Editorial

IGU Golden Jubilee Year:

Already six months have elapsed and IGU could successfully organise various activities, to make IGU Golden Jubilee year a memorable one. As part of the Golden Jubilee Celebrations of IGU, we have successfully organised two workshops at NIO- Goa and NESAC-Umiam (Shillong), Meghalaya . The third at WIHG-Dehradun is being planned to be held on 11-12 June 2013 (as this editorial being prepared). The two workshops were organised successfully, using expertise of Local Organisers and proper support from IGU management. The first one, inaugurated by Dr.H.K.Gupta, Member, NDMA, Govt of India, covered various aspects of Marine Geosciences and stressed the need to enhance quality research in Marine Geosciences by integrating inputs from Marine Geology, Marine Geophysics, Marine Geochemistry, Marine Biology and Physical Oceanography. Dr.Gupta in his inaugural address appreciated the quality research out put produced by Marine Geoscientists of the country, in meeting the needs of our society and in addressing environmental issues. He urged the students and young researchers to pursue scientific research with enthusiasm and commitment. It was also stressed during the workshop that enhanced interaction between Marine Geoscientists and Solid Earth Geoscientists would help in better addressing problems of common interest and protecting the Land and Ocean environment. It was clear from the workshop that both young and senior scientists are well aware of the deteriorating Marine Environment. They advocated through their presentations and active interaction the importance of initiating various steps to arrest the deterioration and there by save both the Marine Life and the Man. We urge both the organisers and the participants to strengthen the bondage developed during the workshop, instead of feeling satisfied with the success of the workshop. Success of the workshop will only be appreciated if all the delegates make proper use of the knowledge gained during the workshop. The second workshop on Natural Hazards was also well organised. It has been stressed that since the vulnerability of various segments of our country to different types of hazards can decelerate the socio-economic progress, it is very important for various government and NGOs to train energetic and capable young people to meet the hazards properly and provide needed support in meeting the needs of the affected people and in rehabilitating them properly, through technologically effective and administratively feasible strategies. It is also stressed that since hazard resultant damages could be huge the government should encourage formation of area specific crisis management teams at local level, instead of concentrating on centralised administrative steps for relief and rehabilitation. In the workshop it has been clearly stressed that the North-Eastern segment of the country is being devastated by different types of Natural Hazards; the prominent being Earth quakes, River water resultant erosion to the land and significant Land Slides. Both the invited speakers and young researchers have opined that capacity building, training and educating the various segments of the society is paramount as Man Induced aberrations have added to the vulnerabilities imposed by the Nature. The Chief Guest Shri P.P.Shrivastava, Member of North East Council (NEC), an eminent administrator, and committed volunteer to safe guard the interests of NE India (by introducing apt methodologies to face the disasters) has energised the proceedings by his dynamic presence and important presentation. He, while appreciating the research carried out by scientific organisations, sought the involvement of scientists and technical experts in managing the natural hazards and mitigating the disaster resultant vulnerabilities. It is clear from the workshop that significant research has been carried out by different scientific organisations. However, the data generated need to be looked and relooked from different angles to develop area specific models. It is also stressed that data needs to be provided by research organisations, to researchers to enhance the quality of disaster management and mitigation efforts. It was heartening to see at both the workshops the enthusiasm of students and young researchers and the commitment of senior scientists in educating the young (by providing an over view of various studies and their importance in enhancing the quality of research in different fields). The invited talks delivered by experts provided an opportunity to the students to get exposed to various research developments and helped the scientists to have first hand information about research carried out in Solid Earth geosciences, Marine Geosciences, Atmosphere, Space and Planetary Sciences by different research institutions and universities. Some specifics of the first workshop were included in the April issue of this journal. Some details of the second workshop are included in this issue, as a News item. Dr.V.P.Dimri, President, IGU lent his able guidance in organising both the workshops. He has presented in detail, through the presidential addresses, the significant strides made by IGU, in serving the earth system scientific community and sought continued support to IGU.

