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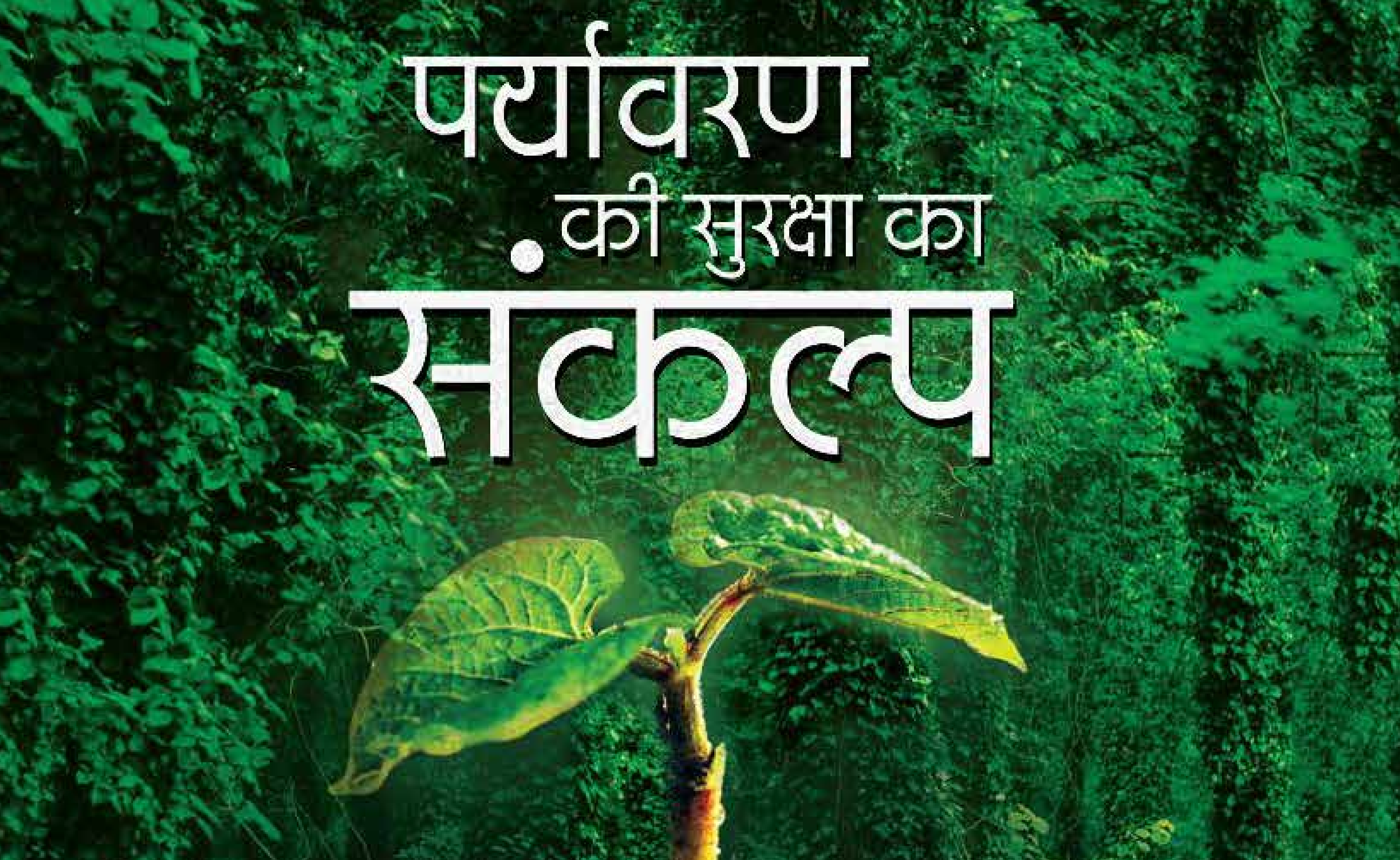

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CONTENTS

From
President's Desk

As we all know to meet the growing need of accommodation and matching infrastructure there is immense pressure on construction industry. The Building materials, energy and water are the basic element of construction, operation and maintenance of buildings which are taking toll on the natural resources and causing environmental degradation. Therefore need of the hour is to adopt sustainable, green and energy efficient materials and technologies.

Materials for a green building should be obtained from natural, renewable sources that have been managed and harvested in a sustainable way; or should be obtained locally to reduce the embedded energy costs of transportation; or salvaged from reclaimed materials at nearby sites. Materials are assessed using green specifications that look at their Life Cycle Analysis (LCA) in terms of their embodied energy, durability, recycled content, waste minimization, and their ability to be reused or recycled.

Passive solar design of buildings will reduce the requirement of energy to a great extent and thereby heating and cooling costs of a buildings. The energy requirement could be further reduced by high levels of insulation and energy-efficient windows. Natural daylight design reduces a building's electricity needs, and improves people's health and productivity. Green buildings also incorporate energy-efficient lighting, low energy appliances, and renewable energy technologies such as wind turbines and solar panels. Passive solar design uses sunshine to heat, cool and light homes and other buildings without mechanical or electrical devices. It is usually part of the design of the building itself, using certain materials and placement of windows or skylights.

Conserving water is the requirement for the survival of life on this planet. Therefore, Reduce, reuse and recycle should be the mantra. Further rainwater harvesting would help in collecting and using precipitation from a catchments surface. Rain water harvesting is enjoying a renaissance of sorts in the world, but it traces its history to biblical times. Extensive rainwater harvesting apparatus existed 4000 years ago in the Palestine and Greece. In ancient Rome, residences were built with individual cisterns and paved courtyards to capture rain water to augment water from city's aqueducts. Further minimising water use is achieved by installing greywater and rainwater catchment systems that recycle water for irrigation or toilet flushing; water-efficient appliances, such as low flow showerheads, self-closing or sprays taps; low-flush toilets, or waterless composting toilets. Installing point of use hot water systems and lagging pipes saves on water heating.

Thus, in nut shell, there is need of paradigm shift for all the stake holders in the construction industry who should find out the ways and means to maximise the use of renewable resources of materials energy and water for use in buildings.

(Vijay Singh Verma)

Review on Indian and Global Grid Codes for Photovoltaic Generation

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Abstract : There has been significant increase in quantum of photovoltaic (PV) generation in India over the recent years. This has increased penetration levels manifolds into the Indian Power System. Increased PV component in grid necessitates reliability, stability and security in compliance with Indian Electric Grid Codes (IEGC). Originally the grid codes were fall out of Electricity Act 2003, which was subsequently enforced 2010 onwards. The grid codes underwent number of reviews and amendments during the period. Revamped regulations were promulgated from time to time by Central Electricity Authority vide their amendments. The key requisites such as frequency, active and reactive power controls have been spelt out in IEGC, although initially were common for all renewable energy sources (RES), however, underwent refinements in due course with changing scenario. The paper elucidates salient aspects of IEGC as well as carries out brief comparison with other predominant nations. The provisions of draft IEGC 2020 has taken into consideration of emerging scenario of PV sector. The relevance of PV-grid integration technology has increased with growing energy needs. Therefore, importance of harnessing renewable energy sources (RES) is now an essentiality by virtue of its merits vis-a-vis conventional fossil fuels.

Introduction

A significant increase in production and installation of PV generating plants has been witnessed world over in the recent years. Approximately 115 GW of PV generation has been added during 2019 globally[1], this makes photovoltaic (PV) systems to cumulatively contribute 58% of global renewable energy capacity[2]. The increase in quantum of PV generation and integration is expected to rise progressively in coming years. It is anticipated by 2030, the global PV contribution alone would pitch to 1582.9 GW. Figure 1 illustrates PV capacities and annual additions made in past 11 years[1]. In India, the installed capacity of PV generation as on 31 May 2020 is approximately 34.92 GW[3]. Out of the total renewable generation of 87.38 GW, the PV component alone contributes 40%. In comparison to collective installed capacity of all generating sources amounting to 370.49 GW, PV generation contributes 10% currently vis-a-vis 2.9% during 2016[4]. India has set a target of 175 GW (100 GW Solar and 60 GW Wind) by 2022 and 450 GW of collective renewable generation by 2030. Similarly, Military Engineering Services (MES) has also been entrusted to establish cumulative 1.5 GW plants pan India[5]. Therefore, the penetration of PV is quite significant and anticipated to increase manifolds in times ahead. The characteristics of PV plants largely differ from conventional generations, thus posing greater challenges when connected to grid. High penetration of renewable energy sources are impinged in terms of stability, reliability, security and power quality of power system. The challenging aspects of voltage fluctuations, sags, imbalances, flickering, power factor at the point of coupling (PCC) dictate health of power system. Thus, the parameters are needed to be addressed voraciously. To obviate these challenges, grid codes have been evolved by several countries to enable smooth integration with the grid. The PV generating plants are expected to behave as conventional power plants, thus the compliance of technical standards are imperative, so that poor quality of power injected into grid can be obviated.

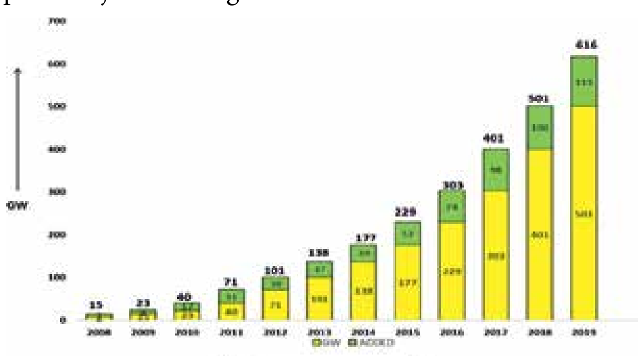

Fig. 1. Global PV Capacity and Annual Addition[1]

In order to achieve effluent power quality, grid codes have been evolved by several countries such as Germany, Italy, USA, Australia etc. International standards such as IEC standards and IEEE have strictly been enforced to enable smooth integration with RES. To illustrate an example, during situation of voltage sag caused during fault, the requirement of injecting reactive current into the PV system becomes imperative to enable stability.

Genesis of IEGC

Post formation of Electric Commission in 1998, draft Grid

Codes were formulated in the year 1999, further approved by Electricity Commission in Dec 1999. The Grid Codes were re- notified twice on 14 Mar 2006 and 28 Apr 2010. The codes notified in 2010 underwent number of amendments from time to time. Total of five amendments were issued for Grid Code 2010. The major amendments incorporated aspects pertaining to forecasting, scheduling framework, especially for renewable generation. During the period of formulating initial grid codes in 1999, the installed generation capacity (all resources) was 89 GW. Whereas in Dec 2019, it crossed 360 GW out of which, renewable capacity was 82 GW. The renewable energy penetration presently is of the order of 10% as on 31 May 2019 and expected to cross 20%[6].

Table 1. Evolution of IEGC[7]

Date	Sequence of Events
30 Oct 1999	IEGC Regulation notified and came into effect from 01 Feb 2000
10 Mar 2002	First review
2003	Electricity Act 2003: Section 178, Sub Section 2, clause(g) empowered Central Commission for issuing Grid Codes
14 Mar 2006	IEGC Regulation 2006 notified and came into effect from 01 Apr 2006
28 Mar 2010	IEGC Regulation 2010 notified and came into effect from 03 May 2010
05 Mar 2012	IEGC first amendment of CERC regulations notified and came into effect 02 Apr 2012
07 Mar 2014	IEGC second amendment of CERC regulations notified and came into effect 17 Dec 2014
21 Feb 2014	Corrigendum issued
10 Aug 2015	IEGC third amendment of CERC regulations gazette and came into effect 01 Nov 2015
29 Apr 2016	IEGC fourth amendment of CERC regulations gazette and came into effect 29 Apr 2016
19 Apr 2017	IEGC fifth amendment of CERC regulations gazette and came into effect 01 May 2017
03 May 2017	Corrigendum issued
28 May 2019	Expert group constituted by CERC to review IEGC
09 Jun 2019	Nomination of expert group from POSOCO and CERC
17 – 20 Jun 2019	Meetings carried out by expert group to re- view IEGC
09 Jan 2020	Draft IEGC 2020 formulated by expert committee promulgated

Provisions of IEGC and CEA Regulations

(a) Highlights of Draft IEGC 2020

The six member study group has carried out comprehensive review of previous IEGCs and evolved perspective draft IEGC 2020[6]. The same is likely to be promulgated through gazette notification soon. The review has especially taken into consideration the growing penetration levels of renewable energies in the Indian power grid. Following are the highlights:-

- The report breaks down structure of codes into role & organization, planning codes, connection codes, protection & commissioning codes (new), operating codes, scheduling & dispatch codes, cyber security (new) and monitoring & compliance codes.
- Measures proposed enforces grid security, reliability and smooth renewable integration in compliance with CEA standards.
- Planning code includes demand forecasting, generation resource planning (flexibility, ramping, minimum turn- down level), requirements of energy storage system, system reserves, system inertia for grid stability, inter- state system planning including re-optimization system study, adequacy, enhancement of total transfer capability (TTC).
- Connection codes elucidates connectivity grantees prior to obtaining the permission of the RLDC/ NLDC/SLDC for first time energizing of a new or modified power system.
- New code of protection and commissioning code

describes about annual self-audit and third party once in five years. Necessary tests prior to trial run have been prescribed for various types of conventional and renew- able generators.

- Draft IEGC 2020 suggests frequency response measures to be taken to correct load generation imbalances in an automated manner. The concept of primary, secondary and tertiary reserves coupled with demand response in terms of load shedding has been described.
- It is now possible to have reserve generating capacity on bar for quick response. National Load Dispatch Center (NLDC) has carried out preparatory work with regards to automatic generation control (AGC). The initial / primary response at the rate of 12 to 14 GW/Hz to contain frequency excursions is being achieved.
- Demand forecasting activity has been illustratively organised and monitoring mechanism has been imposed to check errors in demand forecasting.
- In order to minimize forecasting errors of renewable generators, aggregation of renewable energy sources has been allowed at one or more pooling stations for the purpose of deviation settlement.
- Nominal frequency band of grid has now been narrowed from 49.90- 50.05 Hz to 49.95-50.05 Hz.
- Draft IEGC 2020 mandates sufficiency of generation resources round the clock to supply to all consumers. It proposes load shedding as resort for demand response mechanism in case of emergency situation.
- Wind, Solar, Wind-Solar Hybrid will now be treated as MUST RUN power plants.
- New code of cyber security has been included. The code provisions identification of Critical Information Infrastructure. An appointment of Information Security Officer as per the Information Technology Rules 2018 shall be institutionalized.
- As per the operating codes, the voltage or reactive power controller of wind, PV generating units shall be properly tuned. The tuning will include low and high voltage ride through capability of generators. The tuning shall be carried out at least once in five years.
- The National Reference Frequency is 50.000 Hz, therefore, users, State Load Dispatch Centre (SLDCs), Regional Load Dispatch Centre (RLDCs) and National Load Dispatch Centre (NLDC) will measure grid frequency at a resolution of 0.001 Hz. The frequency data will be at the rate of one sample per second. Measures to ensure grid frequency within the 49.95-50.05 Hz has been elucidated.
- NLDC, RLDCs and SLDCs should bring back frequency above the band within 15 minute of excursion. Beyond the band, secondary and tertiary reserve mechanisms will come into force.
- The levels of reserves shall be three tiered viz primary, secondary and tertiary for the purpose of frequency control.
- As per primary response, the Wind/ Solar (commissioned between 06 Aug 2019 to 31 Mar 2022) with capacity of generating station more than 10 MW and connected to 33 kV or above, should be 110 %. The generating station should be able to ramp back to the original level at the rate of about 1% per minute. Similarly, Wind/ Solar/ Hybrid (commissioned after 31 Mar 2022) with capacity of generating station more than 10 MW and connected to 33 kV and above, should be able to achieve 105%.
- In PV systems, the reactive power limiters or power factor controllers or voltage limiters should not suppress the primary frequency response within its capability. The inherent dead band of a generating unit frequency controller should not exceed 0.03 Hz. For those plants commissioned between 06 Aug 2019 to 31 Mar 2022, the dead band of frequency controller should not exceed +0.05 Hz/-0.03 Hz.
- The primary reserve response should start immediately and attain its peak in less than 30 seconds and should be able to sustain up to 5 minutes.
- Minimum frequency response characteristic during primary reserve condition should have deviation value of 0.3 Hz i.e. 15000 MW/Hz (4500 MW/0.3 Hz).

(b) CEA Gazette Notification Part-3, Section-4, 15 Oct 2013

The notification elucidates the connectivity standards for both wind and Inverter based systems[8]. Following requirements have been laid out in the regulation.

- Harmonics must not to exceed limits given in IEEE standard 519.
- Generating station should not inject DC current more than 0.5% of full rated output at the point of coupling (PCC).
- Flicker not to exceed IEC 61000 (with effect 01 Apr

2014).

