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Shri Dinesh Waghmare, CMD, MSETCL, and Shri A.K. Rajput, Member (PS), CEA, addressing the participants during inaugural session of National Tutorial on 'Smart Grid Standards – Requirements and Technologies', 18 - 19 January 2023, New Delhi

CENTRAL BOARD OF IRRIGATION & POWER
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NEW OFFICE BEARER OF CENTRAL BOARD OF IRRIGATION & POWER

Shri Kushvinder Vohra

CBIP congratulates Shri Kushvinder Vohra on being elevated as Chairman, Central Water Commission (CWC), and welcomes him as Senior Vice President of the Board

Chairman, Central Water Commission & Ex-officio Secretary to Government of India being welcomed by Shri A.K. Dinkar, Secretary, Shri K.K. Singh, Director (WR), and Shri Sanjeev Singh, Director (Energy), CBIP on assuming charge of Sr. Vice President of CBIP

Mr. Kushvinder Vohra, an officer of Central Water Engineering Service, is presently working as a Chairman in Central Water Commission & Ex-officio Secretary to Govt. of India and is also Chairman, Upper Yamuna River Board. He graduated in Bachelor of Engineering from Thapar Institute of Engineering and Technology, Patiala, Punjab, India. He also holds a degree in LLB (Law) from the University of Delhi, India and a Master's degree in Public Administration from IGNOU, India.

He has over 35 years of experience in the Water Resources Sector. He has worked extensively in matters related to Water Resources Development and Management, Basin Planning, Planning & Appraisal of Water Resources Projects, formulation and implementation of schemes such as Pradhan Mantri Krishi Sinchayee Yojana, Inter-State Water issues, International Water Treaties, Inter-State River Water Disputes, Water Tribunal, Human Resources Management among others.

He has made extensive contributions to various journals including International Journals on the issues related to water resources development and management. He has appeared in various talk shows on issues related to water resources on TV/Radio. He has been awarded *"Water Digest Award 2018-19"* for *"Best Infrastructure Pioneer Project"* and *"Aqua Foundation Excellence Award 2019"* for works in *"Sustainable Development in Food and Agriculture (2019)."* He has also been awarded the *"Eminent Water Resources Engineer Award – 2019"* by the India Water Resources Society (IWRS) for his contribution in*"Development of Water Sector in India." He has chaired and is currently chairing various committees on policy/technical issues related to water resources.*

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FROM EDITOR'S DESK

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FROM EDITOR'S DESK

Dear all,

Greetings from CBIP

Reservoirs are constructed for the conservation and utilization of water resources for deriving various benefits like flood moderation, irrigation, hydropower generation, municipal & industrial supply. With the limited supply and high demand for water, the operation of the reservoir becomes complex. A very good article on Integrated Reservoir Operating Systems included in this issue, which gives us the standard operating procedures for reservoir operation. Another article, on morphometric analysis of natural landscapes, which outlines the diverse physical features of watersheds and their spatial disparities in drainage, is very interesting.

Characterization of sediment type plays a vital role in many fields including marine geological surveying, marine engineering construction, and seabed mineral resources development. An interesting article on Satellite remote sensing techniques that can be used for this purpose is also been included in this issue of W&E International Journal.

United States Geological Survey (USGS) estimates that around 5 lakh earthquakes hit the Earth every year, 1 lakh can be felt, and very few cause damage. Moreover, in Indian Subcontinent, particularly the north-eastern and north-western regions are the most earthquake-prone region of the world. 1988 Bihar earthquake, 1991 Uttarkashi earthquake, 1993 Killari earthquake, 1997 Jabalpur earthquake, 1999 Chamoli earthquake, 2001 Bhuj earthquake, 2002 Andaman earthquake, 2004 Sumatra earthquake, 2005 Kashmir earthquake, 2011 Sikkim earthquake are some of the worst hit earthquakes, which cumulatively have caused over 1 lakh death toll.

The seismic zonation map clearly shows that India is highly vulnerable to earthquake hazards. During the last 100 years, India has witnessed more than 650 earthquakes of magnitude ≥ 5.0. In addition to the very active northern and north-eastern range, the recent events of 1993 Killari (Maharashtra) and Jabalpur (Madhya Pradesh) in Peninsular India have started raising doubts as the disasters caused by these earthquakes are alarmingly increasing. Earthquake events reported from the Himalayan mountain range, Andaman and Nicobar Islands, Indo-Gangetic plain as well as the peninsular region of India belong to the subduction category and a few events had also been under the intra-plate category.

A study on 'Local issues & mitigation measures for Hydro Projects in Himalayas-NHPC's initiative towards seismic safety & landslide assessment' elaborate, the importance of the careful selection of seismic design parameters for the design of structures like dam and its components, for building a safe performing structure is included in the current issue of the journal.

Besides this, a few important articles/case studies, first is on 'Use of condenser type bushing for LV side of transformer' which describes that RIP/RIS bushing with a composite insulator to eliminate all risks of catastrophic failure of the transformer during bushing failure; second case study on protection of energy system elements caused by excessive local heating which recommend the use a thermal fuse in sockets designed for the current of 16 A and in hard located places with excessive consumer properties further to increase the safety of operation of electrical networks.

Another useful case study is on the THDC describing the details of challenges faced & mitigation thereof during land acquisition and R&R of Vishnugad Pipalkoti Hydro Electric project is also been included in this journal.

The journal also covers a variety of useful information about Water Resources, Power, RE & allied sectors. It is expected that the readers will find this issue of the journal quite informative & useful. We take this opportunity to request all the professionals' in these sectors to contribute technical papers/articles news etc. which would be of interest for publishing in the subsequent issues of the journal.

We also request the comments /suggestions of the readers so as to improve the utility of the journal.

A.K. Dinkar
Secretary, CBIP

New initiative taken up in Central Water Commission, DoWR, RD & GR, Ministry of Jal Shakti

Integrated Reservoir Operation System for Ganga Basin

KUSHVINDER VOHRA[1] **RISHI SRIVASTAVA**[2] **SANDEEP BISHT**[3]

In the previous publication (September, 2022) of New initiative taken up in Central Water Commission (CWC), *Extended Hydrological Prediction (EHP)-Sub-Seasonal Forecast for Water Resources Planning & Management* was presented. In the current edition of the new initiative taken up in Central Water Commission, **Development of Decision Support System for near real time Integrated Reservoir Operation System for Ganga Basin** has been described.

Prudent operation of reservoirs is crucial in the context of rising demands in competing sectors like irrigation, domestic, industrial as well as due to uncertainties of extreme events (floods and droughts), particularly, due to climate change. Operation of reservoirs is a complex process, especially in case of multi-purpose reservoirs, where joint use of storage for meeting conservational and flood moderation needs meeting of competing and conflicting objectives. In case integrated operation of reservoirs in a basin is attempted to maximize benefits and minimize adverse impacts, the procedure becomes still all the more complex. With the advent of computers and application of system engineering techniques for solving water resources management problems, it is now possible to evaluate the consequences of an operation decision well in advance through computer based simulation of reservoir operation for both planning purpose as well as real time operation. To cater to the above mentioned issues and to assist integrated reservoir operations, CWC has taken up the initiative of development of Decision Support System (DSS) for Integrated Reservoir Operation System (IRO) of Ganga basin under National Hydrology Project (NHP).

ABSTRACT

The conventional methods of operation of reservoirs are based on empirical methods and often the managers of the reservoir system rely on their experience and judgement in taking correct operational decisions. These conventional methods are often not adequate for establishing prudent operation decisions, especially when integrated operation of multipurpose multi-reservoirs is contemplated. Now, with the application of system engineering techniques to solve water resource problems, it is possible to evaluate the consequences of an operating decision well in advance by simulation of the river system and reservoir operation on real time basis. The Integrated Reservoir Operation System (IRO) project aims for development of Integrated Operation Rule curves, Operational Manual and Standard Operation Procedure for integrated reservoir systems for flood moderation considering various flood hydrographs and conservational benefits in Ganga basin, using simulation approach. The objective of the consultancy is to equip CWC and stakeholders with a decision support platform with online interactive dynamic display.

Keywords *: Reservoir, decision, data, naturalization, rule curves.*

1. BACKGROUND

A number of reservoirs have been planned and constructed in India for conservation and utilization of the water resources for deriving various benefits including flood moderation. In the initial stages of development, the projects were generally planned to serve single purpose such as irrigation, hydropower generation, and flood control, municipal and industrial supply etc. However, in the past few decades, the country has witnessed immense urbanization and industrialization. These economic developments, coupled with increase in population have resulted in perceivable increase in demand for water. The ever increasing demands for sufficient quantity and quality of water distributed in time and space, have resulted in contemplation and implementation of

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even more comprehensive, complex, multi-purpose, and ambitious plans for water resources systems. The operation of reservoir (s) in the wake of conflicting nature of conservation demands and flood moderation becomes very complex. In many reservoirs, a delicate balance is always needed, whether to keep the reservoir empty for absorbing the incoming flood or fill it as soon as possible, to cater to the demands in leaner months. What if the reservoir does not fill up later? What if the forecasted flood does not come? Such apprehensions, in the mind of reservoir manager or the project authorities, make the reservoir operation quite tricky in shorter time span/during floods. In the event of very high inflow into the reservoir, last moment decision for a release beyond the current safe carrying capacity of downstream channel to obviate threats to safety of the reservoir itself may create large inundation which is undesirable.

To cater to the above issues and to assist integrated reservoir operations, CWC has taken up the initiative of development of DSS for IRO of Ganga basin under NHP. This DSS will enable the project authorities to take data based rational decisions on reservoir operations in an integrated manner keeping in view the upstream, downstream and reservoir conditions at present as well as forecasted conditions.

Integrated operation of reservoirs is envisaged to be a part of 'Crisis Management Plan (CMP) on Flood Forecasting, Dam Failures, Incidents consequent to Extreme Natural Events and Integrated Reservoir Operation (IRO) for Flood Management as well as fulfilling the conservational needs'. For the purpose of flood management, there will be a Flood crisis management team (FCMT) for each system of reservoirs. To start with, the role of FCMT in IRO for flood management will be advisory only. The reservoirs being multipurpose, both flood and conservational aspects need to be kept in mind for operational rules. The emphasis is on the consultant providing tools that offer much more than mere simulation capabilities to address all those issues simultaneously.

Due to different characteristics of various reservoirs in different States and each reservoir being operated by specific Project Authority, different needs and approaches which co-basin States might follow in the development of river basin management plans, the integrated reservoir operations shall be according to the needs and approaches prioritized within the specific reservoir system and by the concerned authorities and stakeholders through FCMT.

2. OBJECTIVE AND SCOPE

The consultancy work for development of DSS for IRO of Ganga basin under NHP has been awarded by CWC to M/s Tracetebel in joint venture with Kirsters Germany AG and project work started on 01.10.2021.

The Consultancy is divided into three phases as shown in Table 1.

Table 1 : Summary of IRO project phases

Phase	Activity
1	Development Phase (18 months)
2	Testing Phase (18 months)
3	Maintenance Phase (24 months)
Duration of the consultancy: 60 months (01st October 2021 to 30th Sept 2026)	

2.1 Ganga Basin Profile

The Ganga basin outspreads in India, Tibet (China), Nepal and Bangladesh. The major part of the geographical area of the Ganga basin lies in India and it is the biggest river basin in the country draining an area of 8,38,803 sq.km (GIS based), which is slightly more than one-fourth (26.3 %) of the total geographical area of the country. In India, it covers states of Uttar Pradesh, Madhya Pradesh, Rajasthan, Bihar, West Bengal, Uttarakhand, Jharkhand, Haryana, Chhattisgarh, Himachal Pradesh, and Delhi. The basin is bounded by the Himalayas on the north, by the Aravalli on the west, by the Vindhyas and Chottanagpur plateau on the south and by the Brahmaputra ridge on the east. The Great Desert of Rajasthan and the Aravalli hills form the ridge between the Indus and Ganga drainage system. The delta of the greater Ganga basin is one of the largest in the world and is known by the name Sundarbans after the Sundari trees.

3. METHODOLOGY

The methodology consists of following broad steps:

(a) The Ganga basin is divided into five major systems of reservoirs as given in Table 2. The details of reservoirs are given in Table 3.

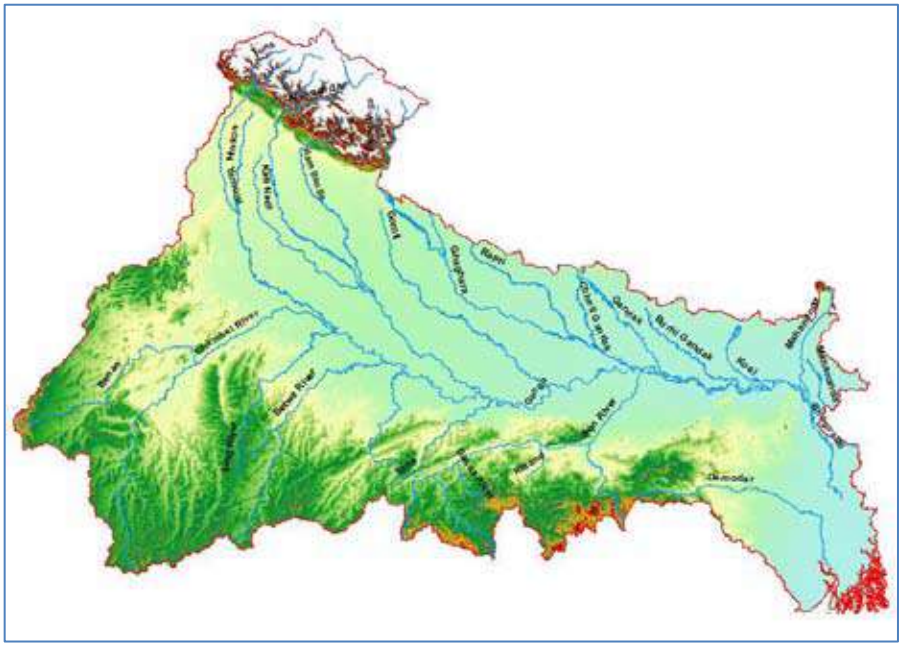

Fig. 1 : Ganga basin

Table 2 : Summary of Reservoir systems for IRO project

Sl No.	River Basin	Total No. of Reservoirs/Dams/Barrages	Total No. of Integrated Reservoir Systems
1	Ganga	11	5

Table 3 : Details of Reservoir systems for IRO project

Systems of Reservoirs for Integrated Operation through Flood Crisis Management Team (FCMT) for Flood Moderation in Ganga Basin						
		Name of Reservoirs	Details of FCMT			
			Name	Chairman	Member Secretary	Members
Ganga	System 1	Tehri Dam Kalagarh Dam	Upper Ganga & Ramganga	CE,UGBO, CWC, Lucknow	SE (HOC), CWC, Dehradun	Representatives of Govt of Uttarakhand, THDC, Uttrakhand Jal Vidyut Nigam Ltd. UP Irrigation Dept.
	System 2	Gandhisagar Rana Pratap Sagar Kota Barrage Bisalpur Dam	Chambal	CE (YBO), CWC, New Delhi	SE (HOC), CWC, Ghaziabad	Representatives of Govt of Madhya Pradesh & Rajasthan (including Electricity Board)
	System 3	Rajghat Matatila	Ken Betwa	CE (YBO), CWC, New Delhi	SE (HOC), CWC, Ghaziabad	Representatives of Govt of Madhya Pradesh, Uttar Pradesh, Betwa Board
	System 4	Bansagar Dam Rihand Dam Indrapuri Barrage	Sone	CE,LGBO, CWC, Patna	SE (HOC), CWC, Varanasi	Representatives of Govt of Madhya Pradesh, Chhattisgarh, Bihar and Bansagar Control Board
	System 5	Whole Ganga	Ganga	Chairman, GFCC, Patna	CE(LGBO), CWC, Patna	Representatives of Ganga Basin States, Chairman of System 1- 4.

Note : In addition to the above 11 reservoirs, 4 reservoirs i.e. Jawahar Sagar (Raj.- Chambal river), Madikheda (MP- Sindh river), Massanjore (WB - Mayurakshi river) and Kangsabatti (WB- Kangsabati river) have been added in the study after State Govt's recommendation.

(b) Firstly, the Rule Levels of individual reservoirs shall be developed using long term inflow series on ten-daily timestep (30-35 years) and taking into account the demands to be met, the salient features of the reservoirs, and constraints, if any.

(c) The individual reservoir shall then be tested for operation during floods.

(d) Thereafter, the Rule Levels shall be tweaked, if needed, by considering the single reservoir as part of the system of reservoirs. For this, the multiple inflow series shall be used and water demand of the system shall be imposed, with relative priorities of different demands.

(e) The system, then, shall be tested against the floods.

(f) Having done this, all such systems shall be taken into account and the basin, as a whole, shall be modelled.

(g) The vulnerable areas shall be studied to minimize the adverse impacts particularly in the downstream of individual reservoir; each system of reservoirs; and at the end of all systems.

(h) The Decision Support System and Web-based Dashboard shall be accordingly developed to help the decision making process in real time.

(i) Operation under different scenarios of Climate Change shall also be studied.

4. PHASE-WISE DETAILS OF THE IRO PROJECT

The project involves three phases as described below:

4.1 Phase 1 : Development Period

The different activities during this phase are described as follows:

4.1.1 *Compilation, Collection & Processing of Required Data*

This activity includes compilation of the

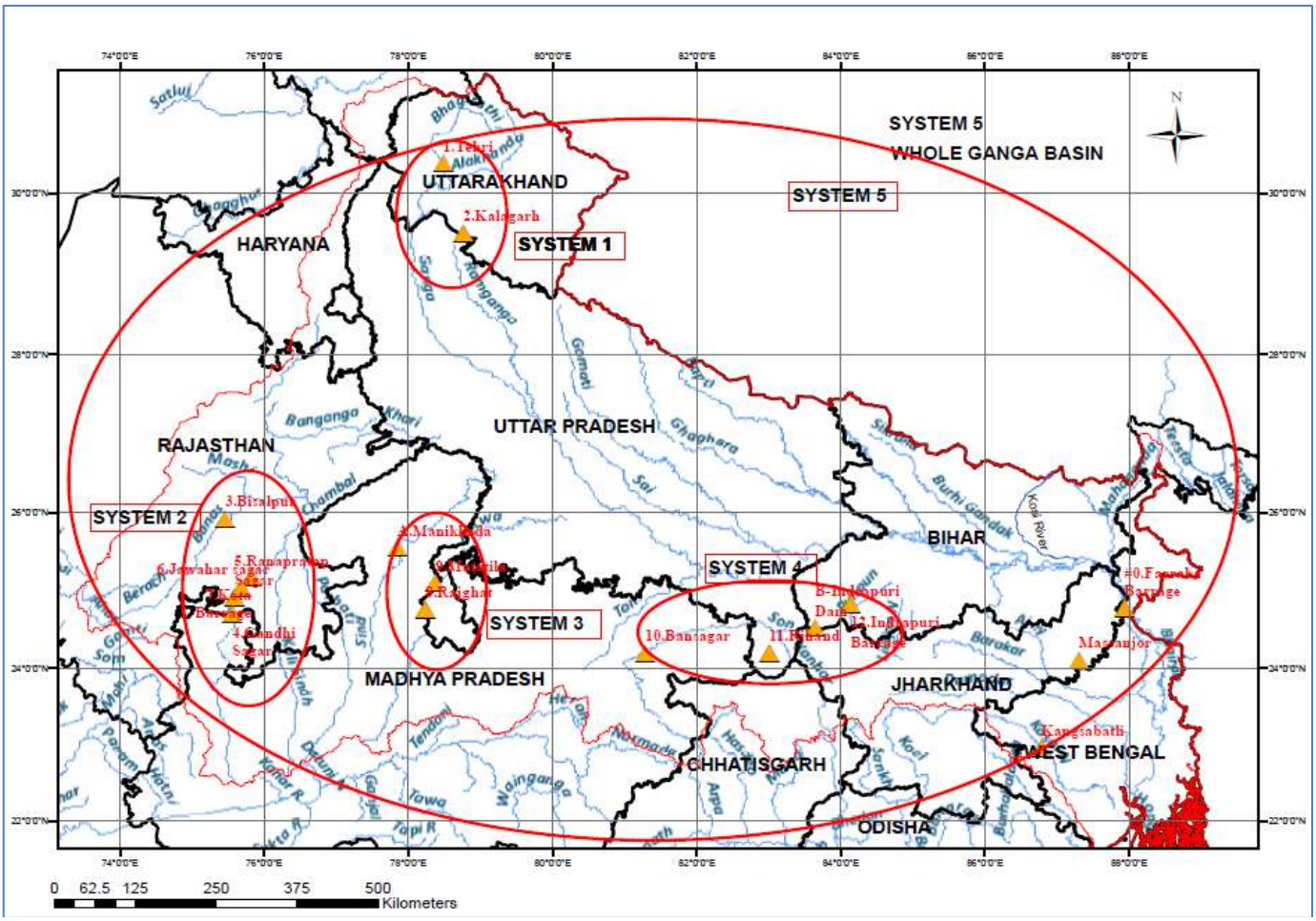

Fig. 2 : Reservoir Systems for IRO

salient features, consumptive demands, non-consumptive demands, evaporation, seepage, etc. of each reservoir for maximum available data series in a proper format with respect to the model requirement and rule curve derivation for flood management. Consumptive demands include demand for irrigation, domestic, livestock, industrial, etc. while non-consumptive demands include hydropower generation, navigation, and environmental flows etc. The losses comprise of seepage, evaporation etc. This activity has been completed.

4.1.2 *Development and Verification of Historic Natural Flows*

In this activity, historic natural (deregulated) flows at several locations in the river basin based on available data have been estimated. Critical locations in the basin represent locations of major reservoirs and diversion structures, which may or may not coincide with the locations of hydrometric stations. Historic natural (deregulated) flows have been estimated on the basis of recorded storage levels, estimated net evaporation on the reservoir, and recorded reservoir outflows. For the period before the reservoirs were built, natural flows may be assessed using recorded flows at hydrometric stations adjusted by the estimates of upstream water use from existing reservoirs upstream. Flow naturalization report has been submitted by the Consultant.

4.1.3 *Development of Integrated Operation Rule Curves, Operational Manual and Standard Operation Procedure*

This involves the setup of model and development of selected modelling scenarios for near real time reservoir operation and production of technical documents. Model is to be set up such that it can easily allow evaluation of various operational scenarios.

The activities include development of detailed Integrated Reservoir Operations Manual & Standard Operating Procedure for 5 integrated systems of reservoirs of Ganga basin for flood moderation keeping in view conservational benefits. In addition to the operating manual, the DSS should be able to derive the best reservoir operation for the current inflows and reservoir levels, taking into account numerous operational options in a system with multiple reservoirs, since user manuals cannot cover all possible options.

Development, optimization and customization of modelling tools, DSS for near real time integrated operation of reservoir systems for flood management keeping in view conservational benefits will be developed under the following two scenarios:

- Scenario 1: With the consideration of present format of input data system;
- Scenario 2: With the consideration of future format of input data system

The present data for demand is available in cumecs only and is to be used in scenario 1, however, in future the system should be able to take input and perform direct calculations of demand from crop area, type of crop and ET requirements, etc. Further, for floods, if extended forecast and/or other downstream condition data are available, the system should be able to consider the same.

4.1.4 *Development of Web-based Dashboard*

The activities include creation of generic web-based dashboard with plug-in facility of different input & output of different modelling software and mobile application development (user friendly public interface for display of results under various developmental strategies/ scenarios) in the form of web services/ web tools and its linkage with existing/ envisaged portals such as WIMS and WRIS, etc.

4.1.5 *Training, Capacity Building and Dissemination to Stakeholders*

The main aim under this activity is capacity building of officials of CWC and other concerned project authorities by their involvement in the development of the tasks (learning by doing), and with the aim of fostering the cooperation between these agencies in sharing data, knowledge and procedures. Training programmes are aimed at imparting required basic and advanced knowledge of the theoretical concepts, analysis and processing of data, preparation of data bases, working on the software/ models used for the study, trouble shooting, dashboard etc. This also involves specified number of workshops at suitable intervals for dissemination to stakeholders.

4.2 Phase 2 : Testing Phase

During the testing phase the main activities will be as follows:

(i) Testing of model including entire application during two flood seasons.

(ii) Collection of additional data generated during the period and preparation of input for the model including data validation and its cleaning.

(iii) Model run in near real time scenario.

(iv) Comparison of actual and model results.

(v) Modifications in the modelling parameters if required based on the test.

4.3 Phases 3 : Maintenance Phase

This phase includes annual maintenance for 2 years after the completion of testing phase. This includes maintenance and updation of the model as well as incorporation of more input data, more information about future water resource plans, more scenarios, modifications required to meet advancement in hardware, software and network, etc. By incorporating more input data, more information about future water resource plans, a few more scenarios, as may be perceived.

5. BENEFITS EXPECTED

Water which was once considered as abundant and inexhaustible has now become a rare resource and its availability to meet the ever increasing demands is becoming a challenging task. There is an urgent need for conservation of the available water resources and their optimal and effective management using scientific approach. Water resource development projects are mostly operated and managed considering them as single entity, instead of attempting integrated operation for deriving maximum benefits and operating decisions are taken based on empirical methods, experience and judgement. Such operation procedures have their own inherent disadvantages and often result in suboptimal utilisation of water. The real time operation technique could be gainfully applied to various reservoirs system. The technique is not a mean for making decisions; rather it is a mean for helping in making a decision. It is not a mathematical or mechanical substitute for the good judgement, wisdom, experience, and leadership of the official/operator, however, it has the potential of significantly improving water resources planning and management in context of increased complexities with multi-reservoir systems.

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Disclamer

The views expressed are of the authors only and not necessarily of the organization they belong to.

Morphometric Analysis of Natural Landscapes of Northern Maharashtra using Geomatics Techniques, Western Ghats, India

DR. A.D. PRASAD[1], NEELRATAN SINGH[2], PADMA GANASALA[3] AND SHUBHENDU SHEKHAR[4]

ABSTRACT

In recent years, geomatics practices have arisen as a potential means for morphometric analysis of earth landscapes. The preparation of a morphometric knowledge base is very important for the decision support system of water resource management. Morphometric constraints are vital for effective natural resource management, soil and water preservation, watersheds, and river network evaluation. These methods offer close real-time and precise evidence linked to diverse geological formations, landforms, and assistances in drainage channel identification, which is transformed by natural forces and from time to time by human actions. Due to increasing anthropogenic activities and land cover, the water regime of the regions is significantly affected particularly base flow and groundwater recharge. There are few studies on morphometric analysis of Western Ghats. However, their analysis extent is not covering the current study portions of the Northern Western Ghats area. The morphometric characteristics emphasizing ecological significance of the study region must still distinguished to comprehend the sustainable development of the natural environment, anthropogenic ecologies. Thus, an effort is made to outline the diverse physical features of the watersheds and their spatial disparities in drainage and morphometric parameters existed are considered to assess hydrogeological and geographical features and recognize the association between them in the region using geomatics techniques. The streams that pose dendritic to a sub-dendritic pattern are of 1st to 4th order. The Drainage density seems to vary from 0.98 to 1.16 km/km^2, which shows the drainage possesses a coarse to moderate drainage texture. The study tells that the central sub-basins of the region is having high, the southern part of the region is having moderate and the northern part of the region is having low hydroelectric potential. Henceforth, geomatics techniques are powerful tools for drainage delineation, knowledgebase preparation, and water resources management of the regions.

Keywords *: Western Ghats, Morphometric Analysis, Natural Landscapes, Geomatics Techniques, Northern Maharashtra*

1. INTRODUCTION

The morphometric analysis can be efficiently used to measure the shape, configuration of the earth's surface, and dimensions of landforms (Agarwal 1998; Obi Reddy et al. 2002; Acharjee, et al. 2021; Shekhar et al. 2021; Gaur, et al. 2021). Quantitative depiction of the drainage system is a significant feature of the categorization of watersheds (Strahler 1964) and this can be obtained by morphometric analysis of the watersheds. Also, geomatics tools can investigate the drainage morphometry of large areas. Numerous studies have been reported on the investigation of morphometry of various places in India using geomatics techniques. For instance, Rudraiah et al. (2009) conducted a morphometric study using Geographic Information Systems (GIS) software in sub-basins of Kagan basin. Similarly, the morphometry analysis of Gurdaspur district sub-watersheds in Punjab state was examined by Chopra et al. (2005). Furthermore, the drainage patterns in the Uttar Pradesh state Naugarh area and Varanasi region were studied using spatial data by Agarwal, (1998).

Western Ghats section is the main catchment of several east and west flowing rivers of India (Bhat et al. 2001). There are several states are located in the Western Ghats region namely Kerala, Karnataka, Tamil Nadu, and Maharashtra. The people living in rural areas of Maharashtra are mainly dependent upon the watersheds of Western Ghats. Therefore, the morphometric analysis of the Western Ghats regions of Maharashtra is vital to observe the changes in watershed services like sediment transport and stream flow. The morphometric studies on the Western Ghats in Maharashtra are scanty and the region was studied by Herlekar and Sukhtankar 2011; Zende et al. 2013 and Samal et al. 2014.

There are few studies on morphometric analysis of Western Ghats. However, their analysis extent is not covering the current study portions of the Northern Western Ghats area. The morphometric characteristics emphasizing ecological significance of the study region must still distinguished to comprehend the

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sustainable development of the natural environment, anthropogenic ecologies. Thus, an effort is made to outline the diverse physical features of the watersheds and their spatial disparities in drainage and morphometric parameters existed are considered to assess hydrogeological and geographical features and recognize the association between them in the region using geomatics techniques.

2. STUDY AREA

The Western Ghats region of Maharashtra state, India was selected as a study area. This region is located between latitude 17° – 19° North of the equator and longitude 73° – 74° East of the Greenwich meridian and covers 16490 km^2 with elevations varying from 1 to 1435 m (Fig. 1). The region has a tropical monsoon climate with well-defined seasons such as summer, winter, monsoon, and spring. It is reported that the yearly precipitation in the region varies from 881 mm to 1,395 mm and major rainfall (around 85%) is reported from July to September. When spatial variables are measured, the annual rainfall is reported to be 600 mm to 3000 mm, the temperature is ranging between Min. 15-20 and Max. 39-43 °C. Humidity was measured in the range of Min. 12-31 to Max.82-87 %.

3. METHODS

3.1 Analytical Techniques

The methodology is illustrated in Fig. 2. The ASTER technique (Advanced Spaceborne Thermal Emission and Reflection Radiometer) was used to develop the study area's Digital Elevation Model (DEM). For processing and knowledge base preparation, 30 m resolution DEM is used as input. The study area is about 16490 km^2 and is divided into 12 sub-basins which range from 503 to 2641 km^2. A drainage network map was generated using spatial analyst tools of ArcGIS software. Basins with their IDs and stream orders are depicted in Fig. 3. Further, the stream statistics of the basins are presented in Table 2A & 2B. Morphometric parameters were computed in Microsoft office Excel using different formulae presented in Table 1. The measurement of slope contribution and areal, linear, and relief aspects of basin was performed by using Nag and Chakraborty (2003).

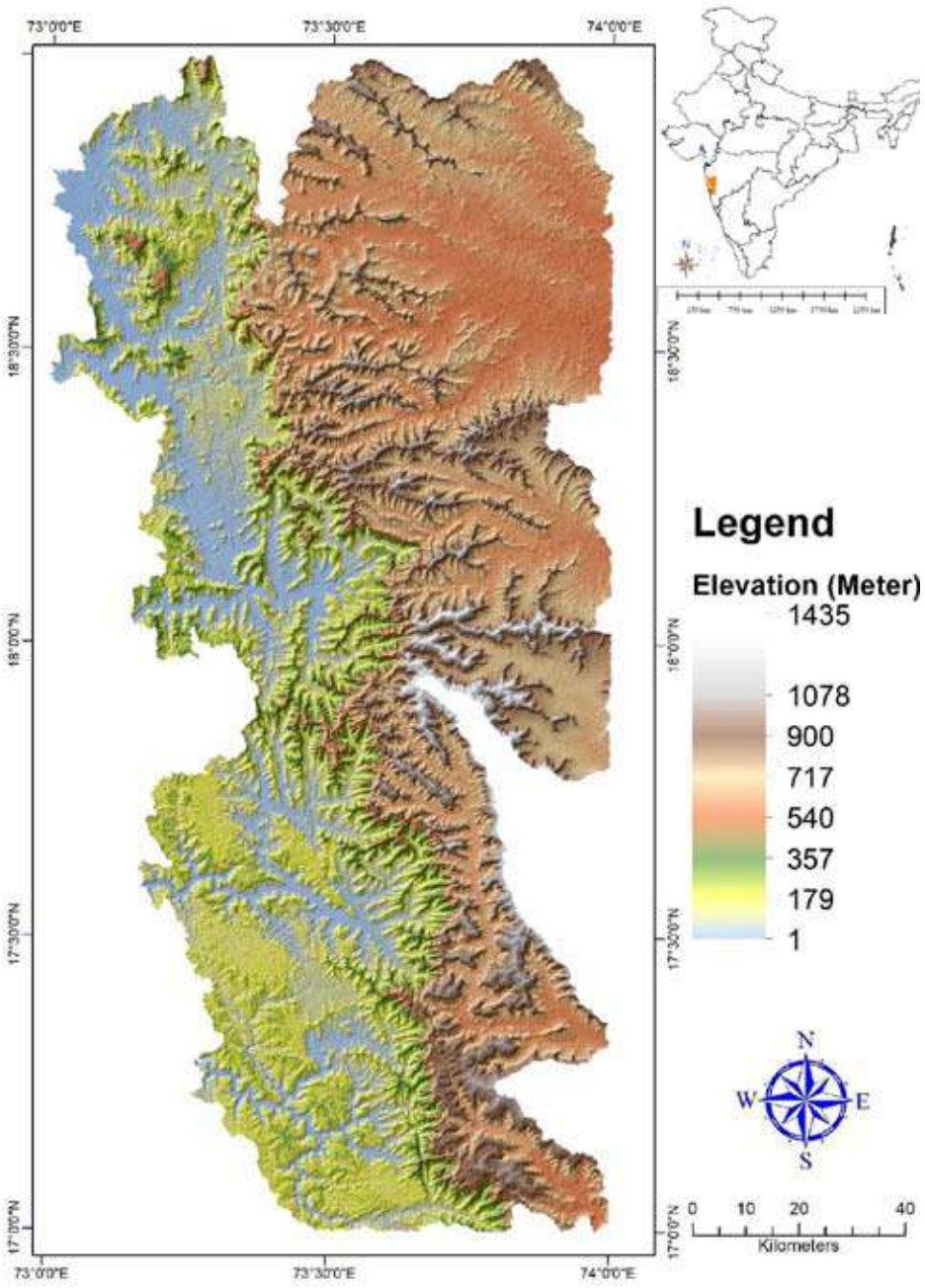

Fig. 1 : Study Area with Elevation

4. RESULTS AND DISCUSSION

Stream Order

It is obtained according to the technique reported by Strahler (1964) and presented in Tables 2A & 2B. It can be observed that the basins IDs 1290, 1351, 1503, 9372, and 5541 possess Vth order streams. Similarly, basin IDs 4964, 4182, 7687, 6937, 1711, and 2371 contain VIth order streams. However, order streams were observed for basin ID 9308. Further, it is noticed that frequency was maximum in first-order streams and further diminutions with increasing stream order.

Stream Length

Table 2B presents the stream length calculated for the entire basins. In the initial order streams, the whole stream length sections are maximal and reduced with increasing stream order.

