the positive feature of each organization and club them to maximize the result.

The study is based on structured interview of senior officers of the organizations, detailed study of manuals, SOPs, relevant GCCs of the organizations, documents available etc.

The paper includes salient features of the project management system of DMRC and NHAI and recommendation for CPWD to further enhance CPWD's effectiveness of project implementation.

II Salient Feature of DMRC Management Processes

1. 10% interest free mobilization advance

There is provision of **interest free** 10% mobilization advance, a big assistance to the agency to ensure financial liquidity for a speedy execution of work, recovery of this starts after 20% of the work is done and paid to the contractor.

2. Release of 80% amount of running account bill on preliminary checking

On submission of the running account bill by the contractor, 80% of the amount is paid within a week time, detail checking of the bill and balance payment is released subsequently.

3. Availability of funds

Work is awarded only if 100% funds is available with DMRC, hence, works don't suffers for want of funds.

4. Compensation for suspension of work

As per clause 8.8 of the GCC, if the work remains suspended by the department for more than 30 days, the contractor is compensated for idle labour/employees, plant & machinery (hired/ owned) with 15% extra to cover overhead costs. Further, if the work remains suspended for more than 90 days, contractor have right to ask for closure of the contract or deletion from the contract part of the work suspended.

5. **Payment of additional cost for unforeseeable physical condition**

GCC Clause 4.23 is an additional assurance to the contractor for his liquidity. However, such unforeseeable physical conditions have not been defined in the contract and it is left to the decision of the Engineer.

6. **Focus on Delivery**

Decisions are taken keeping in view the interest of all stakeholders with a primary focus on project delivery. The general feeling in DMRC is that the attitude of organization matters more than the rules.

7. **Dispute Resolution**

The system includes inter-alia provision of representing the grievances of contractors to the Director Level Committee, having powers to go even beyond the provisions of agreement and resolve the matter.

8. **10% Performance Security**

Performance Security is 10% in DMRC, whereas at other place it is only 5% (however, currently, it is reduced by government to 3% due to COVID-19). It is a big deterrent for contractor to default.

9. **Debarment Policy**

Provision to debar the contractor, if any default by misrepresentation or false representation is made by him in tendering and on any other ground.

10. **Recovery of Liquidated Damages**

System of recovery of liquidated damages are mentioned in contract milestone-wise, and not left to the decision of a particular authority. Maximum quantum of liquidated damages is 15% as against 10% in other departments.

11. **Ease in tendering process**

a. Work experience credentials and financial credentials of L-1 bidder are sent for verification by issuing authority after opening of financial bid and award of work is not kept on hold for want of verification. On verification, if the credentials are not found correct, work is continued but action is initiated against the contractor under “Debarment Policy” of the organization for misrepresentation/ concealment of the facts.

   However, there is always a chance the work gets awarded to a bidder who was actually not eligible for the work. This may cause court cases besides awarding the work to an ineligible bidder a flaw in the system.

b. There is no marking system in deciding eligibility bid considering actual work experience and actual financial credentials of the bidders.
c. The eligible works or ongoing work of the bidders are not inspected before deciding the eligibility bid.

12. Balance Competition in Tender

In DMRC, during deciding packages for the tenders, desired competition level is kept in view, to avoid many contractors to handle and to have proper competition. This ensures proper competition and proper acceptable and workable rates.

13. Exemption from Environmental clearance, DUAC approval

Since EIA is conducted at the DPR stage DMRC is exempted for taking Environmental Clearance of their project from Ministry of Environment and Forest. Similarly, no DUAC approval is applicable for Metro projects.

III SALIENT FEATURE OF NHAI MANAGEMENT PROCESSES

1. Ease in Tendering Process

a. The documents related to credentials of the bidders for work experience and financial status is not verified from issuing authority before deciding the eligibility bid.
b. There is no marking system in deciding eligibility bid considering actual work experience and actual financial credentials of the bidders.
c. The eligible works or ongoing works of the bidders are not inspected before deciding the eligibility bid.

2. Outsourcing of Authority Work

In NHAI, most of the work is outsourced by appointment of expert consultant, normally three consultants are appointed in every work

i. **DPR Consultant** for preparation of Detailed Project Report
ii. **Financial Consultant** for scrutiny of eligibility and financial bid.
iii. **Supervision Consultant** for supervision of works.

3. Availability of funds

In NHAI, work is awarded only when the full funds are available.

4. 15% Mobilisation Advance

The provision of interest bearing Mobilisation Advance in NHAI contracts (Article 19.2) is total 15% (including 5% Mobilisation Advance for equipment and machinery).