In a significant way this exposure has enhanced the visibility of IGU. We are happy to state that our basic objective behind organising workshops, on different topics in different parts of the country, has been met seeing young researchers gaining useful knowledge through interaction with seniors. We place on record our thanks to Drs.S.W.A.Naqvi, Director, NIO, Goa and S.Sudhakar, Director, NESAC, Umiam, Meghalaya for lending their unequivocal support in organising the two workshops. We also thank Drs.Rajiv Nigam, Chief Scientist, NIO, Goa and Dr. (Mrs.) Kuntala Bhusan, Scientist, NESAC for actively organising the two workshops, as Convenors. Once the three remaining workshops are organised at WIHG-Dehradun, SRTM University-Nanded and IIT-Kharagpur, we will have sufficient input for carrying out exhaustive in-house interaction, for preparing a road map for developing IGU in the next 20 years. The knowledge gained by the IGU would be useful in interacting and exchanging ideas with the representatives of American Geophysical Union (AGU) during 50th Annual Convention at NGRI, Hyderabad, during 9-12 January 2014, and help IGU in successfully planning and organising future scientific conferences of importance to the national and international scientific community.

Editorials:

In the last couple of years we have been bringing out editorials covering various topics of interest to both the scientific community and the common man. We have enjoyed preparing the editorials and felt happy in receiving positive feedback. Couple of learned readers have suggested to focus on one topic in one issue, as such an exposition would be of use to the researchers in understanding both the basics and important aspects of that topic. They have also pointed out such a suggestion is not aimed at in diluting the importance of various topics, hither to included in the editorials. Respecting their suggestion/ view, it is decided to write on one topic of interest, in this and the next two issues and see the reaction of the readers. Depending on their valued reaction/ input we will take appropriate measures. Our basic objective in bringing out editorials is to focus on various ongoing issues/ developments that are of importance not only to the Earth system scientific community but also to our society. For this issue we have selected subsidence, as it assumes significant importance in addressing various problems that are affecting our mining sector, groundwater extraction, Oil & Gas extraction zones, coastal corridor, and earthquake and tsunami affected regions. Many of us do not attach importance to this phenomenon (as many of us are not familiar with this phenomenon, compared to other Natural Hazards), even though this phenomenon, at times, can create debilitating impact on our environment and surface & sub surface natural and manmade structures. We do hope the inputs would be of use to our scientists, and pave way for quality research in this field.

Subsidence

What is subsidence?

Subsidence is the motion of a surface (usually, the Earth's surface) as it shifts downward relative to a datum such as sea-level. The opposite of subsidence is uplift, which results in an increase in elevation. Ground subsidence is of concern to geologists, geotechnical engineers and surveyors. Subsidence can happen suddenly and without warning. Detailed investigations of an undermined area are needed before development to resolve the magnitude of the subsidence hazard and to determine if safe construction is possible. While investigations after development can determine the extent of undermining and potential subsidence, often, existing buildings cannot be protected against subsidence hazards. This is because of the inability of available technology to predict exactly where, when and how much subsidence will take place at a given spot and the cost of remedial measure. Subsidence is lowering of the ground surface that results from compaction or consolidation of the geological materials beneath, such as soil and rock. Consolidation of these geological materials occurs when stress is applied that causes them to decrease in volume. Subsidence resulting from consolidation can be caused by a variety of factors that vary from place to place. Subsidence is a natural process in certain landscapes where there are porous sediments and rocks, or where they are highly soluble. Subsidence can affect clay, peat, some silt formations and some sands, limestone with large underground voids and can be associated with mining activity and old mine workings.

How is subsidence measured?

A variety of methods can be used to detect and measure subsidence. These include surveying with real time global positioning systems (RTK GPS), installation of extensiometers in boreholes and advanced satellite mapping techniques. One advanced satellite mapping technique, called Satellite Interferometric Synthetic Aperture Radar (InSAR), is often used for regional-scale subsidence measurement. InSAR can detect how much the ground surface has subsided (or uplifted) by measuring the distance between it and a spacecraft. This is accomplished by measuring the differences between radar signals transmitted to the ground surface from the same point in space at different times, usually months or years apart. The radar data is combined into an interferogram image, which shows the magnitude of the differences between the successive signals, detecting movement as little as 5-10mm. The technology behind InSAR was first used to remotely explore the surfaces of the Moon and Venus. Since then the method has been refined and is now used for many applications on earth, such as earthquake and volcano monitoring. InSAR is less expensive than other methods, providing millions of data points over large areas as much as 10,000 square kilometres.