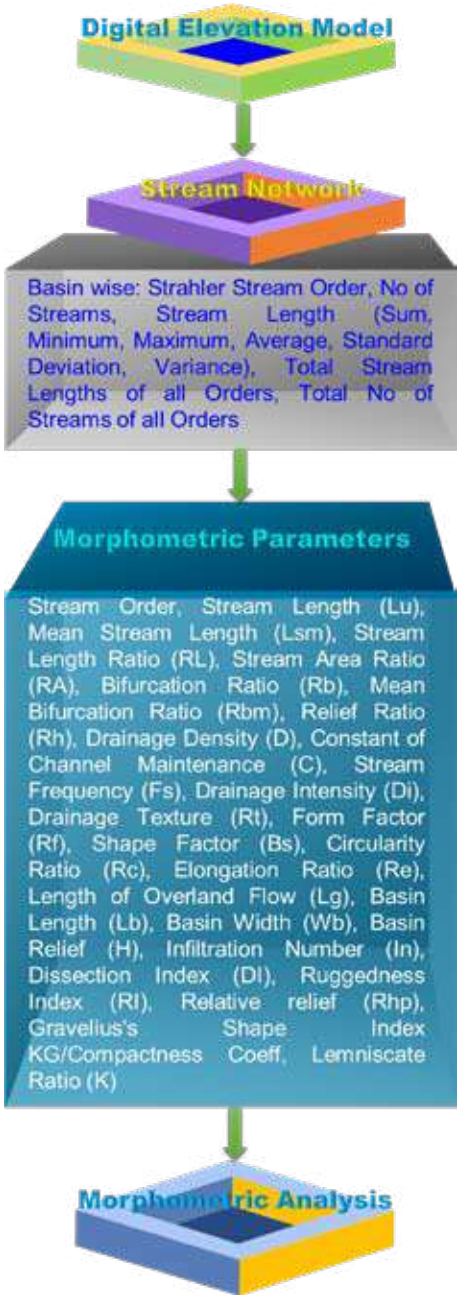

Fig. 2 : Methodology

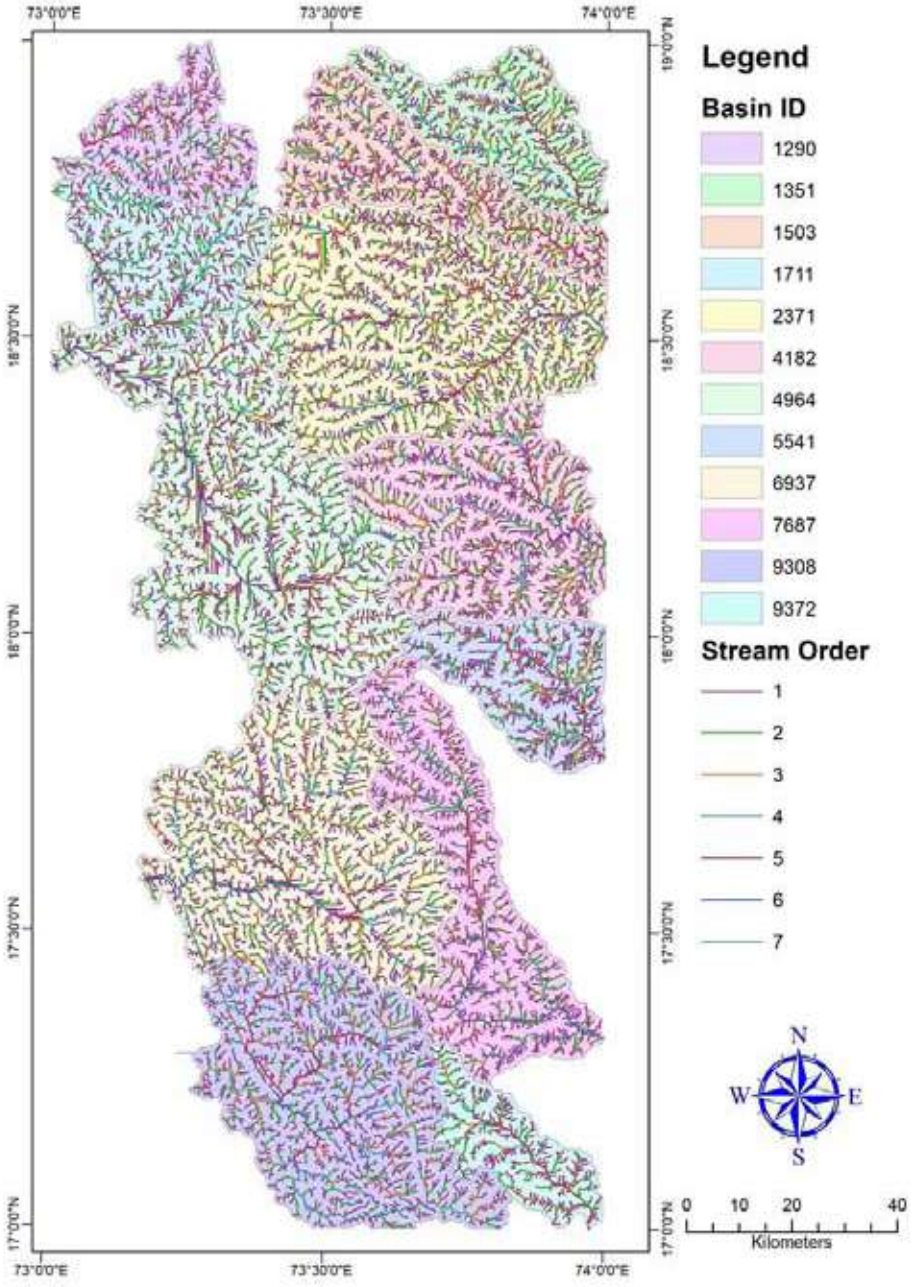

Fig. 3 : Basin and Stream Order

Furthermore, a little deviation is observed for basin IDs 9308 and 6787. This may be due to different reasons such as the flow of streams from a high elevation, different rocks with moderate steep gradients, and apparent upliftment across the basin. A similar observation was reported in various literature (Vittala et al. 2004, Singh and Singh 1997 and Chopra et al. 2005).

Basin Area

Schumm (1956) established a link between total stream lengths and the total watershed areas, that are sustained by the donating regions. The calculated basin areas are ranging from 503.24 km^2 to 2641.00 km^2.

Basin Perimeter

It is an periphery of the watershed that is evaluated along the boundaries within the watershed and probably used as an indicator for size and shape of watershed. Perimeter of the basin is in the ranges of 147.45 to 402.18 km (Table 3B).

Basin Length

According to Schumm (1956), basin length is the most extensive in the measuring of the basin in parallel with the primary drainage line. Computed basin lengths are ranging from 44.93 to 115.21 km.

Stream Length Ratio

It is found to differ from 0.77 to 1.44 for all basins (see Table 3C). It is also observed that the values are significantly varied for each basin. This alteration is due to variations in slope and geography

Table 1 : Computation of Morphometric Parameters

Morphometric Parameters	Formula	Reference
Stream Order	Hierarchial rank	Strahler (1964)
Mean Stream Length (Lsm)	Lsm = Lu/Nu Where, Lu = Total stream length of order 'u' Nu = Total no. of stream segments of order 'u'	Strahler (1964)
Stream Length Ratio (RL)	RL = Lu/Lu-1 Where, Lu = The total stream length of order 'u' Lu-l = The total stream length of its next lower order	Horton (1945)
Stream Area Ratio (RA)	RA = Au/Au-1 Where, Au = The area of the watershed that contributes to the channel segment of order 'u' Au-l = The area of the watershed that contributes to the channel segment of its next lower order	Horton (1945)
Bifurcation Ratio (Rb)	Rb = Nu/Nu+1 Where, Nu = Total no. of stream segments of order 'u' Nu+l = Number of segments of the next higher order	Schumn (1956)
Mean Bifurcation Ratio (Rbm)	Average of bifurcation ratios of all orders	Strahler (1957)
Relief Ratio (Rh)	Rh = H/Lb Where, H = Total relief [Relative relief] of the basin in km Lb = Basin length in km	Schumn (1956)
Drainage Density (D)	D = Lu/A Where, Lu = Total stream length of all orders A = Area of the Basin in km²	Horton (1932)
Constant of Channel Maintenance (C)	C = 1/D Where, D = Drainage density	Schumn (1956)
Stream Frequency (Fs)	Fs = Nu/A Where, Nu = Total no. of streams of all orders A = Area of the Basin in km²	Horton (1932)
Drainage Intensity (Di)	Di = Fs /D Where, Fs = Stream Frequency D = Drainage density	Faniran (1968)
Drainage Texture (Rt)	Rt = Nu/P Where, Nu = Total no. of streams of all orders P = Perimeter in km	Horton (1945)
Form Factor (Rf)	Rf = A/(Lb)² Where, A = Area of the Basin in km² Lb = Basin length	Horton (1932)
Shape Factor (Bs)	Bs = (Lb)²/A Where, A = Area of the Basin in km² Lb = Basin length	Horton (1945)
Circularity Ratio (Rc)	Rc = 4*Pi*A/p² Where, Pi = 'Pi ' value i.e. 3.14 A = Area of the Basin in km² P = Perimeter in km	Miller (1953)
Length of Overland Flow (Lg)	Lg = 1/2D Where, D = Drainage density	Horton (1945)

Elongation Ratio (Re)	$Re=2\sqrt{(A/Pi/Lb)}$ Where, A = Area of the Basin in km² Pi = 'Pi ' value i.e. 3.14 Lb = Basin length in km	Schumn (1956)
Basin Length (Lb)	$Lb = 1.312 (A)^{0.568}$ Where, A = Area of the Basin in km²	Schumn (1956)
Basin Width (Wb)	Wb = A / Lb Where, A = Area of the Basin in km²	Horton (1932)
Basin Relief (H)	Maximum Elevation – Minimum Elevation Where, Elevations are in m	-
Infiltration Number (In)	In = D*Fs Where, Fs = Stream Frequency D = Drainage density	Faniran (1968)
Dissection Index (DI)	DI = (Maximum Elevation - Minimum Elevation)/Maximum Elevation	Singh et. al. (1994)
Ruggedness Index (RI)	RI = D*H/1000 Where, H = Total relief [Relative relief] of the basin in km D = Drainage density in km/ km²	Chorley (1972)
Relative relief (Rhp)	Rhp = H/P Where, H = Total relief [Relative relief] of the basin in km P = Basin perimeter in km	Melton (1957)
Gravelius's shape index K_G]/Compactness coeff	$K_G = 0.28 P / \sqrt{A}$ Where, A = Area of the Basin in km² P = Basin perimeter in km	Gravelius (1914)
Lemniscate ratio (K)	$K = Lb^2 * Pi / 4*A$ Where, A = Area of the Basin in km² Pi = 'Pi ' value i.e. 3.14 Lb = Basin length in km	Chorleye et.al. (1957)

of the research area. This indicates the geomorphic change in the stream's late phases of the youth stage of the region (Vittala et al. 2004, Singh and Singh 1997).

Stream Area Ratio

It is a ratio between watershed areas of one order to next lower order of segments of streams. For all basins, stream area ratio is in the range of 0.21 to 2.77. Moreover, these values are different for each stream of the watershed. These figures suggest variations in slope and geomorphology and prove the late phases of youth geomorphic improvement in streams (Vittala et al. 2004, Singh and Singh 1997).

Bifurcation Ratio

Schumn (1956) projected the bifurcation ratio as a ratio of stream segments for the given order to the next higher order. Usually, the bifurcation ratio is evaluated as a relief index and dissertation (Horton, 1945). Moreover, it is conveyed that the bifurcation displays a trivial range of deviation for a diverse environment. However, the variation in bifurcation ratio is large wherever the geological control governs (Strahler, 1957). In the present work, the calculated mean bifurcation ratios are 1.72 to 4.20 shown in Table 3C. This indicates that all the sub-basins are under standard basin type (Strahler 1957), where the drainage pattern is less disturbed by geologic structures. Further, a higher value of Rb (4.53) is observed for the study area which stipulates a robust organizational mechanism for the drainage pattern. Similarly, the lesser value of Rb (0.23) shows that the sub-basins are pretentious by organizational disorders. A similar kind of observation was reported in different research papers (Vittala et al. 2004, Chopra et al. 2005, Stahler 1964 and Nag. 1998).

Relief Ratio

According to Schumn 1956, Its extreme relief to horizontal measurement along stretched length of the basin is similar to principal drainage line. The Channel gradients and relief have a linear connection with the relief ratio. Gottaschalk (1964) reported that the relief ratio progresses with increasing drainage area and size of watersheds. Relief ratio is found to vary from 1.58 to 8.55 (Table 3B). As this result indicates, the relationship with the slope in the basin 2371 lies majorly below 15 degrees.

Drainage Density

Drainage density as per Horton (1932), is demarcated in a drainage area, a some

Table 2A : Stream Statistics of Basins

Basin ID	Strahler Stream Order	No of Streams	Stream Length						Total Stream Lengths of all Orders	Total No of Streams of all Orders
			Sum	Minimum	Maximum	Average	Standard Deviation	Variance		
1290	1	379	364.43	0.02	4.26	0.96	0.81	0.66	669.74	747
	2	177	148.36	0.04	5.25	0.84	0.71	0.50		
	3	102	91.94	0.04	3.58	0.90	0.73	0.54		
	4	60	42.21	0.04	3.36	0.70	0.56	0.32		
	5	29	22.80	0.04	4.02	0.79	0.91	0.83		
1351	1	519	445.93	0.04	5.83	0.86	0.70	0.49	894.47	1032
	2	252	232.93	0.03	5.44	0.92	0.79	0.62		
	3	120	118.05	0.04	7.11	0.98	0.89	0.80		
	4	86	61.86	0.04	2.40	0.72	0.57	0.32		
	5	55	35.70	0.04	1.96	0.65	0.49	0.24		
1503	1	605	574.68	0.04	5.06	0.95	0.74	0.55	1091.71	1203
	2	296	271.90	0.03	6.32	0.92	0.83	0.68		
	3	145	127.15	0.03	3.62	0.88	0.74	0.55		
	4	61	45.51	0.04	2.92	0.75	0.59	0.35		
	5	96	72.47	0.04	2.45	0.75	0.55	0.30		
9372	1	292	279.28	0.04	3.42	0.96	0.69	0.47	519.32	575
	2	129	122.92	0.03	4.28	0.95	0.82	0.67		
	3	86	66.96	0.03	5.35	0.78	0.79	0.62		
	4	19	15.37	0.08	2.56	0.81	0.89	0.80		
	5	49	34.79	0.04	4.16	0.71	0.72	0.51		
5541	1	471	474.62	0.04	5.67	1.01	0.86	0.75	872.40	937
	2	219	209.82	0.03	5.27	0.96	0.83	0.69		
	3	112	99.38	0.04	3.52	0.89	0.73	0.53		
	4	76	50.86	0.04	5.18	0.67	0.82	0.67		
	5	59	37.72	0.04	2.88	0.64	0.53	0.28		
4964	1	1463	1394.66	0.04	6.06	0.95	0.84	0.70	2756.14	2911
	2	698	682.26	0.03	5.36	0.98	0.80	0.65		
	3	393	375.29	0.03	5.48	0.95	0.84	0.71		
	4	168	133.86	0.04	5.20	0.80	0.75	0.56		
	5	92	86.24	0.04	4.65	0.94	0.78	0.62		
	6	97	83.83	0.03	5.59	0.86	0.84	0.70		

of the length of streams of all orders streams. Moreover, it represents the proximity of the typography of channels. Drainage density is the function of various parameters such as rock types, climate, relief, vegetative cover, infiltration capacity, runoff intensity index, and roughness of the surface. However, the roughness of the surface has no effective association with drainage density. The surface run-off is directly affected by the amount and characteristics of precipitation. For the most part, thundershowers are the reason for more surface run-off results in supplementary drainage lines. Moreover, the soil's capacity for rainfall absorption and vegetation stimulus the surface run-off rate and affects texture of drainage. Besides the similarity of geologic structures and lithology, the drainage density texture of semi-arid regions is improved than in humid regions. In any watershed area, the dense vegetation, low relief, and permeable sub-soil material

Table 2B : Stream Statistics of Basins

Basin ID	Strahler Stream Order	No of Streams	Stream Length						Total Stream Lengths of all Orders	Total No of Streams of all Orders
			Sum	Minimum	Maximum	Average	Standard Deviation	Variance		
4182	1	845	847.31	0.04	6.75	1.00	0.89	0.79	1573.57	1680
	2	399	376.25	0.03	4.34	0.94	0.68	0.46		
	3	183	174.39	0.04	4.90	0.95	0.77	0.59		
	4	134	98.59	0.03	2.98	0.74	0.58	0.33		
	5	65	38.14	0.04	2.47	0.59	0.46	0.22		
	6	54	38.89	0.04	2.96	0.72	0.62	0.38		
7687	1	836	779.55	0.04	6.03	0.93	0.77	0.59	1446.54	1665
	2	406	351.18	0.03	3.90	0.86	0.70	0.49		
	3	185	145.20	0.04	5.03	0.78	0.72	0.52		
	4	95	71.54	0.04	4.19	0.75	0.79	0.63		
	5	27	29.37	0.04	3.00	1.09	1.03	1.06		
	6	116	69.70	0.04	3.00	0.60	0.51	0.26		
6937	1	1213	1143.96	0.04	7.47	0.94	0.84	0.71	2259.54	2409
	2	565	560.66	0.03	4.98	0.99	0.77	0.60		
	3	360	309.88	0.04	5.71	0.86	0.70	0.48		
	4	141	128.79	0.04	3.80	0.91	0.74	0.55		
	5	82	75.10	0.04	4.59	0.92	0.86	0.74		
	6	48	41.15	0.04	4.60	0.86	0.80	0.65		
1711	1	497	503.32	0.04	5.10	1.01	0.86	0.75	953.51	972
	2	243	245.82	0.03	6.57	1.01	0.90	0.81		
	3	101	95.63	0.03	4.39	0.95	0.79	0.63		
	4	79	69.51	0.08	3.23	0.88	0.70	0.49		
	5	47	33.88	0.04	2.46	0.72	0.57	0.33		
	6	5	5.36	0.34	2.12	1.07	0.68	0.47		
2371	1	1291	1291.83	0.04	7.47	1.00	0.87	0.75	2454.99	2565
	2	621	617.96	0.03	6.81	1.00	0.80	0.64		
	3	299	279.03	0.03	6.88	0.93	0.82	0.67		
	4	135	97.45	0.04	3.40	0.72	0.62	0.38		
	5	124	101.56	0.04	2.54	0.82	0.61	0.37		
	6	95	67.16	0.04	2.93	0.71	0.62	0.39		
9308	1	1086	957.12	0.02	5.87	0.88	0.71	0.50	1926.49	2164
	2	503	466.23	0.03	3.85	0.93	0.69	0.47		
	3	275	251.82	0.03	4.18	0.92	0.63	0.39		
	4	117	96.46	0.04	3.79	0.82	0.66	0.44		
	5	88	73.12	0.04	3.47	0.83	0.64	0.41		
	6	21	18.33	0.08	2.30	0.87	0.54	0.29		
	7	74	63.40	0.04	2.60	0.86	0.58	0.33		

Table 3A : Morphometric Parameters

Basin ID	Basin Area (km^2)	Basin Perimeter (km)	Basin Length (km)	Drainage Density	Stream Frequency	Drainage Intensity	Drainage Texture	Form Factor	Circulatory Ratio	Elongation Ratio
1290	627.27	164.58	50.92	1.07	1.19	1.12	4.54	12.32	0.29	0.28
1351	808.95	181.98	58.83	1.11	1.28	1.15	5.67	13.75	0.31	0.26
1503	967.98	222.63	65.15	1.13	1.24	1.10	5.40	14.86	0.25	0.26
9372	503.24	156.96	44.93	1.03	1.14	1.11	3.66	11.20	0.26	0.31
5541	752.75	147.45	56.48	1.16	1.24	1.07	6.35	13.33	0.43	0.24
4964	2641.00	402.18	115.21	1.04	1.10	1.06	7.24	22.92	0.21	0.20
4182	1425.38	207.42	81.16	1.10	1.18	1.07	8.10	17.56	0.42	0.20
7687	1397.88	291.68	80.27	1.03	1.19	1.15	5.71	17.41	0.21	0.24
6937	2237.27	325.31	104.85	1.01	1.08	1.07	7.41	21.34	0.27	0.19
1711	888.97	183.34	62.07	1.07	1.09	1.02	5.30	14.32	0.33	0.25
2371	2268.97	259.33	105.69	1.08	1.13	1.04	9.89	21.47	0.42	0.17
9308	1969.53	292.22	97.53	0.98	1.10	1.12	7.41	20.19	0.29	0.20

Table 3B : Morphometric Parameters

Basin ID	Length of Overland Flow	Compactness Coefficient	Shape Factor	Infiltration Number	Basin Relief	Relief Ratio	Relative Relief	Dissection Index	Ruggedness Index	Lemniscate Ratio
1290	0.47	1.85	4.13	1.27	142	2.79	0.86	0.95	0.15	3.24
1351	0.45	1.80	4.28	1.41	223	3.79	1.23	0.29	0.25	3.36
1503	0.44	2.02	4.38	1.40	109	1.67	0.49	0.16	0.12	3.44
9372	0.49	1.97	4.01	1.18	286	6.37	1.82	0.34	0.30	3.15
5541	0.43	1.52	4.24	1.44	310	5.49	2.10	0.33	0.36	3.33
4964	0.48	2.21	5.03	1.15	362	3.14	0.90	0.98	0.38	3.95
4182	0.45	1.55	4.62	1.30	173	2.13	0.83	0.23	0.19	3.63
7687	0.49	2.20	4.61	1.23	186	2.32	0.64	0.25	0.19	3.62
6937	0.50	1.94	4.91	1.09	897	8.55	2.76	0.99	0.91	3.86
1711	0.47	1.73	4.33	1.17	226	3.64	1.23	0.97	0.24	3.40
2371	0.46	1.54	4.92	1.22	167	1.58	0.64	0.24	0.18	3.86
9308	0.51	1.86	4.83	1.07	244	2.50	0.83	0.95	0.24	3.79

Table 3C : Morphometric Parameters

Basin ID	Bifurcation Ratio							Length Ratio							Area Ratio						
	I/II	II/III	III/IV	IV/V	V/VI	VI/VII	Mean	II/I	III/II	IV/III	V/IV	VI/V	VII/VI	Mean	II/I	III/II	IV/III	V/IV	VI/V	VII/VI	Mean
1290	2.14	1.74	1.70	2.07			1.91	0.87	1.08	0.78	1.12			0.96	0.23	0.49	0.63	0.71			0.52
1351	2.06	2.10	1.40	1.56			1.78	1.08	1.06	0.73	0.90			0.94	0.26	0.55	0.69	0.41			0.48
1503	2.04	2.04	2.38	0.64			1.77	0.97	0.95	0.85	1.01			0.95	0.25	0.52	0.40	1.53			0.68
9372	2.26	1.50	4.53	0.39			2.17	1.00	0.82	1.04	0.88			0.93	0.30	0.51	0.23	2.77			0.95
5541	2.15	1.96	1.47	1.29			1.72	0.95	0.93	0.75	0.96			0.90	0.22	0.50	0.83	0.53			0.52
4964	2.10	1.78	2.34	1.83	0.95		2.25	1.03	0.98	0.83	1.18	0.92		0.99	0.29	0.50	0.42	0.66	1.29		0.63
4182	2.12	2.18	1.37	2.06	1.20		2.23	0.94	1.01	0.77	0.80	1.23		0.95	0.28	0.47	0.57	0.62	0.31		0.45
7687	2.06	2.19	1.95	3.52	0.23		2.49	0.93	0.91	0.96	1.44	0.55		0.96	0.27	0.47	0.58	0.36	1.35		0.61
6937	2.15	1.57	2.55	1.72	1.71		2.42	1.05	0.87	1.06	1.00	0.94		0.98	0.28	0.61	0.51	0.35	0.96		0.54
1711	2.05	2.41	1.28	1.68	9.40		4.20	1.00	0.94	0.93	0.82	1.49		1.03	0.30	0.37	0.68	0.68	0.25		0.45
2371	2.08	2.08	2.21	1.09	1.31		2.19	0.99	0.94	0.77	1.13	0.86		0.94	0.30	0.45	0.52	0.82	0.24		0.47
9308	2.16	1.83	2.35	1.33	4.19	0.28	3.04	1.05	0.99	0.90	1.01	1.05	0.98	1.00	0.28	0.58	0.48	0.81	0.21	1.18	0.59

are due to low drainage density. Similarly, high drainage density is the reason for the formation of sparse vegetation, impervious sub-surface material, and mountainous relief. This work, drainage density in sub-basins is estimated to vary from 0.98 to 1.16 Km/km^2. Results direct that the study area possesses a low drainage density (Table 3A). Also, it indicates coarse drainage texture and highly permeable sub-soil.

Constant Channel Maintenance

This is converse of drainage density as per Schumm (1956). Channel maintenance constant represents maintaining one kilometer (Km) linear length of the stream of channel, the number of km^2 of watershed area required. The basin maintenance of constant channel is high that unraveling the greater perviousness of the rocks of the basin. The Channel maintenance constant is found to be in the ranges of 0.86 to 1.02 Km^2/Km which concludes that the studied area has subsoil material that is highly permeable and has dense vegetation with low relief.

Stream Frequency

Horton 1932, described the stream frequency as the total number of stream segments present per unit area. The basins, which possess identical drainage density, may have unalike stream frequency and vice versa. Stream frequency of entire basins is presented in Table 3A. The Fs vary from 1.08 to 1.28 and drainage density reveals constructive connexons using stream frequency. It indicates that there is a growth in stream population as the drainage density increases. Also, among all sub-basins, there is a faster runoff in basin 1351 and slower runoff in basin 6937 as stream frequency number growths ensure quicker runoff.

Drainage Pattern

The drainage pattern primarily assists in recognizing the phase in the erosion cycle and shows the impact of structure, slope, and lithology in the watershed. Further, it gives complete information about the geology of the structure including the existence of faults, strikes, and dips of rocks deposit. Howard (1967) also reported that drainage texture reflects the perviousness of rocks, climate, relief ratio, and vegetation. The observed drainage patterns are dendritic and radial in the current study. For the most part, the drainage pattern is dendritic which is poised of the same lithology and is not controlled by the inherent geologic structure. The dendritic pattern is formed when the time is longer for the formation of the drainage basin.

Drainage Intensity

Faniran, 1968, defined it as ratio between stream frequency and the drainage density. For all basins, the drainage intensity varies from 1.02 to 1.15 (Table 3A). In this context, it can be pointed out that the stream frequency and drainage density have an insignificant effect on extent to which surface has been let down by denudation agent. Further, results show that stream frequency, drainage intensity, and drainage density, surface runoff are not swiftly aloof on or after the watershed. Therefore, it is greatly prone to landslides, gully erosion, and flooding.

Drainage Texture

Aggregate sum of stream segments per perimeter of the area is called drainage texture as per Horton (1945). Drainage texture is the significant notion of geomorphology that represents the gap between the drainage lines. Mostly, drainage lines are more abundant in impervious regions than in previous regions. Based on drainage density, Smith (1950), has categorized drainage texture into five classes of drainage textures namely very coarse (<2), coarse (2-4), moderate (4-6), fine (6-8), and very fine (>8). Drainage texture ratio of region is found to vary from 3.66 to 9.89. Amongst all, the basin IDs 2371 and 4182 possess the higher value of 9.89 and 8.10, respectively exhibiting a very fine drainage texture. The basin IDs 1290, 1351, 1503, 7687, and 1711 show moderate drainage texture which indicates the possible existence of granite rock. The inferior values may specify the presence of sedimentary rocks. The basin IDs 5541, 4964, 6937, and 9308 show fine drainage texture. The basin IDs 9372 and 9373 are falling under the very course and coarse category, respectively (Table 3A).

Form Factor

As per Horton (1932), it is a ratio of area of basin and the square of basin length. This represents intensity of flow in a basin as per Horton (1945). For a perfectly circular ratio, form factor should not exceed the value of 0.7854. In this work, the form factor varies from 11.20 to 22.92 indicating the elongated shape of the basins (Table 3A). Also, the elongated basins experience higher peak flows over a shorter period than average.

Circularity Ratio

The basin circularity ratio is primarily related to the climate, geological structures, frequency and stream length, relief, slope, land use, and land cover. Circular. The circularity is the proportion of basin area to area of the circle that has the same circumference as being the boundary of the basin. Further, it is reported that the circularity ratio of basins ranges between 0.4 and 0.5 showing that the basins are more elongated and have many previous homogenous geologic materials (Miller, 1953). Similarly, a circularity ratio greater than 0.5 is indicating basins are circular. From our study, it is seen, that the circularity ratio ranges from 0.21 to 0.43 (Table 3A).

Elongation Ratio

It is a ratio of circle diameter of same area as the drainage basin to the maximum basin length. This value is indicative of high relief and a steep slope. The shape of basins particularly circular to sub-circular may be identified based on the elongation ratio. As per Singh and Singh 1997, the circular basin is more competent in discharge in comparison to an elongate basin. The elongation ratio has been measured to be in the ranges of 0.17 to 0.31 (Table 3A). The result suggests that the basins are in a more elongated shape. Low elongation ratio values (<0.50) indicate the basin areas are slightly active tectonically (Bull and McFadden 1977).

Length of Overland Flow

It is equal to half of the mutual drainage density (Horton 1945). This represents the length of water above the ground before it grows into certain stream channels. For all basins, the length of overland flow ranges from 0.43 to 0.51 (Table 3B). Higher values specify the low relief and vice versa. The current study shows that all basins ID possess moderate relief and hence may have a moderate surface runoff.

Compactness Co-efficient

It is a ratio of watershed perimeter to circular perimeter of area. It is slope dependent and independent of the watershed size. If the basin is a circle, then the compactness co-efficient value is 1 (Gravelius, 1914). The compactness co-efficient of the study area was found to vary from 1.52 to 2.21 (Table 3B).

Infiltration Number

It is stream frequency multiplied by drainage density (Strahler 1964). Moreover, it provides an obvious understanding of the penetration physiognomies of the watersheds. The obtained value varies from 1.07 to 1.44. This indicates that there is a high run-off in the watershed.

Relief Ratio

It is a dimensionless factor of the height/ length ratio between basin relief and basin length (Schumm, 1963). The relief ratio is calculated to vary from 1.58 to 8.55 for all basins (Table 3B). The observed low values are due to the low degree of slope and resistant rock basement into the basin. Moreover, it has been noticed that the region having medium low slopes and relief values are exemplified by modest relief ratios.

Dissection Index

This is ratio between relative and absolute relief is the index of dissection. It explains the phases of terrain or landscape growth in any assumed area (Singh et al. 1994). Generally, DI ranges between 0 (complete absence dissection) and 1 (vertical cliff at the seashore). In the study area, the DI varies between 0.16 and 0.99. It is observed that basin ID 6937 is highly dissected.

Ruggedness Value

Multiplication of basin relief and drainage density gives ruggedness value as per Strahler (1968). These values of the study area are varying from 0.12 to 0.91 (Table 3B). The low values of the ruggedness of the watershed demarcate that the study area poses intrinsic structural difficulty and is less susceptible to soil erosion. The study found that basin ID 1503 is less susceptible to soil erosion.

Lemniscate Ratio

Chorely (1957) used the lemniscate ratio to evaluate basin slope. According to Ashour and Torab (1991), low values of K signify basin approximately rounded and predominant vertical and lateral erosions. The highest values characterize stretched-out basins with nearly pear-shaped, tear-shaped lemniscate. The lemniscate (K) value of the basins varies from 3.15 to 3.95 showing that the watershed inhabits most of the area in its regions of inception employing a greater number of higher-order streams.

Debris Flow Deposition

Debris flows are rising and falling flows of water and saturated debris happening in the steep channels of highland environments. Debris flow deposition is predicted based on Gerardo Grelle et.al. (2019) procedure. In this work, a condition of 6o < slope ≤ 15o and -0.3 ≤ curvature < 0.1 is applied to the study area for the prediction of deposition. The slope angle in degrees, curvature, and deposition of study area is presented in Fig. 4, Fig. 5, and Fig. 6 respectively. This enables preparedness for hazards related to debris flows that are a major concern for urban regions.

An interrelationship between morphometric variables is derived to identify a dominant and independent variable presented in Table 4 as a correlation matrix of morphometric Parameters. A comparison of correlation coefficients between morphometric parameters is derived and presented in Figure 7 as graphical correlations with statistics.