5. Additional Performance Security for Low Rated Contract

Amount of Performance Security is 5%. However, Additional Performance Security shall be deposited by the contractor at specified rate as mentioned below. (Article 7.1 of Standard EPC Agreement)

- If the quoted price of the contractor is lower than 10% but up to 20% of the estimated cost, additional Performance Security shall be @ 20% of the tendered price below 10% of the estimated cost.
- If the quoted price of the contractor is lower than 20% of the estimated cost, additional Performance Security shall be @ 30% of the tendered price below 10% of the estimated cost.

6. Damages for delay in handing over the site

As per the terms of contract (Article 8.3), the authority shall pay damages to the contractor in accordance with the following formula for the part of the site which has not been provided to up to the specified time.

Amount of damages in Rs. per day per meter = 0.05 X C X 1/L X 1/N

Where, C = Contract Price, L = Length of the Project Highway in meter, N = Completion period in days

This shall induce extra caution in the department to hand over the site on time.

7. Deemed termination of Contract

As per Article 3.4 of the contract, the contract shall be considered deemed terminated if due to any reasons, whatsoever, the appointed date does not occur within 90 days of signing of the agreement and submission of full Performance Security by the contractor. In such event, the contractor shall be paid damages equivalent to 1% of the contract price.

"Appointed Date means the date declared by the authority as the project commencement date with the consent of the contractor as per the process specified in Article 3 & 2 of the agreement."

8. Debarment Policy

As per article-10.3(iv) of the contract (applicable for the project above 300 crore only), if the contractor fails to complete the project within 90 days from the Schedule Completion Date unless such failure has occurred due to Force Majeure or reasons solely attributable to the Authority, **the contractor shall be deemed to be ineligible for bidding future projects of the Authority.**

9. Trained workman

As per article-4.4 of the contract, the contractor shall appoint at least 10% trained workman as per National Skills Qualifications Framework. **This shall result into better quality and safety.**

10. Dispute Resolution

Apart from provision of Conciliation and Arbitration, there is a provision of referring the dispute to the Chairman of the Authority and the Chairman of the Board of Director of the Contractor for amicable settlement.

IV RECOMMENDATION FOR CPWD

1. Ease in Tendering System

- It is observed that after fulfilling minimum eligibility criteria, most of the bidders get qualified in the evaluation process, hence marking system should be discontinued as in other organizations.
- Similarly, for quality, client's certificate in Form D should be relied upon and system of physical inspection of work should be discontinued as in other departments.
- Since the bidding capacity calculation is dependent only on the declaration made by the contractor about the works in hand, it is not a very reliable system. Either some other more reliable system should be developed for calculating the

bidding capacity or it should also be discontinued. A study of actual effect of bidding capacity criteria on eligibility bid can also be conducted.

2. **Provision of additional performance guarantee**

There should be a provision of additional performance guarantee for contracts priced below 10% of ECPT. For contracts priced below 20% of ECPT, rate of additional performance security should be further higher.

3. **Compensation for suspension of work from department side**

There should be a provision in the G.C.C. to provide compensation to the contractor in case of suspension of work by the organization beyond a period of 30 days for idling of labour/employees and machinery (owned/hired) besides granting EOT.

Further, if the work remains suspended for more than 90 days, contractor should have right to ask for closure of the contract or deletion from the contract of that part of the work, which has been suspended.

4. **Payment of additional cost for unforeseeable physical condition**

For EPC contracts, there should be a provision for payment of additional cost for certain physical conditions which could not have been reasonably foreseen by an experienced contractor while quoting rates. However such decision and the quantum of compensation should be approved by an authority above the PM or CPM.

5. **Release of 80% amount of running account bill within 4 days**

On submission of the running account bill by the contractor, 80% of the amount should be released within 4 days only on preliminary checking.

6. **Focus on Delivery**

Decision should be taken keeping in view the interest of all stakeholders including a focus on project delivery. The attitude of organization matters more than the rules. The grievances of contractors should be addressed in such a manner that it helps the project delivery on time.

7. **Debarment Provision in contracts**

If a contractor fails to complete the project within specified days (to be specified in each contract) from the Schedule Completion Date unless such failure has occurred due to Force Majeure or reasons solely attributable to the organization , the contractor shall be deemed to be ineligible for bidding future projects of the organization for 2 years.

8. **Deemed termination of contract**

There should be a provision in the EPC contracts that the contract shall be considered deemed terminated if due to any reasons, whatsoever, the physical commencement of the work does not occur within the “specified days” of signing of the agreement. The “specified days” should be decided on case to case basis after giving due consideration to all preconstruction activities.

9. **Safety Monitoring**

To improve the safety climate at work sites, the following recommendations are made.