Why does subsidence matter?

Subsidence is of great importance because it is irreversible once it has occurred.

The majority of cases of subsidence recognized so far have been found to have developed due to increased extraction of groundwater, oil and gas.

Subsidence can cause many additional problems including:

- changes in elevation and slope of streams, canals and drains, affecting the rate of flow;
- damage to bridges, roads, railroads, electric power lines, storm drains, sanitary sewers, canals and levees!
- damage to both private and public buildings;
- failure of well casings causing reduction in the quality and yield of extracted groundwater;
- Tidal inundation of low-lying coastal areas that were previously above high-tide levels.

Can subsidence be predicted?

Subsidence can be predicted by developing a detailed understanding of the geotechnical response of the earth to the changes in stress caused by reduced groundwater levels. Predicting subsidence where groundwater extraction occurs involves establishing the thickness and distribution of compressible sediments, understanding how these sediments behave in response to changing stresses, and accurately estimating the level of groundwater expected to remain in an aquifer after extraction has taken place.

Accurately estimating future groundwater levels can pose the greatest challenge to successful prediction of subsidence because groundwater requirements for agriculture and industry are inherently dynamic - and also uncertain - due to the various climatic, socio-economic and policy factors involved (Courtesy: University of New South Wales, Australia). Subsidence due to mining operations and Oil & Gas extraction can be predicted to an extent if the surface and sub surface structural dynamics is recorded systematically in time and space.

Subsidence is caused due to various factors. Some details are provided below. Interested readers are requested to go through a vast pool of information available in the libraries and through internet for further details. Details given here are mainly intended to introduce the topic.

Dissolution of limestone

Subsidence frequently causes major problems in karst terrains, where dissolution of limestone by fluid flow in the subsurface causes the creation of voids (i.e. caves). If the roof of these voids becomes too weak, it can collapse and the overlying rock and earth will fall into the space, causing subsidence at the surface. This type of subsidence can result in sinkholes which can be many hundreds of meters deep. Field observations (Farooq Ahmad Dar et al, ACTA CARSOLOGICA 40/3 – 2011) indicate the extensive karstification of the three carbonate formations present within the Cuddapah sedimentary basin, namely the Vempalle dolomite, the Narji and Koilkuntla limestones. The karstification nature of these formations needs to be taken in to consideration in taking up any development/ management activities such as civil engineering work, water management, and land management as these areas can cave in leading to substantial subsidence of the land surface. Sink holes in limestones around Rewa, Central India, as they are associated with weak sub surface structures, may lead to large scale subsidence if unplanned developmental works are executed. As such it is essential to carry out integrated geophysical investigations (including radar penetrating electromagnetic investigations) to locate hidden cavities in different karst terrains prior to taking up developmental works, to avoid land subsidence.

Mining

Several types of sub-surface mining, and specifically methods which intentionally cause the extracted void to collapse (such as pillar extraction, long wall mining and any metalliferous mining method which utilizes "caving" such as "block caving" or "sub-level caving") will result in surface subsidence. Mining induced subsidence is relatively predictable in its magnitude, manifestation and extent, except where a sudden pillar or near-surface underground tunnel collapse occurs (usually very old workings). Mining-induced subsidence is mainly much localized to the surface above the mined area, plus a margin around the outside. The vertical magnitude of the subsidence itself typically does not cause problems, except in the case of drainage (including natural drainage) - rather it is the associated surface compressive and tensile strains, curvature, tilts and horizontal displacement that are the cause of the worst damage to the natural environment, buildings and infrastructure. Removal of support by underground mining is a common cause of ground subsidence in many areas. Extensive removal of minerals, mineral fuels, rock aggregate, and other materials results in large underground void spaces. Subsequent natural processes including fracturing, chemical changes, caving, flowage, and other related adjustments often produce surface subsidence, fissures, and tilting of the land surface above and/or adjacent to the surface projection of underground workings. Man-induced changes in the hydrology of the underground workings and/or overlying rock and soil materials can affect subsidence. In addition to actual undermined areas, special hazards are posed by certain appurtenant structures such as air shafts and various other mine workings. Additional problems in identifying and delineating areas of potential subsidence include the presence of faults and other geologic complications, and the fact that "final mine maps" may not show the actual extent of mining. Also, discrepancies in survey ties between the mine maps and surface reference points may be sizeable. Many undermined areas have incomplete or nonexistent records. Potential subsidence hazards from underground mine working and shafts exist in many parts of the world, including Colorado. These include areas of past and present coal mining and "hard rock" mining areas (Courtesy: Colorado Geological Survey, USA).