- Generating station should be capable to supply dynamically varying reactive power supply to maintain power factor within limits of 0.95 lag to 0.95 lead.
- Generating units to have operating frequency ranging from 47.5 to 52 Hz and rated output frequency ranging from 49.5 to 50.5 Hz. This will be subject to performance with voltage variation upto 5% (Depending on solar insolation available).

(c) CEA Gazette Notification Part-3, Section-4, 08 Feb 2019

The notification elucidates the connectivity standards for both Wind and Inverter based systems[8]. Following requirements have been laid out in the regulation.

- Generating units to have operating frequency ranging from 47.5 to 52 Hz and should be able to deliver rated output ranging from 49.5 to 50.5 Hz. In case of frequency falling below than range of 49.5 or above 50.5 Hz, The controlling system must get activated to regulate output of the unit.
- The generating station connected to grid shall remain connected till voltage at PCC (any one/ three phase) dips upto the level of blue line.
- During the voltage sag, the supply of reactive power is considered as first priority and active power as second priority. The active power should preferably be maintained even during voltage drop, subject to reduction within capacities the plants design specifications. However, active power must be restored to at least 90% of the pre-fault levels within 1 second of restoration.

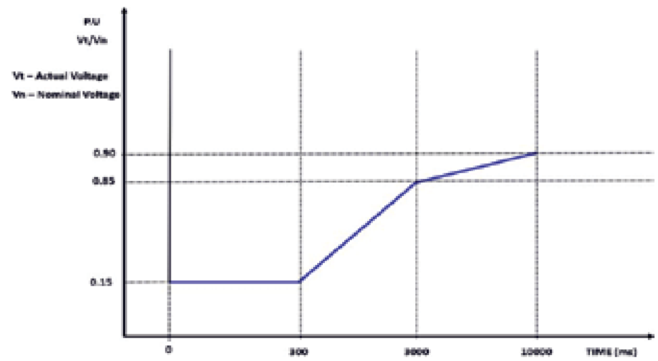

Fig. 2. Ninety Percent Restoration in One Second

- Generating station with installed capacity greater than 10 MW connected to voltage levels of 33 kV and above must comply to the following:-
  - (i) Must be capable to control injection of active power based on set points defined.
  - (ii) Must be equipped to control frequency at drop levels of 3 to 6% and dead band not exceeding 0.03 Hz, provided frequency deviation in excess of 0.3 Hz, the generating station within 1 second must provide real power primary frequency response equal to 10 % of maximum AC active power capacity.
  - (iii) Should have operating range of frequency response and regulation from 10 to 100 % of maximum AC active power capacity.
  - (iv) The plant must be equipped to control rate of change of output power not more than ±10% per minute.
- Voltage standards during asymmetrical and symmetrical over voltage conditions for generating unit to remain connected must comply to following conditions:-

Table 2. Voltage Standards during Fault

Over Voltage (PU)	Minimum Time to be Connected (Seconds)
$1.30 < V$	0 (Instantaneous trip)
$1.30 \geq V > 1.20$	0.2
$1.20 \geq V > 1.10$	2
≤ 1.10	Continuous

- Short Circuit Ratio (SCR) at PCC should not be less than five.

(d) CEA Gazette Notification for Technical Connectivity for Distributed Generation Sources, 30 Sep 2013

The notification elucidates connectivity standards for resources less than voltage level 33 kV[10][11]. The regulations were re-amplified in gazette notification made on 08 Feb 2019. The standards for distribution generation sources are as follows:-

- Harmonic current injections from generating station shall not exceed the limits specified in IEEE 519-2014[12].
- The distributed generating resource shall not inject Direct Current greater than 0.5% of the full rated output at the interconnection point.
- The distributed generating resource shall not introduce flicker beyond the limits specified in IEC 61000[13].
- Over and under voltage trip functions if voltage reaches above 110% or below 80% respectively with a clearing time upto 2 seconds.

- Over and under frequency trip functions, if frequency reaches 50.5 Hz and below 47.5 Hz with a clearing time upto 0.2 seconds.
- Every time the generating station is synchronised to the electricity system, it shall not cause voltage fluctuation greater than ± 5% at the point of connection.
- Voltage and frequency sensing and time-delay to prevent energising of de-energised circuit or to prevent from reconnecting will be minimum 60 seconds.

(e) Summarized Technical Standards Notified by CEA

The technical standards promulgated my CEA are summarised as follows[14][15]: -

Table 3. Technical Standards Notified by CEA

Parameters	Standard specified by CEA	Specified limits by CEA
Harmonics	IEEE 519	h < 11, distortion < 4% 11 ≤ h < 17, Distortion < 2% 17 ≤ h < 23, Distortion < 1.5% 23 ≤ h < 35, distortion < 0.6% 35 ≤ h, distortion < 0.3% I_{TDD} < 5% and V_{THD} < 5%
Flicker	IEC-610003-3 IEC-610003-11	P_{ST} < 1 and P_{LT} < 0.65
DC Injection to AC grid	IEEE 1547	< 0.5 % of full rated output current
Voltage band	IEEE 1547	V < 80%, T_{MAX} ≤ 2 second V > 110%, T_{MAX} ≤ 2 second
Frequency	-	f 50.5 Hz, T_{MAX} ≤ 0.2 second f < 47.5 Hz, T_{MAX} ≤ 0.2 second (withstand upto 60 seconds)
Anti-Islanding	IEEE 1547	-

Universal PV Interconnection Standards

(a) Voltage Deviation

The safe operating ranges for voltages are essential for reliable operation of PV - grid interfaced system. Deviation of voltages above laid down limits can result into detrimental faults creeping into the system. Therefore, lower and upper limits are specified to ensure smooth functioning of integrated system. The fault ride though implies to corrective measures being taken within the stipulated time. The dictated limits of High Voltage Fault Ride Through (HVRT) and Low Voltage Fault Ride Through (LVRT) are therefore essential[16]. A typical characteristic curve is shown in figure 3.

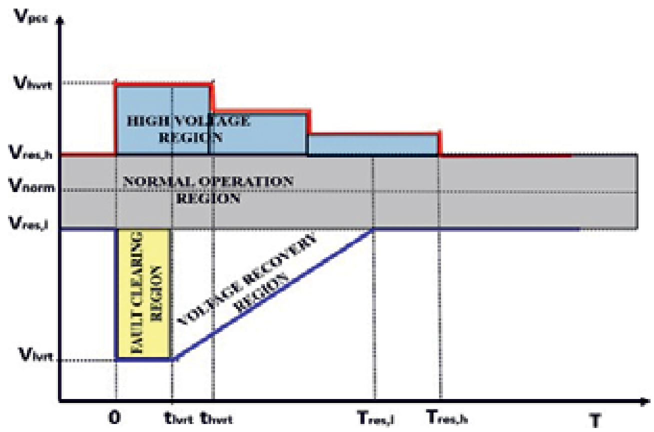

Fig. 3. VFRT Characteristic Curve

The characteristic curve is divided into normal operating region, fault clearing region, recovery region and high voltage region. The voltages on Y-axis are expressed in per-unit values. The normal operating region indicates the continuous operating limits i.e. between Vres, l and Vres, h. The generating units should be able to withstand faults that induce in low voltage region, i.e. between Vres,l and Vlvrt within the time duration tlvrt. Similarly, for induced faults in high voltage region upto thvrt. The generating station is expected to support the network with requisite active and reactive power being injected till Vres,h and V res,l are achieved in time tres,h and time tres,l respectively. The comparative LVRT standards of various countries in terms of voltage and time are mentioned in Table 4.

Table 4. LVRT Standards for Voltages (pu) & Time (ms)

Country	Tlvrt (ms)	Vlvrt (pu)	Tres,l (ms)	Vres,l (ms)
India	300	0.15	3000	0.85
UK	140	0.15	500	0.94
Canada	150	0	1000	0.75
Germany	150	0	1500	0.9
Egypt	250	0	3000	0.9
China	625	0.2	2000	0.9

While, interconnection standards in terms of percentage deviations of various countries is enumerated in Table 5[17].

Table 5. Disconnection Based on Grid Voltages

Country	Standards	Voltage Limits	Trip Time (Seconds)
India	IEEE-1547	80-110%	2
Australia	AS 4777	87-117%	2
Europe	EN50438	85-115%	1.5/0.5
Germany	VDE01261-1	80-115%	0.2
Interna-tional	IEC 61727	50-135% 85-110%	0.1/0.05 2
Italy	DK 5940	80-120%	0.2/0.1
South Korea	PV 501	80-120% 88-110%	0.16 2
Spain	RD 1663/661	85-110%	0.5 1.5/0.5
UK	G83/1-1	90-115%	5
USA	UL1741	50-120% 88-110%	0.16 2/1
China	GB/T 19964 Q/GDW 617 GB/T 29319	± 7 % (for ≤ 10 kV) ± 10 %(for ≥ 35 kV)	

The limits followed by other European nations with respect to over and under voltage conditions are enumerated in Table 6 and 7[18][19].

(b) Frequency Deviations

A stable frequency in a grid is an important parameter to ensure reliable and stable power quality. Whenever, the generated power falls below the consumer power, the frequency decreases and vice-a-versa. Unstable frequency can negatively impinge on health of grid system. Similar to Indian standards promulgated by CEA[20], Germany has also 50 Hz as operating frequency, they have also set limits between 47.5. and 51.5 Hz. However, The moment the grid frequency crosses beyond 50.2 Hz, the inverter output is needed to be reduced in steps of 40 % per Hz, till 51.5 Hz is reached. The comparative matrix with respect to frequency standards adopted by various other nations are in Table 7[17].

Table 6. Over Voltage limits

Country	Max Clearance (Sec)	Voltage Trip Setting
Default	0.2	230V + 15%
Czechia	0.2	230V + 15%
Denmark	40	230V + 10%
Estonia	-	230V + 10%
France	0.2	230V + 15%
UK	1.5	264V
Italy	0.1	230V + 20%
Germany	0.2	230V + 10%

Table 7. Under Voltage Limits

Country	Max Clearance (Sec)	Voltage Trip Setting
Default	1.5	230V - 15 %
Czechia	0.2	230V - 15 %
Denmark	10	230V 10 %
Estonia	-	230V - 15 %
France	0.2	230V - 15 %
UK	1.5	207 V
Italy	0.2	230V - 20 %
Germany	0.2	230V - 15 %

Table.8. Frequency Standards

Country	Standard	Lower Frequency	Upper Frequency	Trip Time (Sec)
India	CEA	< 47.5	>50.5	0.2
International	IEC 61727	-1	+1	2
Australia	AS 4777	-5	+5	0.2
Germany	VDE0126-1-1	-2.5	+0.2	0.2
Italy	DK 5940	-0.3	+0.3	0.1
Europe	EN 50438	-3	+1	0.5
South Korea	PV 501	-0.3	+0.3	2
Spain	RD 1663/661	-2	+1	2/0.2
UK	G83/1-1	-3	+0.5	0.5
USA	UL 1741	-0.7	+0.5	0.16
France	C14-100	-0.5	+0.5	0.2
Denmark	(EU) 2016/631	-3	+3	0.2
Czechia		-0.5	+0.5	0.2
Estonia		50-2%	50+2%	ND
China	Q/GDW 617 GB/T 19964	50.2 to 50.5 Hz(2 min operation time) >50.5 Hz(0.2 sec disconnection time)		

(c) Harmonics

Harmonic signify voltage and current waveform distortions with reference to its original characteristic/ waveform shapes as result of non-linear loads. Resonances too can also lead to performance issues which may eventually damage utility. The harmonics in a PV system normally arise out of inverters, converters and power electronic devices used in the network. Although, there has been significant improvements in inverter technologies, such as the use of low pass filters to curb harmonics, yet impinge power quality significantly. India complies to standards given in IEEE 519-2014 to curb harmonics as promulgated by CEA gazette notification. The comparative matrix of harmonic standards adopted by various other nations are given in Table 9 and 10[21][22]. In addition, the latest IEEE 1547- 2018 standard has introduced the new terminology named as Total Rated Current Distortion (TRD), which includes harmonics and inter harmonic current distortions. The maximum limits have been specified in Table 11. The TRD for a PV system can be calculated using the following formula.

$$\%TRD = \frac{\sqrt{I_{rms}^2 - I_1^2}}{I_{rated}} \times 100\% \qquad (1)$$

Where, I_1 is fundamental current at point of common coupling (PCC). I_{rated} is the rated current capacity and I_{rms} is the root mean- square current measured at PCC respectively.

(d) Flickering

The output of PV generating plant depends on solar in- solation. Cloudy/ shading conditions impinge fluctuations at consumer/ at load end. Uncontrolled fluctuations can result into malfunctioning of appliances. Therefore, limits to curb flickering is imperative[23][24]. Flickering is quantified in terms of emission values which are measured at the point of common coupling (PCC). EPST and EPLT represent emissions of short term flicker severity (P_{st}) and long term flicker severity(P_{lt}) respectively. It is calculated using the following formula.

$$P_{lt} = 3\sqrt{\frac{1}{12}\sum_{i=1}^{12} P_{st}^3} \qquad (2)$$

Where, i = (1, 2, 3..) represent consecutive readings of short time severity. Comparative matrix showing limits of several countries is elucidated in Table 12.

Table 9. Current Harmonics Standards for PV System

Standard	Harmonic Order	Distortion Limit	THD (%)
Australia China Malaysia IEEE-1547 AS-4777.2 GB/T ECM	33 < h 23≤ h≤ 33 17 ≤ h ≤ 21 11 ≤ h ≤ 15 3 ≤ h ≤ 9 (Odd)	< 0.3 % < 0.6% < 1.5% < 2% < 4%	< 5%
	10 ≤ h ≤ 32 2 ≤ h ≤ 8 (Even)	< 0.5% < 1%	
UK (EREC G-83)	h = 3, 5, and 7 h = 9, 11, and 13 11≤ h ≤ 15 (Odd)	<(2.3, 1.14, and0.77) % < (0.4, 0.33, and0.21) % <0.15%	< 3 %
	h= 2, 4, and 6 8 ≤ h ≤ 40 (Even)	< (1.08, 0.43, and 0.3) % < 0.23%	
IEC 61000-3-2	h = 3, 5, and 7 h = 9, 11, and 13 15 ≤ h ≤ 39 (Odd)	< (3.45, 1.71, and 1.15) % < (0.6, 0.5, and 0.3)% < 0.225%	<5%
	h = 2, 4, and 6 8 ≤ h ≤ 40 (Even)	< (1.6, 0.65, and0.45)% < 0.345%	

Table 10. Voltage Harmonics Standards for PV System

Standard	Voltage(kV)	Maximum Harmonics	THD (%)
IEEE-519	V ≤1 1≤ V≤ 69 69 ≤ V ≤ 161 V > 161	< 5 % < 3% < 1.5% < 1%	< 8% < 5% < 2.5% < 1.5%
IEC61000-3-2	2.3 ≤ V ≤ 69 69 ≤ V ≤ 161 V > 161	< 3 % < 1.5% < 1%	< 5% < 2.5% < 1.5%

Table 11. Maximum Current Harmonics based on TRD (I_{rated})

Individual Harmonic Order (h)	Maximum Individual Harmonics	TRD (%)
Odd Harmonics		
h < 11 11≤ h≤ 17 17 ≤ h ≤ 23 23 ≤ h ≤ 35 35 ≤ h ≤ 50	< 4 % < 2 % < 1.5% < 0.6% < 0.3%	< 5%
Even Harmonics		
h = 2 h = 4 h = 6 8 ≤ h ≤ 50	< 1 % < 2 % < 3 % Associated range above	< 5%

Table 12. Flicker Limits

Country	Standard	Limit
India	IEC 61000-3-3 (< 16Amp) IEC 61000-3-11 (> 16 Amp)	EPST <1, in intervals of 10 Minute EPLT < 0.65, over period of 2 hours
Germany	VDE-AR-N 4105	EPST < 1, in intervals of 10 Minute EPLT < 0.65, over period of 2 hours
Australia	AS/NZS 61000.3.3 (< 16Amp) AS/NZS 61000.3.5 (>16Amp)	EPST < 1, in intervals of 10 Minute EPLT < 0.65, over period of 2 hours
USA	IEEE 1547 and IEC 61000	EPST < 0.35, in intervals of 600 Seconds EPLT < 0.25, over period of 2 hours
China	Q/GDW- 617 GB/T 199964 GB/T29319	Same as IEC 61000 standards

(e) Anti-Islanding

The condition in which the grid-connected PV system continues to supply power to load despite disconnection from grid[25] is called Islanding. This is extremely hazardous to any utility. Therefore, the inverters in grid-connected PV system must be sensitive to detect the islanding conditions and cease supplying of power. This is known as anti-islanding phenomena in PV system. Early detection is therefore essential to obviate unintentional islanding situation. CEA mandates regulations to prevent of unintentional islanding as a prime requirement to be strictly complied by all inverters[14][19]. The comparative matrix of anti-islanding standards adopted by various nations are shown in Table 13[26][27]

Table 13. Anti-Islanding Standards

Country and Standard	Limits
Germany (VDE 0126-1-1:2013-08)	Standards for the automatic disconnection of PV system grid has been specified. This includes detection during under / over voltages, frequency and impedance deviations. The disconnection of PV to be within five seconds, moment change of one ohm impedance is detected.
USA (UL 1741 harmonized with IEEE 1547)	This standard requires inverters to detect island conditions to prevent energizing of grid. Must, activate within two seconds of the islanding.
European (Countries (IEC 62116)	Test procedures to prevent islanding
Australia (AS-4447)	To activate within prescribed set points of the grid voltage and frequency. The inverter should immediately disconnect after set points are exceeded. Re- connection is permitted based on permissible range for a minimum one minute. Synchronization process with grid may be permitted after this period.
India (UL 1741/IEEE 1547)	MNRE mandates anti-islanding protection for all PV projects executed under the National Solar Mission (NSM).
China (GB/T 19964, Q/GDW 617, GB/T 29319)	GB/T 19964 stipulates two seconds as disconnection time for small PV systems. Q/GDW617 specifies protection methods and anti-islanding not being mandatory. The capability of anti-islanding protection of the medium PV system shall be de- termined termined by the grid dispatch department. This is applicable for medium and large PV systems. GB/T 29319 stipulates station resorting to anti-islanding phenomenon for not longer than two seconds in compliance with the grid protection scheme.