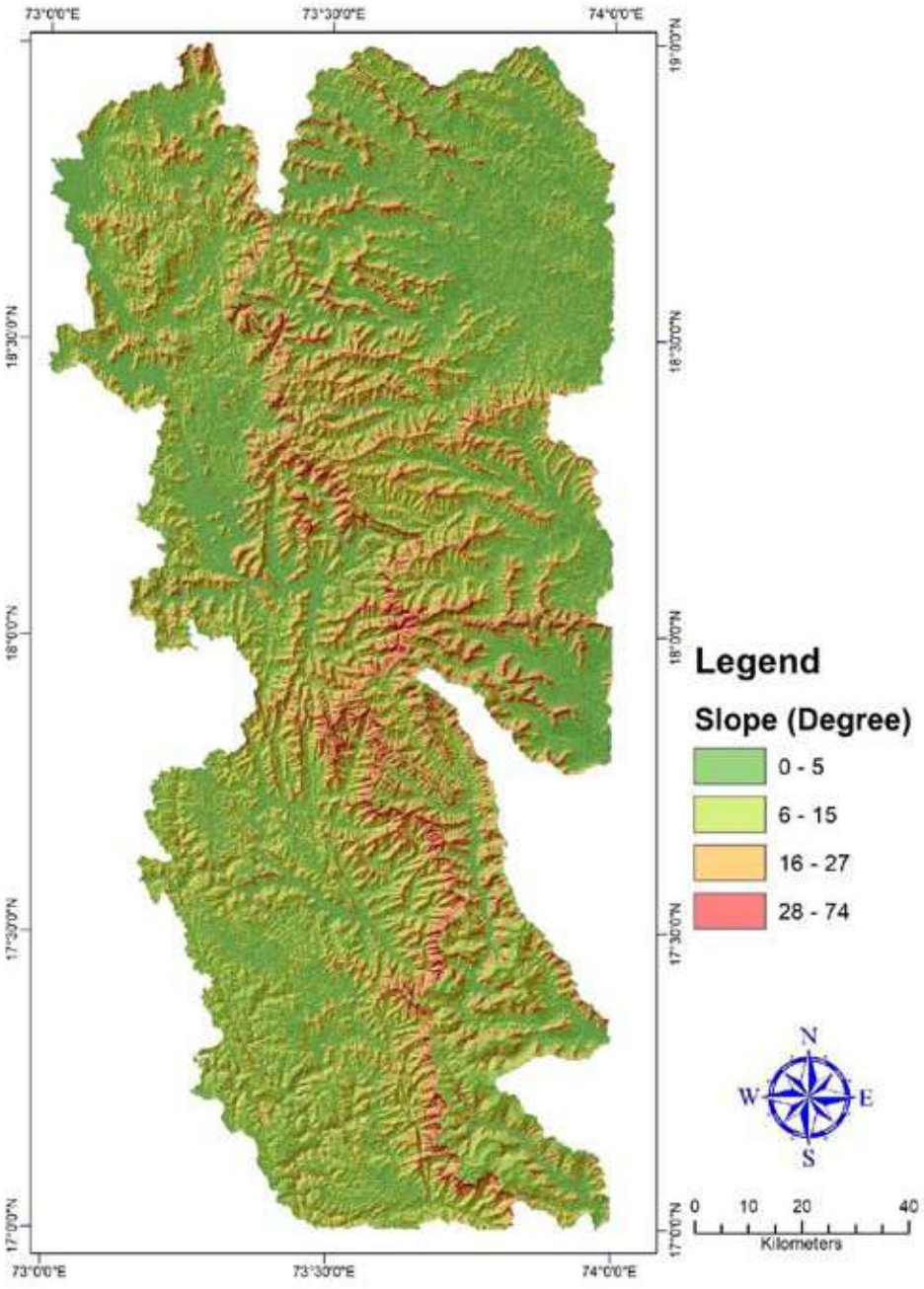

Fig. 4 : Slope

5. CONCLUSIONS

The Morphometric analysis using geomatics techniques of the natural features in the Northern parts of the Western Ghats reveals that the basin's drainage networks show a moderate texture of drainage along with dendritic to sub-dendritic patterns. The ratio of stream length disparity might be due to the changes in the topography and slope. Sub-basins bifurcation ratio demarcates normal category of the basin (Rudraiah et al, 2009). A lesser drainage density value is signifying that it has immensely pervious coarse drainage texture and sub-soil. The Stream frequency of the region specifies that the sub-basins have a positive association with the increasing population of the streams, concerning the drainage density increase. The circulatory ratio and Form factor calculated for the sub-basins suggests that it has been increased in length and has become almost circular. The sub-basin 1503 is having incredibly low relief while the other sub-basins have medium and high relief and steep slopes exist in sub-basin 6937. The study divulges that the central sub-basins of the region are having high, the southern part of the region is having moderate, and the northern part of the region is having low hydroelectric potential. Henceforth, geomatics techniques are powerful tools for drainage delineation, knowledgebase preparation, and water resources management of the regions. As mentioned in section 2.2, a 30 m resolution DEM was used in this study. Since streams are one of the major resources for cultivation, studies with higher spatial resolution than the current data will provide streams with higher accuracy. The formation and analysis of natural features using higher resolution

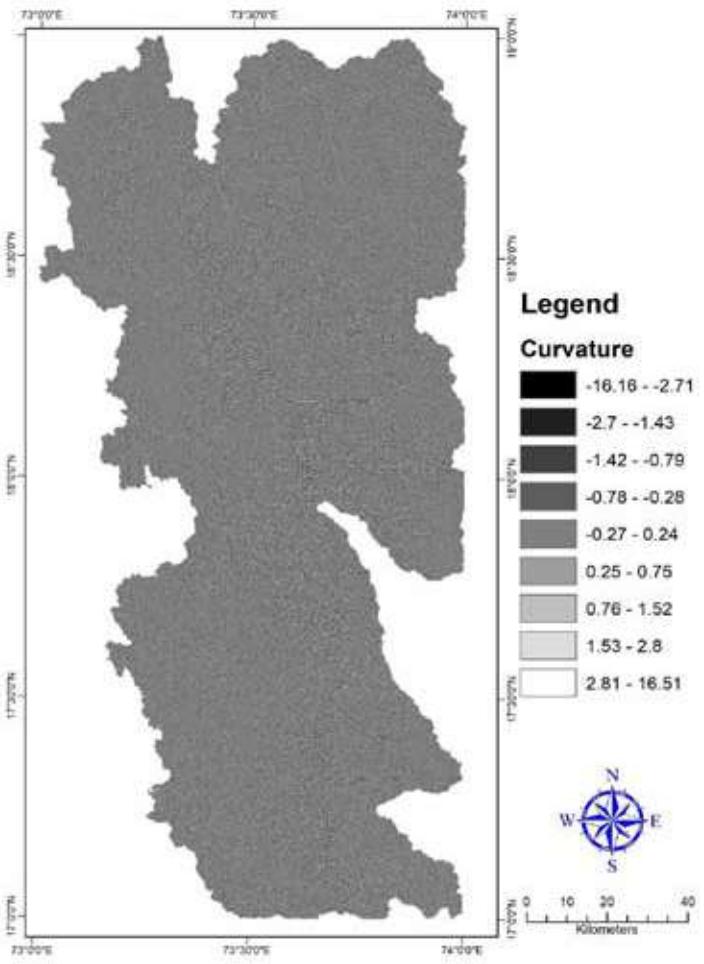

Fig. 5 : Curvature

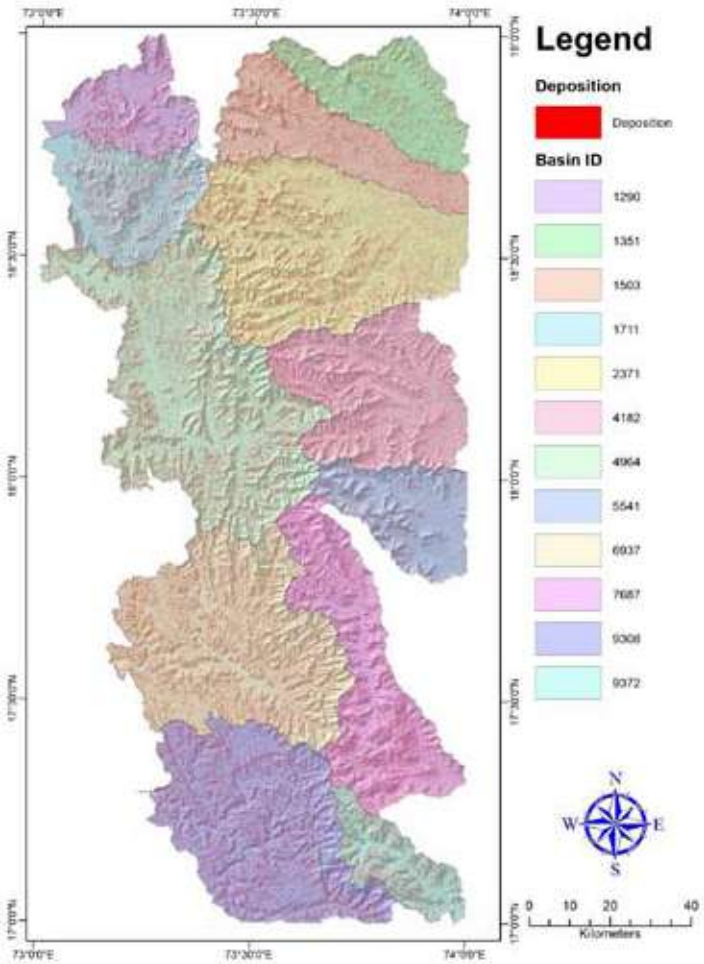

Fig. 6 : Deposition

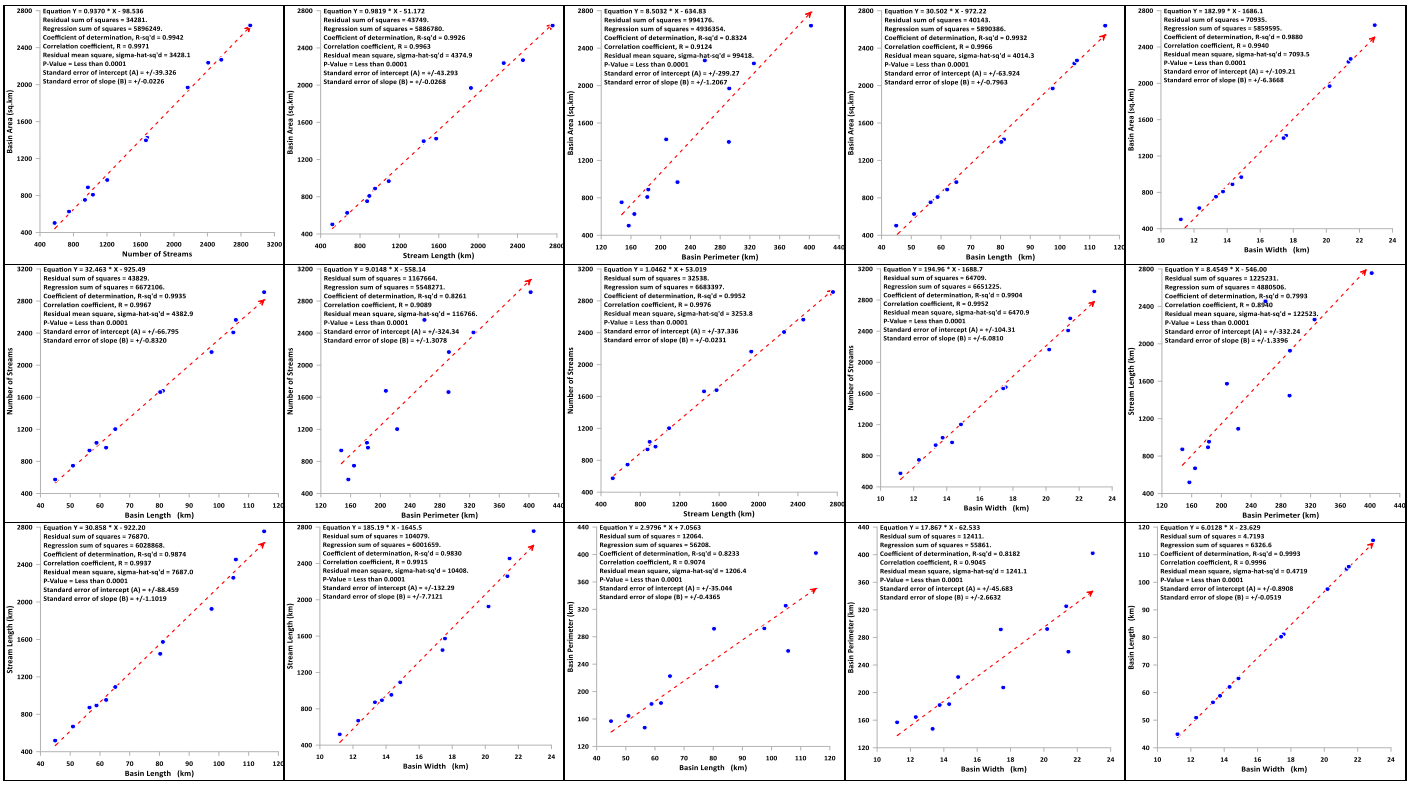

Fig. 7 : Graphical Correlations with Statistics

Table 4 : Correlation Matrix of Morphometric Parameters

	A	P	Lb	D	Fs	Di	Rt	Rf	Rc	Re	Lg	KG	Bs	In	H	Rh	Rhp	DI	RI	K
A	1																			
P	0.912	1																		
Lb	0.997	0.907	1																	
D	-0.478	-0.575	-0.463	1																
Fs	-0.606	-0.546	-0.584	0.750	1															
Di	-0.337	-0.111	-0.327	-0.155	0.534	1														
Rt	0.790	0.504	0.811	-0.049	-0.302	-0.451	1													
Rf	0.994	0.904	1.000	-0.456	-0.575	-0.324	0.816	1												
Rc	-0.115	-0.486	-0.096	0.550	0.177	-0.461	0.477	-0.090	1											
Re	-0.885	-0.668	-0.907	0.205	0.440	0.452	-0.959	-0.913	0.301	1										
Lg	0.479	0.574	0.465	-0.999	-0.744	0.164	0.053	0.458	-0.542	-0.212	1									
KG	0.195	0.565	0.177	-0.511	-0.163	0.428	-0.393	0.171	-0.982	-0.221	0.504	1								
Bs	0.986	0.897	0.996	-0.436	-0.550	-0.314	0.825	0.998	-0.076	-0.923	0.439	0.159	1							
In	-0.584	-0.593	-0.564	0.930	0.940	0.216	-0.202	-0.556	0.370	0.356	-0.925	-0.340	-0.532	1						
H	0.424	0.426	0.405	-0.393	-0.472	-0.207	0.168	0.398	-0.177	-0.324	0.402	0.166	0.379	-0.455	1					
Rh	-0.070	-0.048	-0.104	0.201	0.241	0.085	-0.241	-0.115	0.089	0.152	-0.211	-0.046	-0.141	0.224	-0.837	1				
Rhp	-0.067	-0.106	-0.094	0.078	0.193	0.173	-0.132	-0.103	0.093	0.060	-0.093	-0.129	-0.123	0.136	-0.824	0.978	1			
DI	0.333	0.388	0.306	-0.575	-0.686	-0.254	0.036	0.297	-0.316	-0.165	0.576	0.241	0.277	-0.636	0.460	-0.283	-0.247	1		
RI	0.402	0.398	0.382	-0.343	-0.438	-0.220	0.165	0.375	-0.143	-0.315	0.353	0.136	0.356	-0.410	0.898	-0.852	-0.846	0.437	1	
K	0.986	0.898	0.996	-0.436	-0.551	-0.315	0.824	0.998	-0.077	-0.923	0.439	0.160	1.000	-0.532	0.379	-0.141	-0.123	0.276	0.362	1

A = Area of the Basin, P = Basin perimeter, Lb = Basin length, D = Drainage Density, Fs = Stream Frequency, Rt = Drainage Texture, Rf = Form Factor, Rc = Circularity Ratio, Re = Elongation Ratio, Lg = Length of Overland Flow, KG = Compactness Coefficient, Bs = Shape Factor, In = Infiltration Number, H = Basin Relief, Rh = Relief Ratio, Rhp = Relative Relief, DI = Dissection Index, RI = Ruggedness Index, K = Lemniscate ratio, Wb = Basin Width

are vital in precise cultivation, overseeing the amount of erosion and deposition of sediments in the area. Morphometry is also essential to examine groundwater potential, management of groundwater, soil sciences and the assessment of environment. These studies are very much useful for researchers, and engineers in the development and management of watersheds in the region. Henceforth, geomatics techniques are powerful tools for drainage delineation, knowledgebase preparation, and water resources management of regions.

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Sediment Classification using Spectral Features of Side-Scan Sonar Images

JYOTI RANGOLE[1] AND ANUJA PHARATE[1]

ABSTRACT

Accurate classification of underwater sediment is important in many applications like dredging, study of marine biology, coastal engineering, and hydrography. Active Sound Navigation And Ranging (SONAR) systems are widely used in the classification of sediments. Commercially available active SONAR systems include Single-Beam Echo Sounder (SBES), Multi-Beam Echo Sounder (MBES), and Side Scan SONAR (SSS). The proposed work presents the classification of sediments using Side Scan SONAR (SSS) images using Discrete Wavelet Transform (DWT). To reduce the dimension of the feature vector we used the principal component analysis (PCA) technique which leads to low computational cost and memory requirement. The performance of Support Vector Machine (SVM) classification using three different kernel functions viz. Linear, Polynomial, and Gaussian Radial Basis (GRB) is presented in this paper. Here we have used the EdgeTech DF1000 SSS image database obtained from project REBENT, IFREMER (Location: France). The result showed that using PCA and SVM with GRB kernel function achieves 98.3 % accuracy and is well suitable for all sediment types.

Keywords *: Side-Scan SONAR, Sediment Classification, Discrete Wavelet Transform*

1. INTRODUCTION

Characterization of sediment type plays a vital role in many fields including marine geological surveying, marine engineering construction, and seabed mineral resources development [1-2]. The traditional approach of sediment analysis/ classification by direct sampling could be applicable only on a small scale as it is a cumbersome, complex, and time-consuming process. Satellite remote sensing technique can also be used for this purpose, which results only in the surface sediment classification. Today, a large part of the research is based on the classification of sediment using acoustic means based on SBESs, MBESs, and SSSs [3-9]. The acoustic remote sensing techniques were developed which help measure ocean depths and obstacle detection and also help to characterize and classify sediments to a large extent. The active SONARS are being widely used in the classification of surface as well as deep layer sediment analysis. These active SONARs emit an acoustic signal and record the returns. The SONAR systems analyze reflected energy and will provide a way to classify sediments according to their sediment composition as sand, rock, mud, etc.

Sediment Classification Methods

The sediment classification methods using active sonars have been divided into phenomenological (empirical) and model (physical) methods. The empirical method rely on the features extracted from backscatter signals such as echo energy, maximum amplitude, standard deviation, skewness, kurtosis, etc. which are indicative of sediment type [10-13]. If the extracted feature vector size is large, then there is a need for dimensionality reduction to reduce the computational time and memory requirement. The most popular method used by many researchers is Principal Component Analysis (PCA). The empirical approach needs efforts to extract information such as the mean grain size from the grab samples in the survey area to develop the trained database. Many researchers recommended the use of supervised classifiers such as Support Vector Machine (SVM) [12], K Nearest Neighbour (K-NN) [12], Random Forest (RF) [12-14], and Bayesian classifier [11, 14, 16] while others suggested the use of unsupervised classification techniques such as K means clustering [16].

The model-based sediment classification techniques make use of physical models and determine the sediment type by maximizing the match between measured and modeled signals. These methods establish coupling between sediment type and backscatter strength, reflection coefficients, spectral ratio, central frequency shift, relaxation time, etc. The model-based method requires knowledge about system characteristics such as sensitivity, emitted signals, and directivity to gain a better understanding of acoustic backscatter from the seafloor.

Here we have used empirical method for classification of sediments using SSS images. The SSS systems are being widely used in creating acoustic images of the large areas of the seafloor by transmitting acoustic energy and analyzing the return signal that bounces back from the seabed or submerged objects. The SSS is based on a set of transducers in a line array mounted obliquely concerning the major axes of the ship. The SSS is towed behind the vessel so often called towed fish, as shown in Fig.1.

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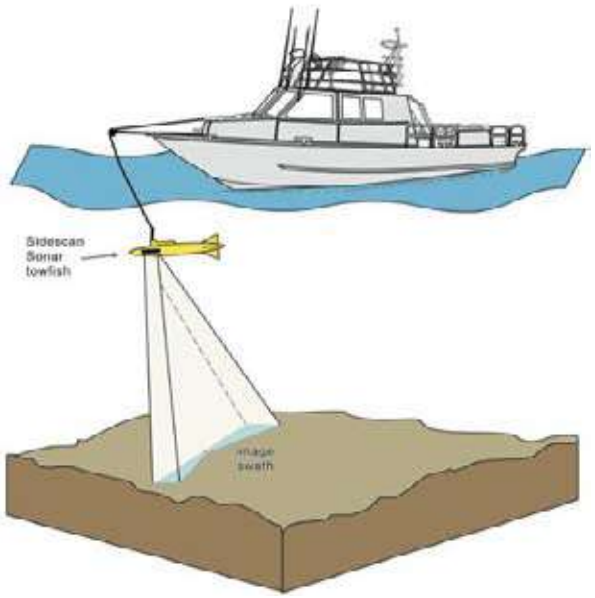

Fig. 1 : SSS Deployment

The SSS systems are widely used in creating acoustic images of the large areas of the seafloor by transmitting acoustic energy and analyzing the echo signal that bounces back from the seabed or submerged objects. Fig. 2 [17] describes the procedure of generating images from a particular side-scan sonar ping.

The top part shows the outgoing pulse, reflected from the seafloor/riverbed from an individual ping (T=0). The hatched portion in the middle section shows the outgoing pulse, and the returns with low amplitude are the time when the ping is the two-way transit time in the water channel.

2. DATABASE DESCRIPTION

The proposed work uses the Edge Tech DF1000 SSS acoustic image database which is a part of project Rebent IFREMER [18] (Location: France). The study was carried out to survey coastal benthic habitats and evaluate biodiversity changes in a 200 km sq. area in the Bay of Concarneau in South Brittany, France. The SSS was operated at a frequency of 100 kHz with 110m for swath width and vertical beam titled down 20 from the horizontal [12]. This database consists of images of six different classes namely mud, sandy mud, clearly sand, rock, mixed sediment, and mg sand with a total of 240 images. Sample images from each sediment type are shown in Fig. 3.

3. METHODOLOGY

Classification of sonar images is divided into three stages pre-processing, training SVM, applying new sonar images to trained SVM, and predicting the output class. (Figure 4)

Pre-processing step involves feature extraction and feature reduction process. DWT can be implemented using wavelet transform (WT) with dyadic scales and positions. DWT generates feature vectors of larger dimensions which is responsible to increase computation times and memory requirements. To reduce the dimensions of a feature vector PCA is an effective technique. Here we have used a second-order statistical texture analysis method Gray Level Co-occurrence Matrix (GLCM). The four properties used in this paper are contrast, correlation, energy,

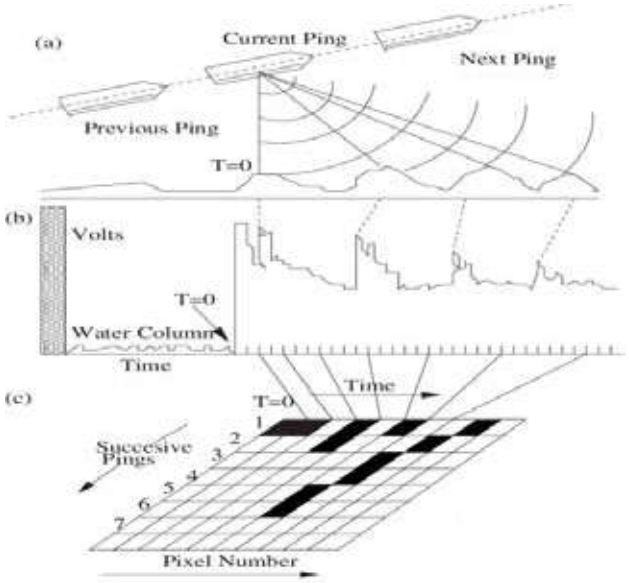

Fig. 2 : Acoustic image formation using SSS

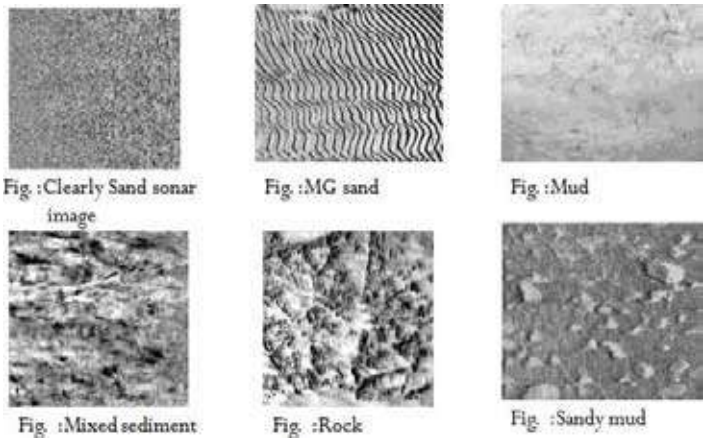

Fig. 3 : Sample SSS images from database

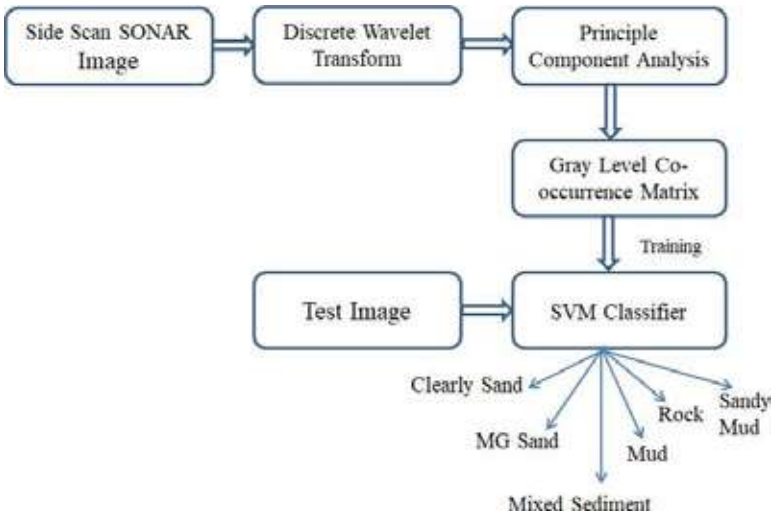

Fig. 4 : Block diagram of SSS image classification

and homogeneity. The GLCM examines the frequency of the combination of pixels in a given direction and given distance.

Here, the GLCM of dimension 8x8 is computed for each class. Four properties from GLCM are extracted as features listed below:

1. *Contrast* : It measures the intensity contrast between a pixel and its neighbor over the whole image, calculated using Eq. (1),

$$Contrast = \sum |i-j|^2 \, p(i,j) \quad ...(1)$$

where *p*(*i,j*) is image matrix, and *i* and *j* represent pixel co-ordinates.

2. *Correlation* : It is a measure of how correlated a pixel is to its neighbor over the whole image. Correlation is 1 or -1 for a perfectly positively or negatively correlated image and can be calculated using Eq. (2)

$$Correlation = \sum \frac{(1-\mu_i)((1-\mu_j)p(i,j)}{\sigma_i \, \sigma_j} \quad ...(2)$$

where *μ* and *σ* represent the mean and standard deviation value of i and j variables respectively.

3. *Energy* : It is the sum of squared elements in the GLCM as shown in Eq.(3). Value of energy is 1 for a constant image.

$$Energy = \sum p(i,j)^2 \quad ...(3)$$

4. *Homogeneity* : Value that measures the closeness of the distribution of elements in GLCM to GLCM diagonal. Homogeneity is 1 for a diagonal GLCM.

In the next step, data is trained with a one-against-all multiclass SVM classifier. The SVM will generate output for test images according to sediment type. DWT+PCA+SVM strategy achieves the best accurate classification results.

Popularly used classifier in sediment classification includes K Nearest Neighbor (KNN), SVM, Neural Networks Self-Organization Feature Map (SOFM), and Fuzzy C Means. All these methods achieve good classification accuracy, still supervised classifiers more popularly used than unsupervised classifiers in terms of accuracy. Multiclass SVM is used in the proposed work due to its direct geometric interpretation and mathematical tractability [18]. Here, the strategy of one-against-all multiclass SVM is used. Classification performance is evaluated for three different kernel functions namely linear, polynomial, and GRB.

4. RESULTS AND DISCUSSIONS

In this section, the step-wise experimental results are discussed. Here, the performance of the proposed classification system for SSS images based on the DWT and Kernel Support Vector Machine (KSVM) classifier is explained. As the image database has a different number of samples, 75 % of images are used to train a classifier and 25% are used as test input images. The classifier performance is evaluated by changing the kernel functions, namely, Linear, Polynomial, and GRB. We have used Daubechies 4 (DB4) wavelet. The performance analysis starts with the first level of decomposition and up to 3 levels of decomposition. There are four filters associated with Daubechies wavelets are listed decomposition low-pass filter, decomposition high-pass filter, reconstruction low-pass filter, and reconstruction high-pass filter. The original image from each class is given as an input image of size 256x256. Approximation and detailed coefficients for the input image are computed up to the third level of decomposition. Fig.5 shows the original input image, low pass approximation of first and second level Daubechies 4 (DB4) wavelet decomposition.

Classification accuracy is calculated from the confusion matrix presented in Fig.7 for each sediment type. It can be observed that the SVM classifier with linear kernel function produces an accuracy of less than 50% for mixed sediment, rock, and sandy mud. Clearly, sand and MG sand areas are classified with an accuracy of 90% and 70% respectively. The linear kernel function is well suitable for muddy areas as all test images are accurately classified with 100% accuracy. The polynomial kernel gives below 50% accuracy for mixed sediment, rock, and sandy mud. MG sand and mud are classified with 90% accuracy with the

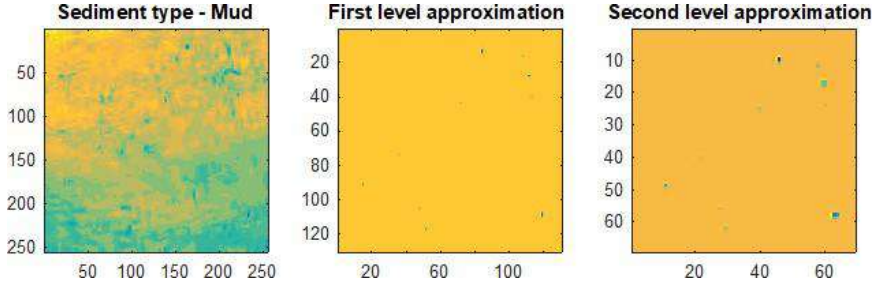

Fig. 5 : First level and second level approximate coefficients for sediment type: Mud

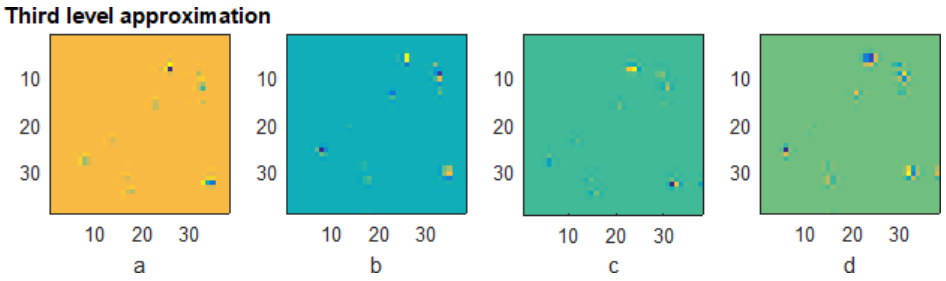

Fig. 6 : Third level approximate (a) and detailed coefficients (b-d) for sediment type: Mud

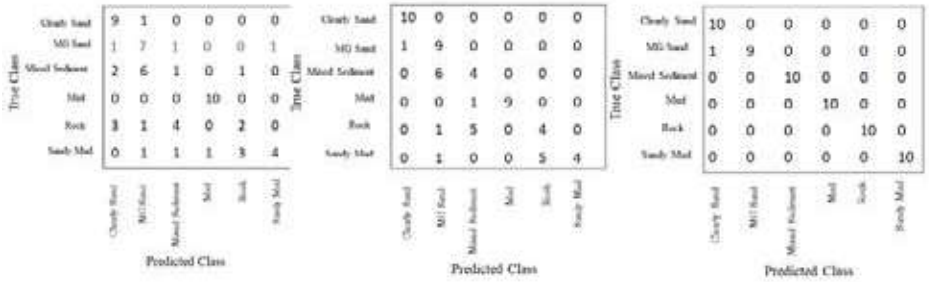

Fig. 7 : Confusion matrix for different kernel functions

same kernel function. This kernel gives 100% accuracy for clearly sand sediment type. SVM classifier with GRB kernel function performs best among the other two kernel functions, achieving the best classification accuracy of 98.3%.

5. CONCLUSION

This paper proposed a technique for the classification of SSS images, which is based on the DWT. Six sediment types clearly sand, MG sand, mixed sediment, mud, rock, and sandy mud are used to assess the performance of the proposed system. Results from the confusion matrix shows that DWT+PCA+KSVM (GRB) technique outperforms with a classification rate are 98.3% for six sediment types.

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Challenges Faced & Mitigation thereof during Land Acquisition and Rehabilitation & Resettlement of Vishnugad Pipalkoti Hydro Electric Project (VPHEP) – A Case Study

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1. INTRODUCTION TO THE PROJECT

THDC INDIA LIMITED, a Public Sector Enterprise under the administrative control of the Ministry of Power (MoP), GoI has been given the responsibility to develop, commission & operate Vishnugad Pipalkoti Hydro Electric Project (VPHEP) across river Alaknanda in district Chamoli in the State of Uttarakhand. The VPHEP is a Run-of-the-River (RoR) Scheme with an Installed Capacity of 444 MW with annual energy generation of 1657 MU.

Being Run-of-the-River (RoR) scheme, the project has comparatively limited land acquisition impact. Although, the project affects 27 villages spread over two blocks/Tehsils, but only one village, namely Haat had to relocate due to the project construction.

2. LAND REQUIREMENT AND PLANNING OF THE PROJECT

A total of 141.57 hectares (Ha) of land was required to construct the project including land required for creating necessary facilities and infrastructure of the total land required, 31.64 Ha of private land has been acquired from 558 titleholders located in 7 villages, 9.54 Ha transferred from the Public Works Department and about 100.39 forest/ van panchayat/civil soyam land (including 23.130 Ha land for underground works) was diverted for the project.

Efforts were made from the planning & designing stage to keep the land requirement minimum so that least disturbance is caused to the local social fabric. Social resistance is one of the main reasons of delay in projects, which also provide opportunities to anti hydro activists to create a hostile atmosphere.

- Site selection for construction of infrastructure and other facilities were done in such a manner which involved minimal land acquisition of private and agriculture land;
- During the design stage, additional care was taken to avoid cultural and religious properties and public property;
- Efforts were made to avoid displacementofhabitation/settlements areas and the project activities were planned in such a way that they do not disturb the main habitation;
- The project infrastructure locations were planned in such a way that the existing approach roads are used to keep the land requirement bare minimum for approach roads.

Land was acquired from 558 title holders of 07 villages through special land acquisition officer under LA act 1894. Table 1.

3. PEOPLE APPREHENSIONS AND MITIGATIONS

Like most projects, the initial challenge before the THDC while entering into the project area is rapport building among the community, who received the project with an atmosphere full of rumors due to lack of awareness, fear & sense of insecurity towards their property and fate, apprehension regarding inadequate compensation, loss of cultural identity etc. This is the time when project developers need to be vigil about the entry of activists (generally outsiders), who start playing with emotions of the affected

Table 1

S. N.	Name of Village	Land Acquired Area (Ha)	Purpose
1	Haat	20.337	Approach Road & Ph Related Works
2	Jaisaal	6.878	Office & Colony
3	Gulabkoti	3.394	Dumpyard & Dam Area
4	Batula	0.542	Approach Road from NH-58 To Haat Bridge
5	Guniyala	0.197	Approach Road from Tundli Bridge to Maina Adit
6	Tenduli Chak	0.170	Approach Road from Tundli Bridge to Maina Adit
7	Naurakh	0.121	Approach Road From NH-58 to Tundli Bridge
	Total	**31.639**	

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2. CGM, Social & Environment, THDCIL

population and mobilize the already scared community against the project by enhancing their fear about loss of rights towards 'Jal, Jangle & Jameen' and make the challenge of project developers more stringent.

As an organized and legal mitigation step, THDC came out with detailed environmental impact assessment studies and management plan prepared conforming to all legal provisions in this regard and shared the same with affected public and other stakeholders during the process of public consultation for addressing their concern and suggestions.

In addition, a well-designed and pro community R&R policy, always having better provisions than the basic mandatory provisions, was prepared after-in-depth independent socio-economic survey through an external expert agency and in consultation with the affected population. Accordingly, based on NRRP 2007, World Bank guidelines, perceived impacts by community and consultations, the Rehabilitation Action Plan (RAP) was formulated. Affected Project Affected Persons (PAPs) were given two choices for compensation package:

Option 1 : Based on NRRP, 2007 (Son of titled holder above 18 year was also considered as a separate family).

Option 2 : Negotiated settlement

After series of formal and informal interactions with the community by project THDC and also by involving/interacting the community along with various govt. and the World Bank authorities during various project activities like public consultation, R&R Policy finalization & approval, land acquisition, forest clearance etc., the rumor phase gradually vanished. However, at the same time, a new & bigger challenge started emerging before the THDC in the form of aspiration phase. Irrational and exorbitant demands were made by the stakeholders, and THDC has a challenge to satisfy them tactfully without compromising project's progress and viability. Prominent demands were 'Land for Land' and that too in Dehradun & Rishikesh area, higher compensation/ R&R benefits, employment, contracts, engaging vehicles, personal level facilitation etc. Here, again, the project developer needs to be vigil as anti hydro elements not only instigate stakeholders for higher compensation, but also try to hamper the project by entangling it into the legal battles both on social as well as environmental fronts.

Frequent consultation meetings with the stake holders either directly or involving Govt/ World Bank authorities

For dissemination of project information to PAF`s & Community, two (02) Public Centre were established at project.

For Redressal of Grievance of PAF`S, A Grievance Redressal Mechanism (GRC) Introduced with Members from affected Villages

4. UNIQUE MEASURES ADOPTED IN VPHEP

Unlike most of the hydro projects, some unique measures were implemented in VPHEP w.r.t. R&R and forest land acquisition.

A. Measures related to R&R

i. Under R&R of VPHEP, only 147 families got displaced. It is different from other projects in a sense that probably first time a village is successfully relocated to some other place without following 'Land for Land' Principle. In addition, certain R&R provisions reflects that involvement of THDC with the affected population in understanding their sentiments & concern and valuing them by customizing specific schemes beyond the statutory requirements. Few such measures/provisions are as under:

One of the most prominent features of R&R Policy of VPHEP is that a village, namely Haat, was relocated with 140 Households without providing "land for land" as Govt. land was not available and private land acquisition would result in an another set of rehabilitation. Additional package of Rs. 10 lacs was given to each household over & above the due compensation as per R&R Policy. But the goal of R&R could not be achieved till they do not settle at some other place. The challenge in this was to refrain them from the tendency of wasteful expenditure, which one generally has when geting sudden cash, and also to convince them to invest first on purchase of land/ construction of house. Another challenging priority was to convince the entire village for self-resettlement in one or two places. The whole exercise was so coordinated, meticulously planned, including timing of release of compensation, that the village Haat was relocated in two clusters namely, Eldana and Daswana along NH 54 without providing Land for Land. All basic amenities viz. electrification, pathways, schools, community building, solar lights etc. have been developed by THDC in located site

A local NGO, Shri Bhuvneshwari Mahila Ashram (SBMA), was engaged for interacting between the PAFS and the project authorities as an interface so that the PAFS can feel comfortable as well as independent feedback can be obtained so that RAP can be implemented in its spirit. Further, for maintaining transparency and ensuring implementation of R&R scheme as planned, an independent agency was engaged for concurrent monitoring and evaluation of the RAP implementation.

B. Other Social, Safety & Environmental Concerns & Measures

Variety of social issues, actual and perceived, were encountered during R&R of VPHEP.

B-1 Social Issue Regarding Widows

A different type of social problem was encountered during R&R of VPHEP. In village Haat, widows especially old, were commanding the entire family with a moral right on ancestral property. The

Skill Development

position suddenly changed at relocation sites as their son and daughter in-law came into the commanding position. This triggered a different sort of social unrest among families.

A different instinct is required to understand the social fabric to the extent that no social issue remains unaddressed though not obligatory. To overcome this situation and to facilitate the widows a dignified & graceful living at new place, a special provision of pension of Rs. 1500 per month for 7 years was made by customizing a scheme through LIC.

Although, nothing adverse was anticipated in the study, still a TBM was introduced to minimize blasting operations as precautionary measures. To ascertain baseline status of existing properties, all the structures falling above tunnel alignment were surveyed and video graphed from inside as well as outside prior to initiating construction activities. Copies were also shared with village head and District Administration.

Further, an insurance scheme was customized for all the public & private assets/ structures falling within a corridor of 250 m either sides of tunnel alignment.

Total 1495 structures (1374 Private and 121 Community Structures) were identified in 15 villages, which were assessed for insurance value of Rs 53 Crs.

