25 Years of Asian Seismological Commission

Preface

In August 2021, The Asian Seismological Commission (ASC) completed 25 eventful years that saw scientists from Asia and other parts of the world coming together, to discuss and understand Nature's fury that manifested itself in the form of destructive earthquakes and tsunami, especially during the early years of this Millennium. It is a poetic justice that the International Association of Seismology and Physics of the Earth Interior (IASPEI), a constituent of the International Union of Geodesy and Geophysics (IUGG) that first announced the formation of ASC in Tangshan in August 1996 held its Silver Jubilee meeting during the recently concluded Joint Assembly with International Association of Geomagnetism and Aeronomy (IAGA) in Hyderabad, India during 21-28 August, 2021.

The Asia-Pacific region has suffered 70% of the human lives lost during global earthquakes and tsunami and the numbers have been increasing. The first 20 years of the 21st century has surpassed number of casualties seen in the entire preceding 20th century. Added to this are the financial losses that grew exponentially due to these twin natural disasters. ASC has played a leading role in addressing these issues by providing a platform where scientists from different countries presented their research work and got the benefit through exchange of ideas and varied experience. Befitting the occasion the Journal of the Geological Society of India agreed to bring out a special issue in December 2021 dedicated to the Silver Jubilee Year of ASC. The issue contains 18 articles on specific topics from experts highlighting significant developments and benefits accrued due to international cooperation in Asia during the last 25 years and stress the need to continue such collaborations in future to counter natural disasters.

Zhu Chuanzhen, Wu Zhongliang and Li Li provide a background on the seeding of idea to establish ASC and the efforts Zhu put in till the final acceptance and announcement during the Regional Assembly of IASPEI in Tangshan in August 1996. The authors present details of Chinese efforts during several meetings and discussions preceding the formation of ASC and provide a glimpse of the progress made during its journey to the Silver Jubilee Year. A mention is also made on the continuing efforts made by the Chinese scientists in the field of earthquake prediction and seismic hazard assessment and mitigation.

R. K. Chadha traces the chronological history of 11 ASC General Assemblies held from 1996 to 2018 in Asia and Oceania regions. In a pictorial depiction he presents an excellent geographical distribution of ASC Assemblies stretching across Armenia and Iran in the west to Australia in the east. He stresses the importance of Pre-Assembly Training Courses in Seismology during each of the ASC meetings in developing a strong workforce of youngsters in best seismology practices. He points out the appreciation and acknowledgement of

ASC activities by the Scientific and Technical Committee (STC) for Global Seismic Hazard Assessment Program (G-SHAP) in its closing report to International Decade of Natural Hazard Reduction (IDNDR)/STC (1992-1998). Chadha has provided a complete list of the ASC Bureau Membership since its inception. In his concluding remarks he underscored the fact that two extreme events of $M_w \geq 9$ earthquakes followed by devastating tsunami on 26 December 2004 in Sumatra, Indonesia and 11 March 2011 in Tohoku, Japan that occurred in early 21st century were in Asia with global impact. He stressed the need to strengthen ASC and make it more vibrant to counter future destructive earthquake disasters.

Prantik Mandal presents interesting facts on all $M_w \geq 7.5$ earthquakes that occurred in the Asian region since the formation of ASC in 1996. He points out that 8 such earthquakes occurred and claimed close to 0.5 million human lives in Asia alone out of the 0.7 million lives lost, globally, due to earthquakes. A map showing the locations of these 8 earthquakes along with their focal mechanism provides an understanding of the tectonic setting in the Asia-Pacific region. This map has been adopted as the cover page of this issue. Prantik supports the objectives of ASC to strengthen and further develop a resilient Asian society to face natural disasters.

Wu Zhongliang, Chaunzhen Zhu, and Li Li briefly review the history of modern seismology in China since 1921. The field expedition of the great earthquake in Haiyuan on 16 December 1920 was regarded as the beginning of modern seismology in China and this year Centenary celebrations were held in the country. They showed that earthquake prediction is an important scientific agenda in the seismological science in China that follows the 'technical hyper cycle', claiming that now is the stage of 'plateau of productivity'.