- There should be a provision of regular safety inspection and safety audit at significant stages of the project. For this purpose, provision should be made for

posting of a Safety Officer of the level of SE at each project region. Provision of third party safety inspection and safety audit should also be introduced.

- Essential safety related items should be introduced in the DSR and should be included in contract BOQ. This shall ensure due payments to the contractors and effective implementation of essential safety items in the work.

10. Dispute Resolution

For resolution of disputes, the matter should be referred to ADG level committee for reconciliation and resolution of disputes. The committee should have powers to go even beyond the provisions of agreement where such approach is logically required.

V CONCLUSIONS

From the study of project management system of three organizations, it is found that though the basic pattern of working is same but there is a significant difference in the detailed procedure and processes adopted for various pre- construction and construction stage activities which make significant difference in their output and timelines. By screening out the best practices of the three organizations and clubbing them together, the result can be maximized and timelines can be reduced.

VI ACKNOWLEDGEMENT

This report is based on the detailed study of three organizations and recorded interview with senior officers of the NHAI and DMRC. I gratefully acknowledge the cooperation extended to me from all the officers which made this report possible.

SETU RATING SYSTEM FOR SUSTAINABILITY EVALUATION FOR TRANSPORTATION CORRIDORS IN URBAN AREAS

Dr. Shishir Bansal, Chief Engineer cum Executive Director,
AIIMS Awantipora project, Kashmir

1. BACKGROUND

The term 'Sustainability' has been broadly accepted as "meeting the needs of the present generation without compromising the ability of future generations to meet their own needs". The aim and ambition of making a provision of sustainable characteristics in the planning and execution of buildings and transportation corridor in an urban environment are to minimise footprints on the natural resources and their consumption, promote the application of latest, modern and most suitable approaches, maintain the archaeological values and integrate these concept for the benefit of society and sound economical practices.

Green Rating for Integrated Habitat Assessment (GRIHA) is most popular system for rating the buildings with 33 criteria to assess its green characteristics. GRIHA is a Sanskrit word meaning – 'Abode' i.e. Human Habitats (buildings). The 33 criteria covered in GRIHA rating system starts with the selection of the site and includes surroundings like greenery, soil conservation, soft paving, utilities, safety aspects, lighting efficiency, air pollution, noise pollution, water pollution including its efficiency, recycling of wastes, reduction in embodied energy, renewal of energy, facilities for differently abled persons and maintenance issues etc.

But, there is no such accepted rating system available for the assessment or rating of transportation infrastructure works. Hence an attempt has been made as per the studies carried out on some important transportation corridors during construction stage in capital city Delhi and SETU rating system has been developed for the sustainability evaluation of transportation corridors in an Urban Environment during the construction stage.

2. SETU Rating System

SETU in Sanskrit means bridge or bond. Otherwise, SETU here stands for Sustainability Evaluation of Transportation system in Urban Environment. Hence on the lines of GRIHA rating system with 33 criteria, SETU rating system has been developed with 43 criteria for a typical construction site of transportation infrastructure project during the construction stage that has been carried out in an Urban Environment.

2.1 Identification of Sustainability Indicators

Various construction sites were studied during the construction stage represent almost whole metropolitan city Delhi as they are spread over different far off locations. The studies were carried out during the mid of the construction period when the progress was about 40% to 60% on different days of the week/month and during different hours.

It was realised that three pillars of sustainability (Social, Economic and Environmental aspects) are more suitable for developed countries whereas in India, it was felt to expanded it with the identification of three more vital categories namely Inner Engineering, Technical and Governance. **Technical** parameters play an important role in infrastructure projects. The designs are generally prepared by the consultants and their wisdom prevails in designing the structure. **Governance** in this country is another issue as everyone tries to look into the gaps in law and tries to deviate for his own convenience rather than looking for the convenience of complete society as a whole. Further, rich heritage in form of spirituality was considered as an essential category that uplifts the morale of workers and helps stakeholders to raise their tolerance.

This **"Inner Engineering"** was considered as another independent category. These 6 categories of sustainability are shown in Plate 1 and 43 indicators are shown in Plate 2.