(f) DC Current Injection

The inverters in PV generation may cause DC bias due to imbalances in impedances. Primarily due to number of switches involved, variations in switching periods as well as flaws associated with implementation of timings for drivers results in DC injection. The universally adopted standard to obviate DC injection limits not exceeding 0.5% of rated output current has been promulgated. The comparative matrix of DC current injection standards adopted by various nations are shown in Table 14[28][29].

Table 14. DC Injection Limits

Country and Standard	DC Injection Limit
Germany (VDE 0126-1-1)	During Automatic disconnection, DC injection > 1 amp is not permitted. If it exceeds, disconnection is mandatory in 0.2 sec.
USA (UL1741/IEEE 1547)	Not more than 0.5% rated current permitted.
Australia (AS-4447)	Output current at AC terminal not to exceed 0.5 % of rated current.
India (IEEE 1547)	Not more than 0.5% rated current.
China (Q/GDW 617 GB/T 29319)	Not more than 0.5% rated current at PCC.

(g) Voltage Unbalance at PCC

Un-balance in voltages are measured at PCC. It occurs when there is any imbalance any single phase/ three phase voltages. Therefore, the voltage balance is an important parameter to ensure a stable system. Voltage imbalance is defined by ratio of positive over negative sequence voltages [30]. Voltage Unbalance Factor (VUF) is primarily used to measure the magnitude of unbalance in a PV system [31]. Following standards in Table 14 are being adopted by various countries with respect to unbalanced conditions.

Table15. Unbalance Voltage Limits

Standard	VUF
IEEE	< 3%
IEC	< 2%
Germany	< 2%
China	< 2%
Canada	< 2 % However < 3 % is also allowed in case the unbalance is due to unbalanced load.
Overall Standards	< 1- 2%

(h) Reactive and Active Power Control during Grid Disturbances

In an erstwhile scenario, PV generating plant were required to get disconnected from grid immediately on sensing of faults or disturbances thereto. However, this underwent recent change, where PV system is also required to stay connected with inherent capability to ride through faults, similar to wind generating plants. There is further scope for carrying out elaboration of requisites in IEGC. Considering German Grid Code for medium voltage network [32], it specifies three distinct regions as in Figure 4, with respect to fault conditions. Region 1 indicates that the PV plant must not disconnect and must remain connected even during single/ two/ three phase faults upto period of 150ms. Region 2 may allow disconnection based on agreement. Region 3 indicates strict disconnection using protective relays.

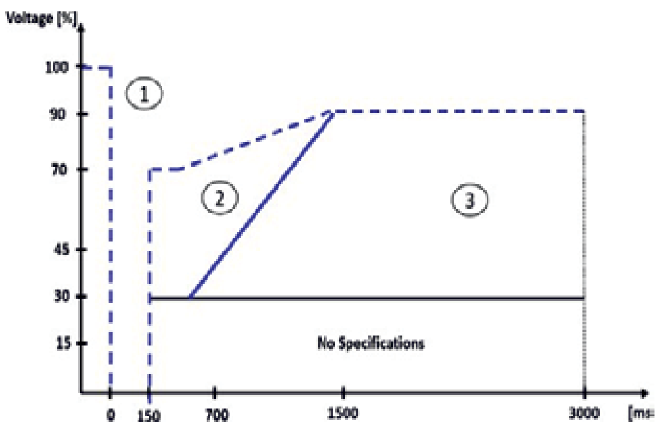

Fig.4. Dynamic Grid Support during Faults (Germany)

German Grid Codes elucidates criteria for reactive current support in case of voltage drops at PCC. Reactive current is injected outside the voltage dead band of 10%. It is directly proportional to percentage of voltage drop. Post clearance of fault, no reactive current must be absorbed from grid. Instead it must restore active power at the ramp rate of 20 % per second.

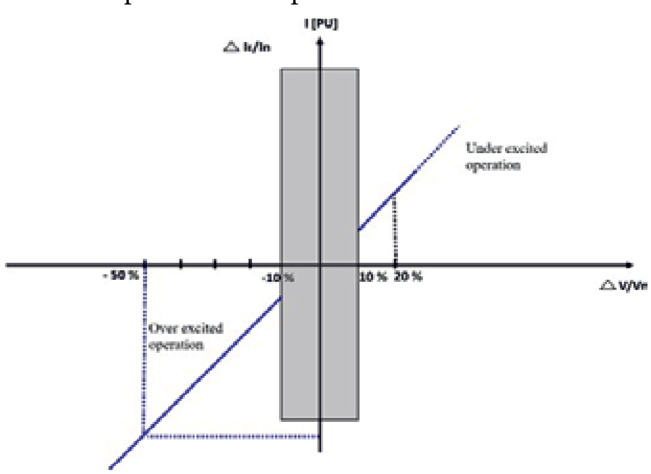

Fig. 5. Reactive Current Requirement during Faults (Germany)

Similarly, Spain stipulates that PV plant must inject/absorb positive sequence reactive currents based on saturation levels represented by polygon ABCDE. During overvoltage conditions, the system is required to get disconnected beyond 1.3 pu using protective relays. Therefore, reactive power support must be in sync with voltage controller action during both normal and fault conditions.

The moment fault is cleared, the voltage controller must stay enabled for minimum 30 seconds, thereafter, the voltage returns back to normalcy and gets disabled. For voltages less than 0.5 pu, active power gets reduced to zero. To commence restoration of active power post clearance of fault, it must restore within 250 ms. The requisite gain of dynamic response be less than 40 ms (V< 0.85 pu) and 250 ms (V< 0.85 pu) [33][34]. During frequency deviations and abrupt disconnection of PV plant from grid, the system tends get unstable. To obviate this, the grid codes impose certain stipulations. Germany for example, after having witnessed the problem of 50.2 Hz Problem evolved strict grid codes.

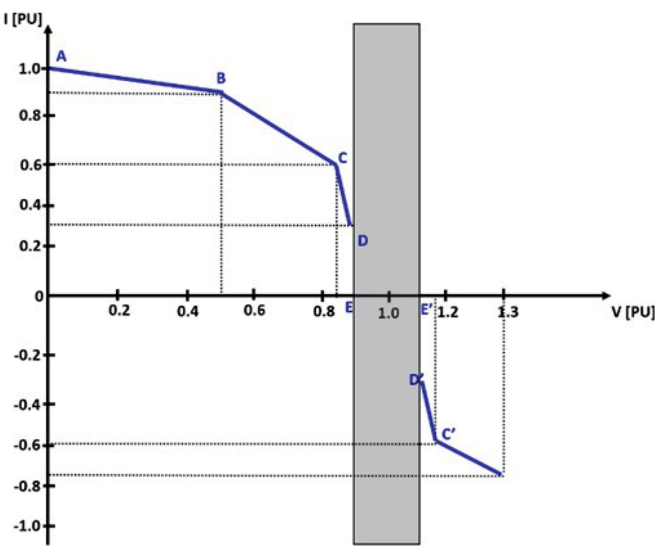

Fig. 6. Reactive Current Requirement during Fault (Spain)

It states that, with increase in frequency, the generating plant must proportionately reduce the active power by 10 % till zero is achieved at the rate of 10% per minute[35]. After it exceeds the threshold, the reduction in active power should be 40% per minute. Similarly, when power is allowed to increase upto frequency of 50.05, the system must get disconnected. After reconnection post resolution of fault, the active power may increase at the rate of 10% per minute. The change in active power is depicted in Figure 7.

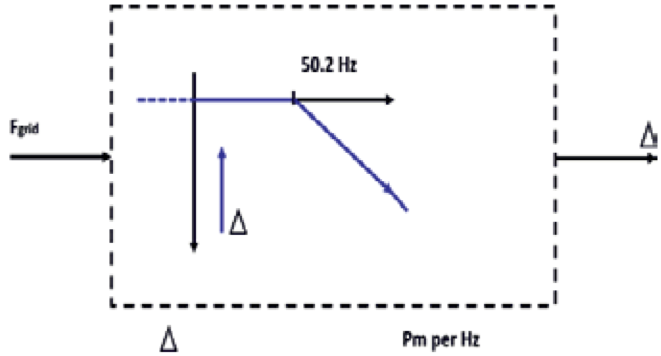

Fig. 7. Reduction of Power with increase in frequency (Germany)

Conclusion

India has been witnessing increased quantum of PV generation under programme of National Solar Mission (NSM) over the recent past. The contribution of PV into the grid system has increased sizably. Considering penetration levels of 2.9% in 2016 vis-a-vis 10% in 2019, it is amply clear that, India is going to achieve much beyond of laid down targets. India is committed towards installing 175 GW (100 GW Solar and 60 GW Wind) of RES by 2022. The current achievement of PV alone as on 31 May 2020 is 34.92 GW. With increase in penetration levels of PV into the grid system, need for stringent grid codes for PV power plants is imperative. Currently, we have comprehensive grid codes existing for wind and conventional power plants, but much needed clarity is needed to be established for PV as well. Although, draft IEGC 2020 and amendment made by CEA has brought out PV codes to great extent, yet there is scope of further improvement[36]. Particularly, improvements to codes in FRTs, dynamic reactive and active power support need more amplification. The paper has carried analysis of IEGC from its evolution to the latest draft IEGC 2020. Brief comparison of major technical standards adopted by various countries have been carried out in verbose.

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Seismic Retrofitting of Multi-Storey RCC Building using Fluid Viscous Dampers & Comparing the Results before & after the Retrofitting

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Abstract

In the past, a large number of building structures in India have been damaged by earthquakes and some of these structures have been repaired and strengthened. The strengthening of existing structures is required in cases where the buildings are constructed according to the old regulations, and they do not fulfill any more requirements of the recent regulations. Most of the buildings in India are normally constructed to resist static loads without considering seismic action. However, this leads to deficiencies in the design of the structures. In our case, one newly built 15 storey RCC framed building which have experienced a strong earthquake and during that time the seismic vibration of the building was much high which settled fear among the tenants about the safety of the structure. After the earthquake the structure was carefully observed but no cracks or any sorts of damages to the frame members were found except the wall on which hair cracks were developed. But for the safety against the future earthquakes and most importantly safety of the structure, the building is to be retrofitted with Fluid Viscous Dampers. Here we will analyze the changes in the storey displacement, storey drift, modal period and frequencies, storey stiffness, critical column and beam forces before and after retrofitting the structure with the dampers using ETABS. This will help to provide extra safety precaution to the joints of the structures also.

Introduction

Most of the buildings in India are normally constructed to resist static loads without considering exact seismic actions. However, this leads to deficiencies in the design of the structures. Typical deficiencies for the studied structure are the following:

- The boundary conditions of the supports. It is important to have proper supports, especially when considering seismic actions since a ductile behaviour of the structure is required.
- If the seismic zone changes for the particular area, the safety measure for the structure should immediately be taken into consideration.
- If building is also seismically designed, the data input and the factors considered for seismic designing are not taken into major consideration such as Response Reduction Factor.
- Irregularities in mass and stiffness. The choice of material and element types is important since they affect the weight and strength of the structure.
- Another type of irregularity is the geometry of the structure, the more complex the structure is the more irregularities it tends to get.
- Moreover, the combination of different types of elements and their distribution in the structure affect the overall stiffness and behaviour of the structure.

In our case, newly built 15 storey RCC framed building which experienced a strong earthquake and due to which the building was undulating at a greater velocity which settled a fear among the tenants about the safety of the structure. After the earthquake, the structure was carefully observed but no cracks or any sorts of damages to the frame members were found except to the wall on which hair cracks were developed. But for the safety against the future earthquakes and most importantly safety of the structure, the building is to be retrofitted with Fluid Viscous Dampers. Here we will analyze the changes in the properties before and after retrofitting the structure with the damper. Though various past researchers worked on it but the retrofitting work using increased damping approach is still not tried yet which will retrofit the structure globally with joints safety also.

Seismic Retrofitting Techniques

Seismic Retrofitting Techniques includes addition of concrete shear walls, use of Steel Braced Frames, use of Moment Resisting Steel Frames, using Concrete Diaphragm walls, Jacketing columns, Beam Jacketing, Jacketing of Beam-Column joints, FRP composites, Dampers such as FVD, Electro-rheological and Magneto-rheological Dampers, Base Isolation, Mass Reduction, Strengthening of footings. Viscous damper functions on the principle of passive energy dissipation by adding damping of seismic forces in the structure. Previous study on response of structure to earthquakes provided with viscous damper shows that it can reduce storey drift, forces in members which lead to less damage to structure enabling it to resist large lateral forces. It is very important to safeguard the structures such as airports, fire department barracks, nuclear power plants, communication centers, hospitals, bus stops, institutions etc. from the earthquakes to reach higher level of safety. By the virtue of damping action of viscous dampers, it reduces forces in the members, enabling provision of smaller cross sections of structural members. This makes the structure safer against seismic action.

Case Study: Modelling of the Structure

ETABS is a computer software package for analysis and design of civil structures. It offers an intuitive yet

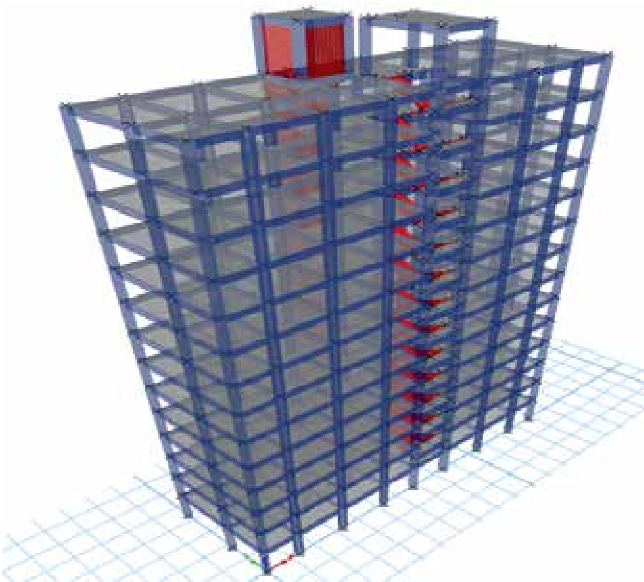

Fig. 1. Without Dampers 3d View

powerful user interface with many tools to aid in the quick and accurate construction of models, along with the sophisticated analytical techniques needed to do the most complex projects. Therefore, in the present study three dimensional analyses with the help of ETABS 18 was used for modelling and analysis of the structure. The work started with modelling and analysis of RCC building for two cases:

1. Analysis of the original building.
2. Analysis of that building with effectively using Fluid Viscous Dampers.

An existing 15 storey RCC building was modeled using ETABSs having the total building height of 46.1m including the base and top floor. Concrete grade of M35 and Fe 500 grade steel were taken. Frame properties such as beams (450mm x 250mm) and columns (400mm x 500mm) are of these dimensions and slab thickness of 125mm. The existing building was designed according to seismic zone II following the IS 1893 (2016): Part-1. Loads such as Dead, Live, Seismic, Wind and default load combinations were applied. Then the fluid viscous dampers were fitted at the four corner sides of the building and also at the staircase side areas and analyzed.