Ruben Tatevossian has stressed the importance of seismic hazard assessment for locating nuclear power plants and to deal with rare events. They underline the importance of seismological inputs while setting up new nuclear power plants to meet the ever-increasing demand for energy. Since, the location of these plants is requirement – dependent, a proper assessment of seismic hazard potential of a chosen site becomes critical. The history of seismic events occurring in the vicinity of the location of the power plant as well as far off, strong events that may adversely affect the power plant need to be thoroughly examined. To some extent paleoseismological studies provide clues where earthquake history is not known but it becomes tricky when the past earthquakes occurred 15,000 to 20,000 years ago and were generated due to postglacial processes, a situation that does not exist anymore. They present a few cases histories in support of their arguments.

Alik Ismail-Zadeh and Abhishek Kumar have addressed deterministic, probabilistic and data-enhanced models of seismic hazard assessment applicable at local level, viz., Shillong Plateau in northeast India and at a regional level in the Himalayan-Tibetan Plateau. They conclude “Disaster risk reduction should be based on firm scientific knowledge, vast information and data, systematic development and application of policies, strategies and practices to minimize vulnerabilities and disaster risks throughout a society. They opined that this approach would result in preventing or at least help in mitigation and preparedness which will avoid adverse impact of hazards within the broad context of sustainable development”. They advocate improving SHAs and integrating them with assessments related to vulnerability and exposure to earthquakes in understanding disaster risks and its reduction as well as to building safety and resilience in Asia and elsewhere.

Vladimir Kossobokov and Aleksander Soloviev addressed the issue of testing earthquake prediction algorithms. They underline the importance of estimating the efficiency of different earthquake prediction algorithms and their operational use for reducing earthquake losses. They point out that M8 algorithm is being used for over 30 years and every six months an advisory is issued based on statistical prediction of world's largest earthquake's source zone. They claim a reliability of 99% in these forecasts. A major outcome of this exercise is the rejection of the null hypothesis of random occurrence in seismically active regions with seismological certainty, at least for the world's largest earthquakes. Indirectly, the results of this analysis provide a hope that earthquakes could possibly be in prediction realm, at last.

Wu Zhongliang, Chaozhong Hu, Long Wang, Yongxian Zhang and Zhigang Shao have presented a tectonic block model for continental earthquakes in China. They successfully tested 'active tectonic block model' with positive results. With the new data that are now available, this 2D model is being upgraded to a 3D model, keeping in mind deep crustal structures such as crustal channel flow. The kinematic model is being upgraded to a dynamic one making use of the computational geodynamics.

Yih-Min Wu, Himanshu Mittal, Da-Yi Chen, Ting-Yu Hsu and Pei-Yang Lin provide details of Earthquake Early Warning Systems currently operational in Taiwan. The earthquake early warning (EEW) system in Taiwan has been developed over the years from rigorous research work carried out after the occurrence of the destructive 1986 Hualien earthquake. After more than 25 years of development, three different EEW systems exist in Taiwan, today. These include (1) the regional EEW system operated by the Central Weather Bureau (CWB), (2) a hybrid EEW system operated by National Taiwan University (NTU) and (3) EEW onsite system run by the National Center for Research on Earthquake Engineering (NCREE). The NTU system also generates near real-time shake-maps for rapid response purposes. The NCREE system consists of 98 stations and can provide several seconds lead-time in the area near the epicenter. The NCREE system can also receive CWB regional EEW messages for warnings to the regions far away from the epicenter. Individually every system has its advantage, however, the hybrid approach will be one of the future systems for real operation.

