Reminiscences - I

Professor Ramanath Keshavarao Katti, Professor Emeritus, IIT Bombay, India.

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***Madhav**: Prof. Katti, it is indeed very nice of you to give this interview. I thank you on behalf of ISSMGE, Prof. Kusakabe, Editor of the Bulletin and Dr. Choudhury, Managing Editor of June 2009 issue of the Bulletin. Can you share your beginnings and entry in to the nascent field of Geotechnical Engineering of which you are a pioneer especially in India?*

Prof. Katti: I was born during the British Raj in Bijapur, Bombay presidency in 1928. My father was an overseer after his Diploma from Poona Engineering College in 1915. I completed my matriculation with high marks in Mathematics, Sciences and Sanskrit. I was keen to go for Arts and pursue my studies in Sanskrit. However, I heeded the advice of my parents to go for Science. I joined Fergusson College and completed my Inter-Science in First Class. I was admitted to Mechanical Engineering but changed over to Civil after the first year even though I was doing very well in Mechanical and Electrical Engineering subjects, because opportunities in Mechanical Engineering were then limited. I joined Kakrapara project, a part of Tapti River Valley Project in 1952. I was posted as a junior engineer at Mahuva, Navasari, in charge of Irrigation Colony. I encountered black cotton soil deposit for the first time and was told that the buildings being constructed would get lifted up when it gets wet instead of settling and in the process walls will crack and floors would be lifted up. When the foundation was cast for the first building and water sprinkled for curing the base course got lifted up and hence cracked. Mr. Nayegamwala, Head of the department at Poona Engineering College, posted as executive engineer on the project told me that there was no solution to construct stable structures on black cotton soils. My elder brother was working for his Ph. D. and I realised that some research is needed to solve this problem. I got admission to Iowa State College, Ames, Iowa USA, soon after to pursue graduate studies under Exchange Visitor Programme. Thus I switched from professional career to academics.

I left India in 1953 by boat and reached Ames after 35 days of travel. Prof. Davidson, my guide, asked me to meet Prof. Stewart, the Head of the Department, to finalise my course programme for the fall session. He put me in structural engineering stream. However, it became necessary for me to pursue my graduate studies in Highway Engineering or Soil Engineering as an assistantship was available only in a Highway Research Board sponsored research. I took Highway Engineering as a major and Soil Engineering and Earth Sciences as minors. The topic for my Masters dissertation was Soil Stabilization with Bituminous Materials. For this purpose I had to take courses in organic chemistry, physical chemistry, electro chemistry, soil genesis and classification, clay mineralogy, in addition to my engineering subjects. These subjects helped me in providing a strong science based research programme for Ph. D. thesis in soil engineering and for solving problems due to expansive soil on scientific basis. They helped me in analysing large organic cations with silica surfaces in the form of thin films, free energy interaction between silica surfaces and water and silica surfaces and large organic chains. At certain conditions thin films of large organic chains can replace thin water films. This was unconventional behaviour but scientifically acceptable. Thus in dealing with unconventional behaviour soil one should consider soil particles as matter and apply thermodynamics, physical chemistry and earth science principles to solve stress - deformation problems. My outlook towards solving unconventional behaviour of soil water system or stabilized soil changed forever. I was awarded National Scholastic Honour. Several papers based on my work were accepted for presentation and published in HRB journal.

***Madhav**: Could you apply your research on expansive soils in US while working for your Ph.D.?*

Prof. Katti: Dr. Davidson got a large consulting project to develop methods to utilize fly ash for stabilization of road bases on various types of soil deposits in Detroit Edison power plant area. 700,000 tonnes of fly ash was being produced per year as a waste product. One dollar per tonne was being spent for disposal. The project involved development of a method to stabilize soils for road building and construction methods including equipment for field construction. The studies were to be conducted both in the laboratory and in the field. The entire work was to be completed in 55 days. The temperature in the field could go below 55^{o} F and the mix would not harden. Many of my colleagues refused to work on the project because of time constraint but I offered to work on it and the project was completed on time. Detroit Edison Co. started selling the fly ash at factory outlet for 1.5 $ per tonne. I had to sacrifice a term but it paid off in my future life as I could handle any difficult problem.

