

# **IGS TCH Activities Report 2016-12**

This year has been very busy for TCH, the Technical Committee on “Hydraulic Applications: Drainage, Erosion Control, Coastal Protection”.

After its official formation, approved during the Council held in Seoul, Korea, in June 2015, TCH has consolidated its membership, which now counts more than 60 members, and started the activities.

The new IGS web site was launched during GeoAmericas 2016 in April, and TCH included its official page.

One very important activity of TCH during 2016 has been the drafting of four new IGS leaflets: Geosynthetics Classification, Geosynthetics for filtration and drainage, Geosynthetics for erosion control, Geosynthetics for coastal protection. Such activity lasted several months and involved the active participation of many TCH members.

Moreover, during 2016 TCH has organized 3 main technical events, with great success and attentive attendance: the Special Session on Drainage at GeoAmericas 2016 in Miami in April; the Special Session on Erosion Control at Eurogeo 6 in Ljubljana in September, and the Workshop on Coastal Protection: The State of The Art, at GeoAsia 2016 in Delhi in November. The summaries of the 3 events are hereinafter reported.

## **Special Session on Drainage at GeoAmericas 2016**

The Special Session on Drainage was held on the last day of the Conference; it was chaired by TCH chair Eng. Pietro Rimoldi (Italy), and it lasted 1.5 hours; 6 invited papers have been presented.

The first presentation was by Prof. Chiwan Wayne Hsieh of the National Pingtung University of Science & Technology in Taiwan, on “Geosynthetics hydraulic and drainage applications for extreme natural and weather events”. Prof. Hsieh showed that the increase in greenhouse gas concentration caused by biotic processes, solar radiation, plate tectonics, volcanic eruption, and other human activities has produced global warming. Scientific evidence has shown that the frequency and intensity of extreme weather events has also increased. Then Prof. Hsieh summarized recent extreme natural weather events and discussed the geosynthetics hydraulic / drainage applications for extreme weather and natural event related remediation programs.

The second paper was “Geotextile filters - 25+ years of research and experience” by Prof. Robert D. Holtz, University of Washington (USA), and Dr Barry R. Christopher, Geotechnical Engineering Consultant. Roswell, Georgia (USA). It was presented by Prof. Holtz, who outlined the work leading to the development of the FHWA Geotextile Filter Design Criteria in 1983-1985. Experiences at Purdue University and the University of Washington on the determination of the pore size distribution of geotextiles was recounted, as is the work on developing a filter criteria based on measured pore sizes. Finally, the development of a flexible wall gradient ratio device for determining the gradient ratio of fine grained soils was described and some test results with the device were presented.

The third presentation was by Dr Sam Allen, Vice President, TRI Environmental, Austin, Texas (USA), on “The determination of hydraulic performance of geosynthetic drains”. Dr

Allen explained that the accurate and standardized measurement of flow capacity of geosynthetic drains is of utmost importance to product comparison, selection, and verification. Standards exist that serve to provide the user with an appropriate measurement tool to measure flow capacity while accommodating the wide variety of drainage product features present in our geosynthetic industry. He reviewed the existing standards for flow rate tests and discussed in details the use of developed test results for the determination of the long term flow rate of draining geosynthetics, taking into account normal compressive stresses, hydraulic gradient, compressive creep, chemical and biological clogging, intrusion of adjacent material causing blinding of the drain. Both planar geocomposites and prefabricated vertical drains (PVD) were addressed.

The fourth presentation was by the TCH Chair, Eng. Pietro Rimoldi (Italy), on “Design of planar geosynthetic drainage systems”. He explained that drainage is an essential feature in the design and construction of most civil engineering structures and infrastructures. Various types of draining geocomposites are presently available on the market, in addition to the traditional method of using coarse granular soil as drainage medium. The different drainage conditions were analyzed and the design principles for planar geosynthetic drainage systems were set. Long-term compressive creep tests to measure the time dependent loss of thickness of geocomposites, and thickness-dependent flow rate tests were proposed to obtain the long term design flow rate of planar geocomposites. Then the selection procedure for the suitable draining geosynthetic in each situation was illustrated. Finally the equivalence between a granular draining layer and a geocomposite was introduced.