T. Srinivasa Kumar and Sunanda Manneela have reviewed the progress of tsunami early warning system for the Indian Ocean. They point out that one of the consequences of the devastating M_w 9.2 earthquake and the resultant tsunami on 26 December 2004 claiming ~ 235,000 human lives has been the development of the science of early tsunami warning capabilities in India. This also led to the indigenous planning, development and establishment of the Indian Tsunami Early Warning System (ITEWS) for the Indian Ocean. In order to be effective, tsunami early warning system should possess the following four elements, namely, (a) Tsunami risk knowledge, (b) A robust technical detection and monitoring system, (c) Effective dissemination of meaningful warning and (d) Community awareness and preparedness to act. They emphasize on giving importance to each of these four elements to ensure a robust end-to-end tsunami early warning system that can save human lives. They discuss the status of ITEWS and advances made to reduce the uncertainty in forecasts. Advance technologies combined with enhanced response capabilities have made the ITEWS a very successful tsunami warning system.

Asem Salama, Mohamed EL Gabry, Hesham Hussein Moussa and I. F. Abu El-Nader have reviewed the tsunami hazard potential for Gulf of Aqaba, Egypt. They note that historically, earthquakes of magnitude ranging from 6.0 to 7.3 have occurred in 1068, 1212, and 1588 in the vicinity of the Gulf of Aqaba. In the recent past a strong earthquake of M_w 7.3 occurred on 22 November 1995 generated small tsunami waves affecting the port of Nuweiba and Eilat and Aqaba beaches. They have estimated the maximum run up heights varying between 0.50 m and 2.10 m at Nuweiba, Dahab coastal cities and other cities in the vicinity of Gulf of Aqaba.

Wu Zhongliang and Li Li have dealt with the China Seismic Experimental Site (CSES) dedicated to multi-disciplinary research on the mechanism of continental earthquakes aimed to reduce the earthquake disaster. A system science perspective is being used to achieve this goal. A major step was taken during the International Conference after a decade of 2008 Wenchuan earthquake in 2018 at Chengdu, China, where CSES was launched. It is very well realized that the goal of making short-term to imminent earthquake forecast may not be achieved within the next decade. However, it is hoped that the potential precursors shall be identified.

Harsh K. Gupta has summarized studies on artificial water reservoir triggered seismicity (RTS) with special focus on Koyna, India, where the largest RTS event of M 6.3 occurred on 10 December 1967. Koyna is found to be a very suitable site for near-field studies of earthquakes genesis. After several deliberations, involving international scientific community and through the technical support of the International Continental Drilling Program (ICDP), a time bound studies were undertaken that led to identification of the most suitable site to put a 3 km deep Pilot Borehole. The drilling started in December 2016 and the borehole was completed in June 2017. Gupta presented a summary of global RTS cases, scientific work done in Koyna, characterization of RTS and establishment of a 3 km deep Pilot Borehole laboratory.

Trong Cao Dinh, Trieu Cao Dinh, Tuan Thai Anh, Bach Mai Xuan, Luc NguyenManh, Duong Van Thanh, Dung Le Van, Hai Dang Thanh and Toan Ngo Quang have reported application of Digital Elevation

Model (DEM) for mapping of seismic zones in the Cao Bang province and adjacent area in Vietnam. The analysis steps include, (a) determination of the geomorphic indices sensitivity with respect to the earthquake activity using the MLP neural network, (b) Calculation of the weight coefficients of all indices according to principal Eigen vector (AHP method), (c) Estimation of the ranking sensitivity of each geomorphic indices to the earthquake activity using their value distribution and (d) Identification of the Seismic Susceptibility Index (SSI). Through these analyses 6 seismic zones have been identified in the study area where 6 earthquakes of $M \sim 5$ occurred from 1943 to 2019.

Trong Cao Dinh, Trieu Cao Dinh, Tuan Thai Anh, Van Dinh Quoc, Dung Le Van, Hai Dang Thanh, Bach Mai Xuan, Huang Pham Nam and Tuyen Nguyen Huu have overviewed the characteristics of reservoir-triggered seismicity (RTS) at hydropower reservoirs in Vietnam. Following is the summary of their work: (1) RTS events of magnitude $M > 4.0$ have occurred at the Hoa Binh, Song Tranh 2 and Son La hydropower reservoirs. All these reservoirs are more than 90 m deep and located on gneiss, granite, or limestone basement rocks, (2) Triggered earthquakes at the Hoa Binh, Song Tranh 2 and Son La hydropower reservoirs are the rapid ones. The earthquake frequency has close ties with the water level change, (3) V_p/V_s ratio can be used as the main factor determining the triggered earthquake source. The natural earthquake sources interconnecting with the reservoir and having the V_p/V_s ratio of 1.63-1.69 have the highest risk of triggered earthquake occurrence and (4) There is no risk of triggered earthquake occurrence at Hoa Binh hydropower reservoir, the magnitude of 4.9 is the maximum. Triggered earthquakes in the Song Tranh 2 reservoir continue to occur with the magnitude of smaller than 4.7. In the Son La reservoir, triggered earthquakes have magnitude of 4.3.