Plate 1: Six categories of sustainability

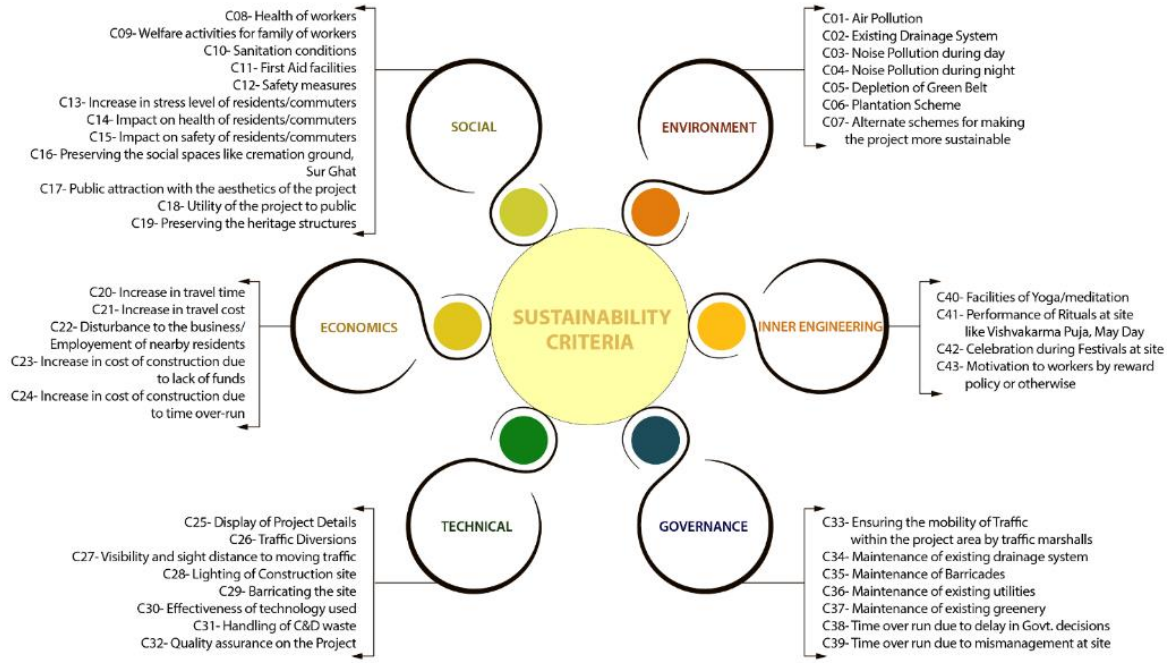


Plate 2: Sustainability Indicators under Six Categories

2.2 Survey to assign the weightage to the various sustainability indicators identified

After the sustainability indicators were identified, a proforma was developed for the experts to have their opinion regarding the weightage to be given to each of the sustainability indicator. This survey was conducted amongst the experts in the field of infrastructure and SETU weightage was assigned to these 43 indicators as shown Table 1 and Plate 3. The thickness of each indicator varies as per the weightage assigned to these indicators.

Table 1: SETU marking system for each criteria

Criteria No.	Criteria Title	SETU Weightage
ENVIRONMENTAL = 18 POINTS		
C1	Air Pollution	4
C2	Existing Drainage system	3
C3	Noise pollution during day	1
C4	Noise pollution during night	3
C5	Depletion of Green Belt	2
C6	Plantation scheme	2
C7	Alternate schemes for make the project more sustainable	3
SOCIAL = 27 POINTS		
C8	Health of workers	3
C9	Welfare activities for family of workers	1
C10	Sanitation conditions	3
C11	First Aid facilities	3
C12	Safety measures	3
C13	Increase in stress level of residents/commuters	1
C14	Impact on Health of residents/commuters	3
C15	Impact on safety of residents/ commuters	2
C16	Preserving the social spaces like cremation ground, Sur Ghat	3
C17	Public attraction with the aesthetics of the Project	1
C18	Utility of the Project to Public	2
C19	Preserving the heritage structures	2
ECONOMICS = 11 POINTS		
C20	Increase in Travel time	2
C21	Increase in travel cost	2
C22	Disturbance to the business/Employment of nearby residents	1
C23	Increase in cost of Construction due to lack of funds	3
C24	Increase in cost of Construction due to time overrun	3
TECHNICAL = 20 POINTS		
C25	Display of Project Details	1
C26	Traffic Diversions	3
C27	Visibility and sight distance to moving traffic	2
C28	Lighting of Construction site	3
C29	Barricading the site	3
C30	Effectiveness of Technology used	3
C31	Handling of C & D Waste	2
C32	Quality Assurance on the Project	3

GOVERNANCE = 19 POINTS		
C33	Ensuring the mobility of Traffic within the project area by traffic Marshalls	1
C34	Maintenance of existing drainage system	3
C35	Maintenance of Barricades	4
C36	Maintenance of existing utilities	3
C37	Maintenance of existing greenery	3
C38	Time over run due to delay in Govt. decisions	3
C39	Time over run due to mismanagement at site	2
INNER ENGINEERING = 5 POINTS		
C40	Facilities of Yoga/meditation	1
C41	Performance of Rituals at site like Vishvakarma Puja, May Day	1
C42	Celebration during Festivals at site	1
C43	Motivation to workers by reward policy or otherwise	2