Where mining activity is planned, mining-induced subsidence can be successfully managed if there is co-operation from all of the stakeholders. This is accomplished through a combination of careful mine planning, the taking of preventive measures, and the carrying out of repairs post-mining. Unfortunately, many types of mining operations in our country are not following strictly the suggested precautionary measures. It has been often reported that after an ore is exploited, the post mining steps to fill the voids with proper binding material is neglected or compromised. The quality control mechanism is often found wanting, resulting in damage to the environment and loss to the local habitat and the government. Subsidence is conspicuously noticed in areas where coal mining is being carried out. As detailed by Singh and Yadav (1995, IAHS Publ, no 234) in India, significant loss of life occurs due to subsidence of land in coal mining areas. Subsidence is prevalent in the Raniganj coal field. The occurrence of thick coal seam at shallow depth is the main reason for the subsidence and as a result collapses have occurred. Using a visco-elastic model they have investigated the effect of mine parameters on the subsidence and suggested various vigilant measures. It has been stressed by a speaker, during the workshop at Umiam (Shillong) that subsidence related problems have been clearly noticed in Jharia Coal field, due to cumulative effect of underground fires and mining of coal.

The Gondwana basins of peninsular India are traditionally considered as extensional-rift basins due to the overwhelming evidence of fault-controlled syn-sedimentary subsidence. These basins indeed originated under a bulk extensional tectonic regime, due to failure of the attenuated crust along pre-existing zones of weakness inherited from Precambrian structural fabrics. The disposition, shape and structural architecture of the Satpura basin, central India suggests that the basin could be a pull-apart basin. Development of a sedimentary basin under the above-mentioned kinematic condition was simulated in model experiments with sand - pack (Chakraborty and Ghosh, 2005, J. Earth Syst. Sci. 114, No. 3, June 2005, pp. 259-273). The experiments revealed that following the development of the through-going lineament, dominant subsidence took place in the graben occurring to the left of the lineament. Moreover, within the rapidly subsiding graben the subsidence rate varied spatially due to differential vertical falls along intra-graben faults. This type of subsidence has created various sedimentary basins (including mineral rich). In-depth knowledge of the dynamics associated with this phenomenon in time and space helps us in better understanding the structure and evolution of various sedimentary basins. This information assumes importance from resource management point of view.

Since mining operations will continue for years to come, a quality control mechanism needs to be established to minimise subsidence related vulnerabilities. Both the Govt and the Mining Industry should work in tandem to address this problem, in an effective way. Engineering and architectural considerations can significantly minimize the risk of all types of structures experiencing mine subsidence damage.

Extraction of natural gas

If natural gas is extracted from a natural gas field the initial pressure {up to 60MPa (600 bar)} in the field will drop over the years. The gas pressure also supports the soil layers above the field. If the pressure drops, the soil-pressure increases and this leads to subsidence at the ground level. Major subsidence of the Mississippi River Delta due to oil and gas extraction has caused the ocean to rise and flood over 34 square miles (88 km^2) of marshes and land each year. Since 1930, Louisiana has lost 1,200,000 acres (4,900 km^2). Since exploration of the Slochteren (Netherlands) gas field started in the late 1960s the ground level over a 250 km^2 area has dropped by a current maximum of 30 cm.