The fifth presentation was by Prof. Dennes Bergado, Distinguished Adjunct Professor, Asian Institute of Technology, Bangkok, Thailand, on “Pvd soft ground improvement with surcharge, vacuum and heat preloading: laboratory and field results”. Prof. Bergado focused on increasing the efficiency in accelerating the rate of consolidation of prefabricated vertical drain (PVD) improved soft Bangkok clay using vacuum and heat preloading. Laboratory model tests were performed in large scale consolidometers with PVD improved reconstituted specimens using surcharge preloading (Conventional PVD), surcharge combined with vacuum pressure preloading (Vacuum PVD), surcharge combined with heat (Thermal PVD), and surcharge combined with heat and vacuum pressure (Thermal Vacuum PVD). Subsequently, the flow parameters in terms of the horizontal coefficient of consolidation ( $C_h$ ) and the ratio between the horizontal hydraulic conductivity in undisturbed zone ( $k_h$ ) to the horizontal hydraulic conductivity in smear zone ( $k_s$ ) or ( $k_h/k_s$ ) were investigated by back calculation. The results showed that the Vacuum-PVD can increase the horizontal coefficient of consolidation, resulting in faster rate of settlement at the same magnitudes of settlement compared to standard PVD. The Thermal PVD and Thermal Vacuum PVD can increase further the coefficient of horizontal consolidation, with the associated reduction of  $k_h/k_s$  values by reducing the drainage retardation effects in the smear zone around the PVD which resulted in faster rates of consolidation and higher magnitudes of settlements. The laboratory test results were confirmed by the corresponding test results in full scale field tests.

The sixth presentation was by Dr George Koerner, Geosynthetic Institute, Folsom, PA (USA), on “Significance of proper geotextile filter selection on the hydraulic performance of drainage geocomposites”. He explained that, with all geotextile filters, the purpose is to allow liquid to pass through and yet retain the upstream soil without excessive blending or clogging. This is also the case when a geotextile is bonded to a drainage core, of which

there are many types. Dr Koerner added that there are hundreds-of-thousands of worldwide successful geotextile filters being used for this application, and interestingly (but not recommended) geotextile filters are even successful with no design and also with relatively casual installation procedures. But Dr Koerner draw attention to those geotextile filter situations that have been problematic and troublesome from a design, testing and/or construction perspective. He particularly focused upon the influence of the geotextile filter used in conjunction with an associated geonet or geospacer drain.

## **Special Session on Erosion Control at Eurogeo 6**

The Special Session was held on the second day of the Conference; it was chaired by TCH chair Eng. Pietro Rimoldi (Italy), and it lasted 2 hours; 5 invited papers have been presented addressing both erosion control on slopes and erosion control of canal and river banks.

The first presentation was by Prof. Chiwan Wayne Hsieh of the National Pingtung University of Science & Technology in Taiwan, on “Fundamentals of erosion control on slopes and the role of geosynthetics”. Prof. Hsieh addressed explained that water and wind erosion are the most common and greatest natural harmful effects among all erosion processes. The soil erosion process includes detachment, transportation and deposition of soil particles from a consolidated soil body. Soil erosion can be divided into natural erosion and accelerated erosion. The factors controlling soil erosion are the erosivity of the eroding agent, the erodibility of the soil, the slope of the land and the nature of the plant cover. Civil engineering projects often result in disturbing on-site slope soil surfaces. The disturbed bare soils on slopes are highly sensitive to runoff and erosion process. The water erosion process on a slope leads to partial or complete loss of the surface soil layer. Such eroded slopes have lower fertility due to the loss of soil particles, nutrients and organic matter, affecting the soil structure, water holding capacity and porosity. The establishment of plants and subsequent development of a protective vegetation cover are hampered. Slopes are therefore exposed to further and more severe erosion processes. The strategies for soil conservation must be based on covering the soil to protect it from raindrop impact; increasing the infiltration capacity of the soil to reduce runoff; improving the aggregate stability of the soil; and increasing the surface roughness to reduce runoff and wind velocity. Various conservation techniques include agronomic measures, soil management and mechanical methods. Erosion and shallow landslides are commonly treated with artificial coverage materials in conjunction with vegetation. Geosynthetic erosion control products have been demonstrated effective in reducing erosion and subsequent slope degradation processes. The soil erosion influence factors and mechanisms on slopes were discussed. Laboratory, field and engineering case studies on various geosynthetics for erosion control applications were also reviewed and discussed.