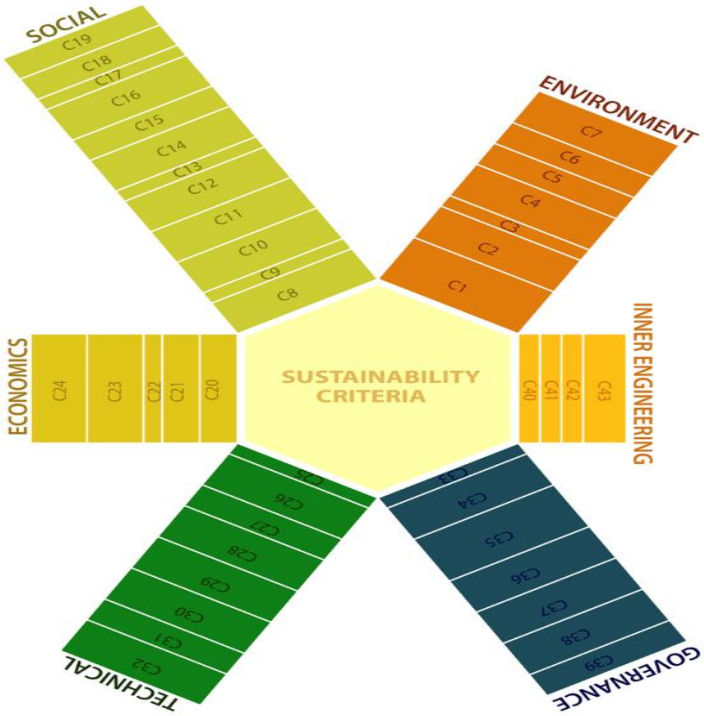


Plate 3: Sustainability indicators with SETU weightage (in pictorial form)

3. SETU INDEX AND SETU RATING

The total weightage of above 43 criteria is 100 and after assigning score against these 43 criteria, a total score is to be calculated. As per the score obtained a project is assigned SETU rating. There are defined guidelines (not covered in this paper) that will be useful to assess a project against all 43 indicators and thus calculating SETU index and assigning a SETU rating to a project in the construction stage. Finally, on the basis of SETU index worked out for a project, it can be graded from Platinum at top to silver at bottom as shown in Table 2. Thus, there will always be an urge to get the best rating to a project for which all stakeholders will strive their best. This will make them to perform in a better manner with a focus on each of the sustainability indicator in order to get the best or closer to the best rating. Thus, SETU rating

system is a very simple and a useful tool to carry out the sustainability evaluation of a transportation corridor under construction in an Urban Environment.

Table 2: SETU Rating

SETU INDEX	RATING
More Than 90	Platinum Rating
75-90	Diamond Rating
60-75	Gold Rating
45-60	Silver Rating
Below 45	Unsustainable project

A project that does not qualify any of these ratings will be called an unsustainable project. Thus, there will develop an urge to get the best rating to a project for which all stakeholders will strive for best rating.

Abstract of Technical Seminar

1. Innovative Technology at IIT Bhillai

Use of Building Information Modelling (BIM), Cloud based system for drawings and document management, monitoring of construction works at the site is implemented at IIT Bhilai project for improving quality, speedy construction and saving cost and time in completion of the project.

2. Digital Transformation on Public Project Delivery Using Common Data Environment and Building Information Modelling

Use of Common Data Environment (CDE), Building Information Modelling (BIM) in the IITPKD project for seamless communication among stakeholders has been used. With these innovations at site, Quality control and documentation at site has improved besides speedy construction and overall saving in cost of the project.

3. Challenges in construction of high-altitude roads

High-altitude hill road located at an altitude of 8,000 ft. or more above the MSL. Challenges include low temperature (up to -35deg C), low oxygen content, short working season (May to Oct), frequent replacement of labour & staff due to health issues, de-rating of equipments, transportation of construction material & labour. Since conventional ready to use solution could not be deployed, hence Polyamide coated (organic coating) gabions with geotextile deployed.

4. Gorton Castle Building – Rehabilitation

CPWD team did restoration works in very methodological and technical manner with safety of occupants during official hours. The Restoration Works were basically consists of 1. Strengthening of Ground Floor and First Floor which were intact and not affected by Fire and 2. Re-construction of Second and Third Floor which were heavily damaged due to fire. Strengthening of stone masonry walls using bond stones, using Pressure Grouting, openings and walls using Galvanized Welded Wire Mesh, Seismic Retrofitting using SS Helical Bars etc were some of the retrofitting technology adopted in Rehabilitation of the prestigious Gorton Castle Building, Shimla.