The oil and gas fields located in the Tertiary sandstones have shown land subsidence in countries like U.S.A (California, Texas, Louisiana), Venezuela etc. With this experience, mitigation measures like repressurising the reservoirs were taken up in some fields. This makes the oil production less profitable. But in case of gas fields, such measures are considered to be not feasible from economic point of view. Knowing the success of exploration by the ONGC and production of oil and gas from the K-G Basin, an attempt was made to study the impact of exploitation of these fluids on the delta land surface. With the available information through published literature, a rough estimate of possible subsidence in the delta land was made and published in a National Journal in 1998.This article was widely published by the News Papers. In this article, it was suggested that the exploration organizations should take up studies related to environmental hazards like subsidence with the computer modeling. Even though residents of this coastal belt expressed concern, the oil well blow outs near Pasarlapudi of East Godavari dist and significant subsidence of a segment of land in the coastal corridor that is used for extraction of oil, has not led to any significant change in the oil exploitation methodology. Experts like Prof.G Krishna Rao, Retd Geology Professor of Andhra University have openly criticised the exploration and exploitation practices, adopted by both the Public and Private sector Oil Industry for the damage noticed in the K-G basin, due to subsidence of land surface. They fear, if these exploitation operations are carried out further, adopting the presently chosen methods, the coastal belt of A.P will suffer considerably as the sea level rise anticipated due to global warming can inundate the lands that are affected by subsidence. They have also cautioned that enhanced saline water ingression would damage irrevocably the soil and surface & subsurface waters.

In Cambay Basin significant subsidence of land has also been noticed (unable to include specifics for want of access to the subcommittee reports).

Sedimentation also causes land subsidence. Subsidence may result from the accumulation of large volumes of sediment at the earth's surface in what is known as a sediment basin. An obvious setting in which this occurs is at river deltas. The weight of this sediment contributes to a gradual subsidence of the land. Wherever sediments accumulate, we can be certain that in some other locality, a source has been relatively elevated with respect to the place where the strata are being deposited. A delta is a subsidence-prone area because it receives a huge volume of sediments, which can be compressed due to post depositional consolidation, and the load of which can result in detectable isostatic sinking of the earth's crust. In such zones any man made activity that can impart additional pressure on the crust can lead to subsidence. This has happened in K-G basin, due to Oil & Gas extraction. The proposed Shale Gas extraction from Raghavapuram Shale beds, using Fracking technique, would further enhance subsidence and add to the misery (P.R.Reddy, April 2013, J.IGU).

Earthquakes and Tsunamis

Subsidence and up lift of land are commonly associated with an earthquake activity. The effect is much more pronounced in seismically vulnerable zones that are underlain by younger geologic formations (loose soils, unconsolidated sedimentary formations and structurally unstable zones).

The Geospatial Information Authority of Japan reported immediate subsidence caused by the 2011 Tōhoku earthquake. In Northern Japan, subsidence of 0.50 m (1.64 ft) was observed on the coast of the Pacific Ocean in Miyako, Tōhoku, while Rikuzentakata, Iwate measured 0.84 m (2.75 ft). In the south at Sōma, Fukushima, 0.29 m (0.95 ft) was observed. The maximum amount of subsidence was 1.2 m (3.93 ft), coupled with horizontal diastrophism of up to 5.3 m (17.3 ft) on the Oshika Peninsula in Miyagi Prefecture.

In our country the Bhuj earthquake of January 2001 caused large scale subsidence in northern parts of Kutch. Considerable amount of subsidence and uplift has been noticed due to 1819, 1897, 1934 and 1950 high magnitude Himalayan earthquakes. Himalayan rivers are known to transport large quantities of sediments. These loads of sediments impart considerable pressure on the sub surface strata leading to earthquakes and land subsidence. Basins between mountains also can subside due to sediments. Such a scenario is present in Himalayas.

Landscape changes in Andaman and Nicobar Islands (India) due to Mw 9.3 tsunamigenic Sumatra earthquake of 26 December 2004 have clearly established occurrence of significant subsidence (Javed N Malik and C.V.R. Murty, Current Scienc, Vol. 88, No. 9, 10 May 2005). The southern portion of the Great Nicobar Island seems to have subsided by about 3 m, as supported by changes in the natural water levels. At the Coastguard Headquarters Building in Campbell Bay, the average water level has increased after the earthquake by about 2 m, as demonstrated by the ocean water lashing the floor of the building located a few metres from the sea. According to the Coastguard Officer, during the high tides prior to the earthquake, at least 25–30 m of beach used to be exposed in front of the building, and during low tide, it was more than 100 m. In contrast, now no beach can be seen. Such submergence is also observed at Indira Point, the southernmost tip of India. Here, the 23 m high lighthouse tower is now standing submerged by at least about 3 m at its base; several houses, the helipad and vegetation near the light house have been washed away by the tsunami. Evidence of subsidence was also observed at the Car Nicobar Island (N9.2° lat.), the northernmost among the Nicobar group of islands. Topographically, this island is characterized by almost flat terrain to the east and an elevated terrain with maximum elevation of about 70 m to the west. Land subsidence is also noted in the Port Blair area. Since earthquakes and tsunamis result in land surface subsidence all the vulnerable areas need to be monitored through real time GPS network, to take up both preventive and post event rehabilitation works. The results from such studies can also help in relocating industrial establishments, which if affected can cause huge man and resource losses.