The second presentation was by Dr. Michael Heibaum, BAW – Federal Waterways Engineering and Research Institute, Karlsruhe (Germany), on “The importance of geosynthetics in erosion control of canal and river banks”. Dr Heibaum explained that any interaction of water and soil at the streambed may cause erosion and scouring. Hydraulic loads on canal and river banks may origin either from natural hydrodynamic processes or from navigation. During flood events, water levels high above the normal lead to interaction of water and ground in often unprotected areas including the risk of erosion. In densely populated areas, the natural development of erosion and accretion cannot be accepted. Therefore special measures are needed to avoid scour and erosion and to

guarantee stability of bed, bank and overbank zone. To avoid unfavourable actions of the water, either the action has to be reduced or the resistance has to be increased. Changing the action means to alter the flow for instance by river training works. Increasing the resistance is necessary if no alteration of actions can be implemented, or the comparison of costs leads to such a decision. In many cases geosynthetics can support or improve the functionality. Sometimes only with geosynthetics the desired result can be achieved. Increasingly effort is put into bioengineering solutions, i.e. the integration of vegetation, at least in areas that are only temporarily drowned or loaded by hydraulic actions. Often the best solution is to combine vegetative with "technical" elements like hard armour or geosynthetics. In all cases, placement of geosynthetic elements has to be done with care, especially if the installation has to be done under water, to provide strong and long lasting structures.

The third paper was "Laboratory tests for evaluating the performance of geosynthetics for surface erosion control", by Dr. N. Touze-Foltz (Irstea, France) and Dr. H. Zanzinger, SKZ German Plastics Center, Würzburg (Germany), and it was presented by Dr Zanzinger. He described laboratory tests that are currently under development for evaluating the properties of geosynthetics for surface erosion control, which have been listed in prEN 00189224 "Geosynthetics – Characteristics required for use in surface erosion control on slopes and banks", produced by CEN/TC189 project group Surface Erosion Control, including rain simulation. A literature review was presented. The effect of various parameters like rain intensity, slope of the testing device, soil used in the test was described based on the existing data. Some insight was given in the features of the rain, and also on the parameter to define to evaluate the performance of erosion control. A single parameter, the yield factor, seems to make consensus.

The fourth presentation was by the TCH Chair, Eng. Pietro Rimoldi (Italy), on "Design of geosynthetics for erosion control on slopes". He explained that, while the mechanisms of soil erosion is well known (consisting of detachment, transportation and deposition), its control is largely empirical. An engineering approach to the design of Geosynthetics for erosion control on slopes can be based on the well known Revised Universal Soil Loss Equation (RUSLE), which can be adapted to the estimation of erosion on a single slope or a defined area comprised of multiple single slopes. The use of RUSLE for designing with Geosynthetics requires the definition of the performance of the various products by laboratory and full scale tests. The general procedure for using RUSLE for the design of Geosynthetics for erosion control on slopes was introduced and examples of practical interest were presented.

