AJUDHYA NATH KHOSLA

(1892–1984)

Elected Fellow 1951

"An eminent engineer, an able administrator and a generous human being" will be the epithets by which AJUDHYA NATH KHOSLA will be known to the posterity in India. Belonging to a generation of Indians, born when the country was under foreign domination, Dr Khosla was proud to be an Indian and had great confidence in the capabilities of Indian engineers. There is no doubt that he had few equals to match his qualities, achievements and abilities.

EARLY LIFE AND EDUCATION

Ajudhya Nath Khosla was born in Jullunder City in the Punjab on December 11, 1892. He had his early education at the Government High School and later at the Anglo-Sanskrit High School, Jullunder, from which he passed his Matric examination in 1908. He had his college education at the DAV College, Lahore, from where he graduated in Arts (Hons) in 1912 securing the first position in the University and the highest marks in mathematics. Young Khosla joined the Thomson College of Civil Engineering, Roorkee in October 1913 and graduated with honours.

SERVICE AND RESEARCH CAREER

Soon after passing out from the Engineering College, in July 1916, he joined the Punjab Public Works Department (Irrigation Branch). It is interesting to note that his first assignment was to investigate and survey connected with Bhakra Dam Project, a major challenge faced and overcame by him with great distinction in later life. The dam, one of the highest in the world, stands on the same axis as he had proposed in 1917 as an apprentice engineer.

From July 1918 to March 1920, during the First World War, he was with the Mesopotamia Expeditionary Force in Iraq as a Commissioned Officer, when he made his first original contribution to engineering by designing Khosla Disc for precision levelling across rivers and wide valleys.

He was appointed to the Indian Service of Engineers in 1919 and returned to India in 1920. He was posted to the Sutlej Valley Project first on the surveys and investigations of all the four headworks and was then posted to the Sulemanki headworks for construction of the barrage. Here during 1921-26 he introduced precast concrete units for use on the barrage and precast reinforced concrete troughs for use on roads

and a variety of other structures. This type of construction saved the cost of formwork and expedited construction since the supports and the covering could be constructed and cured simultaneously. This cut down the time of construction considerably and proved economical in cost.

After completion of Sulemanki Head Works, Dr Khosla was posted successively, to the Headworks of the Upper Chenab Canal, to the Punjnad Barrage and to the Headworks of the Lower Chenab Canal at Khanki. The Weir there was reconstructed during his tenure as Executive Engineer. During these nine years he carried out intensive research on the flow of water through sub-soil in relation to stability of Hydraulic structures. This research culminated in 1936 in the publication of his paper on "Design of Weirs on Permeable Foundation"*. The method of design set out in this publication was adopted in the design of several weirs and barrages and other major hydraulic structures on permeable foundations undertaken in India and other countries and showed consistent success. The method was based on the solution of the well known Laplacian equation which governs the seepage of water through homogenous pervious media. This equation was not integrable for the complex boundary conditions of weir and barrage foundations. The 'method of independent variables' devised by Dr Khosla was remarkable for its ingenuity. He broke up the complex profile into a number of simple integrable profiles, and then superposed them. It was proved by electrical analogy experiments that the results so obtained, and subject to certain corrections given by Dr Khosla, were well, within the desired accuracy. This is his most outstanding contribution to engineering science. Only recently, with the development of speedier numerical methods and availability of fast computers, the use of his paper has been supplemented by new techniques.

This research work, was carried out in addition to the executive duties of the appointments held by him, was a major contribution to engineering science, to the theory and technique of design of river works, and of major hydraulic structures.

In 1926-27, trouble at the syphons under the Upper Chenab Canal became acute. These siphons are for large natural drainages in the head reach of the canal (capacity 12,000 cusecs), completed and opened in 1912, and must have been giving constant trouble ever since. Cracks appeared at the upstream and downstream ends due to undermining of the sub-soil. Repairs were carried out on the accepted Bligh theory but the trouble persisted. As officer-in-charge of the syphons, Dr Khosla initiated steps to probe into the real cause of the chronic problem. A set of pressure pipes with well-points were inserted in the floors of two of these syphons and the observations disclosed that the pressures indicated by these pipes had absolutely no relationship with those calculated from the Bligh Theory."