Groundwater-related subsidence

The habitation of lowlands, such as coastal or delta plains, requires drainage. The resulting aeration of the soil leads to the oxidation of its organic components, such as peat, and this decomposition process may cause significant land subsidence. This applies especially when ground water levels are periodically adapted to subsidence, in order to maintain desired unsaturated zone depths, exposing more and more peat to oxygen. In addition to this, drained soils consolidate as a result of increased effective stress. In this way, land subsidence has the potential of becoming self-perpetuating, having rates up to 5 cm/yr. Water management used to be tuned primarily to factors such as crop optimisation but, to varying extents, avoiding subsidence has come to be taken into account as well. Groundwater extraction can also lead to consolidation and subsidence by causing a decrease in the volume - and loss of pressure - of pore-water in the substrata. The downward movement of subsidence is measured relative to a reference level (datum). Movement of the ground surface in the opposite direction to subsidence is called uplift. Subsidence in groundwater basins mainly occurs in layers of clay, silt and peat, rather than within aquifer materials that conduct the groundwater like sand and gravel. This is because sediments such as clay are very porous and are readily deformed, imparting a high potential for consolidation. The amount of subsidence in clay depends on the initial water content of the clay and how much stress is applied.

Groundwater pumping that exceeds the natural rate of recharge in the basin can lower groundwater levels. This water loss decreases the pore water pressure contributing to the support of overlying sediment, causing an overall decrease in the volume of the sediment matrix. As the sediment is compacted by gravity, the ground surface above becomes lower. This is a common cause of subsidence in groundwater basins.

We have a long coast and many segments of the coastal belt, including fertile Deltas, are having drainage related problems. These segments do have bore wells to lower the water table levels. In some zones in Prakasam and East Godavari districts (A.P) such lowering operations have resulted in land subsidence. Sahu and Sikdar (2011, Jou. Earth Syst Science, vol.120, pp. 435-446) have noticed land subsidence of Kolkata City including Salt Lake City and the adjoining East Kolkata Wetlands located at the lower part of the deltaic alluvial plain of South Bengal basin. Demand of groundwater for drinking, agricultural and industrial purposes has increased due to rapid urbanization. The subsurface geology consists of Quaternary sediments comprising a succession of clay, silty clay and sand of various grades. Groundwater occurs mostly under confined condition except in those places where the top aquitard has been obliterated due to the scouring action of past channels. Currently, the piezometric head shows a falling trend and it may be accelerated due to further over-withdrawal of groundwater resulting in land subsidence. The estimated mean land subsidence rate is 13.53 mm/year and for 1 m drop in the piezometric head, the mean subsidence is 3.28 cm. The surface expression of the estimated land subsidence is however, cryptic because of a time lag between the settlement of the thick low-permeable aquitard at the top and its surface expression. Therefore, groundwater of the cities and wetland areas should be developed cautiously based on the groundwater potential to minimize the threat of land subsidence. Continued excessive extraction of groundwater may lead to significant land subsidence, which causes economic loss. Ground subsidence studies have been carried out in several Australian capital cities using the Persistent Scatterer Interferometry approach. Such studies may help improve our understanding of the deformation of terrain and built structures, and evaluate the effectiveness of any measures taken to ease the problem. The Persistent Scatterer Radar Interferometry approach is an alternative technique for land subsidence monitoring to conventional surveying methods. The Persistent Scatterer Interferometry approach first identifies all the stable point scatterers and a deformation analysis is then applied to these points. Persistent Scatterer InSAR techniques can generate deformation time-series with an accuracy down to the millimetre level depending on the number and quality of SAR images. The Persistent Scatterer InSAR results are validated with other spatial data such as groundwater extraction bore sites and groundwater level. Six cities are selected for these analyses, and the results show that the deformation rate from cities with groundwater significant levels of water extraction are much larger than for those cities with low levels of groundwater extraction (Alex Hay- Man Ng, 2008, Int. Ass of Geodesy Symp., Vol 133, pp. 743-750).