New Houses - At Relocation Sites

B-2 Safety Concern about Property

Resistance by villages located above tunnel alignment

Villagers residing above the tunnel alignment were apprehensive about likely cracks / damages to their property due to blasting operation.

To assess the likely impact of construction activities including blasting operation on villagers' properties, if any, a study was conducted by engaging IIT Roorkee. Nothing adverse was envisaged. In addition to above, frequent counseling/ consultation of residents of 15 villages was conducted.

B-3 Apprehensions towards loss of water sources due to construction activities.

Villagers also had apprehension about likely loss of water sources due to construction activities including blasting operation.

To overcome the situation, following measures were taken:

(i) A commitment was made to all the stakeholders that any loss of water sources shall be mitigated by THDC.

(ii) To ascertain baseline data, the existing water sources in all villages were mapped twice a year in presence of villagers for couple of initial years.

(iii) A DPR was also got prepared from 3rd party for mitigation measures in case of loss of water sources.

C. Measures related to Forest Land Acquisition

Total 100.507 ha. forest land under different categories was required from 18 Van Panchayats for the project. Detail as under:

S. No.	Description	Area Required (Ha.)			Total Area (Ha.)
		Reserve Forest (Ha.)	Civil Forest Land (Ha.)	Van Panchayat Land (Ha.)	
1	Reservoir	1.600	0	18.631	20.231
2	Dam & Appurtenant Structure (open)	0	0	20.909	20.909
3	Dam & Appurtenant Structure (U/G)	0	0	8.000	8.000
4	Power House & Appurtenant Structure (open)	0	6.946	3.623	10.569
5	Power House & Appurtenant Structure (U/G)	0	0	15.130	15.130
6	Quarries	0	1.337	4.331	5.668
7	Infrastructure	0	0	20.0	20.0
	TOTAL	**1.600**	**8.283**	**90.624**	**100.507**

The catch in the diversion of said forest land was the procedural requirement of obtaining NoC from more than 50% of the adult villagers. Villagers took this as an opportunity to show resistance and bargain with the NoC as they were not directly getting benefitted in terms of any sort of compensation.

Considering villagers' dependence on nearby forest, including Van Panchayat Forest land required for the project, for fuel & fodder, the affected community was roped in with following specific measures:

(i) In lieu of forest land diverted for the project, a special provision of paying 100 days of Minimum Agriculture Wage(MAW) per year for a period of 05 years, which later extended for 03 more years, to each house hold of all 18 Van Panchayats was introduced. Approx. 2600 households are benefited.

(ii) The Van Panchayats were also treated as affected villages for extending benefits such as community development works, priority in employment opportunities, skill development etc.

5. CONCLUSION

The R&R policy of VPHEP has been very effective in adhering to the project development objectives and ground level implementation. THDC, while implementing the VPHE project, has taken all necessary actions to reduce the assessed adverse impacts of the project as well as perceived impacts by the community. While following all the policy standards, THDCIL had gone beyond what is mandatory provisions in the policies and tried to benefit the community to the extent possible.

The electric bill won't give you a fright if you remember to turn off the light

Study of the Features of the Protection of Energy System Elements Caused by Excessive Local Heating

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ABSTRACT

The analysis of individual components and elements of energy systems, in particular, power supply systems, which can lead to disruptions in the functioning of these systems, was carried out in the work. It notes that electrical sockets are the places where ignition and subsequent fires can occur due to large values of transient resistance. For an example, a separate element of electrical networks (sockets), experimental studies were carried out on a laboratory installation under different conditions of its operation, which can cause its excessive local heating - damaged or undamaged contacts, the presence and absence of a thermal fuse. It is shown that it is the safest to use sockets with a normal connection, both with and without a thermal fuse, when applying the studied currents for 60 min, whereas the greatest danger can occur when applying a current of 16 A for sockets with affected contacts. It is recommended to use a thermal fuse in sockets designed for a current of 16 A and difficult to locate in places with excessive consumer properties such as service stations, auto repair shops, shopping areas, etc., to further increase the safety of power grid operation.

Keywords : *Energy system, electricity grid, local heating, current, thermal fuse, socket.*

1. INTRODUCTION

The issue of energy supply is currently a strategic element of the development of any state. The priority of using nuclear, thermal, electric or any other types of energy is determined by the country's economic, political, and social needs, features of its geographic location, and resource potential. Relative safeties, ease of production and use have made electrical energy a leader among other energies used by mankind. This, in turn, draws attention to the peculiarities of the functioning of this type of energy systems.

Power supply systems are among the most complex engineering systems. They are characterized by a high reaction rate of various physical processes, the complexity of accumulating electrical energy on an industrial scale, and the need to use automatic equipment for their management. In the conditions of modern constructions and the exploitation of new facilities, there is a continuous development of the electric power complex with appropriate capacities and innovative solutions [1].

Measures to increase the overall security of the global energy system cause the introduction of new equipment. The use of new capacities has a positive effect on the operation of the electric power system, providing a reduction in the load on the power grid equipment, increasing static and dynamic stability, increasing the reliability of the power system, increasing the variability of the distribution of active power between generating equipment operating in several modes, choosing the configuration of connected generating equipment, etc. [2].

Many countries use a maintenance system to maintain electrical systems in good condition, which is the easiest way to plan repairs and ensure stable operation of equipment [3]. However, this cannot fully ensure the adoption of an optimal decision in modern economic conditions, which is explained by the fact that maintenance and repairs are carried out without taking into account the actual technical condition of electrical equipment elements, the sequence of shutdowns, as well as financial, labor, time and technological limitations that complicate the planned repair [4]. All these circumstances lead to an increase in the number of failures due to depreciation, an increase in the number of repair personnel, a decrease in the quality of maintenance and, as a result, the deterioration in the condition of energy facilities [5]. Fires in these networks are another dangerous factor that negatively affects the operation of energy systems. Moreover, the use of fire-resistant coatings [6], special insulating coatings [7] and the latest fire extinguishing methods [8, 9] and fire prevention [10] is not a guarantee of safe long-term operation of electrical equipment.

It is possible to note a number of unsatisfactory factors that exist in

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individual sections or elements of power systems and worsen its functioning.

Thus, the construction of the power grid and the use of new facilities lead to the complication of electromagnetic transients in emergency conditions and the increase in the number of current sources in short-circuit conditions, which also leads to the increase in the total short-circuit current at the fault location. The use of new-generation facilities leads to the installation of new step-up transformers with a grounded neutral, as a result of which the current level of single-phase energy system increases due to the general decrease in zero-sequence resistance. The problem of increasing short-circuit currents directly affects the reliability, operating modes and functional condition of power switches, which, along with power transformers, are one of the most responsible types of power equipment [11].

Today, such elements of power systems as oil switches are gradually being replaced by gas-insulating ones, which have a number of advantages, such as fire and explosion safety of equipment, an environmentally clean environment of inert gas, harmless to humans, a reduction in the weight and size of equipment, high breaking capacity, low level of depreciation of arcing contacts, as well as ease of installation and maintenance of the switch [12]. However, in the conditions of limited investment opportunities in the energy sector, a complete replacement of oil switches with gas ones is impossible, and the problem is to optimize the costs of repairing equipment or purchasing a new one.

It should be noted that the assessment of the actual condition of oil switches based on the results of diagnostics is a rather difficult task within the limits of two known groups of approaches for their diagnosis:

- Control of shelf life and remaining resource based on data provided by the manufacturer. The main part of the manufacturers of automatic switches provides data on the output resource of switches, as well as data necessary to evaluate their technical condition when working in nominal conditions.
- Control of shelf life and residual resource based on data obtained by means and methods of technical tests and diagnostics.

This group of methods provides assessment of the actual condition of the equipment based on the results of control and measurement testing [13]. Today, the existing techniques for assessing the technical condition of circuit breakers are mainly reduced to the analysis of actual parameters and their comparative analysis with the limit values determined by regulatory documents that determine the permissible technological parameters of circuit breakers [14-16].

Based on the results of diagnostics and tests, exceedance of the actual parameters is determined, as well as defects, their location and causes are identified. To assess the technical condition of automatic switches, such studies as chromatographic analysis of gases dissolved in oil are most often used; heat monitoring method; measurement of electrical characteristics; physical and chemical analysis of oil, etc.

Chromatographic analysis makes it possible to detect equipment defects in the early stages, as well as to determine their nature and degree of damage [17]. The method of thermal monitoring is used to detect defects and damage to switch inputs [18]. Temperature is a universal indicator of the condition of electrical equipment, since thermal reactions develop at all stages of its operation. Cases of any equipment malfunctions lead to a change in temperature recorded by a thermal imager, which makes heat monitoring one of the most effective methods of diagnosis. This method allows you to monitor the thermal condition of the switching equipment without taking it out of service, detect damage at an early stage and, accordingly, reduce inspection and repair costs.

Currently, the problem of high levels of short-circuit currents of electrical network elements is also relevant. Since the installed capacity of power plants in the power system and the total load are constantly increasing, it is necessary to increase the capacity of the power grid from large power plants to power centers of industrial and household loads, especially in such places of excessive consumer capacity as MS (maintenance stations) and MTE (motor transport enterprises), which requires construction of new power grids. The increase in the installed capacity of power plants and the intensive development of the infrastructure of energy systems lead to a continuous increase in short-circuit currents in the power system, which leads to the need to develop measures to limit them [19]. This is explained by the fact that the breaking capacity of a large number of switching equipment does not correspond to the calculated levels of short-circuit currents. Replacing existing switches is expensive, which is why it is advisable to consider alternative technical solutions, including the implementation of a stationary section of the electrical network, which in turn requires taking into account a number of criteria of influence on the power system mode.

In addition to assessing the levels of short-circuit currents in the power distribution area, the criterion for assessing the stability and operability of the power grid is also used.

The author's further research is based on the assumption of the following nature - the presence of a large transient resistance at the switching point leads to excessive local heating, in which there are no significant changes in the controlled characteristics of the electric current in the circuit. As a result, the protection devices do not work.

Electrical socket is one of the places where ignition and subsequent fires can occur due to high values of transient resistance. In particular, due to the weakening of the contact between the socket and the plug, the insulation of the electric wire, the combustible parts of the plug and the socket, and then various combustible materials of building structures and decoration (wallpaper, wooden and fabric coverings, etc.) can start to catch fire. The use of poor-quality and old sockets can also cause disturbances in the electrical network and cause fires. Moreover, low-quality electrical sockets can look the same as high-quality ones, although in such models the plastic heats up and catches fire, and the contacts do not always have compression springs.

The main reason that sockets melt is heat, which is always released if there is poor contact of the conductors.

The design of the socket mechanism has two places where heat can be generated. Namely, the contact between the current-carrying wires and the terminals of the mechanism of the socket itself and the contact between the petals of the socket and the plugs of the plug of the electrical appliance.

During the operation of the socket, the screw connection of the terminals weakens and a micro gap is formed between the wire and the terminal, which reduces the contact area of the surfaces. Accordingly, a large current is concentrated on a small contact area, which causes the release of heat. When the gap increases, sparks may occur (sometimes you can hear buzzing inside the socket), which is also accompanied by the release of heat and the further development of a fire.

At the same time, during the operation of plug-in connections, the influence of factors that will lead to the appearance of dangerous transient resistance values, even when using the optimal design of the contact group of socket elements, is possible. In particular, excessive oxidation of contacts, ingress of foreign objects, use of plugs with different pin diameters, damage to the surface of contacting elements due to the action of an electric arc and sparks that may occur when the devices are switched on.

It should also be noted that in places with excessive consumer capacities (technical service stations, transport enterprises, catering establishments, entertainment centers, etc.), the corresponding incorrect operation of these elements of energy systems can lead to ignition and development of fires with corresponding economic and ecological consequences [20] and possible human losses.

Accordingly, to prevent dangerous heat generation, this element of the electrical network system should be equipped with temperature fuses [21], which will operate when the permissible temperature of the connection is exceeded and stop further heating by opening the electrical circuit. It is also necessary to determine the conditions under which the normal operation of the connection in the place of excessive commutation will be ensured for long-term maximum permissible loads and the opening of the electric circuit will occur if the temperature limit value is reached [22-23].

Today, temperature fuses are used to prevent damage to various electrical and thermal devices, electric machine tools and industrial equipment from overheating, including local overheating. The way the fuse works is that at normal operating temperatures, the fusible alloy conducts the current in the normal mode. When the nominal temperature is exceeded, the fusible element melts, which opens the electric circuit. Also, the thermal fuse is designed to protect against current overload. When one of the set parameters is exceeded, the circuit opens and de-energizes, thereby preventing ignition.

Taking into account the above, the purpose of this work is to study the characteristics of the behavior of an element of the electrical network system using the example of an electrical socket equipped with a thermal fuse that operates when the permissible temperature of the connection is exceeded and stops further local heating by opening the electrical circuit.

2. MATERIALS AND METHODS

An experimental laboratory setup was used in the work (control module) on which a plug and a plug with a socket can be attached (Fig. 1a, 1b). The control module supplies the required current, the obtained values are recorded.

The research methodology involves fixing the sample on the stand of the control module (Fig. 1b) and supplying a current of a certain power (6, 10, 16 Amperes) for a certain time (0, 1, 5, 10, 60 minutes) with various simulated variants of socket connections with plug and measurement using the Xintest HTI HT-A9 thermal imager (measurement error does not exceed 2 ^{0}C) of temperature levels.

The study used a high-quality, low-quality (unsatisfactory contacts) socket, a normal plug, an oxidized plug, a socket with a thermal fuse [24] (Fig. 2).

Fig. 1a : Control module with fixed plug

Fig. 1b : Control module with fixed plug and socket

During the experiment, the processes of electrical heating of the structural element and protection were simulated.

3. RESULTS AND DISCUSSION

In the work to assess the possibility of protecting the plug connection in an electric socket with temperature fuses, the peculiarities of the operation of thermal fuses were considered, the conditions under which the normal operation of the plug-socket connection will be ensured for long-term maximum permissible loads and the opening of the electric circuit will occur when the temperature limit value is reached.

Four series of experiments were performed, where the behavior of the electrical system was studied under different conditions of connection of the socket with the plug. In particular, the following conditions were simulated:

- an electrical load element with an oxidized plug and a normal socket;
- an electrical load element with a normal plug and open socket connection contacts;
- an electrical load element with a socket with a thermal fuse and a normal plug;
- an electrical load element with a socket with a thermal fuse and bad contacts and a normal plug.

The loads of 6, 10, 16 A used in the work correspond to the capacities of household sockets.

The obtained results and corresponding visual displays of the experiment are shown in Fig. 3-10.

In conditions of uncertainty of the thermal properties of the materials that make up the socket and adjacent connections (plastic, paper, wood, etc.), an increase in temperature above permissible conditions can be potentially dangerous, for example, the softening or melting of the plastic (from 60 ^{0}C) [25]. You should also take into account time limits in terms of the potential development of fire, namely, that long-term softening and heating of the plastic elements of the socket can lead to a violation of its functioning and subsequent ignition. For the proposed temperature fuse, the estimated time of

Fig. 2 : Socket with thermal fuse

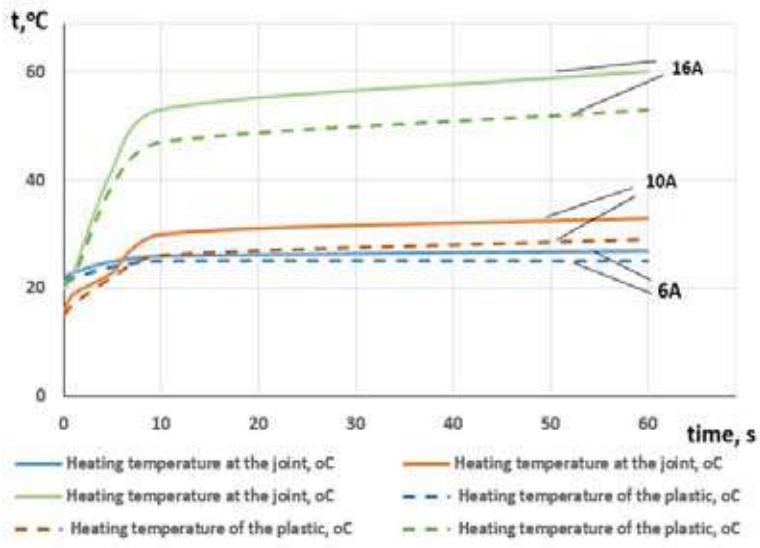

Fig. 3 : Dynamics of temperature values in experiments with an electric load element with an oxidized plug and a normal socket

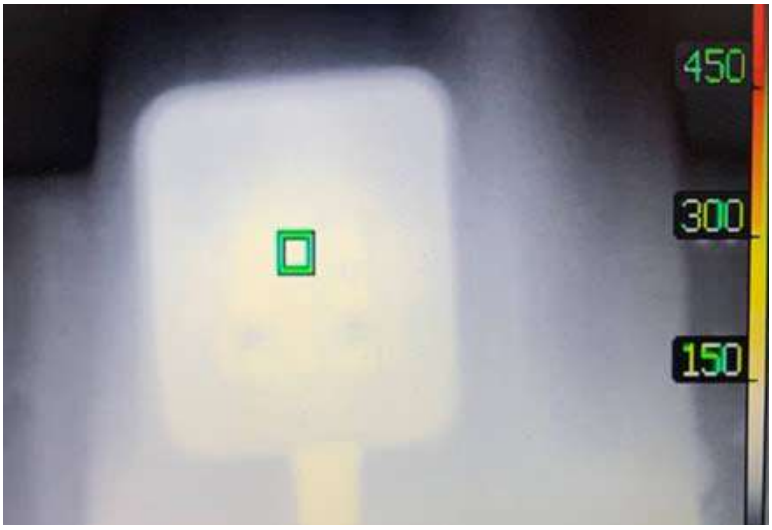

Fig. 4 : An example of temperature distribution (^{0}C) in an electrical load element under the conditions of an oxidized plug and a normal socket

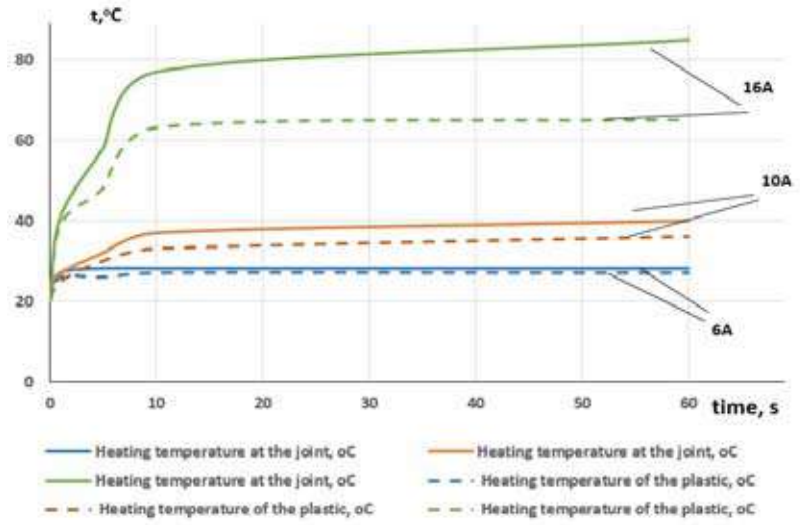

Fig. 5 : The dynamics of temperature values in experiments with an electrical load element with a normal plug and decompressed socket connection contacts

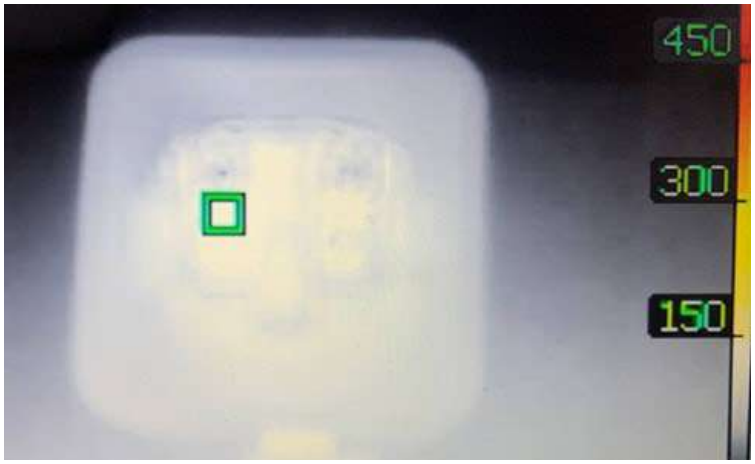

Fig. 6 : Example of temperature distribution (^{0}C) of an electrical load element under conditions of unsatisfactory contact and an oxidized plug.

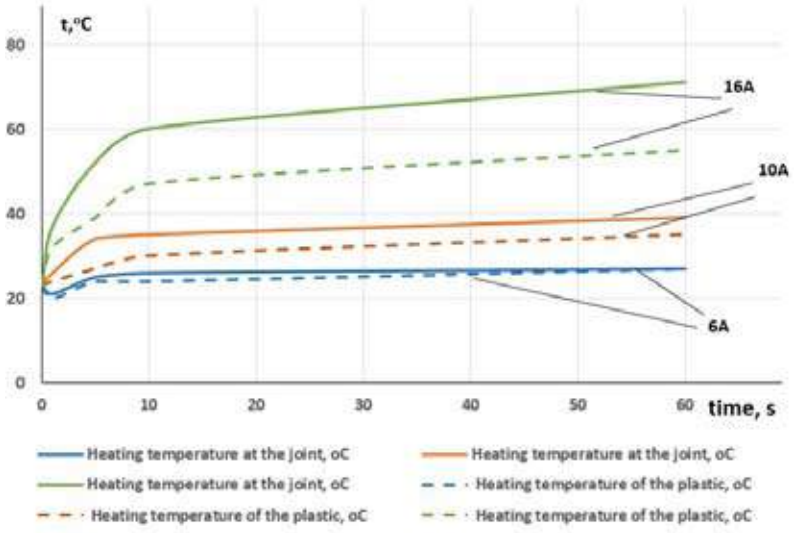

Fig. 7 : Dynamics of temperature values in experiments with an electric load element with a socket with protection and a normal plug.

practical operation is up to - 10-12 minutes [24, 26].

Since long-term use can have certain oxidizing processes for the plug, the experiment with an electrical load element with an oxidized plug and a normal socket can be taken as a typical.

The general type of the researched equipment after conducting experiments is shown in Fig. 11. As you can see, the use of a thermal fuse makes it impossible for the socket elements to overheat and catch fire under the conditions under study.

As you can see from the obtained data (Fig. 3-10), the highest temperature loads occur at the current of 16 A. Accordingly, certain violations in the design of the socket can cause heating and the subsequent potential occurrence of a fire.

As you can see, the worst situation (with tripping of the thermal fuse) occurs in the case of local heating in the electrical load element with a socket with protection and poor contact and a normal plug (Fig. 9), when sudden heating of the socket elements causes the tripping of the thermal fuse.

For a socket with normal contacts (Fig. 3, Fig. 7), as you can see that its long-term use is permissible both under the conditions of an oxidized plug and in the presence of a thermal fuse (heated plastic temperatures below 60 ^{0}C). Whereas for the socket with broken contacts (Fig. 5), there is local heating and an increase in temperature values up to 80 ^{0}C already after 20 minutes under the conditions of applying a current of 16 A and its subsequent gradual increase. In turn, this indicates the potential occurrence of a fire in the future.

Given that work with electrical networks, including the control of the contacts of working household sockets, should be carried out only by specialists, checking the working condition of these sockets can be difficult, especially in places with excessive consumer properties such as technical service station, transport enterprises, shopping areas, etc. Accordingly, the use of a thermal fuse can be recommended in sockets designed for a current of 16 A and located in hard-to-reach places to further increase the safety of operation of electrical networks.

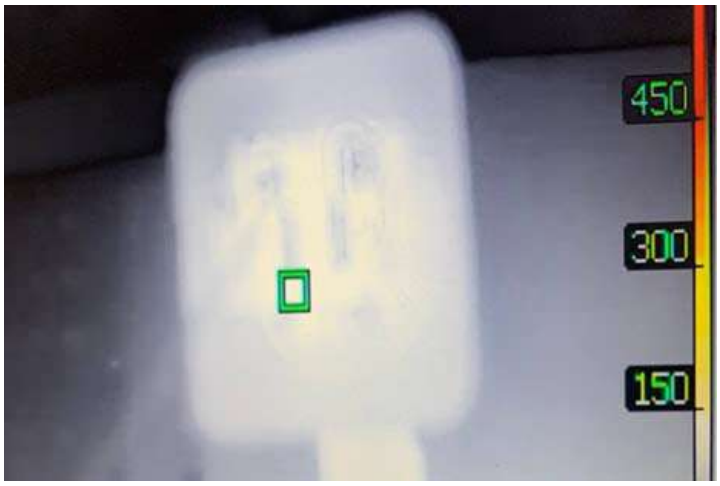

Fig. 8 : Example of temperature distribution (0C) in an element of an electric load under the conditions of the presence of a protection element (socket with a thermal fuse and a normal plug).

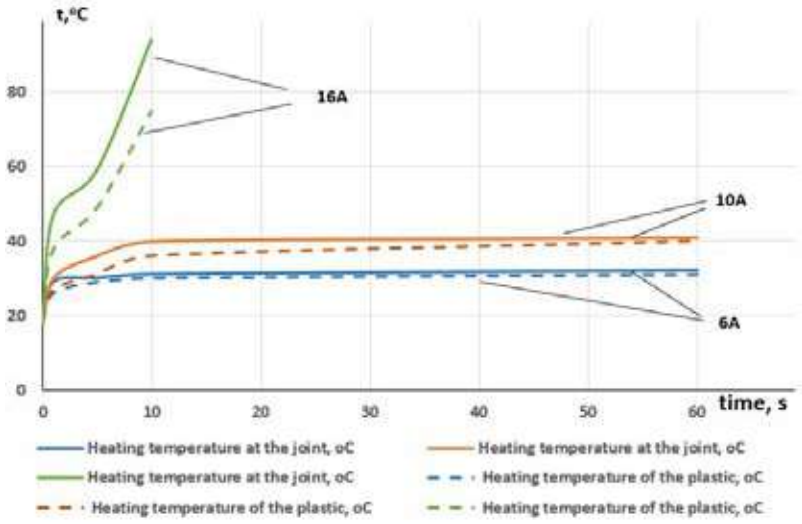

Fig. 9 : Dynamics of temperature values in experiments with an electric load element with a socket with protection and bad contact and a normal plug.

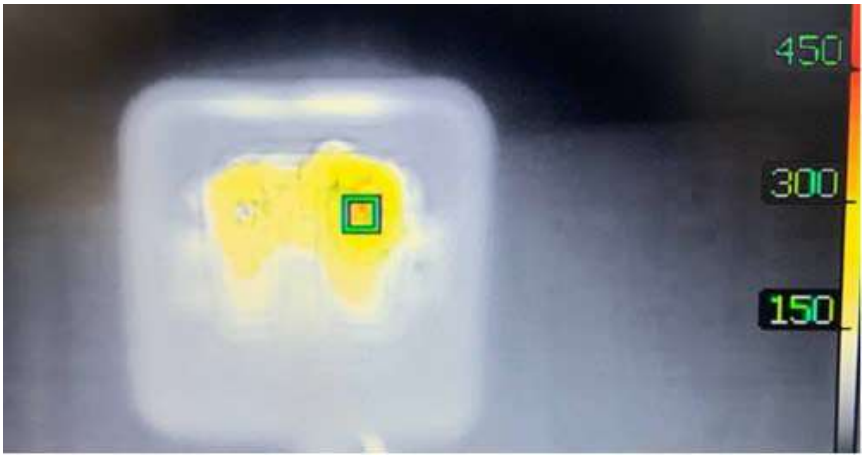

Fig. 10 : Example of temperature distribution (^{0}C) in an electrical load element under conditions of unsatisfactory contact and a normal plug.

4. CONCLUSIONS

Thus, the work analyzes individual components and elements of energy systems that can lead to malfunctions of these systems. The need for further research in this direction is indicated.

On the example of a separate element of electrical networks (sockets), experimental studies were carried out on a modular installation under various conditions of its operation, which can cause its excessive local heating, including with and without the use of a thermal fuse. It shows that the greatest danger can occur when applying the current of 16 A for sockets with affected contacts (above 60^{0}C), while the use of a thermal fuse makes it possible to stop the process of its further heating and ignition.

It is recommended to use a thermal fuse in sockets designed for the current of 16 A and in hard located places with excessive consumer properties such as technical service stations, transport enterprises, shopping areas, etc., to further increase the safety of operation of electrical networks.

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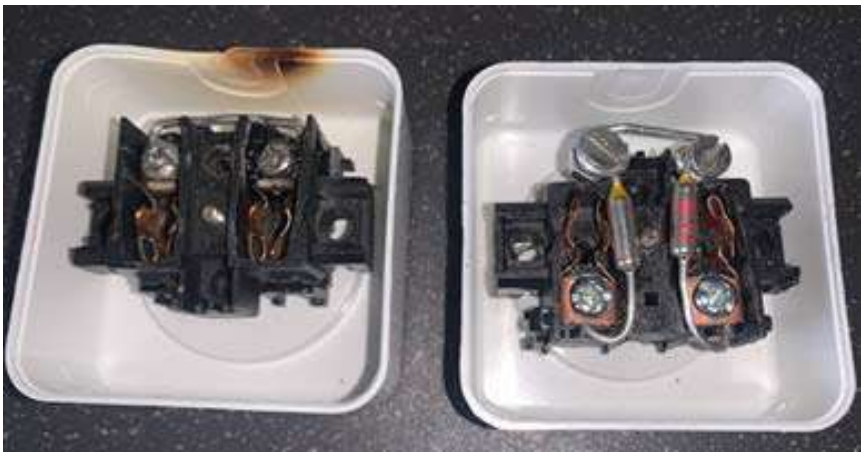

Fig. 11 : General appearance of the equipment after the end of the experiments.

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Use of Condenser Type Bushings for LV side of Transformers

Y.V. JOSHI[1]

PREAMBLE

Winding termination interfaces with bushings shall be designed to allow for repeatable and safe connection under site conditions to ensure the integrity of the transformer in service.

The power transformer has been specified for various types of bushings. Viz. OIP, RIP, RIS & conventional oil communicating. Before availability of Resin Impregnated technology in India, all the HV/IV/TV side bushings used were OIP condenser type. The LV sides (33 kV & below) are terminated through Oil communicating type of bushings.

EVOLUTION OF BUSHING TECHNOLOGY

Reliability Expectations from Transformer Bushings have gained significant attention by end users in view of bad experience of catastrophic failures, loss of power for long time, higher downtime of several weeks, financial losses & urgency to restore the system on failure., etc.

In the event of Failure of Transformer Bushings, sometimes it causes severe irrecoverable damage to transformer and nearby equipments due to catastrophic failure resulting in fire.

The transformer bushings are being evolved over the years based on insulation system used for it. The various types of insulations are being addressed here under.

(1) SRBP / RBP: Resin Bonded Paper Insulation:

First use of this insulation system has been reported in 1913 and this was used for Bushings up to 245 kV Class. However, in view of major failures caused by Partial Discharges (PD), this insulation system is no longer in use. But still there are several bushings reported to be in service around the world.

(2) OIP – Oil Impregnated Paper Insulation:

Transformer Bushings with OIP Insulation System are in use since 1950 & the manufacturing of 800 kV Bushings is reported to be started in 1960s. OIP insulation system is of Thermal "A" class which is suitable for operations up to 105 Deg. Cent. Beyond this temperature it is liable to catch fire due to low fire point of oil used for impregnation.

(3) RIP – Resin Impregnated Paper Insulation:

Bulk commercial use of RIP for Transformer Bushings is reported since ~ 1970s. This is truly a solid insulation system & has become popular as it does not contain oil, which is reported to be main cause of fire / catastrophic failures in OIP Bushings. These Bushings are suitable for operations up to 120 Deg. Cent. However, their failure is of non-catastrophic nature. RIP Bushings are popular & have seen increased usage since 2000, as it does not cause explosive failures like OIP Bushings and are seeing an increased usage by Indian utilities.

(4) RIS – Resin Impregnated Synthetics:

This is a relatively a new development in bushing technology. Bushings with RIS Insulation System have undergone a successful service experience of ~7 years. Since it does not contain insulating paper, it is gaining popularity as RIS does not have adverse effects of Moisture Ingress as reported in OIP & RIP Bushings. It is the latest in dry bushing technology and offer all the distinct advantages of RIP, due to much higher resistance to moisture absorption in event of inadvertent exposure to ambient, as it is a paper free synthetic insulation.

(5) RIF – Resin Impregnated Fiberglass:

This insulation system is reported to be introduced to market in 2003. Again, like RIS, this insulation system does not contain paper. RIF is different than RIS in the Technology by use of fiberglass for manufacturing the condenser core. In RIF, it is reported that in view of limitations on manufacturing, we cannot use higher number of grading foils (like RIP/RIS) and hence RIF Bushings are non-fine graded bushings.

(6) Liquid filled or liquid insulated (oil communicating) bushings:

These are used for low voltages viz. 33 kV and below voltage class of winding for carrying high currents. This bushing contains copper or aluminum rod passing though hollow porcelain insulator. Both ends of rod are terminated through suitable connectors. These are customized to current carrying requirements by individuals.

Today, SRBP / RBP Bushings are no longer manufactured. OIP Bushings continue to be manufactured. However, with RIP / RIS Bushings gaining popularity due to distinct advantage of being oil free it does not cause disruptive failure and fire, owing to which many utilities are adopting RIP/RIS bushings up to 420 kV for new transformers, as well as some progressive utilities have also adopted retrofitting of old OIP bushings with newer RIP/RIS bushings for their existing transformers to increase overall reliability and life cycle of transformers. The manufacturers are now available in India having established localized production and supply of RIP/RIS bushings up to 420 kV. Also now-a-days, oil communicating

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bushings are being replaced by either OIP or RIP condenser type of bushing for higher reliability and safety.

BUSHING FAILURE HISTORY

CIGRE TB 755 has brought out following facts regarding transformer failure due to bushing failures.

(a) IEEE Canadian and American experience stated below bushing failures causes. The bushing population covered is about 67000 bushings, of which about 94 % of them were Oil bushings. Means 90% of these values are contributed by OIP & Oil communicating bushings.

(b) About 35% of transformer failures with forced outages

(c) 47% of bushing failures have a consequence like fire (30,4%), explosion (10,4%), leakages (5,2%) and collateral damages (0,9%).

(d) Bushings are ranked in the third place between transformer parts, after windings (47,4%) and tap changers (23,2%) and before lead exit (6,3%) and core and magnetic circuit (3,8%). Bushings caused 14,4% transformer failures, over all observed voltage ranges.

Limitations of liquid filled or insulated (oil communicating) bushings:

(1) Nonstandard design. For the same current carrying requirement, two individuals can have two different products based on their wit.

(2) No make, hence, no type test being done and no validation of design.

(3) Design solely depends on transformer manufacturer's wit and experience, which do not consider site issues when it is in actual service. The size of rod is arrived with higher current density to reduce sizes.

(4) No oil level monitoring possible.

(5) No insulation test tap. Hence oil inside the bushing cannot be monitored for its condition. Generally, this is part of transformer oil but remains stagnant and may deteriorate faster than transformer oil.

(6) Performance depends on rubber bush provided around current carrying rod at top. Once it loses its elastic property due to heat and moisture.

(7) Rubber quality is not monitored, and every supplier has different size and design which lead to nonstandard product.

(8) High risk of catastrophe. However, for higher safety and to avoid catastrophic failure of transformer nowadays RIP/RIS bushing technology is used for HV/IV/MV windings, but it is not understood as to why the same is not provided on LV side of transformers keeping risk open.

(9) One of the causes of bushing's oil part damage is electrodynamic forces that occur during a short circuit, be it while testing or in-service. Of course, the problem is more often related to LV rather than HV bushings.

Phenomenon of failure mechanism of oil communicating porcelain bushings:

- LV sides have high currents to carry. Hence the conductor rod carrying high current gets heated. The rubber bush around rod is also subjected to same temperature as that of rod.
- The ends of rod are threaded, and connectors are connected at both ends.
- Generally, copper strips at 90 deg to rod are with nuts are used for connection to cables.
- Copper strips are inserted on to rod. The hole punched on strip to insert rod is of higher diameter than that of rod. Some space is left which do not give firm connection. The current also pass-through thread & air space to copper strip resulting into rise in temperature due to higher current density in that area.
- This increased temperature heats the rubber bush making it hard. Over the period it loses elasticity. Due to this it loses to withstand oil pressure coming from transformer tank and oil leakage starts. Oil spill over the porcelain surfaces of bushing. The oil spilled on surface attracts dust particles to stick on it and also absorbs moisture from air, making it sticky and decreases creepage distance. Hence, the surface leakage current increases and over the period tracking starts and ultimately results into phase to ground (TANK) flashover.
- The porcelain shatters and broken parts flew in any direction and hit nearby equipments to damage.
- This is most dangerous condition for transformer as this flashover gives way for oil to catch fire and ultimately it results into catastrophic failure.