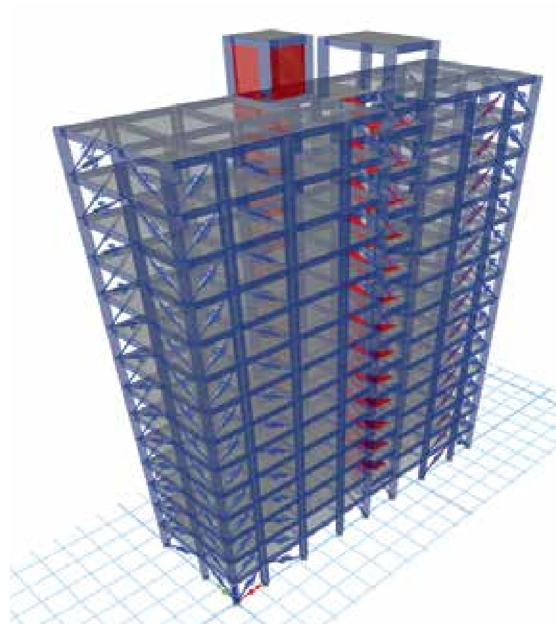

Fig. 3. With Dampers 3d View

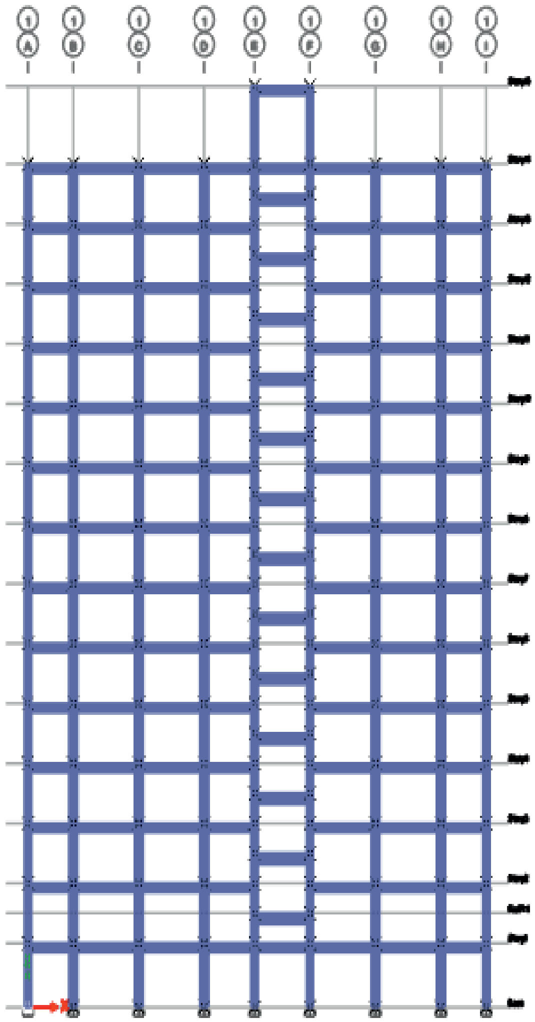

Fig. 2. Front Elevation View

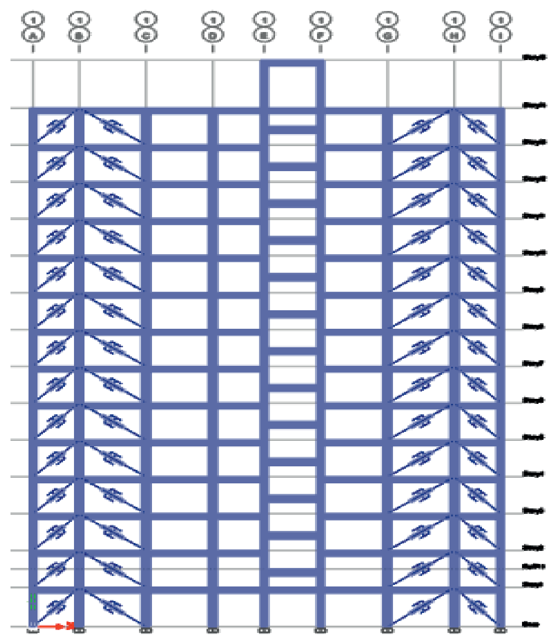

Fig. 4. Front Elevation View

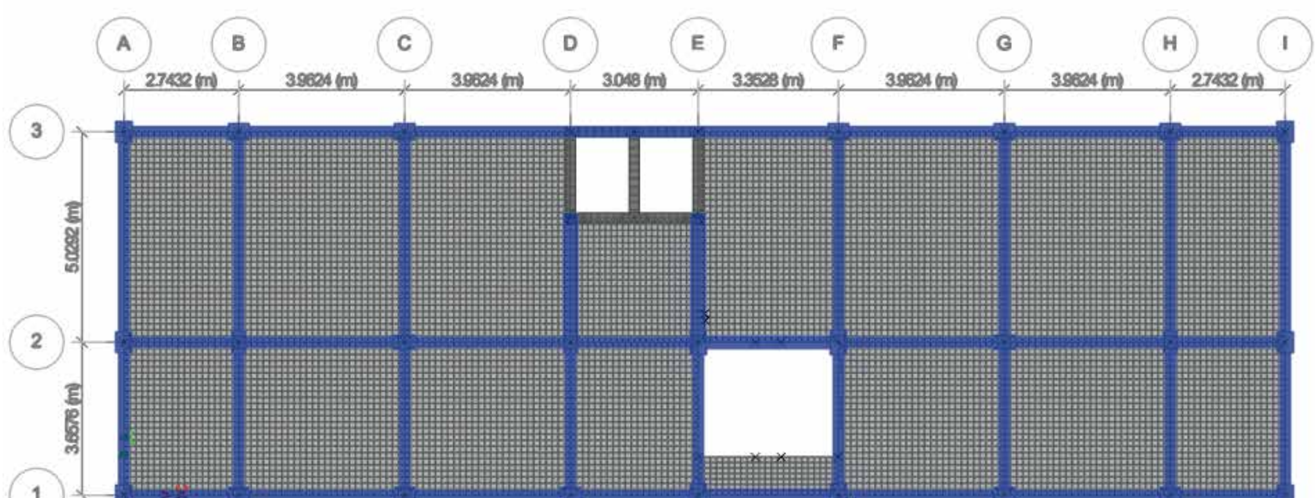

Fig. 5. Without Dampers Plan View

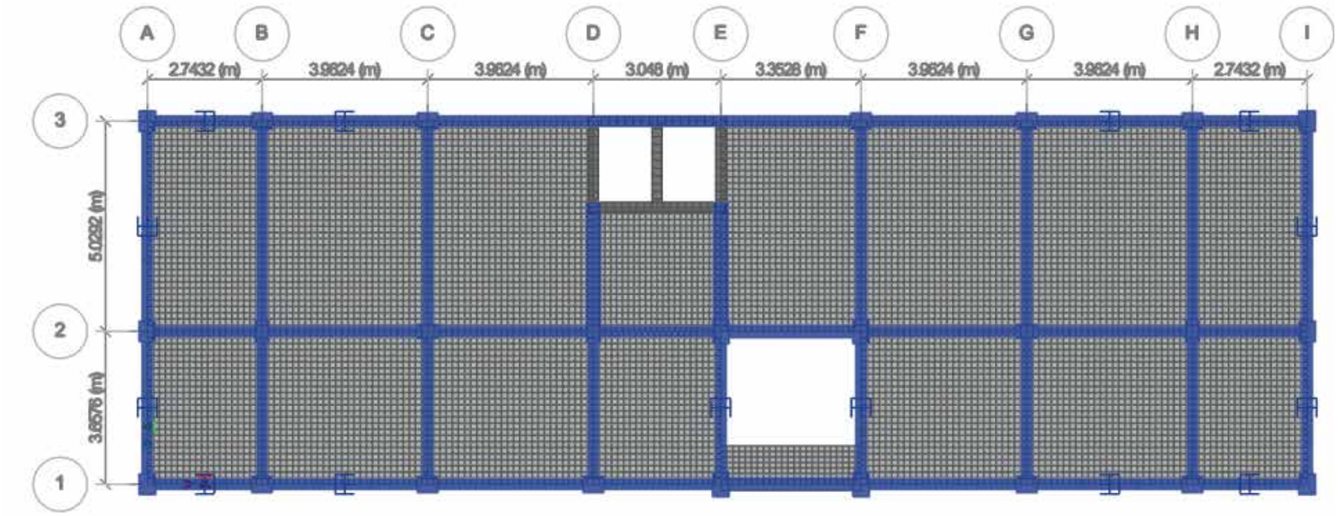

Fig. 6. With Dampers Plan View

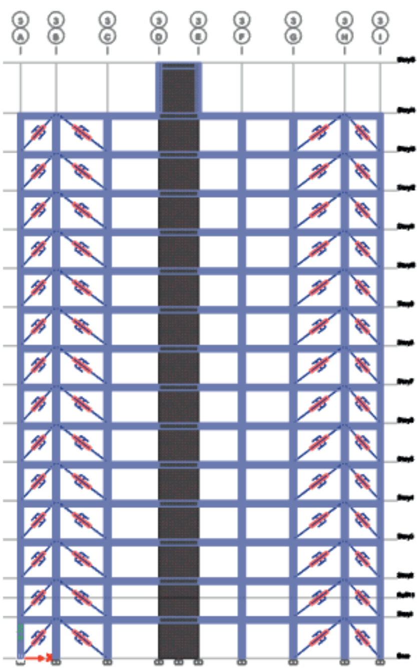

Fig. 7. With Dampers Rear Elevation View

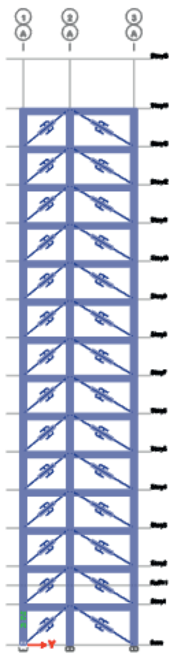

Fig. 8. With Dampers Side View

Results

All the results have been obtained after successfully completing the seismic analysis of the model, once before applying the seismic retrofitting and another after applying the seismic retrofitting. The aim of the project, as mentioned before, was to analyze only the global behaviour without taking into consideration the local behaviour of the model. Therefore, there will not be any analysis regarding the connections between the structural elements, material properties and steel design of the elements. Our goal was to strengthen the building under seismic vibration; hence, the main focus was on the frequencies and the displacements of the structure before and after modifying the structure with a retrofitting method. Improving the frequencies and minimizing the displacements will give rise to a more stable structure.

Table 1: Maximum Storey Displacements at 15th storey

Maximum Storey Displacement (mm)				
Load Case	Original		With Damper	
	Global x	Global y	Global x	Global y
Seismic X	162.66	46.51	70.28	3.02
Seismic Y	11.75	183.63	1.79	73.19

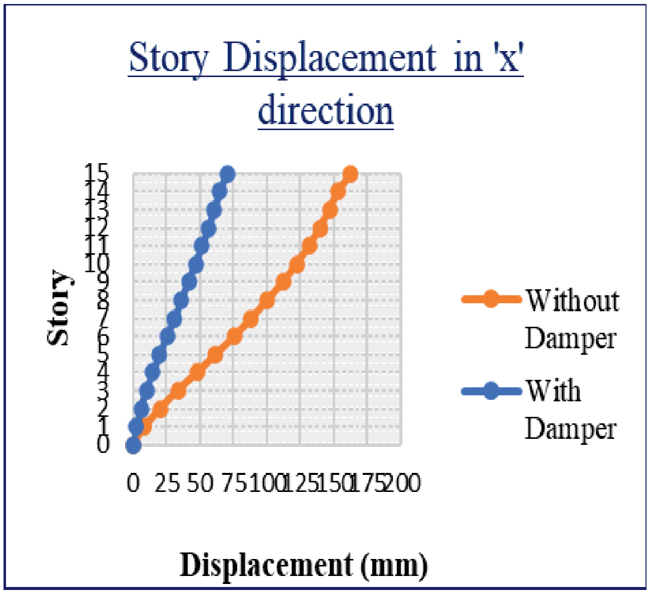

Fig. 9. Storey Displacements of Original and Retrofitted Building

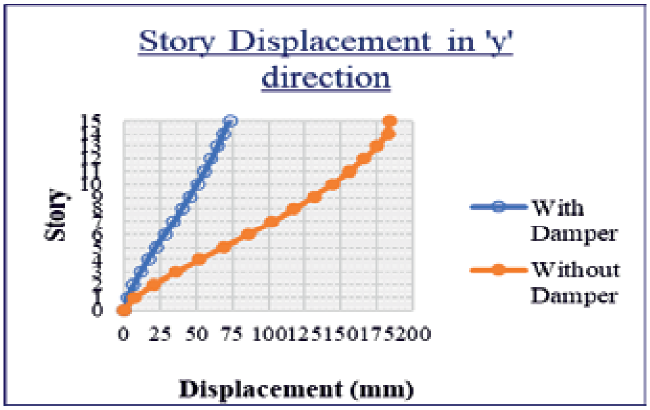

Fig. 10. Storey Displacements of Original and Retrofitted Building

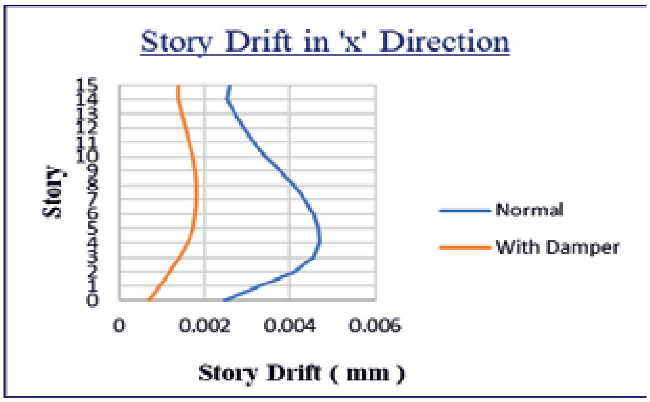

Fig. 11. Storey Drift of Original and Retrofitted Building

Fig. 12. Storey Drift of Original and Retrofitted Building

Table 2: Modal Periods and Frequencies

Modal Periods and Frequencies					
Case	Mode	Period sec Normal	Period sec With Damper	Frequency cyc/sec Normal	Frequency cyc/sec With Damper
Modal	1	1.95	1.065	0.513	0.939
Modal	2	1.742	1.02	0.574	0.98
Modal	3	1.487	0.662	0.672	1.51
Modal	4	0.63	0.3	1.586	3.335
Modal	5	0.486	0.282	2.058	3.548
Modal	6	0.399	0.208	2.507	4.803

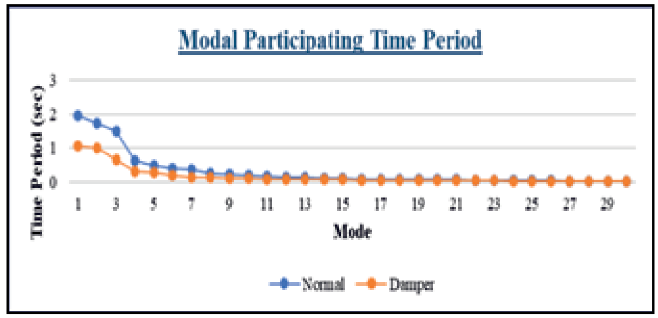

Fig. 13. Modal Periods

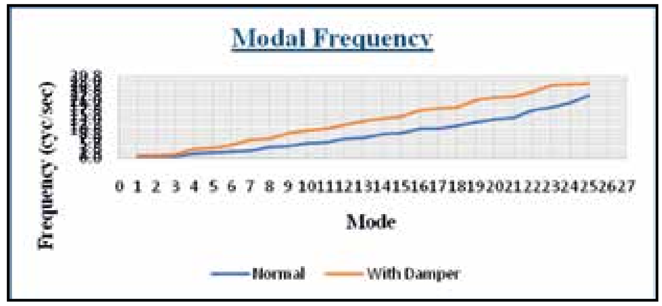

Fig. 14. Modal Frequencies

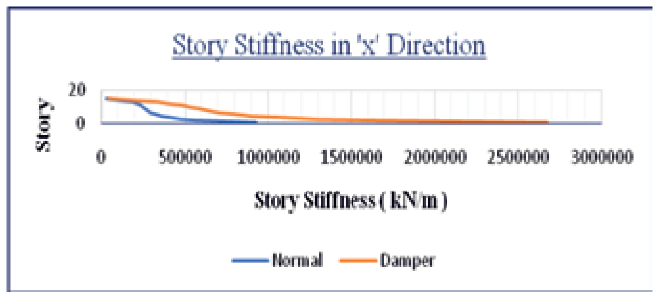

Fig. 15. Storey Stiffness in X Direction

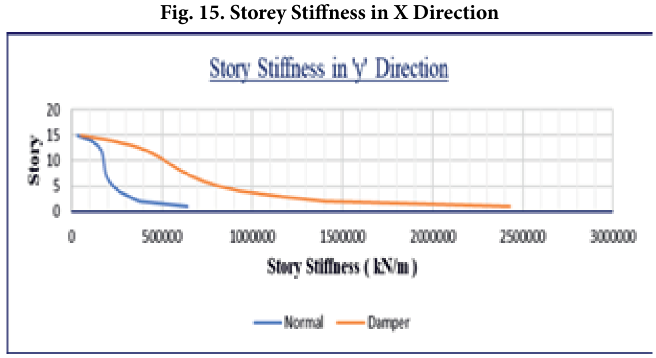

Fig. 16. Storey Stiffness in Y Direction

Table 3 to 6 Critical Column and Beam Forces

Loading Case : Seismic load along X- direction (Seismic X)					
Storey Number	Beam Number	Critical Beam Forces			
		Shear Force (kN)		Moment (kN-m)	
		Normal	Damper	Normal	Damper
1	B31	166.58	54.27	147.2	49.47
	B26	100.53	18.82	101.47	19.22
	B19	100.09	18.53	101.38	18.95
	B34	93	27.42	67.46	22.28
14	B47	90.68	49.44	85.97	46.14
	B32	71.71	40.74	56.29	39.87
	B29	67.54	36.41	50.27	33.39
	B33	64.02	23.92	40	14.31