In 1930, Dr Khosla presented to the Punjab Engineering Congress two papers embodying the results of his researches. Briefly, the simple creep theory of Bligh

*Khosla A N, Bose, N K & Meckenzie Taylor, E 1936. Design of Weirs on Permeable Foundations. CBIP Publication No. 12.

was repudiated and some provisional and important conclusions were arrived at, notable among which were :

(a) The outer faces of the end sheet piles were much more effective than the inner ones and the horizontal length of floor,

(b) The intermediate piles of smaller in length than the outer ones were ineffective except for local redistribution of pressures,

(c) Undermining of floors started from the tail end. If the hydraulic gradient at exit was more than the critical gradient for the particular sub-soil, the soil particles would move with the flow of water thus causing progressive degradation of the sub-soil, resulting in cavities and ultimate failure,

(d) It was absolutely essential to have a reasonably deep vertical cut-off at the downstream end to prevent undermining,

(e) There was an urgent necessity for research work with regard to pressures under existing and new structures and in the laboratory. The former could be done by inserting suitably located pressure pipes in these structures and by maintaining a continuous and comprehensive record of the observations of pressures from those pipes.†

Following the failure of the new Islam barrage in September 1929, two years after it had been built, it was decided to extend the Panjnad barrage, which had, by then, been almost completed as per earlier design. This afforded the opportunity of putting in a comprehensive set of pressure pipes and of conducting full scale experiments. His Executive Engineer complained of the weir being turned into a sieve by the holes to be made for the pressure pipes. The pipes were, however, installed as per Dr Khosla's recommendations. He was, in due course, transferred to Panjnad when the Barrage there was opened. Dr Khosla was thus enabled to supervise the observations of pressure under the floor of the new barrage. This was the first full size experiment in the world, and the results obtained from it paved the way to the final solution of the problem. The main conclusions were :

(a) The flow of water through the sub-soil is in stream lines and therefore susceptible of mathematical treatment.

(b) The ratio of uplift pressure at any point along the base of a particular weir founded on permeable soil to the total head is constant and independent of the head, the class of sub-soil (so long, as it is homogenous) and temperature, but it varies with silt deposits or scour upstream or downstream of the impervious floor.

His next prominent achievement was the construction of the Trimmu Barrage, which was designed according to the method developed by him. He completed this work in a record time of two years. Similar barrages of this magnitude used to take

†Khosla A N 1935. Observations and Record of Pressures below Works on Permeable Foundations. CBIP Publication No. 8.

about 5 years to complete. This was the first major project ever entrusted to an Indian engineer. Its completion in record time and at a substantially lower cost was a tremendous gain for the prestige of Indian engineers. This was also one of the most important applications of the precast concrete units.

As Superintending Engineer, High Dam Circle, from 1941 to 1943, he investigated the water and power resources of the Punjab and prepared plans for their development, a number of which have been or are being implemented. During this period, he made an important contribution by establishing a rational relationship between "Rainfall and Runoff" and wrote his paper on "Silting of Reservoirs".** His approach to the runoff problem was also characterised by simplicity. Assuming that all precipitation which does not evaporate must contribute to runoff, and further that evaporation could be taken as a function of temperature alone, he correlated the runoff to mean temperature.

The figures given by him for rate of silting of reservoirs was the first quantitative estimate for India and was of great help to planners. The actual silt measurements on reservoirs completed during fifties and sixties have shown considerably higher rates of silting—presumably due to accelerating rates of removal of vegetal cover.

Dr Khosla brought about an agreement in 1943 with the Punjab Government and Raja of Bilaspur (now in Himachal Pradesh) about submergence of part of his territory in the proposed Bhakra reservoir. This cleared the way for the construction of Bhakra Dam which had been held up since 1943.

In 1944, Dr Khosla was elected Chairman of the Indian Science Congress, Engineering Section. In February 1945. Dr Khosla was appointed to the post of Consulting Engineer to the Government of India for Waterways, Irrigation and Navigation. In April of that year, on the creation of Central Waterways and Irrigation Commission (later Central Water and Power Commission and now Central Water Commission), Dr Khosla was appointed its Chairman. He continued to hold the post of Consulting Engineer also. Later he was made ex-officio Additional Secretary to the Government of India. He organised this Commission from scratch and simultaneously re-organised and developed the Pune Research Station at Khadakvasla into the Central Water and Power Research Station. These years, till his retirement from the post in 1953, marked a period of outstanding achievements in the field of river valley development.