REMEDIAL MEASURES

Author have adopted ways to safeguard transformer from catastrophe due to failure of bushing in his utility service.

1. By providing OIP condenser bushing with composite insulator
2. By providing RIP/RIS bushing with composite insulators

OIP condenser bushing on LV side can eliminate risk by some extent. Even when the bushing fails the upper composite insulator will not shatter like porcelain and will not damage any associated bay equipments.

RIP/RIS bushing with composite insulator will eliminate all risks of catastrophic failure of transformer as well as surrounding equipments even when fails.

CONCLUSION

When HV/IV/MV bushings are provided with OIP/RIP/RIS condenser bushings for safety and to avoid catastrophic failure there is no point to keep open the window of catastrophe risk by providing the oil communicating type of bushing on LV side of transformers.

RIP/RIS bushing with composite insulator is the best solution to eliminate all risks of catastrophic failure of transformer due to bushing failure. Most of the progressive utilities have understood this failure mechanism and have adopted philosophy of providing RIP condenser bushings for LV side of any transformers for high reliability and protection against catastrophe failure of transformer due to bushings.

Author recommends for the same based on his wide utility experience.

REFERENCE LITERATURE

- CIGRE: Doc No. 755 (2019) – Transformer Bushings Reliability.
- CIGRE: Doc No. 445 (2011) & Doc No. 642 (2015) – Transformer Maintenance & Transformer Reliability Survey.
- Author's 36 years of experience of major utility who adopted this philosophy

Development of Training Need Analysis Scale for the Utility and Power Sector




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ABSTRACT

This paper explores the Organisation-Task-Person level TNA scale from the utility perspective identifying items to analyse the training needs and develop a measurement scale. The survey-based approach is adopted to validate the instrument developed by the authors following a systematic literature review (SLR) and a pre-testing with experts using Fornell and Larcker's (1981) approach checking the construct validity calculating the Content Validity Ratio (CVR) countering the possibility of endogeneity and common method bias. As an outcome of SLR concerning Training Need Analysis theory and models regarding the Organisation-Task-Person level in the Energy and Power Sector, ten items are identified under the Organisation level. Two antecedents technical and commercial each comprising sixteen items were identified at the task level while thirty-one items were identified at the Person level. The findings and conclusion are expected to help the practitioners, academicians, students, and researchers in the utility sector for training need analysis further, the identified antecedents can be developed in higher education graduates and vocational training trainees to match and fit industry needs.

***Keywords** : Utility Sector, DISCOMS, Power Sector, Training Need Analysis, Scale Development, Construct Validity, Content Validity, Reliability, Organisation-Task-Person level, Performance.*

INTRODUCTION

Indian power sector operational environment is bent to a commercial approach as an outset of reforms, setting up independent regulators, restructuring, privatisation of the sector, unbundling of vertically integrated State Electricity Boards (SEBs) into GENCOs TRANSCOs, and retail distribution companies (DISCOMs) [1]. Subsequently, changing the work orientation, performance requirements, and emergence of technologies and commercial practices for customer satisfaction [2]. Frontline managers (FM) in the field offices act as an interface between customers and DISCOM [3]. FMs use most of the technologies and practices. However, their skills must be updated to match new technology to ensure efficient operations and customer service. The question is which skills and technologies will enhance competency of frontline Managers and which customer services the front-line managers need upgradation. In a brief identify the significant items for FMs training at the organization-task-person level [4]–[6]. DISCOMS and electric utilities require a quality-trained workforce in various areas of expertise to deal with competition and opportunities [7]. TNA models of the past three decades differ in terms of their level of concentration [8]. A statistical methods approach is better than an intuitive and behavioural approach [9]. The O-T-P approach [10] focuses on training prospects for continuously refining performance in the match to expected levels for exemplary individuals or groups [7]. There are few studies on a scale to measure performance focusing on either knowledge/skills or task-work environment variables, but none of them covers both, [11]. The novelty of this study is in developing a scale covering the organization-task-person level such that the commercial and technical aspects are considered at the task stage while at the personal level, this study aims to include the knowledge- skills-attitude items existing scales fail to distinguish between training needs and the organizationally-relevant results of training behaviour [12]. A scale is required to indicate how data might be gathered in order to analyse the reasons for performance

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issues and evaluate whether training is necessary[13]. According to research on scale development, it is important to define what is to be measured with the highest possible precision [14] in our case it is the O-T-P level with respect to (w.r.t) the power sector. Research advocates four stage measurement scale development process starting from literature review or expert validation, face validation, semantic validation, and empirical validation [15]. Five respondents per scale item can be taken as a sufficient sample for statistical validation [16]. Though for the data cleaning and other missing data possibilities it is always advisable to take a minimum sample of 20 respondents [17]. For the present paper, the authors are following the four-step method starting up with the literature review, the authors have done an extensive literature review to reach the items under O-T-P levels[10], [18]–[20], for this author tabulated construct, item, and reference [21] they have further checked at stage 2 and 3 w.r.t. Power sector for the expert's validation at stage one of scale development for creating an operational set of items that accurately reflect the TNA to be measured at O-T-P level.

LITERATURE REVIEW

Several studies have used a combination of real site experience, expert opinion, and literature review to extract items for developing questionnaire statements[11], similar methodology has been adopted in the present study for these power distribution companies (DISCOMs) operating in central India were included for the managers view point and training setup regarding the post-reform role of front line managers (FLMs) related to changes in customer expectations and technology to draft items for the questionnaire. The set up related aspects are compiled in Table 1.

The training literature relates numerous instances which enable organisations to empower their workforce and enhance their skills, and competencies [22]. Tables 2, 3 and Table 4 compile expert opinions and relevant studies to develop scale items on the organisational, task and person level concerning frontline managers' roles.

The reflections of the experts with work experience above Additional Chief Engineer level in power distribution companies, and the independent professionals of the power sector on DISCOMs frontline Managers' customer-related skills and technical skills in matching the relevant reports, research and existing scales following the structured literature review advocated training need analysis at Organisation-Task-Person level. Ten items are identified at the Organisation level. Thirty-two items at the task level are classified into two antecedents technical and commercial, each comprising sixteen items. At the person level three antecedents' knowledge, personal skills, and abilities were identified comprising eleven, six, and fourteen items. The next stage is content validity to make sure that all necessary components are present and unnecessary ones within the domain of a given construct are removed [21].

RESEARCH METHODOLOGY

The viability, legibility, consistency of style, readability and consistency of formatting, and clarity of the expression and language used in the questionnaire items are established through Face validity [19]. Five middle managers and fifteen frontline managers of power distribution companies under study were

Table 1 : Power Distribution Companies of Central India

DISCOM	Training activities and programs
MPERDC	• Institute has facilities for classroom training, conducting practical sessions, demonstrations, seminars, workshops, and field visits for Engineers, Programmers, Account Officers, Testing Assistants, Office Assistants, and Line staff. • Induction program for the newly recruited engineers and administrative staff.
MPWRDC	• The company's training institute organizes in-house and external training. • Induction program for the newly recruited engineers and administrative staff. • Workshops and courses on both functional and operational (supervisor) areas.
MPCRDC	• The company has its Power Distribution Training Centre at Bhopal which is responsible not only to conduct training but also to develop and maintain the necessary training infrastructure, resources, and international tie-ups. • Induction program for the newly recruited engineers and administrative staff.
CSPDCL	• The company has its Central Training Institute in Raipur. • Induction program for the newly recruited engineers and administrative staff. • Accounts and audit training. • Linemen Training Centre to train line staff. • In-house training courses.

(Source: Compiled by the authors. Contribution by authors: Dr Suresh Vishwakarma's Site visits, Personal interviews, Dr Ruchi Tyagi and Dr Shariq Mohammed retrieved information from Company's Annual Reports, and Newsletters)

Table 2 : Expert Opinion and Relevant studies for item statements of level O for O-T-P based TNA scale

Expert Affiliation and Reflection	Relevant Literature
"There is hardly any systematic effort to assess the training needs of frontline managers. Even though executives voice their training requirements in their annual appraisal but the decisions on training are often being taken at the management level without consulting frontline managers and their immediate superiors (middle managers). Frontline managers don't get any other platform to voice their training needs. There are hardly any customer satisfaction surveys to assess rising customers' expectations. They often get pressure from multiple sources." Dr. SM Akhtar, Retired Member (Transmission & Distribution) Madhya Pradesh State Electricity Board, Jabalpur	Training Effectiveness [2]; Training Transfer and Peer Support from co-workers and managers when working in teams[13]; Training Need Assessment at the OTP level [20]; Responsible Training and Performance [20]; Factors inhibiting effective staff training[25]; Managing workplace bullying [3]; Fair training practices [26]; Precarious employment - effective communication [18]; The task and person level are assessed for knowledge and ability[28];Applying knowledge-enabling methods[29]; Stressful working conditions and union dissatisfaction [21]; Designing training and development systems, upgrading skills[11], workplace diversity and skill upliftment[27]. Training analysis is at the Organisation level, especially for workforce diversity [9], OTP model is preferred over performance-based models[12]
"TNA is a part of executives' annual performance appraisal and is shared with the training department. The annual appraisal form collects managers' training needs in their opinion. The outcome of collecting this info is however not encouraging. Decision on the election of participants is sometimes biased. Despite management's initiative, at times participants don't get released for training due to work pressure. A large number of managers do not get any training opportunities for years. The scarcity of resources remains quite often. Rarely customer surveys are conducted to know their changing expectations from DISCOMs. There is a need for systematic efforts." BL Ratley, Retired Superintending Engineer, Madhya Pradesh State Electricity Board, Jabalpur.	
"The mid-term and annual appraisals allow all executives to document their concerns and training needs to perform better. Comments of their superiors are then collected before routing the appraisal forms to the management. Management, together with the departmental heads, reviews the comments and makes decisions on training. Systematic efforts to carry out periodic customers-survey are needed to understand their needs. There is often pressure to meet deadlines and targets" NR Vishwakarma, Retired Superintending Engineer, Madhya Pradesh State Electricity Board, Jabalpur	

(*Source*: Compiled by the authors. Contribution by authors: Dr Suresh Vishwakarma's interviews with the resource person; Literature Review by Dr Ruchi Tyagi and Dr Shariq Mohammed)

Table 3 : Expert Opinion and Relevant studies for item statements of level T for O-T-P based TNA scale

Expert Affiliation and Reflection	Relevant Literature
"Quick restoration of power supply if there is an interruption. A clean power supply is a new aspect, pollution-free power supply is the requirement for present-day consumers. Frontline managers with upgraded technical and commercial skills are required to provide cheap power with 100% recovery of the cost of power along with a return on capital investment. They must have better interaction with all stakeholders. They should be good at data analysis." Dr R.P. Bhatele, Retired Executive Director, Madhya Pradesh State Electricity Board.	Customer care executives are the voice of the franchisee; thus, it is very important to build the capacity of the executives on the various aspects related to faults and complaints [7]. By offering customers an array of service options corresponding to different levels of reliability and prices, with higher reliability plans carrying higher prices, retailers could unlock both additional revenues flowing into the power sector from end users and a higher level of welfare for those users [13]. At times frontline managers are caught in the middle between discerning customers' service excellence demands and management's productivity and performance requirements. Also, they often need to participate in unscripted and challenging interactions with customers[14]. There is a demand & supply gap, felt in the power sector be it by the people and/or industry yet Industry is not getting what they require in terms of qualitative inputs the industry requires from the new entrants to the industry. The HR Team in addition the to power sector needed skills have also to focus on communication skills, lifelong problem-solving, professionalism, and teamwork. Frontline employees are perhaps the most critical link in the provision of superior service to customers and their actions [15]. Customers' opinion of overall service quality is very much influenced by the impression when they encounter front-line staff. Providing the right quality staff is even more important than having the right number of staff in any company [10]. Decisions on new capacity and operations will have to be made with a view to its costs and expected revenues [9].
"Improved the customer complaints, better customer interaction, quick supply restoration, consumer data, and monitoring reports, upgraded technical and commercial skills, efforts for clean power, etc." C.P. Sharma, Retired Executive Director (Commercial), Uttarakhand Power Corporation Limited, Dehradun.	
"They must have customer orientation and customer interaction and relationship management skills, good business communication, negotiation skills, and interpersonal skills with emotional intelligence. They should be able to encourage customers to clean power by giving supporting data. They should be prompt in supply restoration and resolving technical & commercial issues." P.A.R. Bende, Executive Director, Madhya Pradesh Power Transmission Company.	
"Customer interaction, clean power, prompt supply restoration, fault data-analysis, are the few newly emerged technical and commercial skills in which DISCOMs' frontline managers need training." S.K. Chaudhary, Principal Director, National Power Training Institute, Faridabad.	
"Technical areas include quick supply restoration and clean power. Commercial areas include meter management, an updated customer database, better customer interaction, and a billing system. They need to be trained on these skills"- Indu Maheshwari, Deputy Director, National Power Training Institute, Faridabad.	

(*Source* : Compiled by the authors. Contribution by authors: Dr Suresh Vishwakarma's interviews with the resource person; Literature Review by Dr Ruchi Tyagi and Dr Shariq Mohammed)

Table 4 : Expert Opinion and Relevant studies for item statements of level P for O-T-P based TNA scale

Expert Affiliation and Reflection	Relevant Literature
"Engineers are not performing their exact duties, as there is no guidance given by the top management and non-availability of the technical map. They are only concentrating on the recovery of the revenue and not on the technical aspects of it. Engineers are not trained on SCADA, IT applications, reducing system losses." K.M Saxena, Retired Member (Transmission & Distribution), Madhya Pradesh State Electricity Board.	Enterprise Resource Planning (ERP) enables an environment for the integration of utility applications[25]. More than 60% of Indian state utilities have not yet implemented ERP solutions to integrate their business [15]. The success of an ERP implementation project depends on meeting some critical factors, including top management involvement & support, organisation culture improvement towards ERP system adaptability, and user involvement and training[11] As the power industry evolves, utilities will have to change the profile of their professionals from technical experts focused on technical excellence to new professionals who possess the management, analytical and commercial capabilities. Power companies are shifting to more complex, data-driven, "smarter" technologies [18]. The crux to increasing power's reliability lies in the capability to remotely observe and control the distribution network. Customization of the SCADA system to suit the needs of the network, and training of operators lays the ground for the automation drive. Adoption of new technology, improvement of processes, and solving encountered problems in a novel way has formed the gamut of technological innovation [10]. In his discussion paper, Lighting the Way: Unlocking Performance Gains in Electricity Distribution and Retailing in India' concludes that the poor management practices at Indian DISCOMs present obstacles to more efficient operation and improved financial performance by distributors [16]. Low levels of computerization and inadequate IT systems at DISCOMs make it difficult to track sales and collection rates [17]. At the corporate and field level, there is a distinct skill gap which has arisen due to a lack of knowledge upgradation of experienced staff or the absence of skill transfer to the newly employed staff. Both existing employees and recruits need an update on technological scenarios. A core team should be identified and trained in the pilot locations selected for commercial process improvement and reduction of AT&C losses [19]. Due to the technology-intensive nature of the business, technical and managerial competency is critical. Training requirements in the power sector include mandatory training after induction, refresher courses for keeping the personnel updated and building competencies [20].
"Electronic meters, computerized billing, IT applications, online accounts, reducing AT&C losses, revenue recovery, SCADA, and smart grid are the newly emerged areas in which DISCOMs' frontline managers need training. Top management should review their training practices" S.K Chaudhary, Principal Director, National Power Training Institute, Faridabad	
"Technical areas for training include IT, SCADA, distribution automation, energy auditing, reducing system losses, energy accounting, timely revenue recovery, GIS etc. Top management needs to emphasise training activities" Indu Maheshwari, Deputy Director, National Power Training Institute, Faridabad.	
"Frontline managers now require IT skills, using SCADA and DSS tools, analytical skills for reducing losses and revenue recovery, working with ERP, MIS, DMS, EA etc. Support of top management is anticipated" P.A.R. Bende, Executive Director, Madhya Pradesh Power Transmission Company.	
"Reducing AT&C losses, recovery of revenue in a scientific manner with IT inputs, SCADA, and using a computer for analysis are the areas of frontline managers' training. Training budget and support of top management are required" RD Agarwal, Retired Chief Engineer, Madhya Pradesh Western Region Power Distribution Company.	

(Source: Compiled by the authors. Contribution by authors: Dr Suresh Vishwakarma's interviews with the resource person; Literature Review by Dr Ruchi Tyagi and Dr Shariq Mohammed); *SCADA stands for Supervisory Control and Data Acquisition

randomly selected [14] to respond to the evaluation form for the face validity on a Likert scale of 1-4, from strongly agree = 1 to strongly disagree = 4. Table 5 (a & b) tabulates the distribution of the face validity responses collected on the questionnaire evaluation form.

Criterions received most responses under 1 (strongly agree) and 2 (agree). 93% in Table 5(a) and 80% in Table 5(b) of respondents indicated they understood the statements clearly. 80% of respondents rated them as easy to answer. While 87% regarded the questionnaire's layout and style as acceptable for target respondents. Using a quantitative method [19,20], the content validity of the questionnaire was carried out following the below-mentioned steps:

Table 5(a) : Face Validity Evaluation Form - Frontline Managers' response

S. No.	Criterion	Strongly Agree	Agree	Disagree	Strongly Disagree
1	The wording of statements has clarity.	14	1		
2	Respondents are likely to be able to answer.	12	3		
3	The layout and style of the questionnaire are good.	13	2		

Table 5(b) : Face Validity Evaluation Form - Middle Managers' response

S. No.	Criterion	Strongly agree	Agree	Disagree	Strongly disagree
1	The wording of questions has clarity.	4	1		
2	Respondents are likely to be able to answer.	5			
3	The layout and style of the questionnaire are good.	5			

1. A sample of statements included under Organisation items, task items, and person items on determining the training needs of Front-line managers are constructed from the reflections of the power sector experts and officials who served in the decisive position in the power distribution companies. This led to the creation of the content validity questionnaire and questions.
2. A content evaluation panel, A total of 12 power sector experts were identified based on their experience and availability to participate with erstwhile SEBs (four experts) or with lately formed DISCOMs (eight experts).
3. The questionnaire was given to each panellist expert. On a three-point scale, the experts were asked to independently reply to each issue pertaining to a certain construct, where: "1= not necessary", "2= useful but not essential" and "3=essential". They were also requested to provide additional comments (if any) on their understanding of items, or any new items to be added.
4. The responses received from all experts were then compiled. The responses indicating "essential" for each item were counted.
5. The content validity ratio (CVR) for each item was estimated utilising the formula CVR = [(n - (N / 2)) / (N / 2)] [26], [27], where N is the total number of respondents and n is the frequency count of the number of experts rating the item as "3=essential".
6. Finally, the CVR value of each item was examined for its significance employing the standard table [21]. Item is accepted if the estimated CVR value is equal to or above the standard value [22]; otherwise, it is rejected [21,22]. The significance level (standard value) depends upon the number of experts rating the item [35]. CVR was then estimated and evaluated for a statistical significance level of 0.05 using Lawshe's (1975) method. This process was undertaken for each item included in the questionnaire. Entries with a significance level < 0.05 were eliminated. Table 6 summarises the CVR derived for the organisational items (10), task items (32), and person (31) items determining frontline managers's training need crucial and recommended to include every single one of them in the questionnaire (the CVR value is significant at 0.05 level).

Table 7 shows the overall items, average CVR and average mean for the items to be included in the construct.

The average CVR value for all items ranged between 0.96 and 0.87 at the 0.05 level of statistical significance [28]. CVR can measure between -1.0 and 1.0. The closer to 1.0 the CVR is, the more essential the object is considered to be [29]. The results illustrated that the data collection instrument possesses a high level of content validity, which means that all items were representative of a construct universe and to be included in the questionnaire.

FINDINGS AND DISCUSSION

Discriminant validity is checked by establishing measure has a low correlation with another measure [28]. If the average variance extracted for each construct is greater than the square of correlations between a given construct and all other constructs verifies Discriminant validity [27]. Table 8 (a,b,c) verifies discriminant validity for the construct's O-T-P items as the variance extracted between all components of organisational-task-person items is greater than the correlation square between them.

The Organisational [O] level items for determining the training needs of frontline managers are the support and care of superiors despite changes in the work environment [O1], antagonise by colleagues and superiors [O2], transparency on training programs [O3], Job demand of individual and workgroup Job [O4], peer support in the transfer of training [O5], performance feedback on

Table 6: Content Validity Ratio Summary (O-T-P items)

CVR	Organisation items	Task items	Person items
0.90 – 0.99	8	15	22
0.80 – 0.89	2	10	5
0.70 – 0.79	0	0	0
0.60 – 0.69	0	7	4
0.50 – 0.59	0	0	0
0.40 – 0.49	0	0	0
0.30 – 0.39	0	0	0
0.20 – 0.29	0	0	0
0.10 – 0.19	0	0	0
0.00 – 0.09	0	0	0
Total	10	32	31
R.L.H.	0	0	0
Grand Total	**10**	**32**	**31**

Legend: *= Not Significant, R.L.H.= Items that rated essential by less than half of participants

Table 7 : Construct Validity (O-T-P items)

S. No.	Construct	Total items	Significant items	Average Content Validity Ratio	Average Mean
1	Organisation items	10	10	0.96	2.98
2	Task items	32	32	0.87	2.94
3	Person items	31	31	0.92	2.96

Table 8 : Discriminant Validity (O-T-P Items)

Table 8a : Discriminant Validity (O-Items)

	Component	1	2	3	4	5
	1					
Correlation Correlation² Var. Extracted	2	.026 .000 .7135				
Correlation Correlation² Var. Extracted	3	.028 .000 .8326	.245 .060 .6756			
Correlation Correlation² Var. Extracted	4	.022 .000 .7999	.049 .002 .6429	.134 .017 ,7620		
Correlation Correlation² Var. Extracted	5	.076 .005 .6834	.090 .008 .5264	.173 .029 .6455	.086 .007 .6128	

Table 8b : Discriminant Validity (T-Items)

	Component	1	2	3	4	
	1					
Correlation Correlation2 Var. Extracted	2	.676 .457 0.5254				
Correlation Correlation2 Var. Extracted	3	.362 .131 0.5855	.316 .099 0.9223			
Correlation Correlation2 Var. Extracted	4	.208 .043 0.6255	.291 .084 0.6189	.158 .025 0.6790		

Table 8c : Discriminant Validity (P-Items)

	Component	1	2	3	4	5	6	7	8
	1								
Correlation Correlation² Var. Extracted	2	.295 .087 .6155							
Correlation Correlation² Var. Extracted	3	.283 .080 .6256	.242 .058 .6325						
Correlation Correlation² Var. Extracted	4	.344 .118 .5531	.449 .201 .5600	.325 .105 .5710					
Correlation Correlation² Var. Extracted	5	.290 .084 .5647	.192 .036 .5716	.316 .099 .5817	.235 .055 .5091				
Correlation Correlation² Var. Extracted	6	.384 .147 .5656	.372 .138 .5726	.278 .077 .5826	.309 .095 .5101	.106 .011 .5217			
Correlation Correlation² Var. Extracted	7	.007 .000 .5663	.044 .001 .5733	.182 .033 .5834	.010 .000 .5108	.031 .000 .5224	.063 .003 .5234		
Correlation Correlation² Var. Extracted	8	.378 .142 .5700	.277 .076 .5769	.079 .006 .5870	.174 .030 .5145	.215 .046 .5261	.352 .123 .5270	.063 .003 .5278	

training transfer [O6], well-planned training with enough budget [O7], Networking possibilities to communicate and share learned skills [O8], political group pressure on management to change training decision [O9], peer and union pressure on management to change training decision [O10]. The task items are categorised under technical [Tt] and commercial [Tc] headings for scale item specification and clarity [14], the task-level items for determining the training needs of frontline managers are- assessing changes in customers' monthly electricity consumption [Tt1], Identify and evaluate the upcoming customer expectations regarding services [Tt2], electricity tariff slabs information and advice to increase customer knowledge on company services [Tt3], Telling customer on electricity theft penalty [Tt4], Telling the customer about drawbacks of low power factor installation [Tt5], Telling the customer about drawbacks of unbalanced load in their installation [Tt6], Telling the customer about paybacks of using energy-efficient appliances in their installation [Tt7], Informing and educating customers sufficiently on their electrical installation and shortcomings if any [Tt8], advising customers sufficiently on the Installation related safety issues [Tt9], Informing and educating customers sufficiently on energy efficiency measures [Tt10], Informing and educating customers on the Government schemes and the role of Bureau of Energy Efficiency for them [Tt11], commercial approach while being technical at work [Tt12], Informing and educating customers to increase revenue of DISCOMs [Tt13], Appropriately resolving customer grievances related to services and bills [Tt14], set appropriate efforts to decrease supply outage [Tt15], proficiency to handle customer issues and settle them reducing customer grievances [Tt16], Informing and educating customers effectively on the duties of electricity consumers [Tc17], appropriate behaviour to customers [Tc18], ensuring quality services towards customers [Tc19], understanding customers' requirements and outlooks [Tc20], representing trust and understand customer feelings, showing empathy while listening to customers' evidences [Tc21], being appropriately inspired and professional to progress DISCOM by performing best customer

services [Tc22], considering and resolving customers' problems creatively [Tc23], influencing customers through positive and responsible behaviour to DISCOM customer [Tc24], genuine, transparent and responsible approach towards customers [Tc25], tracking and follow-up of pending-undecided-awaited grievances [Tc26], respectable communication and public relations performance at job [Tc27], cost conscious behaviour and performance at work and efficient customer services [Tc28], capable of collaboratively working out win-win situation to DISCOM customers [Tc29], customer-friendly DISCOM image among the electricity consumers [Tc30], working with fellow being and team spirit at workplace [Tc31], accuracy and systematic approach in day-to-day activities and DISCOM's work [Tc32]. The person items are categorised in knowledge [Pk], personal skills [Ps] and abilities [Pa] headings for scale item specification and clarity [14]. The statement under each category are as follows: Setting and adjusting contemporary digital relays [Pk1], promoting the distributed generation in remote areas [Pk2], simulating medium and low voltage network study by means of power system software [Pk3], installing appropriate switch gears at the appropriate place in the system [Pk4], Recognize and categorise work-related issues, then use the information provided to derive as many conclusions as possible [Pk5], anticipating the outcome at short and long term period of FLMs' activities and decisions [Pk6], Knowledge of tariffs, surcharges, and penalties as per present policy and norms [Pk7], quality analytical and numerical reasoning for better and effective performance [Pk8], monitoring and follow up progress and work quality at individual and team level for effective performance and output [Pk9], financial methods, information, and standards to prevent fraud [Pk10], knowledge of audit procedure and compliance information [Pk11]. Investigation skills if the same technical fault reoccurs in a similar feeder/area [Ps12], employing utility software to reconfigure the network for more effective technical solutions [Ps13], designing work in alignment with staff and allocating and assigning tasks to achieve performance targets [Ps14], commitment and respect for work ethics and organisational rules and integrity [Ps15], commercial solutions of utility issues increasing revenue [Ps16], need-based commercial and technical programs for work role [Ps17]. feeder wise consumption and energy bill investigation [Pa18], commercial and technical loss assessment in the system [Pa19], encouraging demand side management at DISCOM end [Pa20], promoting demand side management at user end [Pa21], endorse energy efficiency steps [Pa22], producing unbiassed decisions by means of stakeholders' grievance handling case examples [Pa23], showing empathy and trust, hearing the truth, and understanding feelings [Pa24], identifying tasks, evaluating their importance, and setting their priorities to achieve better results [Pa25], changing old habits at work without or with less support for new abilities and behaviours [Pa26], influencing others in a way that results in acceptance, agreement, or behaviour change [Pa27], loyalty towards DISCOM in preparing it to make a positive difference in the future [Pa28], Resolving workplace issues and ensuring a cordial working environment [Pa29], fast decision-making and amicable responses for unforeseen [Pa30], presenting stakeholders with constructive criticism and showing interest in them [Pa31]. Table 9 displays Cronbach's alpha value for the construct on the full scale resulting above 0.60 and up to 0.70 highlighting data are free of bias [29].

CONCLUSIONS

Organisation-Task-Person scale from the utility perspective to identify and analyse the training needs is validated using the survey approach and Fornell & Larcker's (1981) method by calculating the CVR for avoiding the possibility of endogeneity and common method bias. The construct includes the Organisation (10 items)-Task (32 items divided equally into commercial and technical role statements) -Person (31 items divided into knowledge (11), personal skills (06), and abilities (14)) levels for the Energy and Power Sector frontline line managers training need analysis in brief O-T-P (10-32-31) items. This study is a good source for scale development and measurement, especially from operational and field perspectives. The items for training need to construct prioritises on skills for the utility sector which can be a focus area for vocational training. The construct also highlights graduate skills from a higher education viewpoint.

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Table 9 : Reliability

(N=156)

Middle Managers (n=78)	Cronbach's Alpha value	Items	Front Line Managers (n=78)	Cronbach's Alpha value	Items
O-Items	.701	10	O-Items	.625	10
T-Items	0.615	32	T-Items	0.705	32
P-Items	.703	31	P-Items	.652	31

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Local Issues & Mitigation Measures for Hydro Projects in Himalayas-NHPC's Initiative Towards Seismic Safety & Landslide Assessment

S.L. KAPIL[1] AND P. KHANNA[2]

1. INTRODUCTION

Himalayas the mighty mountain ranges span almost the entire breadth of 2500km of the Indian subcontinent. They are examples of mountain ranges formed by two continental plate collision between Indian plate and the Eurasian plate. Because of this typical geography Himalayas are home to frequent seismic activity. Himalayas are also blessed with some mighty rivers with great power potential trapped within them. Any attempt to develop these natural resources into a major energy source in form of Hydroelectric projects is dealt with lot of public hue and cry. Because of this hydropower's share in total energy generation has plummeted to just 15%. In face of drought and flood conditions faced by different parts of the country along with severe power shortages constantly faced, construction of Dams can come as relief to the public. One question which is often raised amidst all this is- **are the Dams built in the Himalayas worth building considering the risks involved. In response to this it is well known that till date not a single dam built in the Himalayas has failed due to earthquakes. Some of these projects are running for more than three decades and have withstood the test of earthquake shaking some as big as 7.9M.**

When it comes to water management on large scale agrarian country like India needs Dams for water storage for adverse times considering the situation faced by the country in past few years. So building of dams will be a big step towards mitigating drought and flood control measures. It is also a fact that earthquakes don't kill but the randomly constructed structures which do not follow the stringent IS codes laid down for aseismic design of structures are the major cause of destruction. Earthquakes can't be controlled but what can be done is to design earthquake resistant structures. The seismological issues have been one of the major hurdles which have led to stalling of some major hydro projects in Himalayas for considerable periods, few examples being Tehri HEP and Subansiri Lower HEP which have in turn caused huge losses to the nation in terms of revenue. NHPC as the leader in hydro sector has taken several measures to ascertain safe design of its structures and to educate the local population.

Landslides and vibration generated due to blasting also remain active issues in most of the hydro projects. NHPC also made sincere efforts to address these issues.

2. BACKGROUND

In spite of all these facts, in recent times questions have been raised on construction of dams in seismically active Himalayan terrain. If designed with great care, taking into consideration the seismicity factors during design and construction of these structures, they perform safely and contribute to the economy of the region. Countries like China and Japan with very high seismicity incidences have successfully built some biggest dams of the world which are functioning safely. In the Indian context also, this fact is strongly supported by the performance of the hydroprojects in high seismicity region of the Himalayas which have withstood some of the big shocks felt in the last decade in the Himalayan belt ranging from Jammu and Kashmir to the NorthEastern region. Example of NHPC projects performance during Himalayan earthquake occurrence is shown in table 1.

From above table it is clearly evident that even though these big Himalayan earthquakes caused large scale destructions in the Indian states and adjoining countries, the operating power stations of NHPC some as close as only about 50km from epicentre performed well without any damage to the structure or its functioning.

3. HIMALAYAN SEISMICITY & NHPC PROJECTS

The intense tectonic activity owning to the crustal movements due to regional continental continental collision and crustal thickening along with mountain building, resulted in the formation of young mountain chains like Himalayas which are still dynamic and rising at about 2cm/yr. All the stresses building up in the Himalayan arc because of the ongoing tectonics results in building up of stresses and incidences of high seismicity NHPC is the leading hydro developer in the country with most of its projects lying in the Himalayan belt Because of this NHPC projects and Himalayan seismicty go hand in hand.

The entire Himalayan belt has been categorized in zone IV/V as per BIS-1893-2016 (part-1)-Criteria for Earthquake resistant design of structures. Because of this all the hydro projects of NHPC in the Himalayas from J&K to NE India fall in the highest seismic zone of the country (Fig. 1.)

Hence, it becomes all the more important that NHPC develops a strict SOP for seismic monitoring of its project. Main

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S. No.	Earthquake Event (Date & Location)	Magnitude of event	NHPC projects within 100 km radius	Distance from epicenter
1.	**8th Oct 2005 Kashmir** earthquake 19 km northeast of the city of Muzaffarabad, (epicentre 34.45°N 73.65°E) (Pakistani territory of Azad Kashmir)	7.6	Uri I	53 km
2.	**18th Sep. 2011 Sikkim Nepal earthquake** (epicentre 27.7^0 N 88.08^{0}E)	6.8	• Teesta V HEP • Rangit Power station • Teesta Low dam III • Teesta Low dam IV	• 56 km • 53 km • 82 km • 88 km
3.	**25th April 2015 Nepal earthquake** 81km from Kathmandu (**28.1 N 84.6 E**) and its aftershocks **Aftershock 1** Date of occurrence: 25th April 2015, Magnitude 6.6 Epicenter: 28.1 N 84.8 E **Aftershock 2** Date of occurrence: 26th April 2015, Magnitude 6.9 Epicenter: 27.6 N 85.9 E **Aftershock 3** Date of occurrence: 27th April 2015, Magnitude 5.1 Epicenter: 26.7 N 88.1 E	7.8	• Rangit Power Station • Tanakpur • Teesta – V Power Station • DhauligangaPS • Subansiri Lower Project	Ranging from 68 km upto 500 km for main and after shocks
4.	**3th Jan. 2016 Tamenglang district of Manipur** (epicentre 24.8N, 93.5E).	6.7	Loktak	53.5 km
5.	8th Nov.2022 Uttarakhand event; Epicenter: 29.24N, 81.06E	6.3	Dhauliganga Tanakpur	94 km 97 km

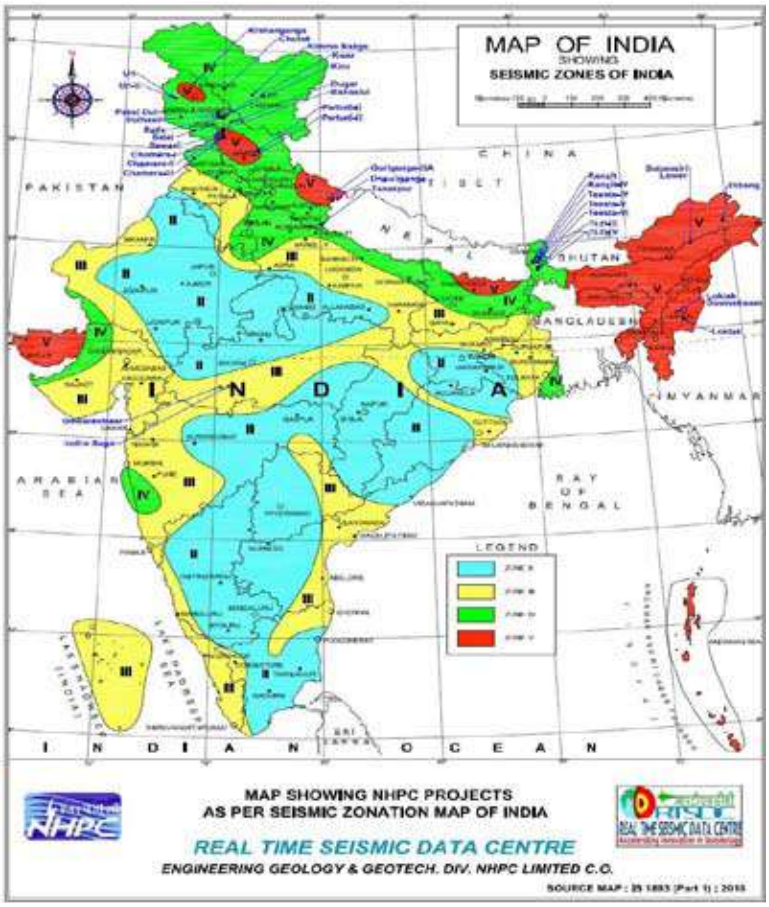

Fig. 1 : Location of NHPC projects w.r.t seismic zones of the country

codes of practice governing our hydro projects followed by NHPC in line with its total commitment and dedication towards seismic safety of its structures are as under:

- BIS-1893-2016; Part 1, Criteria for Earthquake Resistance of structures defining the zone and factors for SDP studies.
- NCSDP guidelines for undertaking Seismic design parameter studies of project issued by CWC in Oct. 2011. The studies are taken up in accordance and detailed documents submitted for approval prior to design.
- Seismic monitoring and surveillance as per Dam Safety Act, Dec. 2021 issued by GoI

4. NHPC'S COMMITMENT TOWARDS SEISMIC SAFETY

NHPC carries out its seismic monitoring for any project in a very structured manner. These measures are categorized as under:

A. Investigation stage measures:

- *Site Specific Seismic Design Parameter Studies* : During Survey and investigation stage of any project, once the project features and its location is firmed up, then a detailed site specific seismic design parameter study as per the NCSDP guidelines, CWC, GoI is carried out considering both Probabilistic & Deterministic Hazard analysis. This study report is then submitted to the National Committee and once approved, the parameters are used for seismically safe design of our structures.
- *Specialized Seismological Studies like* MEQ (Micro Earthquake), LET/MT studies are taken up for projects of height greater than 100m lying in zone II,III, IV, V. LET/MT studies are taken up for projects of height greater than 200m and lying in seismic zones IV/V. These studies assess in a precise way the following:

  NHPC has conducted these pre construction specialized seismological studies for projects like Bursar & Kwar (J&K), Subansiri Lower Project & Dibang MPP (Arunachal. Pradesh), Indirasagar (MP), Tamanthi (Myanmar) & Chamkarchu-I (Bhutan).
- *Liquefaction assessment* Liquefaction is the phenomenon of transformation of a granular material from a solid to liquefied state as a consequence of increased pore water pressure and reduced effective stress. (Marcuson, 1978). The change of state occurs most readily in loose to moderately dense granular soils with poor drainage, such as silty sands or sands and gravels capped by or containing seams of impermeable sediment. As liquefaction occurs, the soil stratum softens, allowing large cyclic deformations to occur. In loose materials, the softening is also accompanied by a loss of shear strength that may lead to large shear deformations or even flow failure under moderate to high shear stresses, such as beneath a foundation or sloping ground. If not taken care of Liquefaction failures can cause great losses. NHPC has developed inhouse expertise in assessment of liquefaction potential for foundation material. Detailed assessments were carried out for Pakal Dul project, J&K & Dagmara HEP, Bihar utilizing the SPT N values and MASW shear wave velocity values. Fig.2 gives the depth to the identified liquefiable zone for barrage area of Dagmara project.