Loading Case : Seismic load along Y- direction (Seismic Y)					
Storey Number	Beam Number	Critical Beam Forces			
		Shear Force (kN)		Moment (kN-m)	
		Normal	Damper	Normal	Damper
1	B46	107.17	65.8	14.17	75.65
	B47	106.37	63.37	94.34	61.13
	B15	90.25	25.96	82.32	22.36
	B13	78.72	23.89	72.27	22.1
14	B47	279.88	185.31	105.99	68.51
	B47	129.63	71.98	82.6	81.98
	B12	63.26	34.36	51.04	27.87
	B7	60.71	27.2	36.36	12.23

Loading Case : Seismic load along X-direction (Seismic X)											
Storey Number	Column Number	Critical Column Forces									
		Axial Force (kN)		Shear Force V2 (kN)		Shear Force V3 (kN)		Moment M2 (kN-m)		Moment M3 (kN-m)	
		Normal	Damper	Normal	Damper	Normal	Damper	Normal	Damper	Normal	Damper
1	C1	857.1	2296.5	58.03	14.46	62.1	6.95	156.9	14.42	145.87	40.19
	C3	900.01	2940.53	25.96	11.37	56.35	5.89	152.89	11.47	69.51	33.82
	C11	1106.66	353.25	85.17	26.07	5.48	1.62	21.4	5.19	168.77	58.18
	C12	2430.42	735.46	62.23	21.12	39.02	3.35	96.69	7.69	144.64	51.02
14	C1	25.56	1.14	10.74	1.69	16.43	0.4	25.53	1.05	16.49	3.16
	C3	34.56	0.65	21.44	0.43	15.68	2.09	21.13	3.01	26.05	1.49
	C11	202.36	111.07	25.5	34.35	60.94	40.37	82.35	55.34	31.9	35.19
	C12	46.97	21.77	52.9	45.71	5.18	1.86	8.93	4.85	67.33	59.1

Loading Case : Seismic load along Y-direction (Seismic Y)											
Storey Number	Column Number	Critical Column Forces									
		Axial Force (kN)		Shear Force V2 (kN)		Shear Force V3 (kN)		Moment M2 (kN-m)		Moment M3 (kN-m)	
		Normal	Damper	Normal	Damper	Normal	Damper	Normal	Damper	Normal	Damper
1	C1	829.53	2518.87	10.36	1.3	12.73	14.42	65.98	51.31	24.09	2.83
	C3	479.04	2481.15	0.73	1.72	11.23	13.75	64.41	50.83	1.57	3.03
	C11	361.35	1229.48	6.38	2.15	95.21	44.33	248.81	111.9	15.47	3.84
	C12	1040.43	1940.52	10.01	1.83	74.4	31.51	242.01	99.6	19.28	2.58
14	C1	27.76	3.42	1.21	3.4	25.89	0.14	38.83	2.31	1.93	4.36
	C3	22.05	5.27	1.71	4.34	30.92	0.82	46.88	3.38	2.27	5.56
	C11	276.19	273.19	28.63	15.99	124.87	77.98	178.33	110.25	40.94	21.84
	C12	108.35	145.2	12.88	1.28	38.66	17.61	62.59	26.73	15.91	1.96

Conclusion

A general overview of the results showed that a better structural seismic performance of the model after the seismic retrofitting was accomplished and proves that the chosen structural methodology of this modification is a sufficient optimized design for this existing building. More detailed, applying FVD as bracing, improved the structure's characteristics such as --

- Storey Displacement got reduced by almost 60%
- Storey Drift also got reduced
- The Frequency of the structure also got improved
- The Stiffness also got improved
- Column Shear Force and Moment got reduced (design will be governed by the axial force mainly)
- Beam Shear Force and Moment got reduced

The stiffness was mainly enhanced by the added FVD at two sides of staircase along transverse direction, which increased the frequency remarkably. Moreover, the structure became more ductile primarily because of the FVD applied; hence, an improved capability to undergo plastic deformation before fracture is achieved. After performing the seismic retrofitting, the strength of the structure was developed. Since our research is regarding an existing structure, all the existing conditions and properties must be maintained as much as possible the same, such as support types, connections between the structural elements, sizes of each structural element, soil type and so forth. The reason is to adjust to the current situation and achieve more realistic results. In conclusion, we maintained as much as possible all the properties and conditions of the structure; therefore, the obtained results are reasonable and realistic. However, another conclusion is that we should not have enormous expectations on the level of strengthening improvements of the structure against seismic hazards since, the present conditions limit the analysis. This research study provides gaining more knowledge concerning the global strengthening of existing structures under seismic vibrations.

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Application of Coconut Coir Fiber for the Improvement of Soil Subgrade Characteristics

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Abstract

Soil subgrade plays a vital role in the performance and longevity of pavement structures. However, numerous soils exhibit poor engineering properties, necessitating the implementation of stabilization methods. An eco-friendly and cost-effective solution lies in utilizing natural fibers like coconut coir to improve soil subgrade characteristics. This research paper investigates the effects of coconut coir fiber on the compaction and strength properties of poorly graded soil with clay fines. The study involves conducting comprehensive laboratory tests on soil samples mixed with varying percentages of coconut coir fiber (0%, 0.5%, 1.0%, and 1.5%). Geotechnical properties, including optimum moisture content (OMC), maximum dry density (MDD), California bearing ratio (CBR), and shear strength parameters (cohesion and friction angle) by Direct Shear Test, are evaluated. The results demonstrate that the addition of randomly distributed coconut coir fiber significantly increases the CBR values of the soil samples. Moreover, the cohesion and friction angle of the soil-fiber mixture surpasses those of the parent soil, indicating enhanced shear strength. These improvements can be attributed to the interlocking and frictional resistance between the soil particles and coconut coir fibers, leading to improved stability. Furthermore, the utilization of coconut coir fiber reduces the thickness of pavement layers, thereby lowering construction costs and contributing to the overall economic viability of highway projects. The transformation from brittle to ductile behavior observed in the soil-CCF composite is a result of the composite effect induced by the natural fiber.

Introduction

India is a vast country with a large population, and it needs a well-developed road network to support its economy and people. Soil is a cost-effective and easily accessible construction material, but it has poor engineering properties. Researchers have been working to improve the mechanical properties of soil to meet the requirements of engineering projects. One way to improve soil properties is to add fibers. Fibers can improve the strength, stiffness, and durability of soil. They can also help to reduce soil erosion and improve drainage. Coconut coir fiber is a natural fiber that is strong, durable, and biodegradable. It is also locally available and affordable.

This research paper investigates the application of coconut coir fiber to improve the subgrade characteristics of soil. The study found that the addition of coconut coir fiber to soil significantly improved its compaction and strength properties. The CBR values of the soil-CCF mixtures were also significantly higher than those of the unreinforced soil. The addition of coconut coir fiber also resulted in a decrease in the brittleness of the soil. This is because the fibers act as a ductile reinforcement that helps to distribute the stress more evenly throughout the soil. This makes the soil less susceptible to cracking and failure. Overall, the results of this study showed that the use of coconut coir fiber is an effective and economical way to improve the compaction and strength properties of soil subgrade. This can lead to the construction of safer and more durable pavement structures. The use of coconut coir fiber is a sustainable and eco-friendly alternative to conventional methods of soil stabilization. It is a renewable resource that is biodegradable and locally available. The use of coconut coir fiber can help to reduce the environmental impact of road construction. In addition to the mechanical improvements in soil properties, the application of coconut coir fiber in soil stabilization offers other advantages.

Literature Review

Several studies have been conducted to investigate the application of coconut coir fiber for improving soil subgrade characteristics.

Amit Tiwari et al. (2014)[1] focused on analyzing the properties of soil by incorporating various percentages of fly ash, coconut fiber, and crushed glass with black cotton soil. The study aimed to determine the physical properties of soil, such as hygroscopic moisture content, grain size distribution, specific gravity, Atterberg's limits, direct shear test, swelling pressure, proctor compaction test, CBR value test, and permeability test. The results showed the potential of these additives in enhancing soil performance.

R.R. Singh et al. (2014)[2] examined the effect of coir fiber on the soaked and unsoaked CBR values of soil. The study revealed that the CBR values increased with the addition of coir fiber, resulting in higher strength and reduced pavement thickness. The composite effect of the natural fiber altered the soil's behavior from brittle to ductile, contributing to the economy of highway construction.

Das et al. (2016)[3] conducted direct shear tests on unreinforced and reinforced soil with coir fiber. The inclusion of coir fiber resulted in increased shear strength parameters, transforming the soil's failure behavior from brittle to ductile. However, beyond the optimum fiber content of 2.1%, a reduction in internal friction angle and shear strength was observed.

Pooja Upadhyay et al. (2017)[4] investigated the effect of coir fiber on the shear strength of soil through direct shear and unconfined compression tests. The study demonstrated that reinforcing soil with coir fiber led to an increase in cohesion and angle of internal friction. This approach proved to be a promising ground improvement technique, particularly in engineering projects involving weak soils, offering potential cost reductions by acting as an alternative to deep or raft foundations.

Sasikala S et al. (2019)[5] The laboratory experiments showed that incorporating 1.2% CCF with fiber lengths ranging from 2cm to 3cm led to a significant enhancement in soil strength. The reinforced soil exhibited a remarkable increase of 43.2% - 47.4% in strength compared to the unreinforced soil. Additionally, the soaked California Bearing Ratio (CBR) value of the reinforced soil was approximately four times higher than that of the unreinforced soil. These findings highlight the effectiveness of CCF as a reinforcement material for subgrade soil.

These studies collectively highlight the positive impact of coconut coir fiber on soil subgrade characteristics. The addition of coir fiber enhances compaction, strength, and ductility, making it a sustainable and cost-effective solution for soil reinforcement in various engineering applications.

Experimental Program

The soil and coir characteristics were assessed by conducting four tests according to IS 2720: Grain sieve analysis, Standard Proctor test, C.B.R. test, and Direct Shear Test. Different mix proportions were prepared by mixing the soil samples with coir fiber in various percentages of 0%, 0.5%, 1.0%, and 1.5%.

Materials and Methodology

Soil

The soil for this study was collected from the Food Corporation of India Punjab, Chandigarh. Based on the Indian Standard of soil classification (IS 1498:1970), the soil belongs to the Poorly graded sand with clay as fines (SP-SC) category.

Table -1: Properties of Soil

S.No.	Properties of Soil	Laboratory Value
1	Atterberg Limits (%) Liquid Limit Plastic Limit Plasticity Index	27.45 % 17.34 % 10.11 %
2	Indian Standard Classification	SP-SC (Poorly graded sand with clay as fines)
3	Proctor Test Results Maximum Dry Density Optimum Moisture Content	1.887 g/cc 15.25 %
4	California Bearing Ratio, CBR Value (under Soaked Condition)	2.148 %

Coir

The coir utilized in this research was sourced from the market, originating from the fibrous portion of fresh coconuts. To extract the fiber, the husk was subjected to a water-retting process, where the organic matter binding the fiber was decomposed and removed. For experimental purposes, the coir was manually cut into 2cm to 5cm segments, corresponding to the specified percentages of 0%, 0.50%, 1.0%, and 1.5%.

Methodology

Firstly, soil samples are collected from the study area and subjected to index property tests to determine their classification. These tests include grain size sieve analysis, liquid limit, and plastic limit determination, which provide crucial information about the soil's composition and behavior.

Next, coconut coir fiber is prepared and mixed with the soil samples at different percentages. The percentages chosen for this study are 0%, 0.5%, 1%, and 1.5% to assess the varying effects of the fiber content on the soil subgrade characteristics.

Standard Proctor compaction tests are performed on the soil samples with different percentages of coconut coir fiber. These tests involve subjecting the samples to a specified compaction energy to determine their maximum dry density and optimum moisture content. These parameters are essential for evaluating the compaction and workability of the soil-fiber mixtures.

Furthermore, California Bearing Ratio (CBR) tests are conducted on the compacted soil-fiber mixtures at the selected percentages. The CBR values provide insights into the load-bearing capacity and strength of the subgrade.

In addition, direct shear tests are performed on the soil-fiber mixtures at different percentages to determine the shear strength parameters, such as cohesion and friction angle. These parameters are vital for assessing the stability and shear resistance of the improved subgrade.

Based on the obtained compaction and strength parameters, the pavement thickness design is carried out using established engineering principles. The minimum pavement thickness required for adequate support and performance is determined.

Finally, the research findings are analyzed, and conclusions are drawn based on the results obtained from the laboratory testing.

Results and Discussion

Comparison of MDD and OMC between (Soil+CCF) mixes

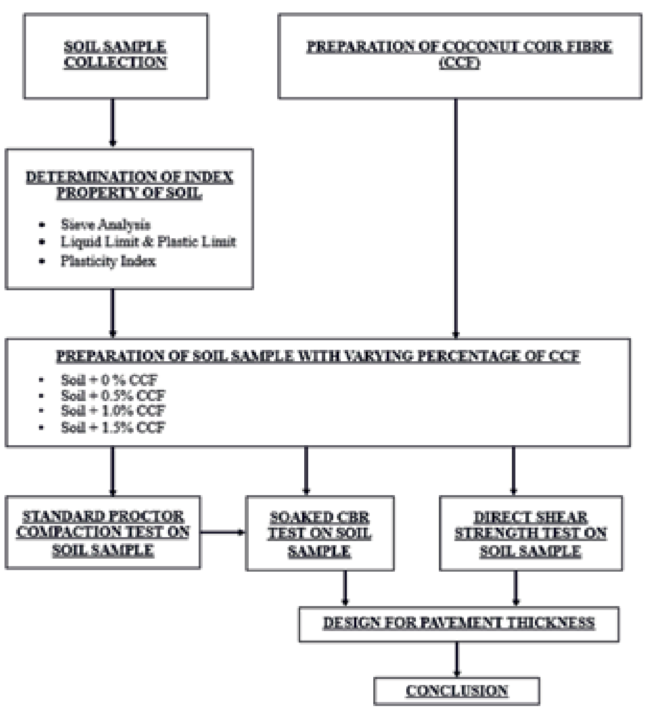

Chart-1: Methodology

Moisture content and Dry density values obtained from the Standard Proctor Compaction Test, conducted on SP-SC soil with varying percentages of CCF are plotted in Figure-1. Table-2 shows OMC and MDD obtained from the Standard Proctor Compaction Test for soil with varying percentages of CCF.

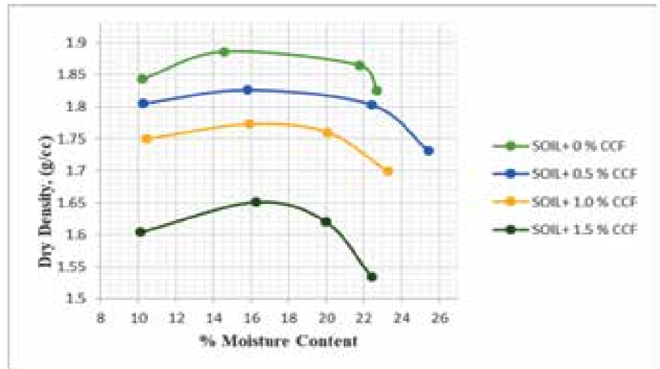

Fig.1: Variation of MDD & OMC with (Soil+CCF) mixes

Table -2: OMC and MDD with varying percentages of CCF

MIX PROPORTION	MDD (g/cc)	OMC (%)
SOIL + 0 % CCF	1.887	15.25
SOIL + 0.5 % CCF	1.826	15.8
SOIL + 1.0 % CCF	1.773	16.5
SOIL + 1.5 % CCF	1.652	16.75

With 0.5% CCF, the MDD decreases to 1.826 g/cc, while the OMC increases slightly to 15.8%. At 1.0% CCF, the MDD further decreases to 1.773 g/cc, while the OMC increases to 16.5%. The lowest MDD value is observed at 1.5% CCF, which is 1.652 g/cc, while the OMC reaches its highest value of 16.75%.

The trend of Maximum Dry Density (MDD) with the percentage of coconut coir fiber is decreasing. As the percentage of coconut coir fiber increases, the fiber occupies space within the soil, displacing some of the soil particles and creating voids. This results in a lower density during compaction, as the soil particles are not able to pack as closely together. The voids introduced by the fiber contribute to a decrease in the Maximum Dry Density (MDD) of the soil.