The fifth presentation was by Eng. David Shercliff, ABG Geosynthetics Ltd (U.K.), on "Accessible design methods for geosynthetics used for erosion control on channel and river banks", who showed that the design of geosynthetics used in erosion control on river and channels has evolved over the last 50 years from its early use in land reclamation and protection in fascine replacing willow/brushwood rafts with woven synthetics. Much empirical experience has been gained throughout Europe. Machine made synthetic sheet, like materials which have much tighter quality control, can be studied in detail in the laboratory in a consistent and systematic way. Practical experience, testing, and design development has occurred and many often complex filter rules have been developed and publicized. However, it is often the case that designers do not have the luxury of sophisticated soil investigation reports for the intermittent embankment erosion schemes they have to design. It was pointed out that the designer has to keep to the established design rules but also that a new pragmatism developed more recently helping designers

focus on more practical elements of installation through service life and maintenance and a greater emphasis on working with nature with a much simpler approach. Designers are given tables and simpler guidelines to cover the majority of designs which have been developed from sound research and experience. A brief preview was given of this new approach which is the basis for latest directives. Reference was also made to the concept of managed overtopping of embankments and the need for reinforced engineered vegetation.

### **Workshop on Coastal Protection: The State of The Art, at GeoAsia 2016**

TCH organized its first full day workshop, as a pre-conference event at GeoAsia 2016.

The workshop included a morning and a afternoon sessions.

Eng. Pietro Rimoldi (Italy, TCH Chair) was prevented at the last minute from attending the Conference and chairing the workshop, due to a surgery operation.

Anyway the workshop was broadly attended and recorded full success.

The following report on the workshop was prepared by Mr. Anil Kumar Gopinath (Former Chief Engineer, Water Resources Department of Kerala and Vice President Coastal, Maccaferri Environmental Solutions Pvt. Ltd., India) and Ms. Minimol Korulla (Vice President Technical, Maccaferri Environmental Solutions Pvt. Ltd., India), both active members of TCH.

The chief guest of the inauguration session of the Workshop on “Coastal Protection: The State of The Art” was Mr. A. K Ganju, retired member of Central Water Commission and earlier Chairman of Ganga Flood Control Commission and guest of honour of the session was Prof. Chandan Ghosh of National Institute of Disaster Management, India (NIDM). For the whole work shop, Mr. Anil Kumar Gopinath (Former Chief Engineer, Water Resources Department of Kerala and Vice President coastal, Maccaferri Environmental Solutions Pvt. Ltd., India) acted as the main co-ordinator in the absence of Mr. Pietro Rimoldi, Chairman, International Geosynthetics Society (IGS) TC-H and Ms. Minimol Korulla (Vice President Technical, Maccaferri Environmental Solutions Pvt. Ltd., India) acted as main anchor of the session. Further, Mr. V.K. Kanjlia, Member Secretary, Indian Chapter of IGS has addressed the audience.



Inaugural session: Mr. Anil Kumar Gopinath, Mr. A. K. Ganju, Dr. Chandan Gosh, Mr. K. Kanjlia (left to right)



Mr. V.K. Kanjlia, Member Secretary, Indian Chapter of IGS addressing the audience

During the inaugural speech chief guest, Mr. A K Ganju has highlighted that in general in India, Water Resource departments use traditional products in design and execution of

river management erosion protection schemes. Moreover, since the jobs are awarded on lowest bid basis, inferior and below standard products are used to keep the bid price low and these schemes are not planned in a scientific basis and river behaviour is not kept in view which results in a lesser life span. However, this can be changed only when more durable materials are being used and works are planned wisely. Even though, Ganga Flood Control Commission (GFCC) has revised their guidelines for the use of Geosynthetics in flood management works, similar action needs to be taken in other departments also which is a healthy development that will go a long way in planning, design and execution of more reliable and long lasting works. Also he has highlighted that the reason being why the new materials are not specified is the lack of awareness of the existence or the advantage or the value addition of these materials to the schemes. Also he raised a point that such workshops need to be organized which will create awareness in engineers regarding the use of these materials. Further, to develop confidence in engineers to use of these materials, the success stories of the application need to be given wide publicity and be brought to the notice of engineers of department of water resource in each state.