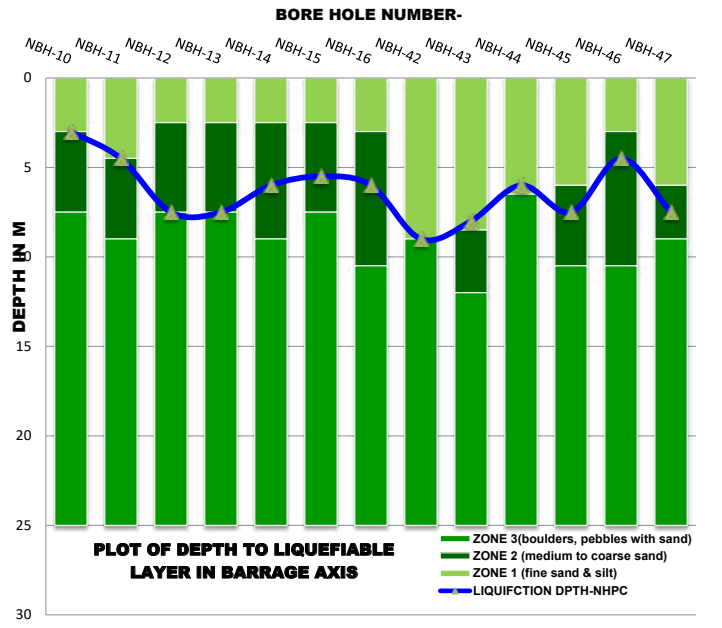

Fig. 2 : The depth to the identified liquefiable zone for barrage area of Dagmara project

B. Construction stage measures:

I. *Reservoir Trigerred Seismicity Studies*

From time to time NHPC projects have to address the fear psychosis of public related to occurrence of seismic activity during reservoir operation in a project. In Teesta IV HE project, Sikkim, NGT Eastern Zone Kolkata in the final judgement dated 15/11/17 in Appeal No. 11/2014/PB/5/EZ had directed NHPC to fulfill the following conditions:

- The project proponent shall prepare a mitigation plan to prevent reservoir Induced seismicity due to Teesta IV Project for consideration and approval of MoEF & CC.

In this connection NHPC prepared inhouse a detailed mitigation plan for RTS and presented it to MoEF. After hearing MoEF granted clearance to the project w.r.t RTS. Some of the details of the proposed plan are reproduced here and they can in general be applied for any Himalayan project.

In general it is observed that the Himalayas have a thrust environment and no incidence of RTS has been observed in the prevalent tectonic regime of the Himalayas. Till date no incidence of RTS has been reported from any hydro project developed in the Himalayas. Some major hydro projects running successfully in the Himalayas for the past several decades without any incidence of RTS are Bhakra project (Dam Height: 226m, Reservoir Capacity: 7.55 BCM), Chamera HEP-I (Dam Height: 140m, Reservoir Capacity: 391 MCM) Salal HEP-I&II (Dam Height: 118m, Reservoir Capacity: 284MCM) and Teesta V (Dam Height 88.6m, Reservoir Capacity 13.25MCM) and Tehri project (Dam Height: 260.5m, Reservoir Capacity: 3.54 BCM).

The seismicity data for Tehri dam is being monitored for last several decades with the objective of RTS. Department of Earthquake Engineering, Indian Institute of Technology Roorkee has been monitoring the local seismicity in Tehri region on behalf of the Tehri Hydro Development Corporation (THDC),

India Ltd. for the last more than twenty five years and the studies have been indicating that there does not exist any RTS activity till now. (Kumar et al, 2010, Sharma et al, 2014). With most of the large hydro projects running successfully in the Himalayas without any incidence of RTS till date, it is observed that the thrust environment of the Himalayas has a major role to play in abetting any RTS. *Moreover, a prerequisite for reservoir-Triggered seismicity is availability of critically stressed rock strata within shallow (~10 km) depths, so that the pore fluid pressure increases and/ or incremental stress due to reservoir loading could trigger failure. This is obviously not the case in the foothills of the Himalaya, where a thick strata of relatively mechanically incompetent sedimentary formations exist. In general, the earthquakes in these regions have focal depths in excess of 20 km. (Harsh K. Gupta and Kusala Rajendran 1986).*

Out of the three identified cases of RTS in the Himalayan region two cases are of Mangla and Tarbela dams in Pakistan and Bhakra Nangal dam in India. There does not seem to be any relation between seismic activity and the Govind Sagar Reservoir created by the Bhakra Dam. On the contrary, in all these cases the effect of reservoir in the seismicity of the area is the reduction in the earthquake activity (Gupta H. K. , 1992). Construction of these projects has resulted in mobilizing the stresses towards a stable environment. Almost all the reported cases of RTS in India are from peninsular India.

(a) Suggested Plan for RTS Assessment

(i) **Identification**: In order to establish a correlation between Reservoir impoundment & RTS, it is suggested to collect the seismicity data of at least a year before impoundment of a large reservoir (dam height >100m, reservoir volume >500MCM). According to NCSDP guidelines the seismicity data around the project needs to be collected for at least a period of six months. This period can be stretched upto a period of one year before reservoir impoundment to get meaningful pre impoundment seismicity data. This pre impoundment seismicity data can be compared with the post filling seismicity data around the reservoir to identify any indications of RTS.

(ii) **Planning** : With the objective to monitor micro earthquakes in and around the reservoir area network of at least six broadband seismographs around the reservoir of the project within the radius of 40-50 km from the dam can be planned to record the activity beneath the reservoir area The instrumentation will include broad band as well as short period seismographs. These Seismographs can be setup for covering the various faults, thrusts and lineaments present within the area. In order to collect uninterrupted earthquake data all these seismographs should have online centralized seismic monitoring facility.

(iii) **Monitoring**: The data from this network shall serve as a sample data of measured seismic activity of the area & can be used to compare the seismicity level after impoundment. The attributes to reservoir serve as the reference attributes. Seismic monitoring is proposed to be continued after impoundment also. The tentative time schedule in general of activities for establishment of seismic monitoring network for assessment of RTS in and around any project can go upto more than 2 yrs.

(iv) **Data Analysis for RTS Assessment**: Variation in the levels of seismic activity including the occurrence, frequency and magnitude with levels of reservoir filling shall be closely monitored along with their attributes. This post impoundment data can then be compared with the pre impoundment data to assess any signature of Reservoir Triggered Seismicity (RTS). If any indication of RTS is obtained from the above observation then proper measures like controlled reservoir impoundment may be taken up.

- **Controlled Reservoir Impoundment**: The level of reservoir impoundment can be closely monitored w.r.t seismicity trend. These findings can then be further utilized to ascertain the optimum reservoir filling level for the project to operate safely and stabilize the seismicity levels.

Besides implementing above mitigation measures, it is also proposed that prior to filling of the reservoir, initial mapping w.r.t vulnerable slopes can be done with proper treatment measures like landslide hazard mapping, provision of drainage holes, land use measures, constructing engineered structures like retaining walls etc. as per the site requirement. During filling of the reservoir careful monitoring shall be done to assess any movement. Help of remote sensing data for identification of slope movements can also be made.

(II) Blast Vibration Monitoring

Blasting is an important factor in planning various stages of surface and subsurface excavation of any hydroelectric project component such as dam, powerhouse, tunnels, shafts and caverns etc. The blast induced elastic waves while traveling through the medium give rise the ground motion. These ground vibrations have become major source of environmental concern as they may cause damage to nearby structures. Due to these concerns, resistance and agitations from local populace are common at the project areas.

Hence, in order to estimate safe charge for excavation, Blast Vibration Monitoring Study is

being undertaken for assessment of blast induced vibrations in terms of Peak Particle Velocity (PPV) and estimation of safe charge for excavation of various components of the project to prevent any damages from blasting.

In NHPC Blast Vibration Monitoring studies have been utilized extensively for many projects viz., Salal, Nimoo Bazgo, Uri-II, Mangdechhu, Pakal Dul HE Projects for solving such issues.

Efforts are being made towards improvement of the available technology, and for advancement of scientific knowledge for increased productivity with minimum disturbance to the ecology and environment.

C. Operation stage measures

I. Landslide Studies Utilizing Remote Sensing & GIS Technology

Landslides are one of the prominent natural hazards which are triggered either by natural phenomena such as high rainfall, earthquakes, etc. or by anthropogenic activities such as man-made construction.

It is also apprehended by local populace and media that construction of hydropower projects may also increase the landslide activities in the surroundings. Therefore, Landslide assessment and monitoring is very important to overcome such issues. Temporal changes in the landslides frequency and areas are key feature of Landslide assessment study.

Recently, a study on landslide inventory for 09 hydroelectric projects of NHPC by utilizing Remote Sensing and GIS Technology for a timeframe of 10 years before the start of construction and 10 years after commissioning of the projects extending up to the current has been undertaken by NHPC with the help of Indian Institute of Remote Sensing (IIRS), Dehradun. Data analysis for most of the project was done for a period of around 50 years.

The study concluded that that the causative factors of landsides were not due to the construction and commissioning of the Hydro projects. Topography, geological conditions and rainfall are found to be the major causative/ triggering factors of landslide activities in the area. Even, due to afforestation under R&R activities of the project, the landslides in the project areas are stabilized. No increase in landslide activity has been observed post construction of hydro projects and in most cases hydro projects have provided stability in the region around the project.

II. Real Time Seismic Data Center

NHPC is actively involved in the seismic monitoring of its operating power stations for taking adequate safety measures. For this NHPC has installed strong motion accelerographs at all its power stations for seismic monitoring. In order to handle proper maintenance of installed accelerographs and earthquake data analysis in an organized and efficient way, Real Time Seismic Data Center has been developed at its Corporate Office, Faridabad and about 54 seismic monitoring instruments (accelerographs) installed at all of its power stations has been connected to the data centre for continuous online monitoring. Fig 3 gives the plots of earthquake epicentres recorded by NHPC SMA network. Total 450 Himalayan earthquake events with more than 850 records till date are available in NHPC network data.

Fig.4(a) is depicting the schematic representation of the NHPC network and data collection Fig.4(b) shows the flowchart for how data is downloaded from the SMA network and report prepared. In case of occurrence of an earthquake event at and around the project site the data is downloaded at the Real Time Data Center and a detailed report is prepared.

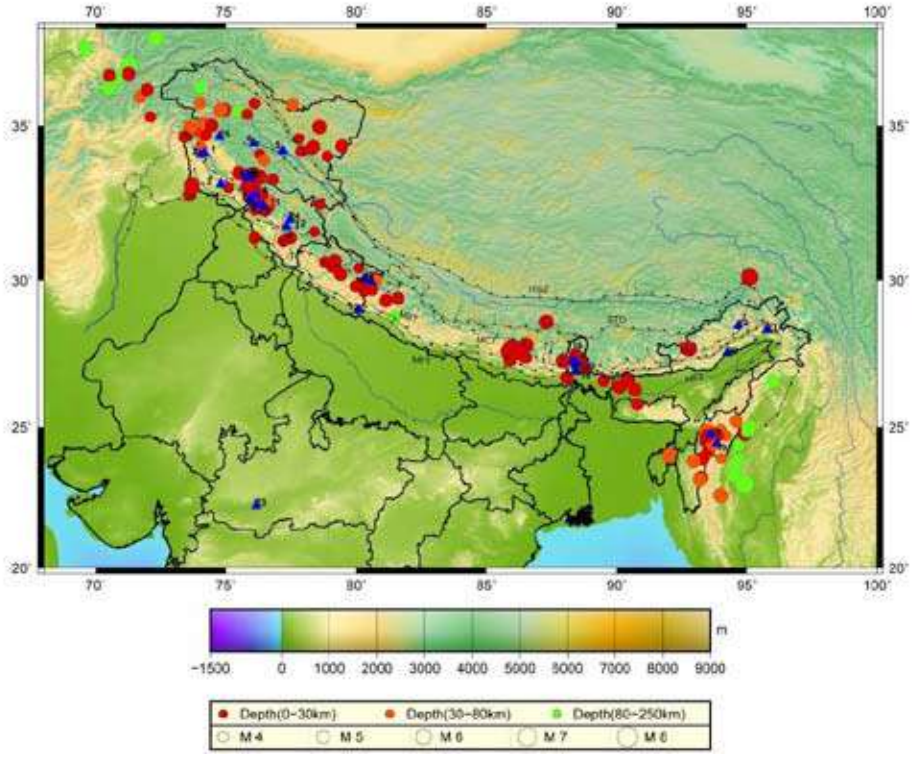

Fig. 3 : Location of NHPC Power Stations and Epicenters of the Events recorded by its SMA network

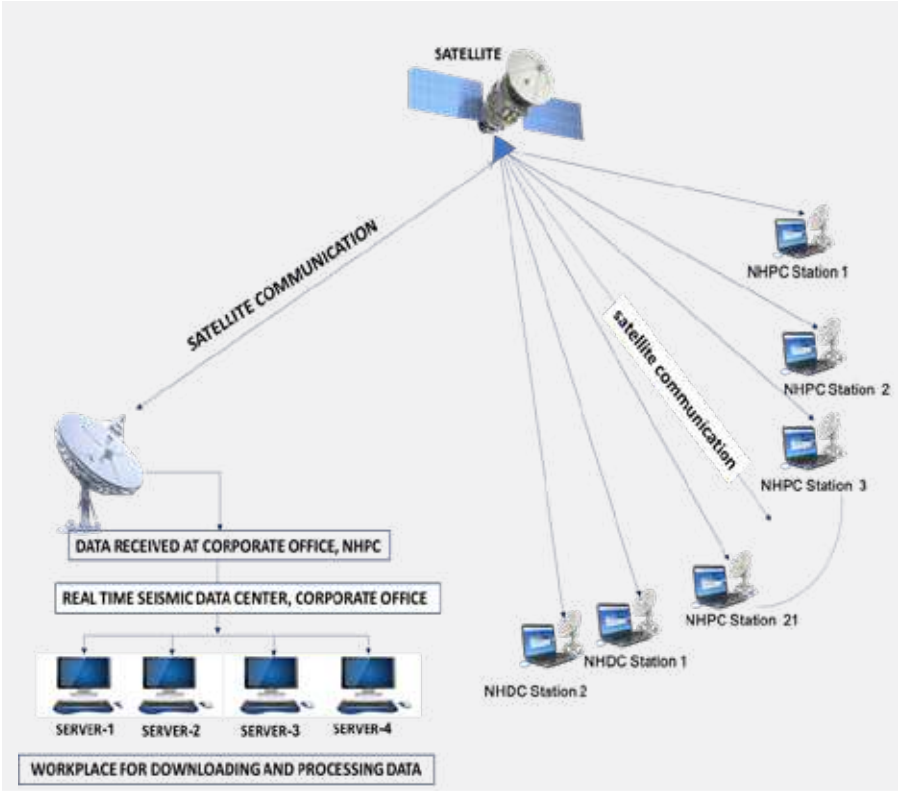

Fig. 4(a) : Schematic of SMA network at NHPC

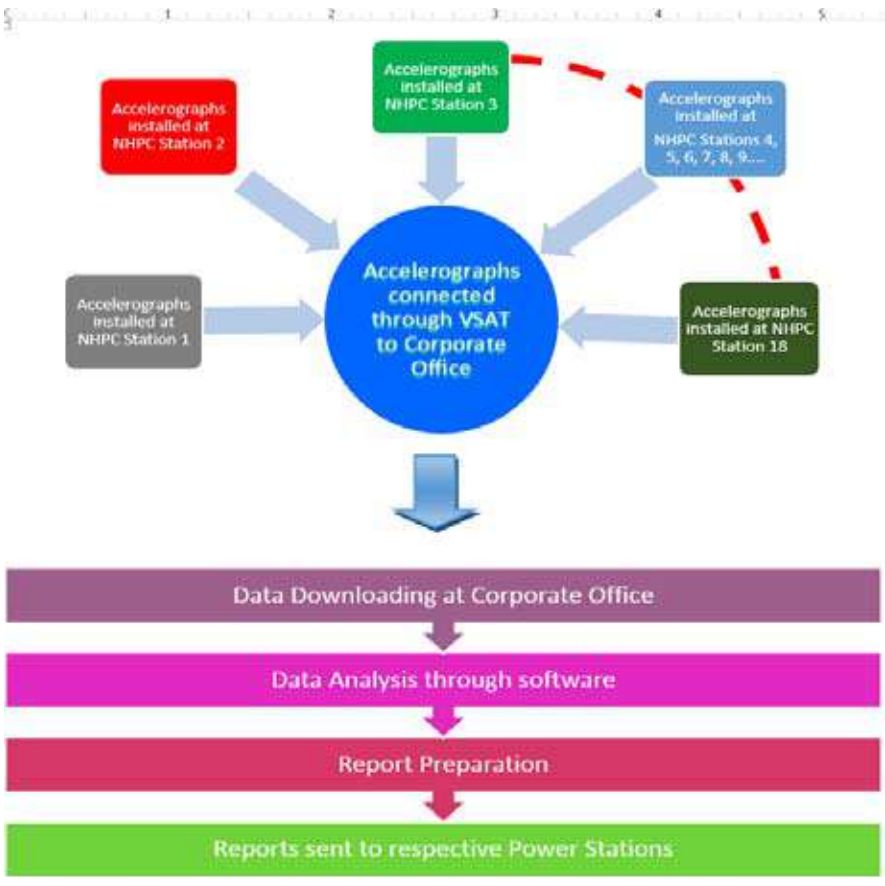

Fig. 4(b) : Flow chart of functioning of RTSDC at NHPC CO.

The Seismic Data Management System developed by our team in-house is utilized to generate the earthquake reports which are sent to the respective projects. These reports are useful during regular Dam safety inspections, are regularly shared with local governing bodies and panchayats to spread awareness towards seismic safety of the running projects. Time to time these reports are also discussed in public hearings to educate the local population in seismic safety of the structures. This way NHPC has gradually inculcated a sense of security within the locals in the remote project locations.

5. OUTCOMES FROM SMA DATA ANALYSIS

The data from the Manipur-Tamenglong earthquake (Fig. 5) was recorded by NHPC station Loktak at only 53 km. This data was shared with National Center of Seismology, NCS, MoES and was used to refine the epicentre depth of the event which was earlier reported as 17km and finally inferred at 59km. The above joint work in collaboration with NCS, Earth Observatory of Singapore NGRI and NHPC was published in Elsevier journal Tectonophysics (2016)

With this initiative NHPC was able to collect some valuable acceleration data for these events at its power stations. On performing a comparative study it is found that the **actual value of PGA recorded at all the power stations is much lower than the computed values of PGA derived after application of attenuation laws like those of Abrahamson & Litehiser (1989) and Campbell, Boore & Joyner** (1981) which are being adopted by different agencies for preparation of seismic design parameter reports. Earthquake data taken for deriving these attenuation laws has most of the events belonging to a different tectonic setup and are not from the Himalayas. Need of the hour is to develop attenuation relationships which are more suited to the Himalayan conditions. Few efforts are being taken at individual level but validity of these relationships require a very strong database of acceleration record of the site specific area. Presently such

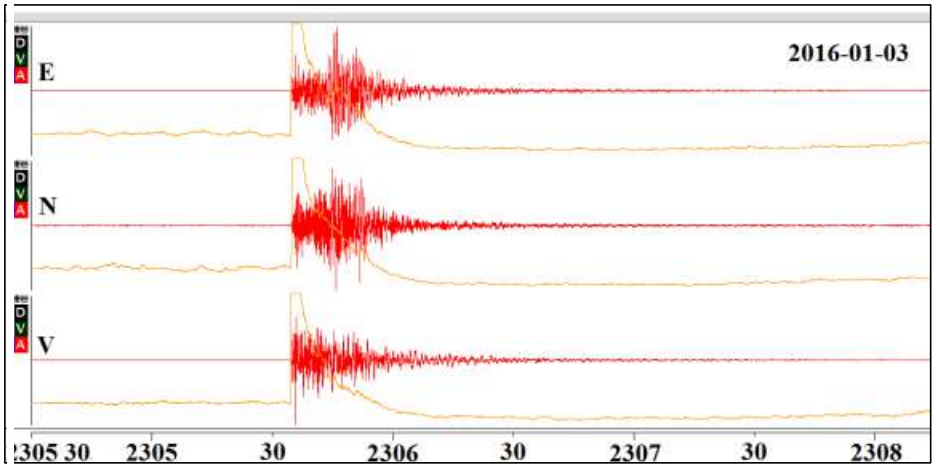

Fig. 5 : Acceleration data of Manipur Earthquake recorded at Loktak Power station (PGA= .0272g, epicentral distance 53.5 km)

records are not available on a common platform. Transparency in data sharing on a national level can help to reduce our dependency on these adopted attenuation laws which give highly conservative design parameters.

6. RESEARCH & DEVELOPMENT WORKS RELATED TO SMA DATA ANALYSIS AT NHPC

Considering the bulk of valuable, unique strong motion data for Himalayan earthquakes collected by NHPC network some preliminary comparative analysis was done and results were published in international forums like ICOLD. Encouraged by the rave reviews received, NHPC has presently taken up a full-fledged R&D project in collaboration with DEQ-IITR for development of Himalayan specific attenuation relationship utilizing SMA data from NHPC network. Benefits of undertaking this Project at RTSDC are as follows:

- Develop a SOP based on international practice for processing the SMA data as per international format
- The development of attenuation relationship for optimizing the site specific design parameter study for NHPC/JV projects
- Providing first hand data for Dam Safety inspection of NHPC projects. With Dam safety Act been formalized, monitoring, compilation & processing of PGA data for NHPC projects is mandatory for earthquake hazard management.
- Preparing a comprehensive data base for the Himalayas which will be used to evolve the attenuation relationship over a period of time with increasing data base.
- Sharing of SMA data from NHPC database with other agencies like CWC for data transparency.

7. CONCLUSIONS

From above, it can definitely be stated that with careful selection of seismic design parameters for design of structures like dam and its components, a safe performing structure can be built. In India it is mandatory to get the seismic design parameters of hydro projects approved from National Committee on Seismic Design Parameters, a high level interdisciplinary official body set up by GoI. From Oct. 2011 onwards CWC has issued stringent & revised guidelines for seismic design parameter studies of hydro projects. The site specific seismic design studies of hydro projects are to be approved from NCSDP before the project clearance. This coupled with implementation of Dam Safety Act, 2021, has led NHPC in becoming a leader in seismic monitoring and safety related issues. Also, NHPC has setup a one of its kind unique facility at its CO, for centralized online monitoring of all 54 SMA installed at its and its JV projects. This continuous monitoring has generated more than 850 records of Himalayan earthquakes measured at its structures and give valuable insight into the performance of these megastructures during occurrence of some big Himalayan events like Gorkha, Nepal earthquake. In continuation of this NHPC has also taken up a high end R&D project in collaboration with DEQ-IITR for development of Himalayan specific attenuation relationship utilizing SMA data from NHPC network. This will help in optimizing the site specific design parameter study for NHPC/JV projects

Moreover NHPC has also developed expertise in blast monitoring technique which is used for optimizing the charge during blasting for excavations in tunnels and caverns. This helps in minimizing the disturbance in the ecology and surrounding environment of the project area.

Also NHPC has taken up a novel study of development of landslide inventory for 09 hydroelectric projects of NHPC, by utilizing Remote Sensing and GIS Technology for a timeframe of 10 years before the start of construction and 10 years after commissioning of the projects with the help of Indian Institute of Remote Sensing (IIRS), Dehradun. The study concluded that the incidence of landslides has not increased post construction of hydro projects in Himalayas and moreover most cases, the construction of hydro projects has provided stability in and around the project area. These are very important findings and will be helpful in handling issues related to landslide.

By generating public awareness about the actual science and engineering involved in construction of hydro projects, the nation can look forward to clean and safe renewable source of energy & water management. With the population boom the country will be facing by 2050 surpassing China, Dams will play a pivotal role in water management of the nation.

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- The new journal regularly covers special features on development activities in three important sectors i.e., Water Resources, Power and Renewable Energy and Allied Sectors.
- CBIP will be too pleased to get feed back from its members/other professionals. This will help in accentuating its value additions and also help in disseminating of knowledge to its readers in a better manner.

Extract Discussion of Experts …. on Power Engineers Whats-App group "SPARK…Ignited to Share"

"If You have Knowledge, Let others candle their lights in it"

We all are at the same concept of knowledge shared is knowledge square. The present software technology with digitisation tools are adding value to our concept and helping us to multiply this theory for the betterment of society. Our senior members are always the path finders for this concept and with kind support from team CBIP, we are able to reach the maximum technical heart of all electrical engineering fraternity across the globe. Let's all to be empowered with knowledge bank, which can be achieved on sharing the same with each other. So, let's everyone to avail this opportunity do feel the basic verse *"If You have Knowledge, Let others candle their lights in it.".*

SPARK group is the platform of educated people, where every member shares, attempts to learn, plans to transforms knowledge into action and most important link among all is that we understand the situation and act as per the circumstances. During the crucial period when the total globe was struggling under the threat of COVID-19, our readers kept keeping us in touch with system. The popularity and acceptance to the concept of technical discussion got raised in multi-fold, whose impact become visible in the form of operating with 19 groups, 8 Sub-groups consisting of around 6000+ engineers under this banner.

The basic objective of this group is to summate the best versions of the discussion held in the group and circulate the same to all Power professionals across nation. We are highly indebted to our readers of extending unflinching support every moment the situation demands, recently on obtaining the responses from engineers all across globe we have created the new Group 19, where we have few slots for inclusion. Hence interested readers can extend their willingness to me (P.K. Pattanaik WhatsApp Number 9438907492).

In these groups we strictly discuss the technical points anything and everything on electrical stream and its allied subjects. **Posting of Social message in these groups is strictly prohibited and on any violation of such, the concerned member with reminder gets removed from the group.**

On behalf of our group, once again I being the admin of these groups take this unique opportunity to extend my gratitude of heartfelt thanks to the experts and technical stalwarts, those who have never hesitated to extend their technical deliberations for the knowledge boosting of all our esteemed members. Our special thanks to team CBIP for making continuous effort to educate the engineers across the globe.

Finally, I wish the readers to enjoy the discussion and urge all to extend their suggestive and corrective views to refine us and to bring the best for the days to come.

STAY HEALTHY AND BE SAFE

P.K. PATTANAIK
General Manager
EHT (O&M) Circle, Bhubaneswar, OPTCL
WhatsApp Number: 09438907492

Query : Er S.K. Pani –OPTCL: How temperature affects the oil level in the oil compartments for thermal station?

Reply :
1. Er C. Siva Sankar Rao: Namaste. In Thermal Station where Ambient temperature sometimes crosses 50 degrees in summer experienced problem of oil level indication crossing max. level and in winter crossing Min. level. Then I practiced the procedure of filling tank taking reference of Oil temperature at that time. A little above that temp. indication in oil level gauge. Of course this is the case if level gauge calibrated in deg. C.
2. Er. Rajarshi Ghosh: In CESC, we put oil level sensors in the conservators, for remote monitoring. It sends both high and low level alarms which is very effective to avoid unwanted tripping.

Query : Er H.K. Bandelkar: Is there any special design for Solar Floating Platform?

Reply : Er P Ramachandran Ex-ABB: CONCRETE FLOATING PLATFORM designed and executed by Dr. Elson John and team from M A College of Engineering for National Thermal Power Corporation (NTPC) Ramagundam solar power project. The dimension of the platform is 15.5m x 7.8 to carry a super imposed load of 20T (including the weight of Transformer, Invertor, Scada and Cabling) and self-weight of 40T. The 100MW project is installing in the artificial lake of approximate area of 900acres made by the NTPC Ramagundam campus with almost 500acres covered with FLOATING solar panels.

These concrete blocks are made of ferro-cement, with half the height (total 1.2 metres) below water level. Hence people can go inside the block and check for any water leaks. Dr John claims that water seepage is remote possibility and he had conducted tests at his lab to simulate all expected climatic disturbances. The floating platform will not sink even under water entry in part of the block.

Query : Er G.K. Mohapatra: Why oil leakage in Power Transformer is considered very serious in practice?

Reply : Er. P Ramachandran Ex-ABB: Oil leaks in transformers must be attended immediately not only because of this, but to avoid water entry in to transformers during rains.

This is a very important point, because most of the transformers today are provided with air cells (rubber membrane). When oil volume exceeds the capacity of conservator, excessive pressure will be developed inside, causing PRD operation and tripping. Without air cell, such situation will result only high oil alarm or oil flowing out through breather pipe.

Oil volume will expand by 8 % with a temperature variation of 100 C . So the effective volume (ie between high and low oil levels) of conservator should be sufficient to take care max and min oil temperatures that occur at site. While approving drawings make sure this point as for some that can be a cost reduction idea!

More than 25 years back, I had a call from Jaipur, informing PRD operation in one of our 250 MVA 400 kV auto transformer. (Standard 315 MVA rating came later) It was at 7 PM during peak of summer. They were overloading the unit by 20% to meet summer peak demand. Transformer was with air cell. Oil pipe coming in to conservator from tank is provided with a projection inside conservator of approx 25 mm. This is done to avoid water collected in conservator not flowing in to main tank. This projection must be provided with a protective guard to prevent air cell coming down and closing the pipe. I had such a problem in a transformer supplied to Texas. Wind chill is experienced there (ambient suddenly coming down from 35 C to 1-2 C) Membrane came down and closed the pipe, Buchholz pipe emptied of oil, tripping the transformer.

Query : Er Rajashi Ghosh: Should the inside pipe projection for Conservator to be taken for DTr also?

Reply : Er P Ramachandran Ex-Abb: Yes, this pipe projection inside conservator is a must for all DTS as they don't have any air cell inside conservator and hence chances of water collection will be more. Engineers must understand why water is collected in conservator. The air inside the conservator above oil level will be very dry due to breather action. Hence moisture from oil will continuously come out and try to saturate air to maintain moisture equilibrium between oil and air. With rain or during cold conditions water droplets will condense on inside upper side of conservator and fall down in to oil. Transformer engineers term this phenomenon as "rain inside transformer ". Being heavier, water droplets will move to bottom of conservator before it get time to dissolve back in to oil. This water will remain at the bottom of conservator. Because of this condition, you will find upper side of DT conservator rusted and holes can be formed through which water can enter. I understand because of this CESC insists for stainless steel conservator for all their DTs .

Query : Er Raghunath Shipa: What is the dis-advantages of RIP/ RIS transformer bushing?

Reply :
1. Er Rajaram Shinde: RIP & RCT both are getting popular everywhere, slight concern of tan delta & storage is still there but it's technology difference which comes with different guideline.
2. Er Rajarshi Ghosh: I think with RIS, the storage is not a major issue.
3. Er. Yash Pramod Rao: Just one additional Point , in case of RIS as there is no paper , it does not have moisture absorption as a concern
4. Er V Ramachandrarao Ex PGCIL: Sir, We are having every standard, literature, Norms but implementation at site right from storage of material and equipment is the key point for quality and workmanship.

Query : Er B.K. Dholakiya: What is Deep Cycle Battery and what is its application in electrical system.

Reply : Er. V Ramachandrarao Ex PGCIL: The deep-cycle battery is built to provide continuous power for wheelchairs, golf cars, forklifts and more. This battery is built for maximum capacity and a reasonably high cycle count. This is achieved

by making the lead plates thick. Although the battery is designed for cycling, full discharges still induce stress and the cycle count relates to the depth-of-discharge (DoD). Deep-cycle batteries are marked in Ah or minutes of runtime. The capacity is typically rated as a 5-hour and 20-hour discharge.

A starter battery cannot be swapped with a deep-cycle battery or vice versa. While an inventive senior may be tempted to install a starter battery instead of the more expensive deep-cycle on his wheelchair to save money, the starter battery would not last because the thin sponge-like plates would quickly dissolve with repeated deep cycling.

There are combination starter/deep-cycle batteries available for trucks, buses, public safety and military vehicles, but these units are big and heavy. As a simple guideline, the heavier the battery is, the more lead it contains, and the longer it will last.

Query : Er. R S Khandagale Retd CE MPEB: Mention few notes on Electrical Fire Safety in the context of CEA guide lines.

Reply :

1. Er Gopa Kumar: Electricity act 2003 empowers CEA to make regulation on electrical safety. It is the CEA regulation “measures relating to safety and electric supply 2010” which need to be followed. Most of these accidents (such as fire due to short circuit) happens in Low Voltage wiring. Unfortunately, the CEA regulation still follows the rules made during 1937 (for LV system). Safety engineers and electrical inspectors follow this 1937 rules, which are not only outdated, but are dangerous to follow in the current scenario. An improvement in this regulation is made during 2018 and 2021, but kept in cold storage, probably for more people to die. (sorry to use some harsh words).

   India is the only country where regulators never heard of TN/TT/IT systems (which are introduced during late 1960’s) and its applicability in LV distribution and wiring.

2. Er PC George, KSEB: True... Lot of confusion about the system of earthing in the LV system is due to lack of adoption of right system in the distribution network.

   It is observed that no one can authoritatively state about the type of earthing used by the distribution licensee in distribution system, particularly the OH system.

   As per the various provisions in the CEA safety regulation, 2010; CEA construction standards,2010; and CEA metering regulation 2006, it is observed that the specified system of earthing in a public distribution system of a distribution licensee in India is supposed to be TN-S system.

   But are we using TN-S system or TN-C system or TN-C-S system.?! Without confirming the type of system used in the distribution network, how can we devise our protection and safety system.

   Again it is observed that the neutral conductor is installed on cross-arm or PSC pole without insulator and liked with the metal parts in the pole and pole earthing.

Query : Er. R S Khandagale Retd CE MPEB: What would be the consequences of GPR rise due to surges in HT/LT lines due such arrangements...?