He initiated investigations on the water and power potential of river valleys in the country as a whole and of several individual projects. Many of these like the Bhakra, Chambal, Damodar Valley, Hirakud, and Tapti (Ukai and Kakrapara) projects have been completed, and others on the Narmada' and other rivers are under construction or under active consideration. Special mention should be made of the Hirakud project on the Mahanadi river, which he conceived in May 1945 soon after assuming charge as Chairman, Central Waterways, Irrigation and Navigation

**Khosla A N 1953. Silting of Reservoirs, CBIP Publication No. 51.

Commission, as the first stage of his plan for the integrated development of the Mahanadi valley. He directed its construction till 1953. This project was completed in early 1957—a record time of 12 years between conception and completion of a project of this magnitude. Dr Khosla also initiated investigations for a Dam on the Kosi at Barakashetra near the Indo-Nepal Border. This project is yet to materialise.

At the time of partition in 1947, many engineers opted for service in India, while the eastern part of Punjab could not absorb all of them. A major decision was then taken that the construction of Bhakra Dam and other projects be undertaken by Punjab directly through their own engineers and not through contractors. This would also train Indian engineers in planning and construction of major projects on their own. This idea proved to be highly successful.

His other achievements during this period were the settlement of differences between Madras and Orissa States on the Machkund project and between Hyderabad, Madras and Mysore States on the Tungabhadara projects.

In 1953-54 as Special Secretary to the Government of India, he led the Indian delegation to the United States for the Indus Waters dispute with Pakistan. These negotiations, in which he played a crucial role led to the World Bank proposals, which later formed the basis of the Indus Water Treaty between India and Pakistan. According to this treaty, Sutlej, Beas and Ravi rivers could be utilised fully by India, and the western rivers—Chenab, Jhelum and Indus could also be utilised by India for Run-of-the River Power Schemes. This decision when fully implemented through construction of projects on these rivers will make Punjab, Haryana and Rajasthan the granaries of India. It may be hoped that, some day a large part of Rajasthan will cease to be a desert.

On September 17, 1954, he assumed charge as Vice-Chancellor of the University of Roorkee, his *alma mater,* a post which he held for a little over five years. During these formative years of the university there was a great expansion not only in its size but also in the quality of its activities. His contributions as Vice-Chancellor included the establishment of the Water Resources Development Training Centre, Refresher Courses Department for serving engineers and teachers, and the School of Research and Training in Earthquake Engineering—which are even today prestigious and distinctive Departments of this University. During this period admissions increased four-fold. New laboratories and other buildings were built. Post-graduate courses and research work were expanded considerably.

One instance of his level of thinking may be mentioned here. A scheme was prepared for the establishment of a School of Research in Earthquake Engineering. This estimate amounted to Rs 15 lakhs for the first five years. When the scheme was put up to Dr Khosla, he asked "Do you require only 15 lakhs?" It was explained to him that since CSIR did not permit allocation of foreign exchange, equipment would have to be designed and fabricated at the School. This would naturally be a slow process and that was why it would not be possible to utilise more than that amount effectively. He was very appreciative of the idea of taking up design of equip

ment locally since it meant "import substitution" and would generate confidence among the scientists engaged in that work. Others thought that the sum of Rs. 15 lakhs was very ambitious since for midfifties, it was quite a large sum for a University; but not for Dr Khosla. He always thought of things in a big way. Incidentally, scientists engaged on this work are now internationally known for their work and are tackling the most intricate problems of Earthquake Resistant Design of major structures in the country.

Another point worth mentioning here is that once this scheme was submitted to him for processing it with the CSIR, he took over the responsibility of getting it sanctioned, and told the scientists concerned that they should concentrate their attention on the preparation to establish the school. Such an attitude encourages the young scientists enormously since they have a leader who takes full charge of the administrative problems. He was, therefore, a leader among men who inspired the younger generation to achieve higher goals without being bogged down by bureaucratic hindrances. He was also a person who considered "rules and regulations" as "guides" and not "masters", and that was why he succeeded in contributing so effectively in every field of his activity.