Kusumita Arora and Y. Srinu have presented the results of morphometric analysis of Koyna-Warna region where reservoir triggered earthquakes are occurring. Even after 60 years of detailed studies of triggered earthquakes at the Koyna-Warna region in western India, questions related to the role of reservoir water on the seismicity, the area of influence and possible pathways through which surface water may catalyze an earthquake at depth remains un-answered. Airborne LiDAR data are used to get high resolution DEM that unravels several aspects of surface features. The characteristics of surface morphology over the region have been discussed. Lineament systems have been delineated, the association of which with subsurface trends and seismicity patterns, establish them as fault systems. They have tried to look at geomorphic parameters over the region and investigate their correlation with seismicity. They conclude that earthquake clusters are controlled by regional tectonics, and these differ in the Koyna and Warna regions.

Arvind Kumar, Vivek Walia, Shih-Jung Lin and Chuing-Chou Fu reported results of radon monitoring in the artesian wells in Mato-san

areas of south Taiwan and their relationship with mud eruption cycles. Using RAD7 radon monitoring in water was carried out where water samples at different depths from different wells for the period of two weeks to one month were collected. Anomalous radon value has been observed before and after some eruptions. A totally different radon behavior was observed at well No. 2 compared to well No. 3(B), which they attributed to movement of gas fluxes during the eruption period.

Harsh K. Gupta and Kanchan A. Sabnis have described the efforts to develop earthquake resilient society in the vicinity of Himalaya in India, which is seismically one of the most active continental regions in the world where four earthquakes of $M \sim 8$ occurred in a short span of 55 years. No comparable earthquake has occurred since then. Since, the region is prone to such destructive earthquakes, developing an earthquake resilient society through the process of developing earthquake scenarios is one practical approach. A most plausible scenario could be to assess the impact of one of the past Great earthquakes, if it repeats today and sharing this information with all concerned, doing needful to educate and enrich the concerned government departments, and making the public a stakeholder, helps. The 1905 Kangra earthquake of $M \sim 8$ had claimed $\sim 20,000$ human lives in addition to causing widespread damage. The National Disaster Management Authority (NDMA), Government of India, built a scenario as to what would be the consequences if such an earthquake occurred today? It was estimated that ~ 0.9 million human lives would be lost in the states of Punjab, Haryana, Himachal Pradesh and the Union Territory of Chandigarh if this earthquake occurred in the middle of the night. A year-long phase of training and educating at various levels to develop an earthquake resilient society in the states of Punjab, Haryana, Himachal Pradesh and Union Territory of Chandigarh during 2012-2013 culminated in a mega mock drill on the 13 February 2013. It demonstrated what all had been achieved and what was missing. Encouraged by the success a similar exercise was carried out for the repeat of the 1897 Shillong earthquake for 8 northeast Indian states during 2013-2014 culminating in mega mock drills on 10 and 13 March 2014. In this communication a brief of these exercises is provided.

We are grateful to Asian Seismological Commission (ASC) to accept our proposal to bring out a special issue of the Journal of the Geological Society of India (J-GSI) commemorating its Silver Jubilee. We wish to thank all the authors for contributing significant articles for this issue. The help of reviewers is gratefully acknowledged; particularly of Dr. R.K. Chadha. Special thanks are due to the Editor of the J-GSI, Prof. B. Mahabaleswar and Managing Editor, Mr. B.R. Krishna as well as to the Council of the Society that made it possible to publish this issue.

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