The guest of honour of the session, Dr. Chandan Gosh has highlighted that based on post tsunami survey conducted by Govt. of India followed up by planning commissions Tsunami mitigation project, World Bank funded national cyclone risk mitigation project (NCRMP) and most importantly coastal regulation zoning act (CRZ), it is very much essential to identify and categorize coastal areas into low, medium and high hazard zones. Moreover, in many coastal areas sea walls, rubble masonry, stone pitching, groynes, etc., are constructed as the routine yet only measures to tackle erosion. But in many situations they are costly and not leading to perpetual solutions, thus causing serious problem with consequences in terms of technical feasibility due to the lacuna in the risk mapping survey and post construction surveillance. Hence, project monitoring and peer reviewing has to be made an integral exercise. He added that, there should be a consortium of experts and expertise consisting national and international professionals, along with port authority or concerned state/central ministry for decision making. Also he emphasize that a systematic detail project report and site surveying is to be done for the new port and development projects are undertaken by the Government based on the current coastal erosion scenarios in the country. Anthropology of Coastal erosion and current dynamics with traditional flora fauna have to be researched by knowledge institutions of the country in terms of doctoral research and pilot projects in association with stake holders in community. Currently applied techniques that have been useful or not useful in the short or long run are to be documented by centrally sponsored teams involving coastal community as the mainstream knowledge bearer of such exercise. Also, the techniques practiced in foreign countries are to be studied and shall be adopted by studying local site conditions with a holistic approach.



Inaugural session: Mr. A. K Ganju (chief guest), Dr. Chandan Gosh (guest of honour)

The first session was on the 'The State of the Art' and was chaired by Mr. Anil Kumar Gopinath, co-chaired by Dr. Chandan Gosh in which six papers were discussed.

The first paper was on "Fundamentals of Coastal Protection and the Role of Geosynthetics" by Prof. Chiwan Wayne Hsieh (Co-Chairman, IGC TC-H), from National Pingtung University of Science & Technology, Taiwan. He brought out comprehensive information's on the coastal processes; the various coastal protection measures adopted both using hard structural and soft structural solutions measures. The paper emphasized the recent popular use of Geobags, Geotubes, Geocontainment systems and Geosynthetic mattresses for revetment protection for coastal protection with case studies undertaken in different countries. Taiwan coastline overview and management programs were also discussed.

The author of the next paper Mr. Ben Sullivan, HOV Environment, India was absent and the paper on "Applications of Geosynthetics for Integral Solutions for Beach Restoration and Long-Term Management" was briefed by the coordinator Mr. Anil Kumar Gopinath to the audience. This paper describes the behavior of the structures engineered with geosynthetics for groins and submerged breakwaters, as part of an integral solution for beach restoration as a long-term management plan. The case studies presented in the paper was based on the experience of Axis Ingenieria since 2004 till date in southeast, Mexican states of Yucatán and Campeche. Special emphasis on the experience gained over the past decade in adopting geotextile tubes as submerged breakwaters in the said regions is also highlighted in this paper.





Prof. Chiwan Wayne Hsieh delivering the presentation (b) Dr. R. K Bhandari addressing the audience

The third paper was by Dr. K. Rajagopal, of the Indian Institute of Technology Madras on “Laboratory Tests for Index and Performance Properties of Geosynthetics for Coastal Protection”. The various test method as per ASTM standards was discussed in detail. Also he emphasize that to ensure the performance of the Geosynthetic material, it shall be subjected to all relevant tests before using it for construction.

The fourth paper on “Design of Geosynthetic Tubes for Coastal Protection” by Mr. Pietro Rimoldi was presented by Mr. Rudra Budbhatti and Mr. Deeraj Kumar of Maccaferri Environmental Solutions Pvt Ltd, India in his absence. This paper primarily emphasized that while designing Geosynthetic tubes (GST) for coastal structures a close interaction between the designer, the supplier of GST and the installation contractor is of prime importance. A comprehensive understanding on the potential failure mechanisms to be considered during construction and operational phases of GST structures, and the iterative design process for GST was brought in detail. Design considerations about GST being used as groin core, submerged breakwater core were also discussed.