Reminiscences (continued)

***Madhav**: Why didn't you continue in USA with this kind of experience? You would have been in great demand?*

Prof. Katti: I had just completed my defence and waiting for the graduation ceremony. I received a call from our embassy at Washington D.C. asking whether I would be ready to join as staff at civil engineering department at Indian Institute of Technology at Powai, Bombay. I was told to develop science oriented engineering programme in my subject. This fitted well with my background and I accepted the offer. I took the opportunity to collect educational data not only from Iowa State but also from M.I.T., Caltech, and other leading universities. I left Ames, visited Glasgow and Imperial College London, etc., on the way and joined IIT temporarily in July 1958. I was told that it would take around two years to shift to Powai where IIT will be situated. By August 1959 some sheds were constructed and I established temporarily a soil engineering laboratories. I proposed to AIMIL that I would give the design and they should provide the equipment at Soil Test equipment listed price and, if the equipment turns out to be defective, they should replace it at their cost.

***Madhav**: Can you please tell when and how you started the graduate program in Geotechnical engineering? Is the work on expansive soil started as soon?*

Prof. Katti: I started my post graduate activities immediately after I returned from U.S.A. I visited Mahuva site where I constructed the buildings on expansive soil. Floors had heaved up, walls and roofs had cracked. I felt sad. I started working on stabilization of black cotton soil with chemical additives and on basic properties of soil and soil fraction using X-Ray, D.T.A. and Gravimetric analysis.
IIT started M. Tech. programmes right from day one. Without Russian expert Prof. Bose encouraged me start M.Tech. programme in 1959. It was the second P.G. programme on the campus in temporary sheds. I was the first Ph. D. in India in soil mechanics and foundation engineering.

The Director (Prof. Bose) permitted me to start M. Tech programme in soil engineering as I had helped in guiding 13 M. Tech. students, at Iowa State. It was a three semester programme, of which two semesters were meant for course work and one semester for dissertation. Five students joined the programme in the first year. Programmed research on expansive black cotton soil was initiated soon after as part of dissertations. I established soil storage, soil mechanics, foundation engineering, soil stabilization, soil physics, soil chemistry, and earth dam laboratories in the newly constructed building. Ample space was available to conduct large scale experiments.

I published papers in Highway Research Board or Industrial Research journals. Annual general meeting of Indian National Society of Soil Mechanics and Foundation Engineering was held in 1960 with CBI&P research session. I came in contact with engineers facing problems in river valley projects especially in Black Cotton deposits area. I also started taking part in the activities of ISSMFE.

***Madhav**: You were probably the first Geotechnical consultant. How this opportunity did arise?*

Prof. Katti: Atomic energy commission faced problems of subsurface exploration and design of foundations for Tarapur Atomic Energy Power Station, one of the most important national project. Tarapur Power Plant foundation problems were referred to IIT Bombay in 1960 as I had worked on Enrico Fermy Atomic Power Project along with Prof. Davidson and my co-worker Dr R L Handy. The report for all the aspects was submitted to the Department of Atomic Energy in 1961. The report was forwarded to Bechtel's the turnkey contractors for constructing the Power Plant. They in turn sent it to Boston. Boston sent a query regarding, Specific gravity. They said that they have never come across specific gravity of 2.81 in US. I conducted heavy mineral and light mineral analysis and sent the reply that Hematite content of our soil is higher than Boston Blue clay which had a specific gravity of 2.67. Bechtel's then relied completely on our report. This showed that Indians could do soil testing of internationally accepted standards. I encouraged Indian companies to set up soil testing facilities with equipment manufactured in India.