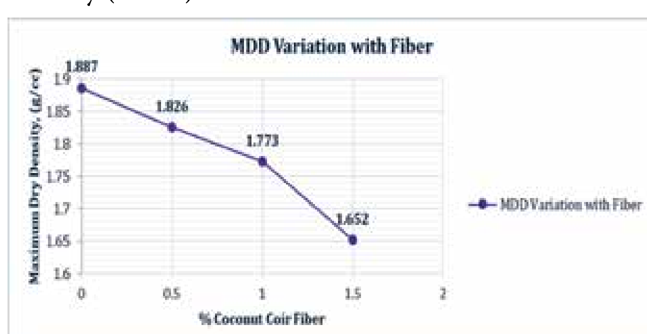

Fig. 2: Variation of MDD with (Soil+CCF) mixes

On the other hand, the trend of Optimum Moisture Content (OMC) with the percentage of coconut coir fiber is increasing. The high water-holding capacity of coconut coir fiber allows it to absorb and retain more water, leading to a higher moisture content needed for optimum compaction.

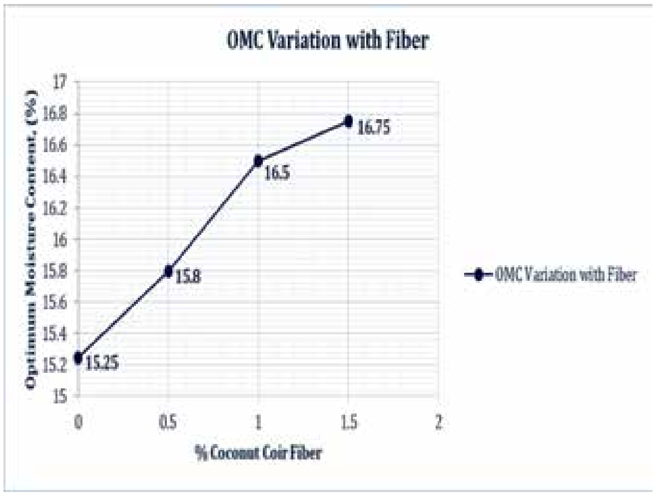

Fig. 3: Variation of OMC with (Soil+CCF) mixes

Comparison of California Bearing Ratio values between (Soil+CCF) mixes

The California Bearing Ratio (CBR) is a measure of the load-bearing capacity of soil relative to that of a well-graded crushed stone. When coconut coir fiber is added to soil, the CBR value of the soil is affected. The CBR value of soil initially increases when coconut coir fibers are added. This is because coconut coir fibers act as a reinforcement and increase the cohesion and internal friction of the soil, which improves the soil's load-bearing capacity. The fibers also reduce the soil's susceptibility to plastic deformation and improve its resistance to shear stresses. However, when the proportion of Coconut Coir Fibers in the soil is increased beyond a certain limit, the CBR value starts to decrease. This is because the fibers tend to form clusters or mats that can act as weak spots within the soil mass, reducing its load-bearing capacity. The increase in fiber content can also lead to a reduction in the compaction of the soil, which further decreases its CBR value.

Table -3: Variation of CBR with (Soil+CCF) mixes

MIX PROPORTION	CBR (%)
SOIL + 0 % CCF	2.148
SOIL + 0.5 % CCF	3.526
SOIL + 1.0 % CCF	6.727
SOIL + 1.5 % CCF	6.525

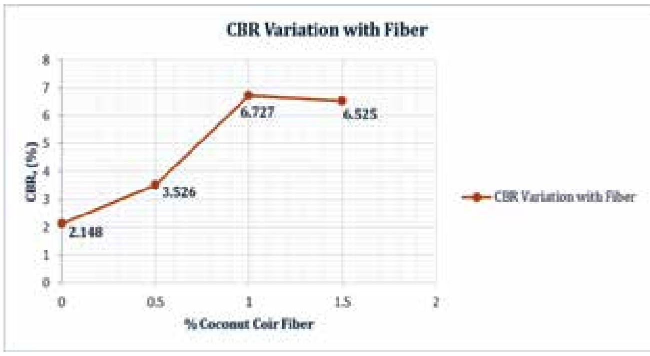

Fig. 4: Variation of CBR with (Soil+CCF) mixes

Comparison of Cohesion (C) and Friction Angle values (Ø) between (Soil+CCF) mixes

The initial measurements of poorly graded soil with clay fines indicate cohesion (C) value of 0.08 Kg/cm2 and a friction angle (Ø) of 15.65°. However, with the addition of coconut coir fiber (CCF) at varying percentages, the values of C and Ø change.

At 0.5% CCF content, the cohesion (C) value increases to 0.10 Kg/cm2, indicating improved internal resistance to shear forces. The friction angle (Ø) increases to 22.2°, indicating enhanced resistance to shear stress. The presence of CCF enhances cohesion and interlocking between soil particles, strengthening the soil and increasing its shear strength.

With 1.0% CCF content, the cohesion (C) value further increases to 0.15 Kg/cm^2, demonstrating continuous improvement in shear resistance. The friction angle (Ø) remains relatively unchanged at 22.42°, suggesting a threshold of fiber content where soil properties stabilize.

At 1.5% CCF content, the cohesion (C) value slightly increases to 0.16 Kg/cm^2, indicating marginal improvement. The friction angle (Ø) increases to 23.60°, highlighting a greater enhancement in shear resistance. Higher fiber content improves interlocking and reinforcement, resulting in increased cohesion and shear strength.

The addition of coconut coir fiber significantly improves the mechanical properties of poorly graded soil with clay fines. Increasing fiber content leads to higher C and Ø values, indicating enhanced cohesion and friction angle. CCF acts as a reinforcing agent, binding soil particles and increasing strength, stability, and resistance to deformation.

These findings demonstrate the potential benefits of incorporating coconut coir fiber in improving the engineering behavior of poorly graded sand with clay fines. It enhances the soil's mechanical properties, making it more suitable for various construction applications.

Table -4: Variation of C and Ø with (Soil+CCF) mixes

CCF Added (%)	Cohesion (Kg/cm²)	Friction Angle (⁰)
0	0.08	15.65
0.5	0.1	22.2
1	0.15	22.42
1.5	0.16	23.6

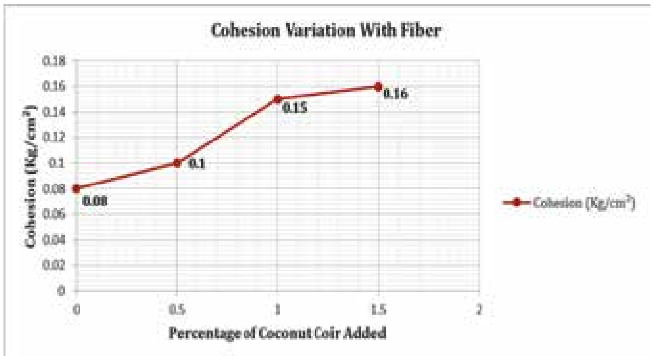

Fig. 5: Variation of Cohesion with (Soil+CCF) mixes

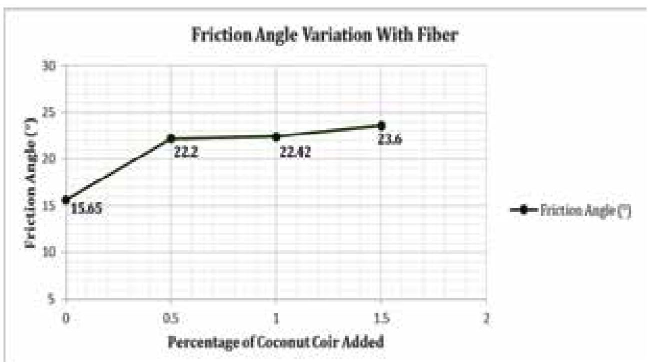

Fig. 6: Variation of Friction Angle with (Soil+CCF) mixes

Design for Pavement Thickness

In order to determine the total thickness of the pavement, the CBR (California Bearing Ratio) design chart recommended by the Indian Road Congress (IRC 37-2001: Guideline for the design of Flexible Pavement) was used. The pavement design catalog was utilized, and the thickness of the pavement was calculated for different CBR values, assuming cumulative traffic of 2 msa (million standard axles).

Table -5: Thickness of Pavement above subgrade (IRC 37-2001)

S. NO.	% OF COIR	SOAKED CBR VALUE	THICKNESS OF FLEXIBLE PAVEMENT (mm)
1	0	2.148	700
2	0.5	3.526	575
3	1.0	6.727	435
4	1.5	6.525	440

In the pavement design catalog, thickness values are typically provided for whole number CBR values. However, when dealing with CBR values that fall between these whole numbers, linear interpolation is used to estimate the corresponding pavement thickness. The soaked CBR value of the sample with 0% coir was 2.148, which required a 700 mm thick pavement. The soaked CBR value increased to 3.526, 6.727, and 6.525 with 0.5%, 1.0%, and 1.5% coir content, respectively. This led to a reduction in the required pavement thickness to 575 mm, 435 mm, and 440 mm, respectively. The soil with 1% coir had the highest CBR value, which resulted in the lowest required pavement thickness of 260 mm. This is the thinnest pavement thickness of all the samples tested. The addition of coir, a waste material, reduced the cost of the pavement.

Conclusion

The project involves conducting various tests on soil samples with different percentages of CCF (0%, 0.5%, 1.0%, and 1.5%) to evaluate their geotechnical properties such as optimum moisture content (OMC), maximum dry density (MDD), California bearing ratio (CBR), and shear strength parameters (cohesion and friction angle).

1. The data shows that adding CCF to the soil increases the OMC, decreases the MDD, increases the CBR, and increases both the cohesion and friction angle of the soil.
2. The increase in OMC indicates that more water is required to achieve the maximum compaction of the soil-CCF mixture. This may be due to the absorption of water by the CCF and the formation of voids between the soil particles and the fibers.
3. The decrease in MDD implies that the soil-CCF mixture becomes less dense and more porous than the parent soil. This may be attributed to the lower specific gravity of CCF compared to the soil and the reduction of interlocking between the soil particles due to the presence of fibers.
4. The increase in CBR suggests that the soil-CCF mixture has a higher resistance to penetration and deformation under load than the parent soil. This may be because of the reinforcement effect of CCF which increases the tensile strength and stiffness of the soil matrix.
5. The increase in cohesion and friction angle implies that the soil-CCF mixture has higher shear strength than the parent soil. This may be due to the interlocking and frictional resistance between the soil particles and the fibers which enhance the stability and bearing capacity of the soil.

6. It can be inferred that a soil composition containing 1% coir fiber demonstrates the highest soaked CBR value, indicating the optimum proportion of materials. Therefore, this proportion can be economically utilized in road pavement and embankment construction, providing an effective and cost-efficient solution.

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IBC News

MOU signed between President, IBC and Shri M.M. Goyal

Shri M. M. Goyal, an eminent railway engineer and a life member of the IBC, has written a number of books, including the following: -

1. Construction Handbook for Civil Engineers and Architects Volume-I, Published in 2012 & 2nd edition in the Kindle version (as an e-book).
2. Construction Handbook for Civil Engineers and Architects Volume-II, (The Essential Source of Modern Construction Technology), published in 2017.
3. Construction Handbook for Civil Engineers and Architects Volume-III (electrical and Voice-Video-Internet Wiring and Equipment), published in 2014

All the above three handbooks have been quite popular with the engineering and architecture fraternity as reference books. The above books provide in one place the best of the current knowledge on the latest building materials, construction practices and equipment.

The said works have so far been published by the Author's own company, M/s Amrindrea Consultancy Private Limited.

Now, in the interest of furthering the knowledge of the fresh engineers and architects joining the profession, the Author has donated to IBC the publishing rights of the hard copies of all the three Construction Handbooks Vol. I, II and III, including the 2nd edition of the Vol. I, purely out of courteous and goodwill gesture of the author. IBC also has agreed to soon publish the hard copy version of these books.

Further, the Author has also donated the royalty from the books to IBC, an institution engaged in advancing the knowledge and professional standards of the building construction industry, provided the authorship of the books will not be altered and it will be acknowledged in all future revisions or reprints of the books.

In furtherance of the above, a Memorandum of Understanding was entered into between Sh. Vijay Singh Verma, President, on behalf of IBC and Sh. MM Goyal on 30.05.2023 at IBC HQ. in the presence of Sh. OP Goel, Founder President and Sh. VR Bansal, Hony. Secretary.

IBC heartily thanks Sh. MM Goyal for this gesture in furthering the cause of engineering profession.

Activities of Local/State Chapters

Kota Local IBC Chapter

इंडियन बिल्डिंगस कांग्रेस कोटा चैप्टर की नई कार्यकारिणी का गठन

इंडियन बिल्डिंगस कांग्रेस के सदस्यों की चतुर्थ वार्षिक बैठक झालावाड़ रोड स्थित इंस्टीट्यूट ऑफ इंजीनियर भवन पर आयोजित हुई। बैठक में सदस्यों ने सर्वसम्मति से कार्यकारिणी का गठन किया।

इस अवसर पर श्री बी.एल.मालव ने कार्यकारिणी की घोषणा करते हुए सार्वजनिक निर्माण विभाग के पूर्व अतिरिक्त मुख्य अभियंता श्री सुरेष कुमार बैरवा को निर्विरोध अध्यक्ष निर्वाचित घोषित किया। इसी तरह उपाध्यक्ष पद पर श्री वी.के. जैन, सचिव; श्री हेमन्त शर्मा, कोषाध्यक्ष; श्री अशोक सनाढ्य एवम श्री ओमप्रकाश जैन, श्री आर.के. सोनी, श्री सुनील गर्ग, श्री अमजद अहमद, श्री भुवनेश मीणा, श्री देवेन्द्र शर्मा, श्री शरद सक्सेना को कार्यकारिणी सदस्य निर्वाचित घोषित किया। बैठक का संचालन पूर्व सचिव श्री आर. पी. शर्मा ने किया। इस मौके पर बैठक में श्री पी.के. जैन, श्री धीरेन्द्र माथुर, श्री बी.डी. माहेश्वरी, श्री राजेन्द्र सिंह, श्री सुरेश हीरानन्दानी, श्री सुरेश मुरडिया, श्री हरीश गर्ग, श्री पीयूष गोयल, श्री मनीष जैन सहित अन्य सदस्य मौजूद रहे। कार्यकारिणी के निर्वाचन की घोषणा होते ही उपस्थित सदस्यों ने सभी पदाधिकारियों का माल्यार्पण कर स्वागत किया और शुभकामनाएं दी।

National News

Prime Minister Inaugurates New Parliament Building

Prime Minister unveiling a plaque to mark the inauguration of New Parliament Building

On 28 May 2023, Hon'ble Prime Minister of India Shri Narendra Modi inaugurated India's new parliament building. The ceremonies began in the morning, with Shri Modi unveiling a plaque dedicating the building to the nation and addressing a gathering of lawmakers. As part of the inauguration, a historically significant gold sceptre called the sengol was installed in the new parliament building.

Rituals being performed by the Prime-Minister for inauguration

The inauguration of the new Indian Parliament was marked with Hindu rituals, the golden sceptre, sengol emerged as a key object encapsulating the meaning of the new Parliament - "to shed not just the remnants of India's colonial past, but also increasingly to replace the secular governance that followed it".

The New Parliament building represents the spirit of self reliant India (Aatmanirbhar Bharat). Replacing the old Parliament building, which has completed almost a century ago in 1927, the new structure is a significant addition to the Central VISTA project in the national capital.

Gold sceptre called the sengol being displayed by the Hon'ble P. M.

The new complex has 888 seats in the Lok Sabha chamber and 384 seats in the Rajya Sabha chamber. Unlike the old parliament building, it does not have a central hall. The Lok Sabha chamber is able to house 1,272 members in case of a joint session. The rest of the building has four floors with offices for ministers and committee rooms. The building has a builtup area of 20,866 square metres (224,600 sq ft) including its open-sky area of 2,000 square metres (22,000 sq ft) for a banyan tree.

Aerial View of New Parliament Building

Inside view of the Loksabha Chamber

Following are main features of the new parliament building which make it a unique building for democracy in modern times.

The Triangular Shape

The new building is triangular in shape, mostly because the plot of land that it is built on is a triangle. According to architect Bimal Patel, the shape is also a nod to the sacred geometry in different religions. Its design and materials are meant to complement the old Parliament, with the two buildings expected to function as one complex.

Built-up area

The new Parliament building has three storeys and a built-up area of 64,500 sqm. The Lok Sabha chamber will have 888 seats, up from the existing 543, with the option of expanded seating up to 1,272. The Lok Sabha will be used for joint sittings of both Houses in the absence of a Central Hall, which was the fulcrum of the old building.

The Entrances

The building has three ceremonial entrances on three sides for the President, the Vice-President, the Lok Sabha Speaker and the Prime Minister. The entrance for the public, including visitors for the Parliament tour, is likely to be on Parliament Street, near the Press Trust of India building, where a temporary reception has been functioning throughout the construction period.