5. Revisiting Architectural Heritage of Kolkata

CPWD has been entrusted works related to conservation, restoration, upgradation, maintenance of numerous Heritage Buildings in Kolkata. Some of the Buildings worth mentioning are (a) Indian Museum, (b) Victoria Memorial Hall, (c) Belvedere House (national Library), (d) Currency Building, (e) Nizam Palace, (f) Customs' House, (g) 1No. Council House Street, (h) GSI Headquarters, (i) Esplanade East.

6. Infrastructure Development a Challenge in Rann of Kutch

Rann of Kachchh is known for hardship, challenges for the Engineers to find an acceptable solution due to the climatic & environmental severity and aggressive engineering parameters. CPWD in its endeavour for excellence had consulted experienced professional body and carried study to negotiate the difficult ground

condition of corrosion, erosion, marshy water-logged area, wave action of both way movement of the tidal water for the development of various infrastructures such as road work, fence & building structures. The adverse effect of Sulphates and Chlorides in the soil and water effectively countered by the use of dense and durable concrete. Soil erosion and tidal wave action of water have been dealt suitably by use of Gabions, Geogrid and Geotextile.

Fence has been re-designed with the aim of anti-cut, anti-climb and anti-rust. Single line 3-5-8 modular fence system with 400 micron thick thermoplast powder coating over G.I primer on M.S. wire and CHS post has been used. The concertina coil elements (blade, core wire, fittings and fixtures) are made of SS 316. Ground contact of fence has been eliminated by providing a precast RCC beam of size 100 X 150 mm placed between two foundation blocks.

7. Revisiting the Built Environment in Post Covid Era

“Revisiting the Built Environment in Post Covid Era” is the vision of the author developed from the learnings of the Covid period in the country. The extra ordinary crisis originated from the outbreak of the pandemic has left a deep scar in everyone’s mind. Broadly, three protocols were developed globally to prevent the spread of the pandemic which are social distancing, wearing the mask and frequent sanitisation. Besides, checking the body temperature before entering a public building, provision of touchless services in various types of buildings, avoiding direct contact of air, work from home also emerged as some other important measures supplementing the above three measures. How to translate these measures in the building design is the task of building designers in post covid era. The design ethos and the technological solutions are to be rewritten suitably in the context of built habitat to take care of future crisis arising out of attack from this kind of viruses which are not only invisible but also mutate. The few solutions on architectural as well as engineering side suggested here are worth deliberation and incorporation in future building designs. The neo norms of the covid appropriate behaviour need also be the reflected in our building designs with wellness at the centre of the Design Philosophy.

8. Emerging Technologies in Healthcare Infrastructure

The purpose of this prescriptive article is to help decision makers become better informed about technologies emerging in healthcare arena by providing a basic description of the technologies. A well-designed architecture is the critical tool in integrating these technologies for a large and rapidly growing health care system. The author aims to highlight the conscious effort required the pre-planning of these technologies in healthcare architecture as these are extremely valuable to healthcare organizations not only because these are the need of the hour but also their proper integration at right stage could be life saving factors for many.

9. Biosafety Levels (BSL)

Bio Safety Level (BSL) concept has suddenly become significant with the originof COVID-19 in Wuhan, China which also hosts a BSL 4 lab. The BSL levels correspond to the classification of hazardousbiological agents as identified in the WHO Laboratory safety Manual 2004. BSL 1 corresponds to the lowest hazardous level and BSL 4 to the highest knownhazardous level of biological agents.

WHO in its latest publications(2020) of Lab Bio safety manual 2020 has dwelt upon evidence based and transparent assessmentof risk involved in workingwith biological agents thereby enabling countries to implement economically feasible and sustainable labs with bio safety practices. The India acts/regulations/guidelines pertaining to BSL are majorly Covered under regulationsand guidelines issued for Recombinant DNA research and Bio containment2017 and guidelines for establishment of containment facilities 2020. The role of CPWD in the construction of BSL lab is to ensure effective facility design and execution. WHO bio safety Manual 2020 specifies the core requirements for all laboratories handling biological agents. While Level 1 has virtually very few requirements, BSL 4 requirements are very complex and largely dependent on type of biological agents proposed to be handled. So much so there are no fixed guidelines for facility design released for BSL 4 eitherby Indian Government or by WHO. BSL 4 therefore requires the services of design and construction experts specific to BSL 4 technology.

The facility design for BSL suitability involves almost every facet of civil and electrical construction. Starting with site selection, electrical back up, fire safety, facility related to personal hygiene, restricted and sterilizedaccess finished surfaces, air locking doors, HVAC, filtration, waste management etc. The level of complexity rises with the level of hazardous biological agents handled and provides a typical challenge to the construction agencies. In terms of relative costs BSL 4 lab costs approximately six times the cost of BSL 1 lab.