Reply : Er PC George, KSEB: According to OSHA earthing standards “there must be a low-impedance equipment grounding conductor between each electrical enclosure and the source transformer grounding electrode. During a ground fault, enough current must flow to open a breaker or fuse quickly to prevent shock, electrocution, or equipment damage. Even a few ohms in the grounding circuit will prevent, or greatly slow, the opening of a breaker or fuse. If there is a ground fault and the circuit is not cleared, electrical enclosures, motor frames, and other conductive structures such as handrails and walkways can become energized. A person touching any of these may be shocked fatally or electrocuted.

Query : Er PC George, KSEB: What about protection in our LV distribution system?

Reply :

1. Er PC George KSEB: The existing distribution system by itself constitute a safety risk for the public and the employees in many ways due to its inherent complexity out of non-compliance of mandatory standards. Moreover, designing or engineering of a protection system or safety system that functions effectively for the existing distribution system is practically impossible due to its non-standard construction practices. It is to be noted that a protection system with RCD is possible for a proper TN-S or TT system, whereas such protection system is not viable for existing distribution system constructed without compliance of any specific standard. Normal field incidents like neutral break or snapping of conductors shall have serious safety consequences in existing system which has been constructed without safety earthing system or without complying of regulation 73 of CEA safety regulation, 2010.

   As such, it is important that the existing distribution network need to be standardised with a purpose, at least complying the relevant mandatory standards specified by Central Electricity Authority (Which need to be made simple and less confusing) for better performance on safety, quality, and reliability of the supply of electricity.

2. Er. R S Khandagale Retd CE MPEB: Sir, I have understood above as bellow

   (1) The existing network is not constructed and maintained as per rules, regulations and codes and is prone to all electrical hazards.

   (2) Not possible due to its complex nature to rectify as per regulations.

   (3) Then why not to switch over from overhead system to underground system in phased manner as the situation tells that we cannot construct and maintain over system due to various reasons some beyond control like political interference etc.

3. Er PC George KSEB: Is it practically possible to switch over to the underground system within next three decades? Even many developed countries still maintaining the OH system due to various reasons.

   Do we have the finance to invest? Do we have proper right of way or cable corridors to lay cable without interference with other agencies to ensure reliable & safe supply?

   What about the consumer...? Do they have the capacity to ensure the necessary return for the investment...?
4. Er PC George KSEB: While an extra safety earth conductor in compliance of regulation-16 or 73 of CEA safety has not considered to reduce the investment(?!) in distribution network, how can we think about switching the entire system to underground...?
5. Er Gopa Kumar:
   1. At the distribution, regulations are not followed by utility.
   2. At the point of commencement of LV supply, the regulations are too old (1937) + understanding is poor, hence all mistakes are continued.
   3. Inside the consumer premise, actually there is no regulation exist, but inspectors try to apply the regulation which is applicable for point of commencement of supply.

   As a whole it's a complete mess, resulting in accidents, death of people and loss of property.

   As the first step regulation must be made clear (if possible with pictures), If the inspectors start following it properly, improvements will happen automatically.
6. Er. V Ramachandrarao Ex PGCIL: Sir, It is high time in our country to introduce approval system for House electrical wiring system, Apartment and Big multiplex complexes electrical wiring system from a Licensed practical Engineer.
7. Er. R S Khandagale Retd CE MPEB: Sir, I agree with your opinion on its plain surface but can we not take following points in to consideration to make underground system economically viable.
   (1) Due to present substandard works cost of reduction in life of assets including reduction life of electrical assets of consumers
   (2) Cost of increased breakdown maintenance during storms rains in every season, and increased tripping due inadequate tree and other various clearances.
   (3) Various thefts in overhead system of materials and very tremendous theft of energy by hooks etc.
   (4) Various fires to agriculture crops and trees
   (5) How we can estimate the cost of loss of human, animal lives and workers that is being electrocuted in electrical accidents in huge number
   (6) What about the loss of production of consumers due to various, break downs and interruptions.
   (7) What about the very dangerous less clearances of overhead line bear conductors from houses and accidents happening. Can we estimate the losses in such situation?
   (8) Residual life cost of the existing network.

   Regarding right of way existing OH line right of can be used. Also recurring maint. cost will be less in underground than overhead. Or other wise

   All construction and maintenance shall be done as per existing rules, regulations, IS codes strictly word to word.
8. Er PC George KSEB: Sir, I am totally agreeing with you about the merits and long term viability of the underground cable network, if executed as per standards, good workmanship and appropriate vision.

   Cable network need an entirely different approach and skill to implement it with quality and to maintain it with reliability.

   Actually, it is all related to the attitude, approach and the environment.

   When we have an environment of compromise with respect to standards, will it be possible to ensure the expected quality and reliability...?

   Actually this attitude of compromise in standard is the real issue in OH network.

   Practically, it is observed that the UG cable project is implemented without appropriate separate corridor and shares the road side with water distribution agencies, telecom agencies and many other public utilities. It ends up creating lot of issues with respect to the reliability of supply.

   Another issue is the quality of workman ship and strict compliance of standards during cable installation in the cable trench.

   Practically all these issues create problems during the useful life of the cable assets.

   As such, it is important to ensure compliance of correct standards and quality of works without confusion to ensure reliability and quality of supply irrespective of the fact that whether the system is OH or UG cable.

National Tutorial on
Smart Grid Standards – Requirements and Technologies

18 - 19 January 2023

View of the dais during opening session (L-R) Shri Sanjeev Singh, Director, CBIP, Shri N. Murugesan, Former DG, CPRI, Shri Ganesh Srinivasan, CEO, TPDDL, Shri Dinesh Waghmare IAS, Chairman and Managing Director, Maharashtra State Electricity Transmission Co. Ltd., Shri A.K. Rajput, Member – PS, Central Electricity Authority & Addl. Secy. to GoI and Shri A.K. Dinkar, Secretary, CBIP

The Central Board of Irrigation & Power organised a tutorial on this important subject 'Smart Grid Standards – Requirements and Technologies', on 18-19 January 2023, at the CBIP Conference Hall, New Delhi.

Apart from providing the requisite information on the applicable standards, the aim of the tutorial was also to provide a forum for open discussion and the exchange of information and to acquaint and update the concerned professionals/ engineers about the various smart grid standards, their specifications and the need thereof.

The tutorial started with the opening session on the 18th January 2023.

Following dignitaries graced the dais during the inaugural session:

1. Shri Dinesh Waghmare IAS, Chairman and Managing Director, Maharashtra State Electricity Transmission Co. Ltd.
2. Shri A.K. Rajput, Member – PS, Central Electricity Authority & Addl. Secy. to GoI
3. Shri Ganesh Srinivasan, CEO, TPDDL
4. Shri N. Murugesan, Former DG, CPRI
5. Shri A.K. Dinkar, Secretary, CBIP
6. Shri Sanjeev Singh, Director, CBIP

The opening session started with a welcome address by **Shri A.K. Dinkar**, Secretary, CBIP. He welcomed the Chief Guest, Shri Dinesh Waghmare IAS, Chairman and Managing Director, Maharashtra State Electricity Transmission Co. Ltd., Shri A.K. Rajput, Member – PS, Central Electricity Authority & Addl. Secy. to GoI and Shri Ganesh Srinivasan, CEO, TPDDL and praised them for their contribution over the years in the Power Sector. He also welcomed Shri N. Murugesan, Former

DG, CPRI, and the main faculty for the two days program, the invitees and all the participants of this Tutorial. He further brought it out that in the present competitive and challenging era, updating the knowledge in our respective fields is an essential need, which helps us in improving the skills of the individual, the organization and the country as a whole. CBIP organises such knowledge sharing sessions on some important topics, on a regular basis, and is contributing to the maximum extent, for helping the professionals in accentuating their knowledge, he added. Further, he requested the participants to take maximum advantage of the opportunities, and take part in the CBIP programs being organised from time to time.

Shri Murugesan in his brief address informed that there are many agencies formulating and issuing standards. But the Professionals in the Power Sector are not fully aware of many of the standards applicable to the Power System, and he was hopeful that he would be able to achieve the objective of the tutorial.

Shri Ganesh Srinivasan, in his address, appreciated CBIP's choice of this important topic for this Tutorial. He informed that his organisation, TPDDL, is responsible for the distribution of electricity in North & North-West Delhi; serving a populace of 7 Million and having a customer base of 1.9 Million. He also made a mention of some of the standards adopted by TPDDL, for strengthening their services to the consumers. He informed that CBIP has tied up with a good faculty, Shri Murugesan who is highly renowned and respected, and has expertise on the smart grid standards, etc. He once again complemented CBIP and advised all the participants that this was a major opportunity to interact with the expert and to understand in detail the need and the importance of the Smart Grid Standards.

Shri A.K. Rajput, in his address, highlighted the importance of digitisation of the Power System & the Economy. He further informed that now a days consumer expectation are increasing by the day. The adoption of standards in any power system helps everyone; it brings in simplicity, a defined course of actions, transparency and completion in business, he added. He further shared that Smart Grid is helpful to the Utilities in many ways, like power quality related issues; grid security, i.e. self-healing grid concept; operational issues & fault identification and rectification. Smart Grid applications provide a bigger platform for the improved system planning and the communication practices. Peak load management through system controls, becomes a priority many a times. The data flow is improved and, based on data analytics, better decisions can be taken. The introduction of systems, i.e., SCADA, PMU, WAMS, along with the use of standards, such as, IEC-62056 communication protocol for meters, IEC 61850 protocol for Substation automation system, and IS 16444 standard for meters, improve the system stability. He concluded his address with the message that

Shri A.K. Dinkar, Secretary, CBIP welcoming Shri Dinesh Waghmare, CMD, MSETCL

Shri A.K. Dinkar, Secretary, CBIP welcoming Shri A.K. Rajput, Member (PS), CEA

Shri A.K. Dinkar, Secretary, CBIP welcoming Shri Ganesh Srinivasan, CEO, TPDDL

our vision should be to transform the Indian Power Sector into a secure, adaptive, sustainable & digitally enabled ecosystem, that would provide reliable and quality energy for all with the active participation of all the stake holders. The Standard formulation is a result of the collective wisdom, and is undertaken in a transparent manner. The formulation of a standard is not an end in itself. Thereafter, it has to be adopted and the devices have to be tested as per the applicable standards. He wished the tutorial all success.

Shri A.K. Dinkar, Secretary, CBIP welcoming Shri N. Murugesan, Former DG, CPRI and faculty of the tutorial

On this occasion, **Sh. Waghmare** in his inaugural address stated that, in the present scenario, the modernisation of the grid is a must. This will help to make the generation & the transmission of power more cost effective and efficient i.e. reduced losses. This would also provide the consumer with the facility of electronically available information and some automated tools, to help them make better informed decision about their energy consumption. The increased use of renewable sources would help reduce the production of greenhouse gases in electricity generation, he added. He further pointed out that the modernisation of the Grid would ultimately improve the reliability of the services, i.e., transmission optimisation. It would also prepare the Grid to support the growing population of electric vehicles, being introduced in order to reduce the dependence on oil. Further, it would facilitate the integration of Distributed Resources into the grid and prepare for the challenges involved in the integration of the roof top solar, etc. The difference between the traditional grid and the Smart Grid

In his address, he also briefly covered the need and the role of Asset Optimisation, Demand Optimisation, Distribution Optimization, Transmission Optimisation, Smart Meter and Communication. He also mentioned the benefits of the Micro grids, and the Challenges of Smart Grid in a Power Systems.

The opening session concluded with the vote of thanks by CBIP to all the dignitaries on the dais for their gracious presence, and also the invitees, the faculty and the participants, for their participation in this important tutorial.

TECHNICAL SESSION

The following topics were presented and deliberated upon in the two days of technical sessions by **Shri N. Murugesan**, the main faculty of this tutorial:

- Evolution of Energy Systems; Concept, Definitions and Need; The difference between the Conventional and the Smart Grid; the drivers, the structures, the functions, the opportunities, and the challenges
- An Overview of the Smart Grid development, and the Smart Grid-relevant organizations

Shri Dinesh Waghmare, CMD, MSETCL, addressing the participants

Shri A.K. Rajput, Member (PS), CEA, addressing the participants

Shri Ganesh Srinivasan, CEO, TPDDL, addressing the participants

Shri N. Murugesan, Former DG, CPRI main faculty addressing the participants during opening session

Shri A.K. Dinkar, Secretary, CBIP, delivering welcome address during opening session

- The impact of the Renewable Energy Generation and the Renewable Energy Systems on the Smart Grid
- The challenges of integrating the Intermittent Renewable Energy Systems to the existing Power System
- An Overview of the Power Grid and the important Key Standards for the Power Grid and the Energy Management Systems
- Building Block 1: Smart Home and Building Automation Standards
- Building Block 2: Smart Meter and Advanced Metering Infrastructure, and the Standards for the Communication Requirement for the Smart Grid
- Building Block 3: The Communication System requirement for the Smart Grid, review of Wired Communication, Wireless Communication and Satellite Communication to meet various requirements and the various building blocks of Smart Grid.
- Building Block 4: Sub-Station and Distribution Automation and the Standards thereof
- Transmission System, EHV, HVDC systems, Wide Area Monitoring Protection and Control, and the relevant Standards
- Building Block 5: Standards for Communication system in Smart Grid
- Building Block 6: Standards pertaining to Renewable Energy and the other energy systems like Solar, Wind, Hydro, and fuel cell
- Building Block 7: An Overview of the Electric Storage Technologies, its Applications and the Standards
- Building Block 8: Importance of E-Mobility/ Electric Vehicles, impact on the Grid and the Standardization, Overview & the Evolution of MICROGRID – The Issues, Challenges and the Standards
- Renewable Energy Based Distributed Generation & Smart Grid of the future
- Analysis of the relationship among the related Standards
- Demand Response Technology and the Barriers, and the Standardization efforts related to Demand Response
- Threats and Vulnerabilities of Smart Grids
- Building Block 9: Security and Safety of the Standardized Smart Grid Networks
- International and National Standards for Interoperability
- Future of the Smart Grid
- Comprehensive list of international Standards to implement Smart Grid

The program was attended by about 50 participants from the various PSUs, the State, and the Central Power & RE sector organizations, including some from the manufacturers, and also from IIT Roorkee.

Shri Mohit Kumar, Regional Application Specialist from Omicron, also made a detailed presentation on IEC 61850: Transition to Digital Substations on very first session on 19th January 2023.

A certificate of participation was distributed to each participant, at the end of the tutorial. The feedback received from the participants was very encouraging.

The program concluded with a Vote of thanks, proposed by Mr Batra, Consultant, CBIP, expressing thanks to Shri Murugusan for conducting the two days tutorial; and also to the participants for making the sessions participative, interactive & lively.

Shri N. Murugesan, delivering lecture during technical session

A view of the audiances

Hands on Training on
Diagnostic and Condition Monitoring of Switchyard Equipment

18-20 January 2023

Central Board of Irrigation and Power (CBIP) and Hitachi Energy India Limited organized Hands on Training on 'Diagnostic and condition monitoring of switchyard equipment' on 18-20 January 2023 at Vadodara.

The training program was attended by about 26 participants from esteemed organizations such as TATA Power, Power Grid corporation India limited, Adani transmission limited, THDC India Limited.

PROGRAM SCHEDULE

For 3 days, sessions were planned to cover all important topics about Diagnostic and condition monitoring of switchyard equipment: Circuit breaker - Maintenance concept & spare parts management, Failure analysis & actions of circuit breaker and transformer, condition monitoring through digitalization, condition monitoring challenges, present status and technology way forward, condition monitoring of other switchyard equipment (CT/CVT, Isolator, LA).

The unique sessions included practical demonstration of MSM and CRM, SFRA and tan delta of transformer, Experience centre visit at EnergyTEC.

EXPERT SPEAKERS

Following eminent experts were invited to give specific insight on the topic including case studies:

- **Dr. A.J. Chavda** – Addl. Chief Engineer, GETCO delivered expert talk on "Utility perspective of switchyard condition monitoring".

- **Mr. Parin Shah** − AIS Service Manager, Hitachi Energy delivered expert talk on “Maintenance concept & spare parts management of circuit breakers, failure analysis & actions, condition monitoring through digitalization”.
- **Mr. Vijay Patil** − Asst. Vice President, Power Transformer – Hitachi Energy delivered expert talk on “Failure analysis & actions, condition monitoring using conventional methods – SFRA, Tan delta, remote condition monitoring”.
- **Mr. Vishal Dubey** − Electrical Engineering Manager-Power Transformer, Hitachi Energy delivered expert talk on role of “Modern design and manufacturing criteria in condition and life of transformer”.
- **Mr. Rahul Patil** – Site Testing Manager, Hitachi Energy delivered expert talk on “Condition monitoring of other switchyard equipment such as CT/CVT, Isolator, LA”.

The programme was a grand success.

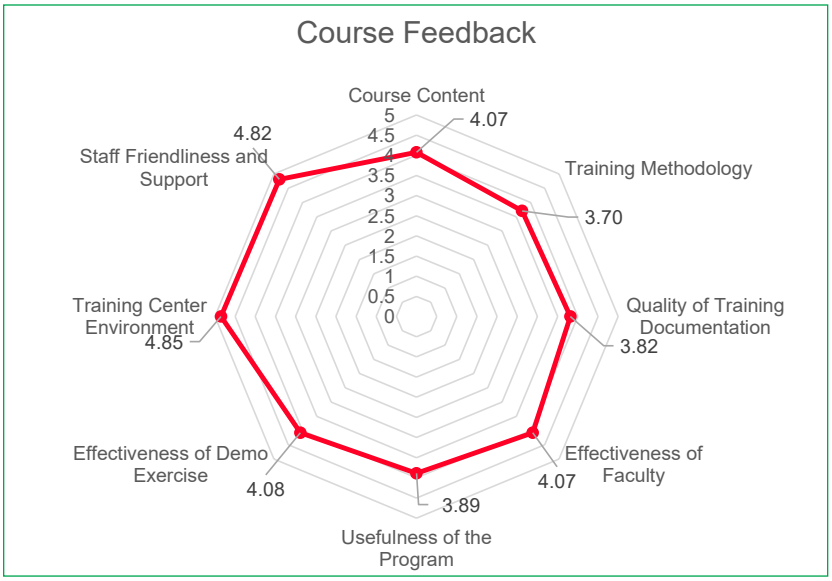
We received excellent feedbacks. Here’s the glimpse of few participants’ feedback:

“Enlightening us in the topic such as SFRA, tan delta, CRM and etc. “

“In depth knowledge of transformer design and digital technologies.”

“Best hospitality... Some lecturers were excellent like Chavda sir and Dubey sir...”

“Transformer design and Utility perspective of condition monitoring session was very good.”



Training Program on Diagnostic and Condition Monitoring of Switchyard Equipment’s organised by CBIP and Hitachi EnergyTEC, Hitachi Energy India Limited, Vadodara, 18-20 January 2023

CBIP activities during January - February 2023

S. No.	Topics	Date
	Water Resources Sector	
1	National Conference on "Preparedness on Disaster Prevention & Management for Hydro Power Projects",	23 January 2023, New Delhi
	Power Sector	
1	National Tutorial on 'Smart Grid Standards - Specifications, Requirements and Technologies'	18th -19th January 2023 CBIP, New Delhi
2	Hands-on Training Diagnostic and Condition Monitoring of Switchyard Equipment	18th – 20th January 2023 Hitachi Energy India Limited, Vadodara
3	National Conference on CEA Regulations on Safety Requirements	3rd February, 2023, New Delhi.
4	National Tutorial on 'Electric Safety and Accident Prevention - Practice and Standards'	15th - 16th February 2023 New Delhi
5	National Workshop on 'Energy Management, Energy Conservation and Energy Audit'	9th – 10th February 2023 New Delhi
6	National Conference on 'Failure of Major Equipment's of Sub Station - Case Studies'	23rd – 24th February 2023 New Delhi
7	Hands-on training on "Principles of Protection Technology"	22nd – 24th February 2023, Goa
	CoE, Gurugram	
1	07 Days Specialized Training Program on EHV AIS Substation Design for Executives of Nepal Electricity Authority (NEA) from Nepal Hydro and Electric Ltd. (NHE)	5th to 12th January 2023
2	Online Certification Course in "Renewable Energy Development including Grid Integration and Energy Storage System"- 4th Batch (Duration 65 Hrs)	Starting from 30th January 2023
3	One day Program on FGD System and NOx Reduction Technologies for Air Quality Improvement.	30th January 2023
4	26 Weeks PGDC Course in Transmission and Distribution Systems with Automation SCADA/ DMS	1st Feb 2023
5	1 Day training programme on FGD System and NOx reduction technologies for air quality improvement	Feb- Mar 2023
6	1 Week Advanced Training Program for the Management Trainees of OPTCL	Feb- Mar 2023
7	5 Weeks Induction Training Program for Executives from NHPC	20th Feb 2023
8	One Day Program/ Workshop on GST	CBIP Centre of Excellence, Gurugram, Haryana
9	One Day Program on Water Optimization (WBPDCL)	WBPDCL
10	Training Program on Induction Motor	WBPDCL, Bandel Thermal Power Station (BTPS)

STATISTICAL DATA (WATER RESOURCES SECTION)

State-wise Sewage Generation and Treatment Capacity of Urban centers-India

States / UTs	Sewage Generation (in MLD)	Installed Capacity (in MLD)	Proposed Capacity (in MLD)	Total Treatment Capacity (in MLD) including planned / proposed	Operational Treatment Capacity (in MLD)
Andaman & Nicobar Islands	23	0	0	0	0
Andhra Pradesh	2882	833	20	853	443
Arunachal Pradesh	62	0	0	0	0
Assam	809	0	0	0	0
Bihar	2276	10	621	631	0
Chandigarh	188	293	0	293	271
Chhattisgarh	1203	73	0	73	73
Dadra & Nagar Haveli	67	24	0	24	24
Goa	176	66	38	104	44
Gujarat	5013	3378	0	3378	3358
Haryana	1816	1880	0	1880	1880
Himachal Pradesh	116	136	19	155	99
Jammu & Kashmir	665	218	4	222	93
Jharkhand	1510	22	617	639	22
Karnataka	4458	2712	0	2712	1922
Kerala	4256	120	0	120	114
Lakshadweep	13	0	0	0	0
Madhya Pradesh	3646	1839	85	1924	684
Maharashtra	9107	6890	2929	9819	6366
Manipur	168	0	0	0	0
Meghalaya	112	0	0	0	0
Mizoram	103	10	0	10	0
Nagaland	135	0	0	0	0
NCT of Delhi	3330	2896	0	2896	2715
Orissa	1282	378	0	378	55
Pondicherry	161	56	3	59	56
Punjab	1889	1781	0	1781	1601
Rajasthan	3185	1086	109	1195	783
Sikkim	52	20	10	30	18
Tamil Nadu	6421	1492	0	1492	1492
Telangana	2660	901	0	901	842
Tripura	237	8	0	8	8
Uttar Pradesh	8263	3374	0	3374	3224
Uttarakhand	627	448	67	515	345
West Bengal	5457	897	305	1202	337
Total	**72368**	**31841**	**4827**	**36668**	**26869**

Note: (i) Sewage Generation is estimated based on Water supply @ 185lpcd and rate of sewage generation as 80 %.

(ii) Sewage generation for NCT of Delhi is estimated based on their 80 % of water supply of 925 MGD

STATISTICAL DATA (ENERGY SECTION)

GROWTH OF INSTALLED CAPACITY

(Figures in MW)

	At the end of 12th Plan (August 2017)	As on 31.12.2022
THERMAL	218330	235808.911
HYDRO	44478	46850.17
NUCLEAR	6780	6780
RENEWABLE ENERGY SOURCES	57244	120900.145
TOTAL	**326832**	**410339.226**

Source : CEA

ALL INDIA REGION WISE INSTALLED CAPACITY

As on 31.12.2022

(Figures in MW)

Region	Thermal	Nuclear	Hydro	RES*(MNRE)	Total
Northern	62708.127	1620	20751.76	31649.31	116729.197
Western	86779.58	1840	7562.5	37488.51	133670.59
Southern	56770.809	3320	11827.48	49423.71	121341.999
Eastern	27119.697	0	4764.42	1786.43	33670.547
N. Eastern	2311.155	0	1944.01	513.755	4768.92
Islands	119.543	0	0	38.43	157.973
All India	235808.911	6780	46850.17	120900.145	410339.226
Percentage	57.46682161	1.652291463	11.41742418	29.46346275	100

Source : CEA

SECTOR WISE INSTALLED CAPACITY AND GENERATION

As on 31.12.2022

Sector	Installed Capacity (MW)					Percentage Share	Net Capacity added
	Thermal	Nuclear	Hydro	RES*(MNRE)	Total		During Dec. 2022
STATE	75179.868	0	27254.45	2483.462	104917.78	25.56854752	1178.02 MW
PRIVATE	85911.135	0	3931	116784.383	206626.518	50.35504892	
CENTRAL	74717.908	6780	15664.72	1632.3	98794.928	24.07640356	
TOTAL	235808.911	6780	46850.17	120900.145	410339.226	100	

Source : CEA

**Off-grid RES Capacity has been included from July-2021 onwards*

GROWTH OF TRANSMISSION SECTOR

	Unit	At the end of 12th Plan (August 2017)	As on December 2022	Addition after 12th plan (2017-22) (up to Dec. 22)
TRANSMISSION LINES				
HVDC	ckm	15556	19375	96944
765 kV	ckm	31240	51938	
400 kV	ckm	157787	196471	
220 kV	ckm	163268	197011	
Total Transmission Lines	**ckm**	**367851**	**464795**	**96944**
SUBSTATIONS				
	Unit	**At the end of 12th Plan (August 2017)**	**As on December 2022**	**Addition after 12th plan (2017-22) (up to Dec. 22)**
HVDC	MW	19500	33500	410957
765 kV	MVA	167500	269200	
400 kV	MVA	240807	411878	
220 kV	MVA	312958	437144	
TOTAL	**MW/MVA**	**740765**	**1151722**	**410957**

RURAL ELECTRIFICATION / PER CAPITA CONSUMPTION

Total No. of Villages	597464
% of Villages Electrified	100.00
No. of Pump-sets Energized (at end of 12th plan)	21212860
Per Capita Consumption during 2021-22*	1255 kWh

**Provisional*

RE SECTOR IN INDIA: POTENTIAL AND ACHIEVEMENTS

Sector	FY 2022-23	
	Achievements (April-Dec. 2022)	**Cumulative Achievements (as on 31.12.2022)**
I. Installed RE Capacity (CAPACITIES IN MW)		
Wind Power	1572.20	41929.78
Solar Power*	9305.97	63302.49
Small Hydro Power	86.75	4935.65
Biomass (Bagasse) Cogeneration	0.00	9433.56
Biomass (non-bagasse) Cogeneration	4.20	776.25
Waste to Power	25.00	248.14
Waste to Energy (off-grid)	20.68	274.28
Total	**11014.80**	**120900.15**

Source: MNRE

Water & Energy Abstracts
Water Resources Section

Emerging Challenges in Dam Safety Management with the Background of Climate Change – *Zeping Xu, China Institute of Water Resources and Hydropower Research, Beijing, China –* *International Dam Safety Conference, 10-12 October 2022, Jaipur, Rajasthan*

Climate change is one of the major global issues at present. By changing the status quo of the global hydrological cycle, climate change causes the redistribution of water resources both in time and space. It will exacerbate the instability of water resources distribution and the contradiction between supply and demand, increase the frequency and intensity of floods and droughts, as well as the occurrence of the extreme events. Those impacts pose a major challenge to the design, construction, and operation of water infrastructures, as well as the safety management of dams and reservoirs.

Water infrastructures are fundamental tool for managing water resources. By facing the situations of population increase and the climate change of global warming, dams and reservoirs will play more and more important role in future. But, at the same time, large reservoirs will also pose certain risks to people's lives, properties, and environment on downstream area. Therefore, while giving full play to the benefits of reservoirs, it is also necessary to effectively manage the safety of dams and to control the risks of dam failure.

China has the largest number of dams in the world. On the one hand, among the built dams, many of the dams built in 1950s to 1970s have various defects, with poor safety status, and urgently need to be rehabilitated. On the other hand, China is currently still at the peak period of dam construction, many high dams will be built in its western region. Most of these dams are located at the sites with very harsh natural conditions. For the development of water resources in river basins, cascade reservoirs will be built on the mainstream and tributaries of the river. The portfolio dam safety of cascade reservoirs is becoming an increasingly important issue in dam safety management. In addition, in the context of climate change, the increase of extreme events will lead to frequent occurrence of natural disasters, which will also threaten the safety of dams.

All the above problems have created new challenges for dam safety management, which need to be dealt with by taking active measures. First, it is necessary to establish and improve the laws and regulations framework on dam safety management, strengthen government supervision. In dam safety management, the concept of risk informed dam safety management is suggested to be adopted. On the bases of risk analysis, through risk assessment, the decision-making on dam safety management and defect dam rehabilitation should be guided. For the construction of dams with the uncertainty of hydrological data caused by climate change and dams built under the complicated conditions, advanced science and technology should be fully applied, such as remote sensing, real-time hydrological forecast model, BIM application, information technology and artificial intelligence, etc., to solve the technical challenges of dam engineering. In order to deal with the threat of extreme events and natural disasters to the safety of dams, it is necessary to enhance the resilience of dams, to improve their adaptability to sudden and extreme events. To guarantee the safety of dam, it is also necessary to pay full attention to the capacity building on emergency response. Through the analysis of the potential failure mode of the dam and the fault chain of the accident, a complete emergency action plan should be formulated, and sufficient drills are recommended to be carried out.

Reservoir Management Model Optimized for Flood Risk Periods – A Portuguese Case – *J. Mendes and R. Maia, Faculty of Engineering of the University of Porto (FEUP) and Interdisciplinary Centre of Marine and Environmental Research (CIIMAR), Porto, Portugal* *International Dam Safety Conference, 10-12 October 2022, Jaipur, Rajasthan*

This paper presents a decision support model developed to optimize the operational management of the Medium Mondego multi-purpose reservoirs' system, in the center of Portugal, where the downstream flood control function is a constraining factor for the remaining uses of the system, namely hydroelectric power production. This model, based on daily streamflow forecasts for a 10 days' period with a 3-hourly time step, enables the computation of the volume to be discharged by each reservoir of the system in the following 24 hours, with the objectives of: (i) minimizing downstream impacts in flood situations; and (ii) keeping the reservoirs' water levels as high as possible. A wet period, in which one of the most serious floods after the construction of the reservoirs' system occurred, was selected for application, verification and evaluation of the model's performance. In this period, the results show that the model would display a better reservoir management performance, than the ones corresponding to the management actions actually undertaken, since these did not take into account the hydrological forecast data. In addition, it would ensure high water levels to be maintained in the reservoirs, particularly during the typically wet annual periods, which is beneficial for other uses, in particular energy production.

Water & Energy Abstracts
Energy Section

Requirements for Models to Study and Prevent System Separation and Collapse – *Anton Janssen, Liander, Netherlands; Andreas Kubis, PSI Software AG, Germany; Sean McGuinness, EPRI International, Ireland; Mirko Palazzo, ABB, GEIRI Europe; Qikai Zhuang, Switzerland, Germany; Jean-Marc Willième, GE Energy Connections, France; Giorgio Poggi, EdF, France; Konstantin Aprosin, Prosoft-Systems, Russia; Ton Geraerds, RWE Generation NL, Netherlands* – *CIGRE Paris Session 2018*

Early 2018 CIGRE JWG A3/B5/C4.37 has published its Technical Brochure on conditions for and the probability of out-of-phase (out-of-step) [7]. In this Report C4-305 some aspects published in [7] are shortly summarized. In comparison to [7] special aspects related to modelling are further elaborated.

Out-of-step phenomena cannot be neglected, especially with the increasing effects of larger and more volatile power transfers through the power system. After studying large disturbances, we find their origin in the stage of power system design and planning. Disturbances start with an event roughly one hour before system separation followed by a continuous acceleration of new events. Similar causes can be recognized at the system operation stage as well as at the system design and planning stage. Such causes include: the lack of situational awareness, the common causes defined in section 2 and homogeneity of controls and protection. A policy with a much wider scope (beyond the own area, own interest, own discipline, own technology) is required to reach a better system performance with respect to preventing and controlling large disturbances.

Policy makers, power system designers and planners, operational staff all need adequate tools to support them. Power system models need the input from power plants experts, protection and control experts, circuit breaker experts, power electronic and converter experts, etc. Examples are given in this paper.

Models for power systems in distress are not easy to build, especially when unforeseen events must be incorporated and the consequential interaction between primary plant and protection/control equipment.

Keywords : Power system separation, out-of-phase, out-of-step, large disturbances, power electronic converters, power swing blocking, defence plan, system protection scheme

Revision of the French Capacity Market – *Elsa Merckel and Colas Chabanne, Réseau de Transport d'Electricité (RTE), France* – *CIGRE Paris Session 2018*

In 2010, France made the choice to implement a capacity market to ensure its security of supply. The French capacity market is organized as a decentralized market, designed to guarantee that the reliability target fixed by the French authorities (LOLE of 3h/year) is met at the least cost. The rules of the French capacity market were first adopted on the 22th of January 2015.

End of 2015, the European Commission, guarantor of competition within the European Union, opened an in-depth investigation to assess whether the French capacity market was in line with the European Union's state aid rules. This inquiry happened in a broader European context focusing also on other already implemented/in project capacity mechanisms in Europe (German strategic reserve, Italian capacity market, Spanish capacity payment…).

The European Commission gave its clearance for the French capacity market on the 8th of November 2016, based on French public authorities' commitment to implement modifications in the market rules. The Commission concluded that the revised market design improves the security of electricity supply whilst maintaining competition.

Consequently, market rules were revised end of November 2016 based on a consultation of French stakeholders. The main design elements of the French capacity market have not been impacted by the Commission's inquiry, but the new market rules include several significant evolutions, especially on three aspects: (1) measures to improve competition in the capacity market (implementation from 2017), (2) opening of the French capacity market to cross-border participation (implementation from 2019), (3) fostering of new investments with dedicated long term capacity contracts (implementation from 2019).

The regulatory and political obstacles to the implementation of the French capacity market, following the European Commission state aid inquiry, have thus been overcome. In accordance with the schedule fixed by the French authorities before this inquiry, the first delivery year of French capacity market started on the 1st of January 2017.

Keywords : Capacity market – Capacity mechanism – European Commission – European regulation – Competition – Cross-border participation – Investment incentives

News - Water Resources Section

THIRD MEETING OF STEERING COMMITTEE OF KEN-BETWA LINK PROJECT

3rd Meeting of Steering Committee of Ken-Betwa Link Project held at Vigyan Bhawan under Chairmanship of Secretary, DoWR, RD & GR, Ministry of Jal Shakti

The Third Meeting of Steering Committee of Ken-Betwa Link Project (SC-KBLP) was held today at Vigyan Bhawan, New Delhi under the Chairmanship of Secretary, DoWR, RD & GR, Ministry of Jal Shakti. The meeting was attended by representatives of both the states of Madhya Pradesh and Uttar Pradesh and officials of various Central Ministries and NitiAayog.

Secretary, DoWR, RD & GR, MoJS in his opening remarks stressed that Ken-Betwa link project is critical for the water security and socio-economic development of Bundelkhand region. It is a flagship project of the Centre and State. We have the responsibility of implementing this project in a time bound manner using state of art technologies and know-how duly taking care of R&R of project affected people and conservation of the region, particularly the landscape dependent species of Panna Tiger Reserve.

- The Third Meeting of Steering Committee of Ken-Betwa Link Project (SC-KBLP) was held today at Vigyan Bhawan, New Delhi under the Chairmanship of Secretary, DoWR, RD & GR, Ministry of Jal Shakti
- The Secretary stressed that Ken-Betwa link project is critical for the water security and socio-economic development of Bundelkhand region
- Two wildlife sanctuaries namely Nauradehi Wildlife Sanctuary and Rani Durgawati Wildlife Sanctuary of Madhya Pradesh and Ranipur Wildlife Sanctuary of U.P. have been approved by state govt. for bringing them under project Tiger
- It was intimated to the committee that orders for transfer about 5480 ha non forest govt. land of Panna and Chhattarpur district of M.P. have been issued by state govt. for transfer to PTR for compensatory afforestation
- Proposal for Constituting an R&R Committee to monitor the implementation of R&R plan in transparent and time bound manner was finalized during the meeting
- A Greater Panna Landscape council is also being constituted for implementation of Landscape Management Plan (LMP) and Environment Management Plan(EMP) of the project

During the meeting, deliberations were held on various agenda items covering follow up actions on decisions taken during the 2nd meeting, work plan for year 2023-24, engagement of Project Management Consultancy, land acquisition and R&R of affected villages, establishment of offices of Ken-Betwa Link Project Authority, implementation of integrated landscape management plan prepared by Wildlife Institute of India for Greater Panna, financial powers of KBLPA, reimbursement to state on expenditure made etc.