Faulting induced

When differential stresses exist in the Earth, these can be accommodated either by geological faulting in the brittle crust, or by ductile flow in the hotter and more fluid mantle. Where faults occur, absolute subsidence may occur in the hanging wall of normal faults. In reverse or thrust faults, relative subsidence may be measured in the footwall. This is clearly noticed along and across Himalayan belt.

Isostatic subsidence

The crust floats buoyantly in the plastic asthenosphere, with a ratio of mass below the "surface" in proportion to its own density and the density of the asthenosphere. If mass is added to a local area of the crust (e.g. through deposition), the crust subsides to compensate and maintain isostatic balance. The opposite effect to

Isostatic subsidence is known as isostatic rebound - the action of the crust returning (sometimes over periods of thousands of years) to a state of isostacy, such as after the melting of large Ice sheets or the drying-up of large lakes after the last ice age. Lake Bonneville is a famous example: Due to the weight of the water once held in the lake, the Earth's crust subsided nearly 200 feet (61 m) to maintain equilibrium, when the lake dried up, the crust rebounded. Today when you go to Lake Bonneville you will find that the center of the former lake is about 200 feet (61 m) higher than the distant edges. Crustal underplating and its implications for subsidence and state of isostasy along the Ninetyeast Ridge hotspot trail and related effects in the oceanic and main land segments of India has attracted the attention of scientists, leading to systematic research by both the Indian and International scientific community.

Seasonal effects

Many soils contain significant proportions of clay which because of the very small particle size are affected by changes in soil moisture content. Seasonal drying of the soil results in a reduction in soil volume and a lowering of the soil surface. If building foundations are above the level to which the seasonal drying reaches they will move and this can result in damage to the building in the form of tapering cracks. Trees and other vegetation can have a significant local effect on seasonal drying of soils. Over a number of years a cumulative drying occurs as the tree grows, this can lead to the opposite of subsidence, known as heave or swelling of the soil, when the tree declines or is felled. As the cumulative moisture deficit is reversed, over a period which can last as many as 25 years, the surface level around the tree will rise and expand laterally. This is often more damaging to buildings unless the foundations have been strengthened or designed to cope with the effect. This information is very vital in building multi storeyed buildings in coastal belts and river basins. As we have two coasts of significant length, in addition to Indo-Gangetic Plains and Brahmaputra Valley the structural engineers need to take in to effect this fact to avoid improper coupling between soil and foundation. A speaker, during second workshop at NESAC, Umiam has pointed out that floods, landslides do destabilise slopes and lead to subsidence of significant magnitude in different segments of NE India.

Need for a systematic scientific and technical initiatives

The consequences of improper utilization of land subject to ground subsidence will generally consist of excessive economic losses. This includes high repair and maintenance costs for buildings, irrigation works, highways, utilities and other structures. At times, structures are condemned because of the damage. This results in direct economic losses to citizens, and indirect losses through increased taxes and decreased property values. Spontaneous ground openings can be dangerous if a sinkhole were to open below an occupied structure. In view of such a significant impact on our socio-economic structure it is essential to take proper scientific measures. Since, even the disaster management experts and authorities give least importance to subsidence related problems, it is essential for the earth scientists to draw their attention to initiate appropriate measures, including real time GPS monitoring of vulnerable segments of our country .

We do believe that details given above would be useful for earth scientists in carrying out appropriate studies in subsidence prone zones and help the planning and execution authorities in minimising subsidence related losses.