10. Use of fly ash in construction industry

Fly ash is a by product obtained from coal burning in thermal power plants.In the past, it occupied hectares of land all over the countrydue to non-usage of it.Lately its pozzolanic properties have been recognized and has since been used in construction industries widely. In 2010, only 33% of fly ash producedof 160MT was utilized as against 83% of 226MT produced in 2020. It has been realized that the use of fly ash is not only environmental friendly but highly economical also if proper control is exercised in making products like bricks, blocks, cement, concrete mix or is used in base course of road and embankments. Govt of India has prepared a draft notification 2020, which will force Thermal power plants to supply fly ash to construction agencies free of cost within 300 Km radius. A case study has been presented in the article, which will pave the way of using fly ash into the filling within the plinth of buildings thereby recyling waste, making building greener and reducing carbon footprints for clean development.

11. Legal framework governing damages in contracts

Section 73 of the Indian Contract Act 1872 is a law of General damages. As per this section, a party who breaches any term of the contract, is liable to compensate the other party who suffers damages due to such breach for the actual loss or damages suffered by it. In government contracts, the contractors use this section to claim compensation for damages suffered by them due to breaches by Government party. There are however certain conditions in this section to claim damages and to filter out genuine damages from the non-genuine ones. This article lists out such conditions. A proper understanding of these conditions can be helpful to government officials in defending inflated claims of damages by contractors during arbitration proceedings. Hadley versus Baxendale [1854] is the famous case law on section 73 disallowing entertainment of remote or indirect damages not contemplated by the parties at the time of entering into the contract.

If rate of compensation is pre-specified in the contract, then such damages are called liquidated damages. Liquidated damages are dealt under section 74 of the Indian Contract Act 1872. Liquidated damages law under section 74 may be treated as a sub-class of law of General damages covered under section 73. Since delay is the most common type of breach in the contract, most Government contract forms provide liquidated damages for delay in performance of contract which is solely attributable to the contractor. Though a plain reading of the language of section 74 gives an impression that liquidated damages need not be proved. However, the section as interpreted in some landmark court decisions, does not obviates the need of proof of damages completely. The ratio on law of liquidated damages as built in landmark case of Fateh Chand vs Bal kishan Das 1963 AIR 1405 was later enforced in other landmark cases like Maula Bux vs Union of India 1970 AIR 1955, Variety Body Builders versus the union of India 1973 Guj 256. It restricts compensation amount to a reasonable figure (read actual figure) only notwithstanding the higher amount which may be mentioned in the contract.

Section 55 of the Indian Contract Act 1872 mandates serving of noticeat relevant time (at the time of breach)by the innocent party for claiming compensation for loss or damages suffered by it due to breach of the contract by the other party. The silent acceptance of performance at any other time (other than the specified time in the contract) may disentitle the innocent party from claiming damages suffered by it due to such delays. Section 55 also give right to the innocent party to opt out of the contract in case of delay by the breaching party if time was the essence of the contract. Compensation right for loss or damage suffered is however available to the innocent party as per this section even if time was not the essence of the contract.

12. A Comparative Study of Contract Management Systems in CPWD, DMRC, NHAI

To achieve optimum results in projects management, a study has been conducted to understand the project management system of three organizations viz. CPWD, DMRC and NHAI and screen out the positive feature of each organization and club them to maximize the result. In the study it is found that though the pattern of working of the