In 1964 Mr. Karpa of Bechtel complained to Department of Atomic Energy (DAE) that they are not getting the rocks at foundation levels as described in the report. DAE asked him to meet me directly and get the clarification. We visited the site jointly. I told them that I have mentioned that rock will be encountered at R.L. 93 with light house plinth at R.L. 100. When levels were taken jointly by both the parties the rock strata were encountered at R.L. 93 as predicted thus establishing the competence of Indian consultants. The location of heavy reactor unfortunately fell at a point where the rock encountered was tuff and the bearing capacity was just adequate with factor of safety of 3. DAE and Bechtel asked me whether I would take responsibility for the safety of the foundation and after recalculation I agreed to pour the first basket of concrete. The foundations of reactors are functioning satisfactorily till to date even though they have gone through a few earthquake tremors. I told them that if I could be correct in U.S., there is no reason why I should be wrong in India. DAE wanted foundations be designed for zero settlement but I told them that it was not possible to design foundations on weathered or boulder strata at zero settlement and they have to design their mechanical parts to take care of the allowable settlements. USA counterparts concurred with my observations.

***Madhav**: Prof. Katti can you please elaborate your contributions to research on expansive soils?*

Reminiscences (continued)

Prof. Katti: Large scale failures I noticed in Kakrapara river valley project I programmed the research in the following way: (I) Analyse the properties of Expansive Black cotton soils and their constituents physically, chemically and engineering wise. This gave a direction for my further stabilization research as the soils contained MT clay mineral with expanding lattice. (II) Started developing open system and close system swelling pressure and heave equipment and also tri axial testing equipment to measure ratio between axial and lateral swelling pressure and heave These studies were conducted on soil fractions.. They were conducted with varying densities and moisture content. These studies conclusively proved that MT clay minerals are responsible for swelling pressure and heave and not sand or silt. Prof Bose wanted me to evolve a method at College of Military Engineering (CME) to stabilize expansive black cotton soil for military purposes. Here to decide about depth to which stabilization should be carried out, my student observed that the change in density took place within 1m to 1.5m and then the density remained the same both during rainy season and summer. This I presented it in conference held at CME and also at IISc Bangalore. (III)Later large number of people from academic institutions as Ph.D. or M.Tech projects, and immediately applied by Malaprabha authorities in the field. Nalini, my wife used to help me taking down dictation between 3 am and 5 am and in correcting students' works. She would feed them with refreshments while working late nights. I could not have done so much work in research, development, consultancy, postgraduate education, etc. without her unstinted help and devotion.

Extremely divergent swelling pressure tests were reported in one of the meetings of I.R.C. I was convinced that one should study the mineralogical constituents using available X-Ray, D.T.A, Index properties and gravimetric methods. A large number of graduate students based on scientific approach proved that tests under different conditions gave different swelling pressure in axial and radial directions. We tried to ascertain the depth up to which the swelling takes place. Mr Ketkar, my graduate student, observed that density remains constant beyond a depth of 1.5 to 2.0 m throughout the year. IIT funded earlier research work with large scale models. Large scale models, 1.5 m wide, 3 to 4 m long and 4 to 6 m in height were required to simulate field conditions. Indian Road Congress was active in promoting research in the area of soil stabilization and published a bulletin entitled 'Research on black cotton soil without and with inorganic additives'. This gave impetuous to our research in the area of black cotton soil.

***Madhav**: What was your role and contribution to Indian National Society of SM & FE?*

Prof. Katti: Some annual general meetings of INS SMFE (later to become IGS) were held with IRC. Papers on soil mechanics were presented on one day during the conference. INS SMFE became an independent body with proper constitution around 1968 or 69. Dinesh Mohan, Shamsher Prakash, Ramamurty, etc. participated in drafting the constitution of IGS. Prof. Ramamurthy, Prof. Gulhati and others participated in the development of IGS. Dinesh Mohan took over as president; he was followed by Ramamurthy and Jagdish Narayan. I took over as president of IGS in1977. I encouraged a large number of people to participate in various committees. Indian Geotechnical Conference (IGC) was successfully held in Bombay In 1970, under the auspices of IIT, supported by several organisations in Mumbai. Subsequently IGC's were hold in Bombay in 1980, 1990 and 2000. I understand that IGC2010 would be held in Mumbai. This will be a Golden Jubilee conference at Mumbai. I retired from IIT Bombay 20 years ago. The light is kept burning, the torch of Geotechnical engineering taken over by the younger generation. It is encouraging to see the growth of IGS which has attained international recognition and participation. Geotechnical Engineering is growing in all aspects of profession with professionals actively participating in the growth and dissemination of knowledge.