Environment Friendly

Built using green construction techniques, the new building is supposed to reduce electricity consumption by 30 per cent, compared to the old one. Rainwater-harvesting and water-recycling systems have been included. It has been designed to be more space efficient, and meant to function for the next 150 years, according to the Ministry of Housing and Urban Affairs.

Earthquake-safe

As per building codes, since Delhi is in seismic zone-V, the building is primed to be earthquake-safe.

Lok Sabha

The new Lok Sabha chamber has a peacock theme, with designs drawn from the national bird's feathers carved on the walls and ceiling, complemented by teal carpets. The Rajya Sabha chamber has been decorated with the lotus as its theme, with red carpets. In both the Lok Sabha and the Rajya Sabha, two MPs will be able to sit on one bench and each MP will have a touch screen on the desk.

Rajya Sabha

The Rajya Sabha chamber can accommodate 384 Members of Parliament (MPs), as opposed to the existing capacity of 250. The increased capacity of both chambers is meant to cater to any future increase in the number of MPs following delimitation.

Constitution Hall

The new building has a Constitution Hall, where the journey of Indian democracy has been documented.

Facilities for MPs

MPs will have access to a lounge, dining hall and library. The building opens into a central courtyard with a banyan tree.

Office Space

There are six new committee rooms in the new building, as opposed to three in the old building. In addition, there are 92 rooms as offices for the Council of Ministers.

Material from across India

For the interior and exterior of the building, construction materials have been brought in from across the country, including sandstone from Sarmathura in Dholpur and granite from Lakha village in Jaisalmer, Rajasthan. Similarly, the wood used in the decor is from Nagpur and craftsmen from Mumbai have led the wooden architecture design. Bhadohi weavers from Uttar Pradesh have made the traditional hand-knotted carpets for the building.

Gandhi Statue

The 16-foot-tall bronze statue of Mahatma Gandhi, which has been the site of numerous protests and gatherings by MPs and photo-ops for students, will remain on the lawn between the old and new buildings. The statue, which was installed at the main entrance of the Parliament in 1993, was shifted during construction. Made by Padma Bhushan-awardee sculptor Ram V Sutar, the statue now faces the old building, near the entrance used by the Lok Sabha Speaker.

National Symbols

The building is replete with national symbols, including the national emblem — the Lion Capital of Ashoka — that weighs 9,500 kg and is 6.5 metres in height, and is visible from a distance. To support this massive bronze sculpture, a structure of 6,500 kg was constructed on top of the central foyer. At the entrance, the Ashoka chakra and the words 'Satyameva Jayate' have been carved in stone.

The cost of Building

The cost of the new Parliament, however, remains unknown. The initial contract was given for Rs 861.9 crore to Tata Projects, but by the time the project started the cost had gone up to Rs 971 crore.

Golden Sceptre

Sengol is a historical sceptre that is believed to have been used by the Chola Dynasty kings of South India. It is made of gold and encrusted with precious stones. Sengol is being displayed in the new Parliament House, near the Speaker's chair. A golden sceptre, given to Jawaharlal Nehru on the eve of Independence to mark the transfer of power from the British, will sit in the new Lok Sabha chamber, near the Speaker's podium. This sceptre was given to him by priests from Tamil Nadu.

Going Digital

In line with the environment-friendly focus of the new Parliament, all records — House proceedings, questions and other business — are being digitised. Besides, tablets and iPads will become a norm.

Galleries in the Building

A gallery called 'Shilp' will exhibit textile installations from across India, along with pottery items made from the mitti of all Indian states. The gallery 'Sthapatya' will exhibit the iconic monuments of India, including those from the different states and UTs. Besides monuments, it also amalgamates yoga asanas.

Vaastu Shastra

At all the entrances of the building, auspicious animals as guardian statues will be exhibited, based on their importance in Indian culture and vaastu shastra. These include the elephant, the horse, the eagle, the swan, and mythical creatures shardula and makara.

Recognising the Workforce

The contributions of around 60,000 workers — on-site and in various locations across the country — can be seen in the new building. Since the building was constructed during the pandemic, health clinics and vaccination camps were organised for the workers at the site and labour camps.

PM Modi inaugurates Chennai Airport's New Terminal Building

Prime Minister Shri Narendra Modi on April 8, 2023 inaugurated the ₹1,260 crore New Integrated Terminal Building (Phase-1) of the Chennai International Airport, a facility that will boost passenger handling.

Union Minister for Civil Aviation, Jyotiraditya M. Scindia, Tamil Nadu Governor R.N. Ravi and Chief Minister M.K. Stalin among others were also present.

The New Integrated Terminal Building (NITB) is uniquely designed to showcase the rich culture and heritage of the state.

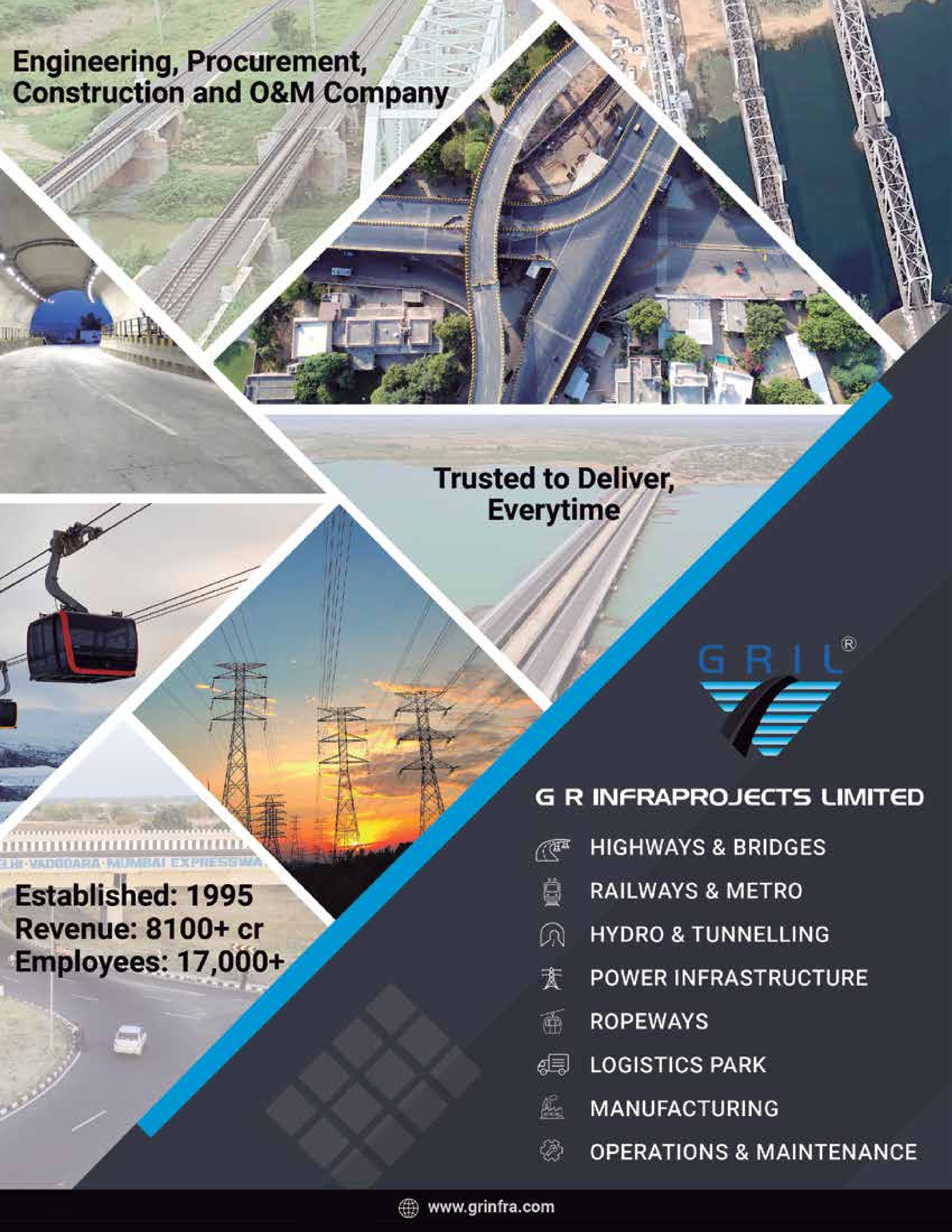
The addition of this new integrated terminal building will increase the passenger serving capacity of the airport from 23 Million Passengers Per Annum (MPPA) to 30 MPPA. The new terminal is a striking reflection of the local Tamil culture, incorporating traditional features such as the Kolam, saree, temples, and other elements that highlight the natural surroundings.

Each and every design integrated into the building is well thought out. The columns are designed to create the visual effect of a palm tree, ceilings are adorned with motif lights, reflecting the Kolam (Rangoli) patterns of South India, and the roof design is derived from Bharatnatyam, the Airports Authority of India (AAI) said.

"The wavy roofing of NITB replicates the pleated costume that fans out attractively during dancer movements of traditional dance form of the state Bharatnatyam," it added.



View of Chennai Airport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Plants Can Generate Electricity

Plants can generate electricity… and we may be able to use it. If, as a child, you were lucky enough to build a clock powered by a potato, you may not be surprised to learn that plants generate electricity. Given the billions of years put into its development, photosynthesis is unsurprisingly much more efficient at generating energy from the sun than solar panels. Plants are nearly 100% efficient at converting photons from sunlight into electrons. New solar panels by comparison are being developed with a 30 to 36% efficiency, according to PV Magazine, which almost doubles the efficiency of current solar panels.

In 2013, the University of Georgia reported on research allowing scientists to tap into electricity created through photosynthesis before it's used by the plant. The procedure basically takes electricity from the plant with nanotubes that are almost 50,000 times smaller than the thickness of a human hair. Thylakoids, the part of a plant where energy from the sun is stored, are disrupted and nanotubes conduct electricity away from the plant. The key is capturing electrons from the plants before the energy is stored as sugar. Once the electricity is siphoned off from the plant, the electricity can be used for any human application that electricity is usually used for. It's been suggested that genetic engineering could be used in tandem with the technology to create plants specifically designed for electricity generation. The idea of creating usable electricity from plants only continues to grow.

Researchers from the University of Washington have conducted similar work on plants to generate electricity. There, electrical engineers designed a circuit that when attached to plants converts the plant's natural energy into usable electricity. When attached to maple trees, the circuits were able to create 1.1 volts, less than a typical 1.5 volt battery such as the normal AA cell.

There are companies like Plant-e already poised to capitalize on plant electricity generation. Plant-e explains that not all of the energy a plant creates is used for itself. Many plants actually improve soil content through the creation of 'excess' organic material that is secreted into soil and taken up by bacteria. The idea behind the 'Plant Microbial Fuel Cell' technology (P-MFC) is to collect and use electrons created by the breakdown of this organic material by soil bacteria for the generation of electricity.

So far, this type of electricity generation has only produced exceedingly small amounts of electricity. However, the technique has some obvious advantages.

Plants Creates Electricity

Unlike with the use of nanotubes and some other techniques, the plant itself isn't disturbed. As with all schemes to use plants to generate electricity, the distribution of plants is more even globally than say fossil fuels. The method is also clean when compared to fossil fuels.

Land used for agriculture could also be used to produce electricity. The method typically requires use of plants that grow in waterlogged conditions, which would work with crops such as rice or cranberries but is also a limitation, especially in arid environments. Research and development are needed if the use of plants to generate electricity is to become practical in any real sense.

Another company, Voltree Power, holds the patent to this technology and was first to develop a tree-powered circuit. Voltree has tested using trees to power low voltage sensors to detect forest fires. Unfortunately, the sensors still require traditional batteries. The trees merely extend the battery life of the sensors, making the system less than impressive.

IstitutoItaliano di Tecnologia (ITT) in Pisa, Italy reported on new research to use plants for the generation of electricity. Researchers found that they can generate more than 150 volts of electricity from a single plant. The electricity generated is enough to power 100 of the highly efficient LED light bulbs. The researchers created a sort of cyborg tree made of natural and artificial leaves which generate electricity from wind. The research was headed by Barbara Mazzolai who previously created the world's first 'robot plant' in 2012.

Structures in plant leaves are able to generate electricity from the leaf simply moving in the wind. This electricity is then transmitted through plant tissue. This new research aims to plug into the plant tissue and use this electricity, rather than electricity generated through photosynthesis as previous methods attempted.

Researchers used a nerium oleander tree in an experiment, by adding artificial leaves that touch the trees natural leaves. The research was published in October 2018, ushering in a new way to potentially generate electricity from plants.

There are still real obstacles to overcome before electricity can be widely generated by plants and it seems doubtful whether all our electrical usage could be supplied from plants, at least at current levels. It's also unclear which method of electricity generation using plants will rise to the top as the most practical. Another problem less often looked at by scientists is one of ethics.

The ethical dilemma of genetically modifying organisms is one that is sometimes raised. Still widespread use of GMO technology in plants has gone forward without much of a broad public discussion. GMO crops are commonly grown now. According to the Center for Food Safety, currently 92% of US corn is genetically modified as is 94% of soybeans and 94% of cotton. The technology has vastly outpaced our ability to discuss its consequences rationally as a society or create laws to regulate it.

Whether using GMO technology or simply marrying electrical technology with natural plants, using plants to generate electricity represents engineering the natural. The act of using a plant to generate electricity is an act of modifying the life of intrinsic organism for our own purposes. It means changing another life without regard to that life's ability or inability to give consent. This may seem trivial to some, as plants are not highly regarded. We still don't have any idea of the consequences involved in modifying a plant in this way. We once had no idea of the consequences of burning fossil fuels to generate electricity. We're clever at using the environment for short term gain but not so good at guessing at the long term consequences of our actions. With many simple but demanding solutions, humans have a knack for creating complex ways to solve our problems. Scientists also can't ask a plant how it feels about being made part of an electrical generator.

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Vishwas Swaroopam in Nathdwara, Rajasthan – World's Tallest Shiva Statue

In Rajasthan's Nathdwara, the tallest statue of Lord Shiva in the entire world was unveiled on October 29, 2022. The statue, which is referred to as 'Viswas Swaroopam,' means 'Statue of Belief,' is 369 feet high and is located in Nathdwara on a hillock called Ganesh Tekri and depicts all the characteristics, feelings, and expressions of Lord Shiva. Located around 45 kilometres from Udaipur, the statue possesses amenities including stairs and elevators. Additionally, it contains a VIP lounge, visitor's room, administration office, and meditation room.

View of Nathdwara Shiva Statue

The statue has been constructed by Sant Kripa Sanatan as a part of dream project of Shri Madan Paliwal, the Chairman of Miraj Group, to boost up religious tourism in the state, which is a crucial part of Rajasthan tourism sector. The Nathdwara Shiva statue, which took 10 years to complete and was built on a hill of 51 bighas, is a big part of Madan Paliwal's visionary proposal for the Miraj Group in Udaipur as per the reports.

The interior of the statue contains an exhibition hall as well as public viewing galleries accessible by elevator at 20 feet (6.1m), 110 feet (34m), and 270 feet (82m). The installation includes a statue of Nandi, Shiva's bull measuring 25 feet (7.6m) tall and 37 feet (11m) long. The 16-acre ground also include a parking facility, three herbal gardens, a food court, a laser fountain, and an area for handicraft shops, viewing platforms, musical fountains, souvenir shops and a pond. There is a mini-train on site for quick local sightseeing.

Interesting Facts about Nathdwara Shiva Statue

- The new Shiva Statue at Nathdwara, Rajasthan has a height of 369 feet along with two large water tanks built above the head of the statue.
- Previously, it was decided to be a height of 251 feet but after drafting the idea of planting the Ganges stream on Shiva's head, the total height of World's tallest Shiva statue became 369 feet.
- The statue can be seen from a distance of 20 kilometres.
- The sculptor of the Lord Shiva statue is Shri Naresh Kumar, who is from Pilani.
- The foundation of the statue was laid by Sant Morari Bapu, 10 years ago in 2012.
- Along with the statue, arrangements for Jalabhishek have also been made above by planting two large water tanks. One tank will be used to draw 'Gangaajal' and the other is made for emergency purposes.
- On the right side of the statue in Rajsamand, there is a statue of Nandi, which is 25 feet high and 37 feet wide.
- One of the amazing facts about the statue is that it can stand like this for 250 years and can withstand thunderstorms and hailstorms up to the speed of 250 kmph.
- A sum of Rs. 300 crores has been spent in preparing this tallest Shiva statue in the world.
- 30,000 tonnes of Panchdhatu or metal have been used in the making of this statue.
- According to reports, 2600 tonnes of steel, 2601 tonnes of iron, 26618 cubic metres of cement concrete have been used to make the statue.
- The base of the statue has a dimension of 30×25 metres.
- The statue is decorated with laser lights which will be reflected in the night sky.