Dr. K Rajagopal delivering the presentation

The fifth paper presented was by Dr. Vijaya Ravichandran, National Institute of Ocean Technology, India on “Design of Sustainable Shore Protection Solution using Geosynthetic Tubes”. The paper discussed the Importance of Hydraulic model studies for coastal structures, the stability aspects of submerged GST structures, and a brief introduction to the design of Geosynthetic tubes used as submerged reef. The ecological impact of shore protection measures and impact of marine growth on strength of Geosynthetic tubes was also discussed.



Dr. Vijaya Ravichandran delivering the presentation

The sixth and final paper of the forenoon session was presented by Ms. Minimol Korulla (Vice President, Maccaferri Environmental Solutions Pvt. Ltd, India) and Mr. Deeraj Kumar (Design engineer, Maccaferri Environmental Solutions Pvt. Ltd, India) on the topic “Selection of Suitable Geotextile Materials for Geotextile Containment Systems - Onshore and Offshore Structures”. The presentation started with introduction of geosystems, their role in coastal protection and offshore engineering and essential requirements of systems that are used for coastal applications. The criteria to be kept in mind while selecting the fabric for Geocontainment systems were discussed in detail. Presenter has stressed on importance of various properties of geotextile like type of polymer, effect of alkalis, tensile strength, apparent opening size, permeability, UV and abrasion resistance. Selection of

geotextile material considering each property of geotextile where clearly described along with emphasis on installation methodology of the geotextile tube and quality assurance/quality control criteria. She highlighted that, due to the uniqueness of majority of the coastal and marine structures, the selection of suitable material for Geosystems are application specific.



Mr. Rudra Budbhatti and Mr. Anil Kumar Gopinath delivering the presentation

Afternoon session of the workshop started with a panel discussion on the topic “Geosynthetic systems used for coastal hazards”. The panel members were Dr. K Rajagopal, Mr. Sudhir Mathur (Central Road Research Institute (CRRI), India), Mr. Anilkumar Gopinath, Dr. Vijaya Ravichandran and Prof. R K Bhandari (Former Director, CSIR- CBRI Roorkee) as the moderator. The suggestions set forth by the panel members constituted of:

Since coastal protection process is a multidimensional problem, a holistic analysis is required based on which solution has to be selected.

Every coastal protection problem shall include three stages i.e. problem investigation, solution selection, design and analysis, there shall be cognizance of data and the same should be utilized while analyzing coastal situations.

To tackle every coastal erosion problem both short term and long term solutions need to be thought off. For short term solutions readily available inputs such as satellite imageries may be used, but for long term solutions detailed past data also has to be analyzed.

Henceforth the collection of data is also of prime importance. Super computers can be used for numerical modeling of the coastal climatic date. However, in India collection of data have limitations due to financial funding, requirements of continuous efforts and monitoring.

Rather than reporting only success stories of GST structures, failure also needs to be investigated and documented and the key learning’s from failure needs to be discussed along with the successful case studies for new technologies to move to a state of art stage.

Another important issue raised was since all the coastal problems are unique, site specific applicability of the solutions has to be verified and selected as empirical methods are in general thumb rule based.

There should be national policy on coastal management to reduce the risk and plan for design, maintenance, instrumentation and monitoring in initial investments. Coordination between departments and various stake holders is essential before fixing a problem for coastal protection.

Members also highlighted that an organized effort shall be taken to observe the structure built, so that one can anticipate or predict future behavior of the structure which helps in reducing risk as well as money for repair and rehabilitation. Moreover, even though World Bank funded projects are continuously being monitored while others doesn't. Hence this approach needs to be changed.