It was intimated to the committee that orders for transfer about 5480 ha non forest govt. land of Panna and Chhattarpur district of M.P. have been issued by state govt. for transfer to PTR for compensatory afforestation.

In addition to this, two wildlife sanctuaries namely Nauradehi Wildlife Sanctuary and Rani Durgawati Wildlife Sanctuary of Madhya Pradesh and Ranipur Wildlife Sanctuary of U.P. have been approved by state govt. for bringing them under the project Tiger. This is a significant step in increasing the carrying capacity of PTR. Proposal for Constituting an R&R Committee to monitor the implementation of R&R plan in transparent and time bound manner was finalized during the meeting. A Greater Panna Landscape council is also being constituted for implementation of Landscape Management Plan (LMP) and Environment Management Plan (EMP) of the project.

MINISTRY OF JAL SHAKTI ANNOUNCES WINNERS FOR 'WATER HEROES SHARE YOUR STORIES CONTEST' FOR THE MONTH OF NOVEMBER 2022

The Department of Water Resources, River Development and Ganga Rejuvenation, Ministry of Jal Shakti has launched the 'Water Heroes: Share Your Stories' contest. Till date, three editions of the contest have been launched on MyGov portal. The 1st edition was launched from 01.09.2019 to 30.08.2020. The 2nd edition was launched from 19.09.2020 to 31.08.2021. The 3rd edition has been launched on 01.12.2021 and ends on 30.11.2022.

The objective of the contest is to promote value of water, in general, and for supporting country-wide efforts on water conservation and sustainable development of water resources. In accordance with the vision of Prime Minister Narendra Modi, a large population should be motivated to adopt the cause of water conservation in the country. The aim is to create awareness for water conservation by enhancing knowledge and sharing experiences of water heroes; and to create an attitude towards water conservation

and management so that a behavioral change can be created amongst all stakeholders.

- In accordance with the vision of Prime Minister Narendra Modi, a large population should be motivated to adopt the cause of water conservation in the country
- The objective of the contest is to promote value of water, in general, and for supporting country-wide efforts on water conservation and sustainable development of water resources
- The aim is to create awareness for water conservation by enhancing knowledge and sharing experiences of water heroes
- The aim to create an attitude towards water conservation and management so that a behavioral change can be created amongst all stakeholders
- During 2020-22, about 762 Chal-khals or water ponds with total rainwater retention capacity of more than 16 millions of rainwater have been constructed

For the month of Nov'2022, there are three winners, they will get a cash prize of Rs. 10,000/- and a certificate, details given as below:

(i) Shri Bapu Bahusaheb Salunkhe: He belongs to Nashik, Maharashtra. He has received National Water Mission Award in 2019. He has been encouraging farmers to do rainwater harvesting, groundwater recharge, well recharge, borewell recharge in their fields by using minimum water through drip irrigation and micro irrigation. On his request around 800 - 1000 farmers have made watersheds in their fields, and these watersheds are filled in the rainy season through rainwater harvesting. He has also made two big watersheds in his farm, which get filled during the rainy season, which is utilized for farming activities.

(ii) Ms. Gungun Chaudhary: She utilized pot as a water saving device. She has used double-walled earthen pot, with the outer wall of the pot that is water resistant. Water is poured in between the two walls, which seeps through the inner wall to the plant as needed. Thereafter, she covered the space between the walls of the pot, so that it does not evaporate and goes out. With this method, one pot could save around 150 glasses of water in a month. She has installed around 400 pots in 40 houses in 3 villages. In this way she could save plenty of water in a month.

(iii) Shri Vaibhav Singh, IFoS: He is Indian Forest Service Officer, serving in the middle Himalayan belt of Uttarakhand, the forests of Rudraprayag Forest Division. Since he took over as DFO in August 2019, he started building a soil moisture conservation (SMC) structure which include Chal Khals ('water ponds' in Garhwali), contour trenches, check dams, percolation pits, among other such structures, in an organized and planned manner. During 2020-22, about 762 Chal-khals or water ponds with total rainwater retention capacity of more than 16 millions of rainwater have been constructed. A total of 2010 Check Dams were made which resulted in thousands of tons of top soil conservation along with increasing ground water percolation with eco-restoration of 472 hectares of degraded forest land by construction of contour trenches and percolation pits.

1st ALL INDIA ANNUAL STATE MINISTERS CONFERENCE ON WATER TO DELIBERATE WATER VISION@2047

Marching forward with Prime Minister Shri Narendra Modi's vision to make India a developed Nation by 2047, the Government is deliberating on the preparation of the Action Plan and Vision Document of India@2047. While addressing the challenges of water security as part of the India@2047 plan, the Prime Minister has proclaimed the '5P' mantra which includes Political will, Public financing, Partnerships, Public Participation and Persuasion for sustainability. India's water sector will play a significant role in achieving heights India strives to reach in the next crucial years. To take forward action plan, the Ministry of Jal Shakti is organizing the "1st All India Annual State Ministers Conference on Water'' with the theme "Water Vision@2047" in Bhopal, Madhya Pradesh on 5th & 6th January, 2023. The primary objective of the 2-days Conference is to gather inputs for the India@2047 and 5P vision from the different water stakeholders of the states, water being a state subject, and also to improve engagement and partnership with the states and to share the initiatives and schemes of the Ministry of Jal Shakti.

- 1st All India Annual State Ministers Conference on Wate to be held in Bhopal, Madhya Pradesh on 5th & 6th January, 2023.
- Water Vision@2047 is part of PM's India@2047 plan
- Thematic sessions at the conference to focus on water security, water usage efficiency, water governance, water infrastructure and water quality
- State Ministers of Water Resources, Public Health Engineering Department (PHED) and Irrigation from all States/ UTs of the country will participate
- Participants to prepare a blue print of Water Vision@2047 and prepare a road map to address the water problems of the country

The Chief Minister of Madhya Pradesh, Shri Shivraj Singh Chouhan and the Union Minister of Jal Shakti, Shri Gajendra Singh Shekhawat will grace the occasion. The Minister of State for Jal Shakti and Food Processing Industries, Shri Prahlad Singh Patel will also be present during the event. The Deputy Chief Minister of Maharashtra, Shri Devendra Fadnavis will chair one of the important thematic sessions on Water Governance during the Conference. State Ministers of Water Resources, Public Health Engineering Department (PHED) and Irrigation from all States/ UTs have been invited to prepare a blue print of Water Vision@2047 and prepare a road map to address the water problems of the country.

The Senior Secretaries of Water Resources, Public Health Engineering Department (PHED) and Irrigation from all States/ UTs along with Agriculture Production Commissioners will also be attending the Conference. There will be an exhibition where young innovators/ startups will showcase on new innovations in the water sector.

With an objective to enhance the insights of this conference, there will be one Plenary Session which will set the agenda of the Conference with a focus on Water Vision@2047. The Conference will have 5 thematic sessions viz.

(i) Water Security in Water Deficit, Water Surplus and Hilly Regions;

(ii) Water Use Efficiency including Reuse of Waste Water/ Grey Water;

(iii) Water Governance;

(iv) Climate Change Resilient Water Infrastructure, and

(v) Water Quality.

The 1st Thematic Session addresses the various aspects of "Water Security in Water Deficit, Water Surplus and Hilly Regions" The 2nd Thematic Session is on "Water Use Efficiency including the Reuse of Waste Water/Grey Water" focusing to make the objective of community participation successful at grassroots level. The 3rd Thematic Session on "Water Governance" aims to break the silos in the water sector by bringing various states together facilitated by the Centre. The 4th Thematic Session addresses the present scenario of climate change in the country and the measures that need to be taken to reduce the effects of Climate Change. The 5th Session on Water Quality deals with the problems of water quality of drinking water, surface water, and groundwater. The Thematic Sessions have been devised so that we can together work towards the bigger vision of making India a Developed Nation by 2047

NATIONAL LEVEL STEERING COMMITTEE REVIEWS OVERALL PROGRESS OF ATAL BHUJAL YOJANA

The third meeting of the National Level Steering Committee of the Atal Bhujal Yojana held under the Chairmanship of Secretary, Department of Water Resources, RD & GR, Ministry of Jal Shakti. The third meeting of the National Level Steering Committee (NLSC) of the Atal Bhujal Yojana was held today at New Delhi under the Chairmanship of Secretary, Department of Water Resources, RD & GR, Ministry of Jal Shakti. The meeting was attended by Senior Officers of 7 States where the scheme is being implemented as well as some line Departments. Special Secretary, and Joint Secretary, DoWR, RD & GR along with Principal Secretary, Uttar Pradesh and Secretaries from Karnataka and Gujarat were also present.

Atal Bhujal Yojana (ATAL JAL) is being implemented as a Central Sector Scheme since April, 2020 in 8220 water stressed Gram Panchayats of 229 administrative blocks/ Talukas in 80 districts of seven States, viz. Gujarat, Haryana, Karnataka, Madhya Pradesh, Maharashtra, Rajasthan and Uttar Pradesh for five year period (2020-25).

- The Committee directed the States to expedite convergence for the implementation of the interventions proposed under Water Security Plans
- One of the key aspects of ATAL JAL is to bring in behavioral changes in the community, from the prevailing attitude of consumption to conservation & smart water management
- Secretary underscored that the sustainability of the drinking water sources are to be given utmost priority while taking up interventions under this Scheme
- The Special Secretary, DoWR, RD & GR highlighted the importance of continued engagement with the community with a focus on the aim that the WSPs are to be owned by the Communities

One of the key aspects of ATAL JAL is to bring in behavioral changes in the community, from the prevailing attitude of consumption to conservation & smart water management. It is imperative that this message is driven across all levels, especially at the grass-root level, so that the objectives of the scheme are achieved. Creation of awareness among the general public about the program objectives and creation of an enabling environment for scheme implementation at various levels through information, education and communication (IEC) is an important activity under this scheme. Awareness campaigns have been undertaken using different media of mass communication. The thrust of the campaign is at the GP level, where communication tools such as nukkadnataks (street plays), audio-visual clips, wall-writing, display boards, pamphlets and cable TV are being extensively used.

The third meeting of the National Level Steering Committee of the Atal Bhujal Yojana was attended by Senior Officers of 7 States where the scheme is being implemented as well as some line Departments. The Committee reviewed the overall progress of the scheme and directed the States to expedite convergence for the implementation of the interventions proposed under Water Security Plans. (WSPs). Completion of majority of the WSPs was praised by the Secretary and at the same time it was emphasized that this is a iterative process and the WSPs are to be updated annually in consultation with the community.

Secretary underscored that the sustainability of the drinking water sources are to be given utmost priority while taking up interventions under this Scheme. Further, since incentive money is an untied fund, it can be used for undertaking pilot projects in any of the Atal Jal Gram Panchayat in order to sustain ground water. Since communities are at the forefront in this scheme, importance of capacity building of the communities was also emphasized. The Special Secretary, DoWR, RD & GR highlighted the importance of continued engagement with the community with a focus on the aim that the WSPs are to be owned by the Communities. For that regular IEC and awareness activities are to continue.

The NLSC Meeting followed by wrap up of Mid Term Review by World Bank, wherein Task Team Leader for the Scheme summarized the month long Mission in terms of overall and state wise progress and challenges. One of the main challenges which were highlighted was low convergence by the States as compared to what was expected. Since, convergence is the backbone of next round of incentives, it is important to speed this activity.

All 7 States also presented the best practices under Atal Bhujal Yojana which is happening in their respective State and how this scheme is bringing change in Ground Water Management.

News - Energy Section

GOVERNMENT APPROVES RS 19,744 CRORE NATIONAL GREEN HYDROGEN MISSION

The Union Cabinet on Wednesday approved National Green Hydrogen Mission with a total outlay of Rs 19,744 crore.

The move is targeted to help India, one of the world's biggest greenhouse gas emitters, achieve net-zero carbon emissions by 2070 and make it a global hub for manufacturing of this clean source of energy. Briefing about the decisions of the Cabinet, Union Minister Anurag Thakur said: "mission seeks to promote development of green hydrogen production capacity of at least 5 MMT (million metric tonnes) per annum with an associated renewable energy capacity addition of about 125 GW in the country by 2030."

The initial outlay for the mission will be Rs 19,744 crore, including an outlay of Rs 17,490 crore for the SIGHT programme, Rs 1,466 crore for pilot projects, Rs 400 crore for R&D, and Rs 388 crore towards other mission component.

The Mission will have wide ranging benefits -- creation of export opportunities for green hydrogen and its derivatives; decarbonisation of industrial, mobility and energy sectors; reduction in dependence on imported fossil fuels and feedstock; development of indigenous manufacturing capabilities; creation of employment opportunities; and development of cutting-edge technologies, an official statement said.

The Mission will facilitate demand creation, production, utilisation and export of green hydrogen. Under the Strategic Interventions for Green Hydrogen Transition Programme (SIGHT), two distinct financial incentive mechanisms -- targeting domestic manufacturing of electrolysers and production of green hydrogen -- will be provided under the Mission. The Mission will also support pilot projects in emerging end-use sectors and production pathways. Regions capable of supporting large scale production and/ or utilisation of hydrogen will be identified and developed as Green Hydrogen Hubs, the minister added.

Source : TOI, January 4, 2023

NTPC POWER GENERATION RISES NEARLY 12% TO 295 BILLION UNITS IN APR-DEC 2022

State-owned energy giant NTPC's power generation grew 11.6 per cent year-on-year to 295.4 billion units (BU) in April-December this fiscal. This assumes significance as NTPC supplies one-fourth of the electricity in the country. NTPC recorded a generation of 295.4 BU during April-December 2022, registering a growth of 11.6 per cent compared to the same period the previous year, a company statement said.

On a standalone basis, NTPC generated 254.6 BU during April-December 2022, a 16.1 per cent year-on-year rise.

Its coal-based thermal power plants registered a PLF (plant load factor or capacity utilisation) of 73.7 per cent for 9 months in FY23 (April-December 2022) compared to 68.5 per cent in the year-ago period.

NTPC's captive coal production remained at 14.6 MMT in the said period, with 51 per cent year-on-year growth.

NTPC group's installed capacity is 7,0824 MW. Recently, the company has crossed 3 GW of renewable capacity.

Source : PTI : Jan 02, 2023

PSUS TO BE ROPED IN TO BUILD NUCLEAR POWER PLANTS: JITENDRA SINGH

India is all set to rope in its public sector behemoths for building nuclear power plants as it aims to achieve its goal of net zero emissions by 2070, Union Science and Technology Minister Jitendra Singh said here on Tuesday. Addressing the media on the sidelines of the 108th Indian Science Congress here, Singh said the nuclear sector has been opened up for joint ventures with public sector undertakings to generate financial resources for building atomic power plants.

Singh is the Union Minister of State in the Prime Minister's Office and in-charge of the Department of Atomic Energy. The government had amended the Atomic Energy Act in 2015 to enable joint ventures between the Nuclear Power Corporation of India Limited (NPCIL) and public sector companies to build nuclear power projects.

"We are now building nuclear power plants in northern parts of the country as well," Singh said citing the construction of a nuclear power plant in Gorakhpur in Haryana.

In 2017, the government has approved the building of 10 nuclear power plants of 700 MW each under the fleet mode to expand the contribution of atomic power in the country's energy mix. The NPCIL, which operates almost all nuclear power plants in the country, has formed joint ventures with National Thermal Power Corporation, Indian Oil Nuclear Energy and Nalco Power Company Limited for expansion of the nuclear power sector.

India's current installed nuclear power capacity is 6780 MW and it plans to add 21 more atomic power generating units with a total installed capacity of 15,700 MW by 2031.

Source : PTI : Jan 03, 2023

ON THE CARDS: 11 GW HYDEL PROJECT IN ARUNACHAL PRADESH

India is planning a hydropower project on the strategically important Siang River in Arunachal Pradesh of 11,000 MW capacity, people aware of the matter said. "The purpose of the project, apart from generating electricity, is also to control floods," one of the persons cited earlier said, adding that state-owned NHPC Ltd has submitted a pre-feasibility report for the Upper Siang Multipurpose Storage project.

The project, spearheaded by the ministry of jal shakti, will aim at live storage of 9 billion cubic meters of water. The report on the project has been sent to the Central Electricity Authority for approval.

"The pre-feasibility report for the project was submitted around December end," said the person quoted above. "The next step after its approval would be the pre-detailed project report."

NHPC may be asked to develop the project as a joint venture with either North Eastern Electric Power Corporation Ltd or the Arunachal Pradesh government, according to the sources. The cost of setting up a hydroelectric project is generally ₹6-10 crore/MW, and the gestation period for such projects is usually over nine years, depending on the size and the works. Siang is the most important river in Arunachal which also forms the main trunk of river Brahmaputra. The river flows from China, where it is called Yarlung Tsangpo. China is also planning to build a dam on its part of the river to produce 60,000 MW of electricity.

Source : ET Bureau, Jan 18, 2023

TRIPURA FORMS SEPARATE ENTITY FOR INTRA-STATE ELECTRICITY TRANSMISSION

To bring down the power sector's aggregate technical and commercial (AT&C) losses, the Tripura government has formed a separate entity for electricity transmission in the state, a senior government official said. Tripura State Power Transmission Ltd (TPTL) has been formed this month as a wholly-owned subsidiary of Tripura State Electricity Corporation Limited (TSECL) for power transmission, State Power Secretary Brijesh Pandey told PTI here.

The official was part of a delegation which visited New Delhi recently to sign an agreement with NTPC for the development of renewable energy projects in the northeastern state.

"Carving out a separate transmission segment from TSECL was a big challenge. However, it was possible with the support of the government and various stakeholders," the official said.

Until now TSECL was responsible for the generation, distribution and transmission of power in Tripura. A dedicated entity for intra-state transportation of power will help reduce AT&C losses which were at 31.7 per cent in FY2021-22, he said.

The target is to bring down the same to 28 per cent in FY23, he said.

The new entity will receive power produced by OTPC, NEEPCO, and Agartala-based TSECL from the National Grid for transmission of power across Tripura.

TPTL has come into operation with effect from January 14, 2023. The New entity TPTL will manage 83 operational power sub-stations and 1,861 km of transmission lines (including 59 sub-stations and 875 km of lines in 33kv systems) within the state.

A committee constituted by the Union Ministry Power had recommended bringing the 33 KV system under state transmission utility for improvement in performance.

The committee under the Chairman and Managing Director, Power Grid Corporation of India Limited with representatives from Central Electricity Authority, State Transmission Utilities and Central Transmission suggested measures for the reduction of losses in the sub-transmission system and for ensuring reliability and efficient performance.

Source : PTI, Jan 22, 2023

MAHANADI COALFIELDS TO SET UP 1,600 MW POWER PLANT IN ODISHA

Mahanadi Coalfields Limited (MCL), a subsidiary of Coal India Limited, is looking to diversify into power generation, and plans to set up a Rs 12,000 crore power plant in Odisha.

It also aims to enter into aluminium business and may soon set up a greenfield aluminium project.

Sources informed that the 1,600 megawatt capacity coal-fired power project would come up in Odisha's Sundargarh district as a wholly owned subsidiary of MCL.

MCL also plans to enter into the aluminium business, they further said.

The mini ratna company is currently looking to secure a bauxite mine for the purpose. Coal India's board in October 2021 had approved a pre-feasibility report for setting up an integrated aluminium project in Odisha.

Earlier, the coal behemoth in December 2020 had got in-principle approval for venturing into aluminium and solar sectors and creation of special purpose vehicles.

Coal India in a regulatory filing in October 2021 had said that the proposed aluminium project would include bauxite mining, alumina refinery, aluminium smelter and an associated captive power plant by its wholly owned subsidiary MCL.

Source : IANS, Jan 23, 2023

BOARD'S ASSOCIATION WITH INTERNATIONAL AND NATIONAL ORGANIZATIONS

WATER RESOURCES AND HYDRO POWER SECTORS

THE COMMITTEE FOR INTERNATIONAL COMMISSION ON LARGE DAMS (INDIA) – INCOLD

The International Commission on Large Dams (ICOLD) is an International Organization, established in the year 1928, headquartered at Paris, France having membership of 103 countries with approximately more than 20000 individual members who are practicing engineers, geologists and scientists from governmental and private organizations, consulting firms, universities, laboratories and construction companies.

INCOLD

The Committee for International Commission on Large Dams, India (INCOLD) is the Indian Chapter of International Commission on Large Dams (ICOLD) joined ICOLD in the year 1930, to help in dissemination about the advancement of dam engineering in planning, design & development, management, science & technology, research and education at International level, to the Indian dam professionals and agencies involved with the development of dam engineering in the country. INCOLD provides forum for the planners, decision makers, administrators, managers, scientists, engineers, educators & others who are associated with dam engineering, to exchange of information on the various issues such as dam safety evaluation, rehabilitation and resettlement, RCC dams, instrumentation of existing dams etc.

TUNNELLING ASSOCIATION OF INDIA (TAI)

Tunnelling Association of India (TAI) is the Indian Chapter of International Tunnelling and underground Space Association (ITA) having membership of 78 Members Nations including India established in the year 1974 and presently having the headquarter at Geneva, Switzerland. India joined ITA in the year 1976, by the initiative of Central Board of Irrigation and Power, a Non-Profit and Non-Governmental Organization registered under Societies Registrations act 1860 in the year 1991 with the mission to encourage the use of the subsurface for the benefit of public, environment and sustainable development and to promote advances in planning, design, construction, maintenance and safety of tunnels and underground space,by bringing together information thereon and by studying questions related thereto. The Association is involved for increasing the awareness of public and decision makers about the unique benefits of the underground space, especially social and environmental benefits, managing and minimizing risk and assuring safety and security in all tunnelling activities, and ensure sustainable development of tunnel and underground space. The network of the Tunnelling Community is based on communications by Individual, Institutional and Young professional from the Govt. Utilities, corporate world, construction and manufacturing industries etc.Presently, TAI is holding more than 600 Members which includes individuals, institutions and young professionals involved with the tunnel and underground construction works.The diversity of membership is our main asset as it gathers all professional involved in the tunnelling and the use of underground space such as owners, engineering agencies, town planners, architects, designers, heavy construction and specialist contractors, material and equipment suppliers, lawyers, politicians, academics and researchers, economists, financiers, mine owners and operators. TAI is working closely with Government authorities dealing with the tunnel and underground space development for infrastructure projects like hydropower, railways, metro, highways, irrigation, water supply & Sewerage and underground gas storage etc.

INTERNATIONAL SOCIETY FOR ROCK MECHANICS AND ROCK ENGINEERING (ISRM)

The Indian National Group of ISRM i.e., ISRM (India) has been involved in dissemination of information regarding rock mechanics, mining and tunnel engineering by organising symposia, seminars, workshops, and training courses, both at national as well as international level, in liaison with international organisations. Since its inception, in 1991, ISRM (India) represents as Indian National Group of International Society for Rock Mechanics and Rock Engineering (ISRM). ISRM was founded in Salzburg in 1962 as a result of the enlargement of the "SalzburgerKreis". Its foundation being mainly owed to Professor Muller who acted as President of the Society till September 1966. The Society is a non-profit organization supported by the fees of the members and grants that do not impair its free action.

ISRM (India)

INTERNATIONAL GEOSYNTHETICS SOCIETY (IGS)

In the year 1985, Central Board of Irrigation and Power, (CBIP) as part of its technology forecasting activities identified geosynthetics as an important area relevant to India's need for infrastructure development, including roads. After approval of IGS Council for the formation of Indian Chapter in October 1988, the Indian Chapter of IGS was got registered under Societies Registration Act 1860 of India in June 1992.

NEW DELHI CENTRE OF WORLD WATER COUNCIL (NDC–WWC)

The New Delhi Centre of World Water Council, a multi-stakeholder platform was established in 2001 on the initiative of renowned water specialists and national organizations, in response to an increasing concern about water sector issues from the Asia region community. The centre was established "to promote awareness, build political commitment and trigger action on critical water issues at all levels, including the highest decision making level, to facilitate the efficient conservation, protection, development, planning, management and use of water in all its dimensions on an environmentally sustainable basis for the benefit of all life on earth."

GEOGRAPHICAL COMMITTEE OF INTERNATIONAL WATER RESOURCES ASSOCIATION (IWRA) INDIA

The International Water Resources Association (IWRA), established in 1972, has been recognized and respected as a leading advocate in advancing the understanding and management of water resources worldwide. The Geographical Committee of IWRA (India) with its secretariat at the Central Board of Irrigation and Power (CBIP) is representing IWRA, in India, as its Geographical Committee, since 1991.

INTERNATIONAL ASSOCIATION FOR SMALL HYDRO (IASH)

IWRA-India

The International Association for Small Hydro was formed in the year 1994 with headquarters at New Delhi. The Association draws its member from all countries who are associated with eminent engineers in the field of small hydro. The objective of the Association are to promote research, planning, consulting on construction, operation of small hydro including Mini and Micro.

INDIAN NATIONAL HYDROPOWER ASSOCIATION (INHA)

Indian National Hydropower Association (INHA), was established in June 2003, to provide a forum for the exchange of views and enhancement of knowledge on various aspects relating to hydropower in India, advocating the interests and representing the views of hydropower fraternity before all concerned agencies, and seeking to influence energy and environment policy of Government and profess the merits of implementing hydro policy in India. INHA is an Affiliate Member of International Hydropower Association (IHA), thereby providing an opportunity to remain in touch with the international hydropower development and take advantage of the developments and best practices.

POWER SECTOR

CIGRE INDIA – THE NATIONAL COMMITTEE FOR INTERNATIONAL COUNCIL FOR LARGE ELECTRIC SYSTEMS (CIGRE) PARIS

CIGRÉ, The International Council for Large Electric Systems, is a Worldwide, non-profit association of more than 14,000 Professionals in 90 Countries Engaged in Power System Engineering for Generation, Transmission and Distribution. Headquartered in Paris, CIGRÉ brings these Professionals together through a Variety of Symposia and Technical Conferences Around the World. It is an honor for the country that the President, CIGRE-India (at present Shri I.S. Jha, Hon'ble Member of CERC) is member of CIGRE Steering Committee, the top decision making body of CIGRE. The President CIGRE-India is also the Administrative Council Member of CIGRE from India. Beside India is representing in all the sixteen technical committees of CIGRE and in various working groups created under these study committees. Secretary, CBIP is the ex-officio Secretary to CIGRE India. Presently there are more than 800 member from India in CIGRE India condut more than 20 to 25 no. of event, annualy at country level in addition to CIGRE Paris events.

INTERNATIONAL ASSOCIATION ON ELECTRICITY GENERATION, TRANSMISSION & DISTRIBUTION (AARO)

The International Association on Electricity Generation, Transmission and Distribution (Afro-Asian Region) is a Regional non-Governmental organization formed in 1990 with headquarters in New Delhi, India. The Association is an autonomous, professional organisation of which central / state Govt. organisation, State water resources departments SEB's Corporations, Power Utilities, Project Authorities, Educational Institutions, Planners, Developers, Engineers etc. are subscribing members. It provides an information service to all concerned of power development and encourages the development of techniques of Multidisciplinary planning of Power Generation, Transmission and Distribution. This objective is achieved by arranging seminars, workshops etc. and by publishing Journals.

AARO

SOCIETY OF POWER ENGINEERS (SPE)

Society of Power Engineers (India) is an apex body, constituted in the year 1947, engaged in the activities of technological upliftment of the power engineers of this country by making available latest technological developments all over the world to the members. Publication & distribution of information Journal, Workshops/Seminar, group discussion are regular features of the society. The aims and objects of Society is to promote the advancement of power engineering and allied subjects, and their applications, and to provide facilities for the exchange of information and ideas on those subjects amongst the members of the Society. The Headquarter of the SPE is at New Delhi with chapters at various places in the country. SPE India has presently about 2,400 experts and eminent engineers on its strength who share their rich experience, express their views and give suggestions for sustainable growth of power sector with state of art technology.

CIRED INDIA – INTERNATIONAL CONFERENCE ON ELECTRICITY DISTRIBUTION (CIRED)

An international association was set up under the name of CIRED in Belgium. *'CIRED' is derived from "Congrès International des Réseaux Electriques de Distribution"* in English 'International Conference on Electricity Distribution'. CIRED is associated in the technical field of Electricity Distribution Systems, including dispersed and embedded generation issues. CIRED is dedicated to the design, construction and operation of public distribution systems and of large installations using electrical energy in industry, services and transport. CIRED India, is the laison committee of CIRED and coordinate acitivites from India. Secretary, CBIP is the Secretary CIRED India.

To join as member, please contact at : secretary@cbip.org; cbip@cbip.org

MANUAL ON SUBSTATION AUTOMATION SYSTEM
PUBLICATION NO. 345 COST : Rs. 2000/-

To achieve the objective of bringing out manuals, CBIP constituted an Expert Group under the chairmanship of Shri S.G. Patki, Former Chairman CIGRE National Committee on Protection & Automation and Former VP, The Tata Power Company, and Members from all eminent organizations/utilities and consultants. The Expert Group has made laudable efforts and after a gap of more than 3 years of untiring work has recently prepared the Manual on SUBSTATION AUTOMATION SYSTEM which is a unique document. This publication contains the following eight chapters:

1. Introduction and Context
2. Requirements of Substation Automation System and Functional design specifications
3. Basics of IEC 61850 standard for SAS
4. Communication Protocols and Architectures
5. Migration Strategies
6. Testing and Validation
7. Cyber Security Management Systems
8. IEC 61850 Process Bus and Digital substation

MANUAL ON SUBSTATION
Publication No. 342, COST : RS. 3,500/-

CBIP published first edition of the "Manual on Substation Layout" in 2006. The manual has been well appreciated and is widely used by engineering fraternity. Taking into account the technological developments and revision in National/ International standards, it was deemed necessary to revise the document on Substations in a comprehensive manner.

CBIP constituted an Expert Group headed by Shri S.K. Ray Mohapatra, Chief Engineer, Central Electricity Authority to revised and rename the 'Manual on Substation Layouts' as 'Manual on Substation' to cover various aspects of Substations. Representatives from various utilities across the country, comprising manufacturers, Power utilities, R&D and Testing organizations were associated as members of the Expert Group.

New chapters on Type of substations, General Requirements, insulation co-ordination, Erection & Commissioning, New Technologies, Refurbishment and upgradation / uprating of existing substations, safety, Life Cycle Management etc. have been included for the benefit of prospective users. Copy of this document is available for sale and can be had by sending demand draft/cheque for Rs. 3,500/- drawn in favour of Central Board of Irrigation and Power, New Delhi.

GUIDELINES FOR 'DESIGN OF PILE FOUNDATION FOR TRANSMISSION LINE TOWERS FOR RIVER CROSSING AND OTHER SPECIAL LOCATIONS'
Publication No. 344, COST : Rs. Rs.500/-

CBIP had brought out the first manual on transmission lines in 1977. In view of fast technological advancements in transmission sector this Manual has been updated in 1998 and in 2014. For updating this Manual, CBIP constituted an Expert Group headed by Shri I.S. Jha the then Director, POWERGRID and presently Member CERC. A chapter on Foundations which contains optimal solutions for foundations, illustration on adoption of latest methodology on foundation design in different types of soils, rock foundations etc. was also updated in the manual. However, the Expert Group suggested to prepare a separate Guidelines on the above subject. Accordingly, this work for preparation of this Guideline was assigned to Shri D. Chowdhary, the then ED, Power Grid Corporation of India Ltd. This Guideline deals with design of Pile foundations (Bored cast in Situ) for Transmission line towers at Special locations like River crossing, marine deposit, marshy land and slushy land etc. It covers the design and brief aspects of construction of concrete bored cast-in-situ pile foundation.

POWER MAP OF INDIA 2021 (400 KV & ABOVE)
COST: Rs. 1,000/-

CBIP has been bringing out Power Map of India for the reference of concerned organizations. Last edition of this Map was brought out in 2020. This map has earned appreciation both at National and International level and is very much in demand by Government/private organizations engaged in power sector including PSU's, utilities, Contractors, professionals and individuals not only in India but also in other countries. In view of the persistent demand from the various professionals and other allied organizations, the CBIP has updated this map upto November 2020 under the guidance of Central Electricity Authority. This map covers details of generating stations and transmission system for 400 kV level and above both existing and under construction. This map is printed on the laminated art paper and is in folded version.

MANUAL ON EARTHING OF AC POWER SYSTEMS 2020

GP-339, Cost 2500/-

In the present day scenario the Earthing System in Generation, Transmission, Distribution and electrical installations of domestic and commercial use is of paramount importance. Sound and reliable earthing system is intended not only to protect the installation but also the operating personnel's as well as domestic users of electrical equipments from over-voltages as well as leakages. Over the years, the Central Board of Irrigation and Power (CBIP), India, has contributed substantially to the development of techniques, methods and procedures, and assimilation and exchange of information on earthing for various components of electric power systems through earlier published documents. However, it was felt that there should be a document covering comprehensively all aspects of earthing to meet the requirements. In view thereof, an Expert Group to prepare the document 'Manual on Earthing of AC Power Systems" had constituted. The first manual on Earthing was published in 2007. To incorporate the latest developments and facilitate the professional engineers associated in the field; this Manual has been updated in 2020.

MANUAL ON POWER DISTRIBUTION SYSTEMS

Publication No. 335 – Cost Rs. 2,500/-

CBIP had brought out a publication on the subject 'Modern Trends and Practices in Power Sub-Transmission and Distribution Systems' way back in the year 1996. In view of the latest technological developments a strong need was felt to bring out a new document on distribution system covering latest technical developments. CBIP, with the aim to prepare a document covering comprehensively all aspects of distribution system constituted an Expert Group and decided to prepare the document 'Manual on Power Distribution Systems" under the chairmanship of Smt. Anjuli Chandra, Chief Engineer, Central Electricity Authority. In this Manual a systematic attempt has been made to bring out details in various chapters relating to Planning and Design, Losses in Power system, Transformers, Switchgears, GIS Technology at Sub-Transmission Level, Metering, O&M and Condition Monitoring, Capacitors, Power Quality, Reliability, Role of Smart Grids in the Distribution Sector in India, Micro-grids, Construction of Sub-Station, Construction of Sub-Transmission and Distribution Lines, Renewable Energy, Safety in Distribution System and Testing.

MANUAL ON RENOVATION, MODERNIZATION, UPRATING AND LIFE EXTENSION OF HYDROPOWER PLANTS

Publication No. 334 – Cost Rs. 2,500/-

CBIP had brought out the Manual on "Renovation, Modernization, Uprating and Life Extension of Hydropower Plants" in 2005 which has been well appreciated and is in great demand by engineering professionals. Since then, there have been many fast developments. For updating this Manual, CBIP constituted an Expert Group headed by Shri S.D. Dubey, Former Chairperson, Central Electricity Authority. The Expert Group has updated existing chapters covering overview of R&M activities of hydro power plants and cover exhaustively Methodology and Engineering of Renovation & Uprating of HPPs covering Hydro Turbines and auxiliaries, Hydro Generators and auxiliaries, Power Transformers, Civil Structures, Control metering and protection systems,Plant Electrical and mechanical systems, Gates and hydro mechanical equipment, Quality Assurance Plans and funding options & contracts for RMU&LE of hydro power stations. The manual also contains many case studies connected with the subject for the benefit of prospective users as a reference material and guide to tackle similar problems. CBIP has gone way ahead by adding one new chapter on 'Diagnostic Tests to Facilitate R&M Studies'. This would help to address the various issues and problems in Renovation, Modernization, Uprating and Life Extension of Hydropower Plants.

MANUAL ON POWER SYSTEM PROTECTION

Publication No. 328 – Cost Rs. 2,500

CBIP constituted an Expert Group on Protection under the chairmanship of Shri S.G. Patki, Chairman CIGRE National Committee on Protection and Chief, The Tata Power Company and Members from all eminent organizations/utilities and consultants. The Expert Group has made laudable efforts and after a gap of more than 2 years of untiring work has recently completed preparation/revision of Manual which is a unique document covering all aspects of 'Protection'.

The manual gives the Fundamental Concepts, Location of CT PTs, Requirements, Protection Performance Indices, Generator and Generator Transformers, Power Transformer /Auto Transformers Shunt Reactor, Protection of AC Lines, Auto reclosure, HVDC Lines and systems, Busbar Protection, breaker failure Protection, Special protection Schemes, Protection for Renewable energy sources, Fault Disturbance Recorder and Event logging, DC battery and aux Power supply system, Switching devices, Communication system for Protection, Basics for design of Protection schemes based on IEC 61850 standard, Validation, acceptance and Field Testing which form important elements of the protection system.