The Delhi Mumbai Expressway - India's Premier Engineering Marvel

Delhi and Mumbai in just 12 hours. One of the India's dream Infrastructure projects, the Delhi-Mumbai expressway, will soon be a reality allowing vehicles to maintain a tremor-free top speed of 120km/h on roads built from German technology that are expected to last atleast 50 years. The express way will be operational this year. It will be the country's first animal over pass and stretchable highway. The 8 lane expressway which can be stretched to 12 lanes if needed, is spread over a distance of 1350km. It will halve the commute time between Delhi and Mumbai from nearly 24 hours to 12 hours and shorten the distance by 130km. The premiere expressway will link Haryana, Rajasthan, Gujarat, Madhya Pradesh and Maharashtra connecting important cities like Gurugram, Mewat, Ranthambore, Kota, Ratlam, Vadodara, Surat and many more. No toll will be charged to enter the Delhi-Mumbai expressway. The toll will be applicable as per the distance travelled and deducted at the time of exit. Toll charge on Delhi-Mumbai expressway will cost only 65 paise per kilometer. With regard to the expressway's share in the states and the expenditure - 1800 crore will be spent for 9 km in Delhi,10400 crores will be spent for 160 km in Haryana, 16600 crores for 374 km in Rajasthan, 11100 crores for 245 km in Madhya Pradesh, 35100 crores for 423 kilometres in Gujarat and 23000 crores will be spent for 171 kilometres in Maharashtra. CCTVs have been installed after every 500 metres on the highway. Rest areas will be constructed at 93 locations along the sides of the highway after every 50 km. Trauma centres will be set up at every 100 km where people injured in accidents or those needing emergency medical services will be treated. This will be Asia's first highway with a green overpass for wildlife between Bundi and Sawai Madhopur. Five green overpasses are in the making in almost every 3 and a half kilometers. These overpasses will have no adverse impact on the animal habitats of Ranthambore National Park, Bundi-Ramgarh tiger reserve and Kota-Mukundra Hills Tiger reserve. Creating an industrial corridor on both sides of the Delhi-Mumbai expressway also remains in the pipeline. It is fascinating to witness the incredible work done by the Central Govt. to revolutioni33ze India's highway infrastructure on which very soon people will be able to travel.

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Eco-friendly Home, Earns Rs.70,000 from Surplus Energy

Manju Nath and wife Geeta with their eco-friendly home in Bengaluru

In the year 2007, Shri Manju Nath built in eco-friendly house at Bengaluru using stones and bricks. His wife defined the intentions.

It is the house executed with the concept of cross ventilation at different levels and has no air conditioners. The large openings of the house also allow for plenty of natural light, thus cutting down on artificial light usage.

Due to the use of bricks and cross ventilation, the temperature inside the house is always 2 to 3 degrees lower than the temperature outside. Due to passive cooling techniques, the temperature inside rarely crosses 28^0C.

Shri Manju Nath also installed 10 kilowatt solar panels on the roof a couple of years ago by availing the various beneficial schemes of the Government.

10 kilowatt solar installation generates around 1000 units of solar power every month. The owner consume around 250 units. The surplus power is sold to the electricity board@ Rs.9 per unit, as per the solar scheme which earns Rs.70,000 to the owner of house from surplus power, and this contract is valid for 25 years. The installation cost was Rs.9,00,000.

The house is also harvesting rainwater. The house sits on a sloping terrain so the garden is designed in a way that pushes all the water towards a particular site where the water percolates underground through a pit. The sand and gravel help filter the water which is then transported to the borewell. This way, the groundwater tables remain charged and the borewell is full.

The capacity of rainwater harvesting structure is around 4,50,000 litres per year, of which 2,00,000 litres is consumed by the house owner. The rest recharges the groundwater tables.

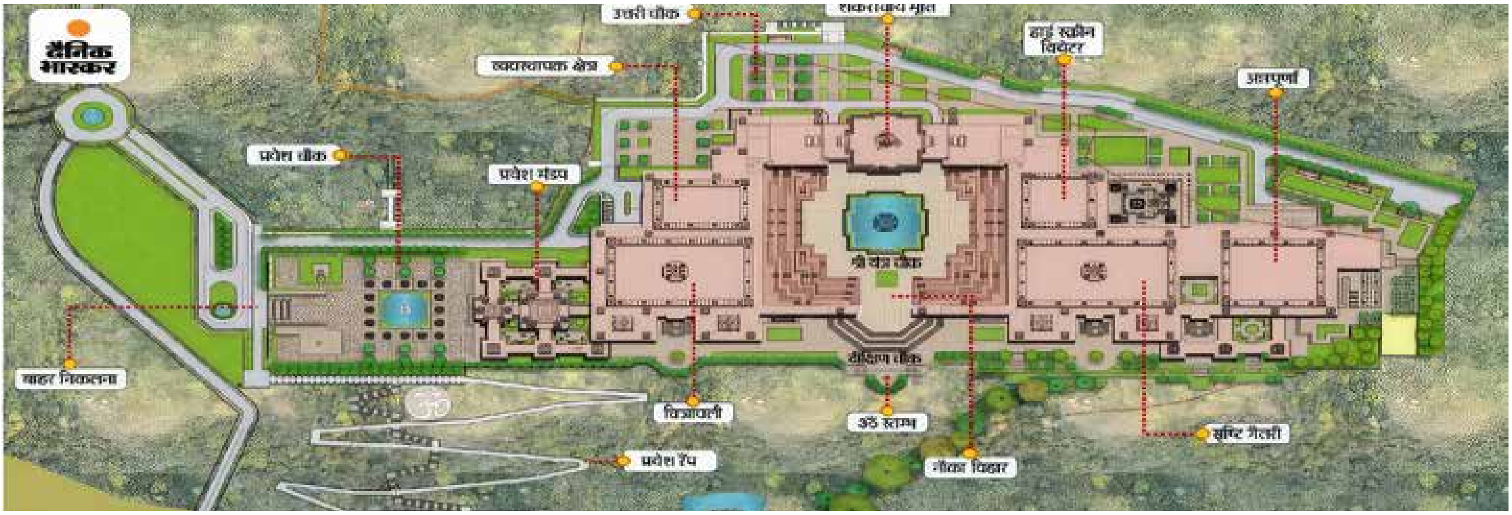
The high concentration of underground water improves the fertility of the soil, which in turn aids the growth of vegetable and fruit-bearing trees, vegetables, brinjal, carrots, chillies and fruit trees like pomegranate, papaya and guava have been planted in the house compound. The food is grown organically from compost made from household and garden waste.

Two-drum system to deposit the waste, each with a capacity of 40 kilos has been installed in the compound to generate the organic manure. Every month approximately one quintal of nutrient-rich compost is generated.

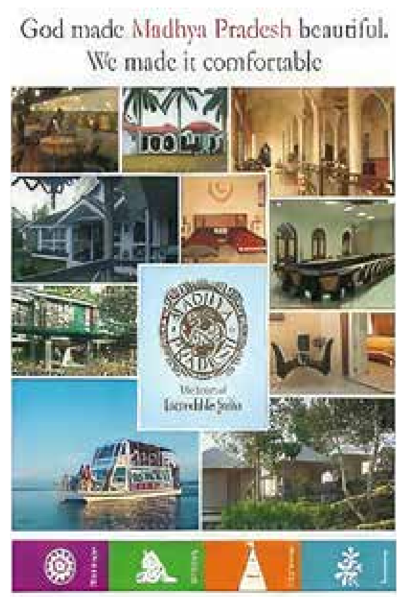
Having adopted all possible eco-friendly practices in an urban setting, Manju and Geeta now enjoy a healthier lifestyle — one with fresh air and water and healthy food.

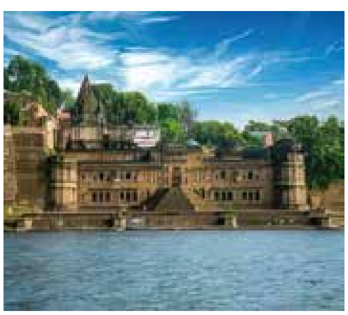
WITH BEST COMPLIMENTS













Madhya Pradesh State Tourism Development Corporation Ltd.

IBC welcomes the following New Individual Members during 04/03/2023 to 21/05/2023

S.No.	M. No.	Name	Qualification	Designation	Department	City	State
1	Ml-9614	Shri Mihir Panwar	B.tech. (Civil)	Assistant Manager	Rajendra Singh Bhamboo Infra Pvt. Ltd.	Jaipur	Rajasthan
2	Ml-9615	Shri Surendra Laxman Topale	B.e. (Civil), M.e. Strct.	Superintending Engineer	Maharashtra Pwd	Navi Mumbai	Maharashtra
3	Ml-9616	Shri Anurag Shukla	B.tech.(Civil Engg.)	Deputy General Manager	Nbcc (India) Ltd.	Bahraich	Uttar Pradesh
4	Ml-9617	Shri Mohd. Nizamuddin Hashmi	B.e. (Civil)	Assistant Manager	Mp Rrda (Pmgsy)		Madhya Pradesh
5	Ml-9618	Shri Khushel Abrol	Gradute, P.g. Diploma	Bdm	M/S R.r. Construction	New Delhi	Delhi
6	Ml-9619	Shri Tarun Magendra	M.tech. (Strct.)	Director	Magendra Construction & Consultants	Raipur	Chhattisgarh
7	Ml-9620	Shri Jinesh Kashiwal	B.tech. (Civil)	Proprietor	Sanjeev Kashiwal & Associates	Bhilai	Chhattisgarh
8	Ml-9621	Shri Yash Goyal	B.tech.(Civil)	Proprietor	M/S Yash Goyal	Bilaspur	Chhattisgarh
9	Ml-9622	Shri Shashank Tamrakar	Diploma In Civil Engg.	Propprietor	V. Shashank & Associates	Durg	Chhattisgarh
10	Ml-9623	Ms. Nisha Netam	Ph.d	Assistant Professor	Nit Raipur	Raipur	Chhattisgarh
11	Ml-9624	Shri Ravi Kumar	B.tech.	Executive Engineer	Border Roads Organisation		Bihar
12	Ml-9625	Shri Sahadeva Singh	B.e. (Civil) Iitr, M.tech (Wr) Iitd	Former Director (Projects & Planning)	Gujarat Metro Rail Corpn. Ltd.	Gandhinagar	Gujarat
13	Ml-9626	Shri Debang. Y. Joshi	Diploma In Civil Engg.	Proprietor	Bhadrashilp Consultant	Rajkot	Gujarat
14	Ml-9627	Shri Abhyuday Titiksh	Ph.d, M.tech (Strct. Engg.)	Project Manager	Principle Securities & Allied Services	Nagpur	Maharashtra
15	Ml-9628	Ms. Anita Vaidya Kathuria	B.tech.(Civil)	Superintending Engineer	Hp Pwd	Mandi	Himachal Pradesh
16	Ml-9629	Shri Shubhankar Debbarma	M.tech.(Civil Engg.)	Assistant Professor		West Tripura	Tripura
17	Ml-9630	Brig. Deveshwara Nand Bhatt	Be (Civil), Me (Strct Engg), Mba (Finance)	Dy Md (Technical)	Army Welfare Housing Organisation	New Delhi	Delhi
18	Om-9631	Shri Bithnath Pattnaik	M.tech (Water Resources)	Managing Partner	Rg Civil Consultants	Bhawanipatna	Odisha

19	Ml-9632	Shri Shitiz Goyal	B.tech.	Partner	Svk Infrastructures	Delhi	Delhi
20	Ml-9633	Shri Vivek Sharma	B.tech. (Civil), M.e (Strct.)	Executive Engineer	Hp Pwd	Mandi	Himachal Pradesh
21	Ml-9634	Shri Nirav Ashokbhai Prajapati	M.tech. (Constn.)	Civil Engineer	Adcmpul	Anand	Gujarat
22	Ml-9635	Shri Abhishek Girishkumar Shah	B.arch, M.plan (Urp)	Architect, Urban Planner	Consulting Architect & Urban Planner	Ahmedabad	Gujarat
23	Ml-9636	Shri Yogesh Sharma	B.e. (Civil), Pgd (Ip)	Consultant Engineer	Utkarsh Associates	Raipur	Chhattisgarh
24	Ml-9637	Shri Aviral Agrawal	B.tech. (Civil Engg.)	Civil Engineer	Aviral Agrawal Design & Construction	Raipur	Chhattisgarh
25	Ml-9638	Shri Ankush Sahu	M.tech, Ll.b	Proprietor	Ankush Sahu & Associates	Raipur	Chhattisgarh
26	Ml-9639	Shri Damodar Prasad Agrawal	Amie Civil Engg.	Executive Engineer	Rajasthan Pwd	Kota	Rajasthan
27	Ml-9640	Shri Avvaru Suri Nageswara Rao	Diploma In Civil	Approved Valuer & Licensed Engineer	Avvaru Elevations	Guntur	Andhra Pradesh
28	Ml-9641	Shri Mukesh Dnyaneshwar Pawar	B.e. (Civil)	Proprietor	Omkar International Corporation		Maharashtra
29	Ml-9642	Shri Ashok Kumar Patni	B.tech.	Managing Director	M/S Cand I Calibrations Pvt. Ltd.	Kota	Rajasthan
30	Ml-9643	Shri Kamalesh Kumar Jangid	Diploma In Civil Engg.	Junior Engineer	Rajasthan Pwd	Sikar	Rajasthan
31	Ml-9644	Shri Abhishek Roy	B.tech. (Civil Engg.)	Technical Assistant (Civil)	Panchayat & Rural Development Deptt.		West Bengal
32	Ml-9645	Ms. Madhavi N. Sukanya	B.tech.	Chief Engineer (R&B) Bldg. Deptt.	A.p. Transport Roads & Buildings Department	Vijayawada	Andhra Pradesh
33	Ml-9646	Shri Sai Kiran Kolluru	Post Graduate In Advanced Construction Mngt.	Manager (Planning)	K. Raheja Corp.	Mumbai	Maharashtra
34	Ml-9647	Shri Abdul Aziz Lone	B.e. (Civil)	Assistant Executive Engineer	Pwd	Srinagar	J & K
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From Editor-in-Chief Desk

Coordination between administrative authority and Implementation agency for Building Projects

Building projects belong to administrative authorities and these are implemented by agencies like PWDs. In order to ensure that project is implemented in proper manner, it is necessary that there is effective coordination between the agencies, right from the beginning, till project is fully implemented and handed over. Different stages at which coordination is required are brought out here:

The administrative authority should give request for implementation of the project in comprehensive manner bringing out requirement of area for various activities and administrative authorities. In-turn, in the first stage a preliminary plan is to be evolved by implementation agency. Broad specifications can be given, to ensure that administrative authority can take the decision that plans as brought out are according to requirements. At this stage, plans can be discussed and modifications, if any, are incorporated. Modified-plans along with broad specifications can be fialised and approved by administrative authority. On the basis of these plans, the preliminary estimate should be prepared by implementation agency. Besides, sub-soil investigation should be simultaneously done, to find the details of substrata so that the preliminary concept of foundation can be decided.

On the basis of approved plans, and sub-soil investigation report, the preliminary estimate should be prepared by the implementation agency and submitted to administrative authority. In turn they can study details of preliminary estimate and accord the administrative approval and expenditure sanction. Simultaneously necessary budget provisions are also required. Once administrative approval and expenditure sanction are given, the implementation agency has to go for preparation of detailed estimate and issue notice inviting tenders. At this stage project work is divided into different packages for tendering purpose. After receipt of tenders, the work is awarded and implementation of the project starts. At the stage of implementation, difficulties are faced and at times it is difficult to implement the project. Some of the difficulties faced are brought-out here which delays projects:-

(i) Representatives of administrative authority start interfering in approval of specifications and materials. Sometimes higher level executives expect that routine decisions are taken with their consent. It becomes difficult to implement the project. Therefore, such initiative should not be accepted and workable solution found. Generally, if junior level officer of Administrative Authority are involved such difficulties will not be faced.

(ii) At times, new officers join as administrative authority on transfer. They can create difficulties in implementation of project, by demanding such variations which are beyond the scope of approved estimate. Their proposal should be critically examined and, if found suitable then revised administrative approval should be asked.

(iii) At times, administrative authority demand that some portion of project be completed early so that, these portions could be occupied. It becomes difficult to do so, contractually. But, in the interest of administrative authority, efforts are necessary to accommodate such demands. Sometimes it becomes contractually difficult but solutions are to be found.

Thus, for proper implementation of projects coordinated working is necessary between Administrative Authority and Implementation Agency. In a way the implementation agency has to accommodate and find solution.

(K.B. Rajoria)

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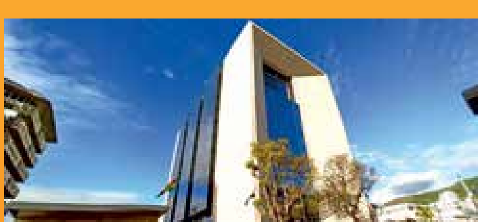
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