Geosynthetic systems used for coastal hazards-Panel discussion 1 with members Mr. Anilkumar Gopinath, Dr. K Rajagopal, Mr. Sudhir Mathur, Dr. Vijaya Ravichandran

The second session on (industry experience) had 3 papers on the theme “Experiences of Coastal Protection Projects with the Use of Geosynthetics in the Asian Region” . The session was chaired by Prof. RK Bhandari (Former Director, CSIR- CBRI Roorkee) and co-chaired by Mr. Sudhir Mathur (Central Road Research Institute (CRR), India). The session started with the first paper by Mr. Tiru Kulkarni (Garware-Wall Ropes Ltd., India) on “Sea Wall Embankment at Pentha, Odisha - An Indian Experience on Sea Shore Protection using Geotextile Tubes”. The case study site was at Pentha along the Paradeep-Dhamara stretch in Odissa ,India which is a severely affected sea shore village due to the ingress of sea. The shortcomings of the traditional method of protection of seashore embankment using PVC sandbags was brought out along with the advantages in using Geosynthetic tubes as the core layer with the outerlayer covered with stone filled rope gabions. The construction and design difficulties faced during the course of construction due to the ever changing shore line was discussed along with the current status of the site after completion.

The next paper “Importance in Considering Site Specific Externalities while designing Geosynthetic Tubes for Offshore Coastal Structures: A Case Study” was presented by Mr. Anilkumar Gopinath. He has pin pointed that site specific externalities are not considered by researchers and scientific community while designing multilayered geotextile tubes and filled breakwater structures. The paper brought out the importance of considering the impact of the upland riverine environment along with the off shore coastal processes during the planning and design stage of an offshore coastal structure. The difficulties encountered during the offshore installation of Geosynthetic tubes when the upland riverine impact was not considered was discussed based on a case study at LNG Petro, Kochi ,Kerala, India. The difficulties faced and how the situation was tackled with future recommendations were also discussed.

The last paper was on the “Experiences of Coastal Protection Projects with the Use of Geosynthetics in the Asian Region” was by - Dr (Ms) Vijaya Ravichandran, National Institute of Ocean Technology, India. An innovative methodology as regard to the laying, confirmative surveys for maintaining the alignment underwater and installation of a submerged Geosynthetic containment system as a dyke for the navigational channel in Hugli estuary was discussed. The paper also demonstrated that a Geosynthetic containment dyke can be effectively constructed within a short time and within reasonable cost.

The last session of the work shop was a panel discussion on the topic “Future of geosynthetics in coastal sector” with panel members as Mr. R.R Sambharia (Director, BCD, E&NE, CWC, New Delhi, India), Mr. Rakesh Kshyap (Director, BCD, NW&S, CWC, New delhi, India), Dr. Manoj Verma (President, Indian National Group of ISRM, Mr. Vikramjiet Roy (Managing Director, Maccaferri environmental solutions pvt ltd., India), Mr. Ashutosh Kaushik (Chief Executive Officer, PARSAN, India), Mr. Tiru Kulkarni (President - Geosynthetics Division, Garware Wall Ropes Ltd Garware-Wall Ropes Ltd., India), Mr. Nawraj Bhatta (Vice president, Intercontinental Consultants Technocrats, India), Mr. Anilkumar Gopinath (Vice President, Coastal, Maccaferri environmental solutions pvt ltd., India) and Dr. R. K Bhandari as the moderator.

The members emphasized the need for documenting the failures along with the success stories of works undertaken using geosynthetics for future corrections and development. The success in use of Geosystems in adverse conditions like a tidal bore attack was pointed out to emphasize that the future is bright in the use of geosynthetic systems for coastal and estuary protections.

Another important issue raised was designs shall be planned not only from the past experience but also from the future needs and anticipated problems.

Extended coast lines, increasing concern of environment, greening and carbon footprint reduction indicates the huge potential of geosynthetics in coastal applications. Also it was highlighted that India has not only coastline but also huge floodplains where geosynthetics can be of huge requirement.