In this Issue:

We have included in this issue six research papers. In the first paper Chaudhari et al., using a high resolution seismic tomographic study delineated weak zones in an underground power house site. By suitably constraining the iteration process through prior knowledge of rock velocities at the site nine tomograms were obtained. In the combined tomogram, where velocities of individual cells are used, eight isolated weak zones of varying dimensions and orientations were inferred. These tomographic studies indicated that the selected site would be suitable for the power house after treatment of the weak zones. Such studies are essential to ensure stability of structures, especially in earthquake vulnerable zones. In the second paper Dhorde and Zarenistanak applied homogeneity tests for the precipitation and temperature series of meteorology stations operated by Iranian Meteorological Organization and Iranian Water Resources Management Company from south-western part of Iran. Three standard tests were applied. Each test was evaluated separately and inhomogeneous stations were determined. The series were then grouped into three classes which were categorized as 'useful', 'doubtful' and 'suspect'. It was revealed by the homogeneity analysis that none of the series belonged to the class 'suspect', and therefore, it was concluded that the temperature and precipitation series are homogeneous. In the third paper Kesava Rao et al., have delineated Crustal structure along Permanallur-Pallapatti deep seismic reflection/refraction profile and inferred evolutionary history of Palghat-Cauvery Shear System. In the fourth paper Reddy presented in detail the relevance of minor irrigation and the necessity to revive it by rehabilitating dilapadated tanks and reinstating abandoned borewells. He stressed the need for farmer participation management to strengthen minor irrigation in Andhra Pradesh to achieve higher food production. In the fifth paper Anitha and Mohanty carried out a comparison of Wave Equation Migration Techniques over Complex Geological Structures and concluded Stolt`s migration technique is superior to Phase-Shift (PS) and Phase-Shift Plus Interpolation (PSPI) migration techniques. In the sixth paper Prasad and Singh, as the 4th part of their study on monsoon patterns, have found out that in spite of large intra-seasonal changes, performance of South Indian Convergence Zone (SICZ) model, in producing long range forecasts of rainfall, was quite satisfactory.

A change in News & Views Format:

We have been including under the section News & Views at a glance some important details to enhance quality of life on this planet. As a part of this we have collected useful information on LIFE, ENVIRONMENT and POLLUTION and published them in the last three issues. We have put in considerable effort to make the presentations useful and educative. If you closely follow these details you would appreciate the rationale behind our writings. From the three presentations we have tried to show the interlinkage between quality of life and healthy environment. Both these factors are affected by pollution. And as such to have sustenance of life on this planet we need to arrest pollution. And this can be achieved only when we know to what extent every one of us are contributing to the ever increasing pollution. Unfortunately, majority of the readers seem to have neither time nor interest in going through these details. Since it is not our policy to forcefully motivate learned scientists to go through these details, we have decided to discontinue this sub section of News & Views and restrict the News & Views section to details pertaining to forth coming seminars, awards / honours and a brief exposition of specific developments of scientific interest of recent origin.

Request and Thanks:

Since this journal belongs to all of you please extend your support by contributing articles. The response to our request is rather Luke-warm. If the readers have any reservations they are requested to bring to our notice their concerns, for us to take remedial steps. Please do extend your support. We also welcome constructive criticism, to correct ourselves and there by enhance the quality of the publication.

We appreciate very much the positive remarks and suggestions made by Dr / Shri D.N.Avasthi, T.M.Mahadevan, B.M.Reddy, K.Narayanan, Kuldeep Chandra, Walter D Mooney, B.S.R.Murthy, Umesh Kulshrestha, D.Sarkar, T.Hari Narayana, P.Sivasubramanian, M.V.Ravi Kumar, Rima Chatterji, N.K.Thakur, V.Vijaya Rao, K.Sain and MRK.Prabhakara Rao. We assure one and all that we are striving assiduously to enhance the quality of the publication and seek their unequivocal support and guidance to reach higher targets.

We do hope this year we will have good monsoon and receive adequate supply of drinking water and good quality food. In our part let us try our best to avoid wastage of these life saving products and initiate steps to save energy. Let us also resolve to arrest pollution.

We request students, research scholars and scientists/ technical experts to please go through the brochure/ circular released by IGU and send abstracts in time to the organisers of 50th annual convention, scheduled during 9-12 January 2014 at NGRI, Hyderabad.

P.R.Reddy
P.Koteswara Rao