***Madhav**: Your name is synonymous with CNS (Cohesive Non Swelling Soil) layer. Can you describe its development and application?*

Prof. Katti: CNS technology has been found economical for constructing earth dams, foundations of both light and heavy civil engineering structure, roads, retaining walls and irrigation canal structures. CBI&P supported the work with adequate research grants. Malaprabha River valley project authorities conducted field trials and used it for lining of 108 km long canals passing through deep seated expansive soil. CWC, World Bank, USAID and CBI&P approved the technology as a viable technology for construction in expansive soils. BIS has brought out standards. The technology performed satisfactorily for more than 4 decades. The technology was extended for the construction of canal lining and cross drainage structures in Indira Gandhi Nehar in Rajasthan on deep seated bentonite having high swelling pressure and heave. Government of India established several IITs and regional engineering colleges between 1960 and 1970. IITs were expected to work on emerging areas and give support to engineering and science based technologies. I was a member of delegation to visit various universities in U.S.A. and study the patterns of programmes there. I visited several Institutes conducting research on soil engineering in general and expansive soil in particular under a programme supported NSF. This helped me in formulating post graduate research and educational programmes.

Picture of Prof. Katti at Malaprabha River Valley Project

Reminiscences (continued)

***Madhav**: Prof. Katti, you were instrumental in developing New Bombay in 1970s. What was your contribution to it and other works?*

Prof. Katti: Government of Maharashtra was planning to develop New Bombay area along a coastal stretch. Depth of marine clay varied from 1 m to more than 20 m. The soil has high liquid limit and void ratio making soil-water system close to slurry when the structure is disturbed. The engineers had advised them to avoid the area and develop New Mumbai on murum (residual soil) deposits. I was asked to give geotechnical appraisal for the entire area as I indicated to them that it is possible to construct civil structure using ground improvement techniques and also develop new techniques to construct light to heavy facilities. We developed air photo interpretation techniques coupled with modified pedalogical classification to suit the engineering attributes for the Geotechnical appraisal of the entire New Mumbai area. This also helped in solving offshore exploration and foundation problems, prevented ONGC from abandoning the site for oil exploration and facilitated CIDCO in developing New Mumbai on vast coastal deposits.

ONGC found that Sagar Samrat, a fixed exploratory vessel, started sinking more than permissible. Unfortunately vane shear strength of 750 psi was assumed against 150 psi observed by IIT during CIDCO work. Side sonar's were used to assess whether the depth of soft marine clay was less than 15 m. We succeeded in relocating the rig in a stable location. Subsequently we designed the foundations of six platforms. Cementation Co. helped in mounting the drill on the side of the ship to drill in 90 m of water followed by another 90 m in mud and sand stone or lime stone and retrieve soil samples and test them to obtain design parameters. This again proved the competence of Indian geotechnical professionals in handling offshore jobs.

In 1988 just before my retirement, Simplex Concrete piles India Ltd. offered me to be adviser and consultant to help them in bidding for the jobs involving emerging technologies. I agreed to work on their job for three days in a week and devote the remaining time on my research. During this period I brought out treatises on work done by me on expansive soils.

I have spent 52 years of my active professional life in various aspects of geotechnical engineering in India. Today mind is still alert but the body is failing**.**

***Madhav**: Can you please give a message to our community?*

Prof. Katti: No problem in Geotechnical engineering is difficult as it can be solved using principles of sciences and earth sciences.