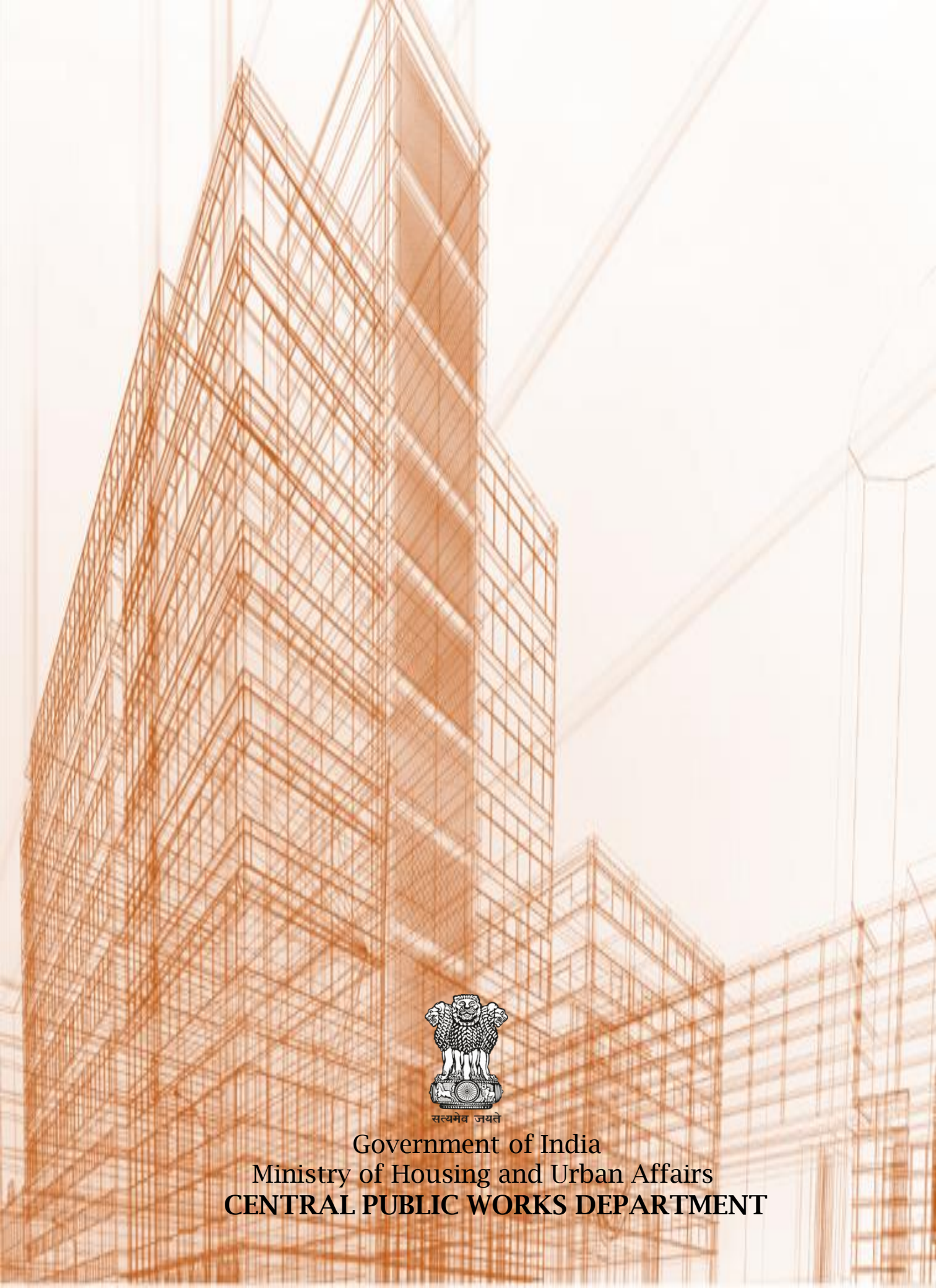
three organizations is the same but the detailed procedure and processes for various activities are different which make significant difference in their output and timeline.

This paper is exclusively for bringing out the relevance of the study for CPWD. The paper includes salient features of the project management system of DMRC and NHAI and recommendation for CPWD to further enhance CPWD's effectiveness of project implementation. As a result the following recommendations have been made in the paper with detailed justification:

a) Suggestions for ease in tendering system
b) Provision of additional performance guarantee for low rated contracts
c) Compensation for suspension of work from department side
d) Payment of additional cost for unforeseeable physical condition in EPC Contracts
e) Release of 80% amount of running account bill within 4 days
f) Focus on Delivery
g) Debarment Provision in contracts
h) Deemed termination of contract for delay in start of work beyond a specified time
i) Safety monitoring related issues
j) For dispute resolution, referring to disputes to ADG level committee instead of CE level

13. SETU Rating System for Sustainability Evaluation for Transportation Corridors in Urban Areas

SETU stands for Sustainability Evaluation of Transportation system in Urban Environment. SETU rating system is a very simple and a useful tool to carry out the sustainability evaluation of a transportation corridor under construction in an Urban Environment. Like Green Rating for Integrated Habitat Assessment (GRIHA) for rating the buildings with 33 criteria to assess its green characteristics, there was no such accepted rating system available for the assessment or rating of transportation infrastructure works. Hence as per the studies carried out on some important transportation corridors during construction stage in capital city Delhi, SETU rating system has been developed with 43 criteria for a typical transportation infrastructure project during the construction stage in an Urban Environment. There are defined guidelines to assess a project against these 43 indicators and thus SETU index can be calculated and to a project in the construction stage can be assigned a SETU rating. Finally, on the basis of SETU rating, a project can be graded from Platinum at top to silver at bottom. Thus, there will always be an urge to get the best rating to a project for which all stakeholders will strive their best.



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Government of India

Ministry of Housing and Urban Affairs

CENTRAL PUBLIC WORKS DEPARTMENT