Out of the savings of Dr Khosla's consulting fees amounting to Rs 1,15,000, supplemented by contributions from the earnings of other staff for similar work, a fund has been created at the University to award prizes for good research work. The prizes carry his name and are greatly valued by those who earn them. In 1957, he was deputed by the Government of India to advise the Government of Sudan on the appraisal and development of water resources in that country.

He was a Member of the Rajya Sabha from April 1958 to October 1959. In December 1959 he was appointed Member of the Planning Commission in-charge of Education, Health and Scientific Research. In 1962, he was appointed Governor of Orissa. This marked the first time an engineer was appointed as Governor of a State. Despite his exacting duties as Governor, Dr Khosla continued to take active interest in professional activities, particularly in river valley development. He retired from the post of Governor in January 1968.

He continued to be the Chairman of the Board of Consultants of various river valley projects like Balimela, Beas, Bhakra, Pamba-Kakki (Sabargiri), Ramganga and Yamuna.

Dr Khosla was appointed by the Government of India as Chairman of the Committee for preparing a Master Plan for the optimum and integrated development of Narmada water resources—a plan which he had originally mooted in outline in 1945-46.

After his retirement as Governor of Orissa, he devoted most of his time to the education and socio-economic uplift of the tribals, harijans and other weaker sections in the State of Orissa. Dr Khosla established a Women's Degree College, a Women's Polytechnic and a Girls' High School at Rourkela, and three colleges and four High Schools for boys, a Teachers' Training School, an Auxiliary Nursing and Midwifery

Training Centre, and three Medical Aid Centres at various places in Orissa. Also, he established a residential High School for Adivasis at Lungei (near Rourkela). All these educational institutions were under the management of DAV College Trust and Managing Committee of which Dr Khosla was Vice-Chairman. They are located in the backward area of Orissa and their establishment needed a large sum of money. His wife Smt Susheela Khosla contributed the first one lakh of rupees from her personal savings to start this scheme.

Awards and Honours

Dr Khosla was awarded a number of Gold Medals for his outstanding performances. Some of these are : William Rattigan Medal for standing First in BA Examination in 1912; Rai Bahadur Kanaihya Lal Medal for Civil Engineering from Civil Engineering College, Roorkee; two medals from Punjab Engineering Congress in 1930 and 1936 respectively; Kennedy Medal from Punjab Irrigation Department in 1940; Medal from National Institute of Sciences in 1960 and the Shanti Swarup Bhatnagar Medal from Indian National Science Academy in 1974.

Dr Khosla was elected to numerous high offices in national and international bodies and conferences. From a list too numerous to be catalogued should be mentioned the following : President of the Institution of Engineers (India), 1949-51; President of the Central Board of Irrigation and Power, 1946-48 and 1951; President, National Institute of Sciences of India (now Indian National Science Academy) 1960-62; Founder President, International Commission on Irrigation and Drainage, 1951-54, and its Honorary President; Vice-President, International Commission on Large Dams, 1946-51; Vice President, International Association for Hydraulic Research, 1948-53 and Vice-President, Union of International Engineering Organisations of the UNESCO, 1950-53. Dr Khosla was a Life Member of the American Society of Civil Engineers, and Honorary Life Fellow of the Institution of Enginees (India) since 1972.

He was the recipient of numerous honours. Before independence of India, he was awarded the title of Rai Sahib in 1929, and Rai Bahadur in 1933. After independence, the honour of Padam Bhushan was conferred upon him in 1955 and Padam Vibhushan in 1977 by the President of India.

Dr Khosla was awarded Doctor of Engineering (Honorary) by Renesselaer Polytechnic Institute, USA in 1956; Doctor of Engineering (Honoris Causa), University of Roorkee in 1959; and Doctor of Science (Engineering) (Honoris Causa), University of Punjab in 1961. He was awarded Doctor of Science (Honoris Causa) by Sambalpur University, Orissa, Indian Institute of Technology, Delhi, Orissa University of Agriculture and Technology, and by Jadavpur University.

Personal Qualities

Khosla came from a modest middle class family. In fact, his father had to incur debt to bring up and educate his children. Dr Khosla paid these debts after joining service. Thus, he was not an inheritor of privilege and position; but rose to eminence by sheer merit, dedicated hard work, and pride in his profession. He never considered any work too small or too big for him. He was a person who became an example to many in his life time.

Dr Khosla was an eminent engineer—dynamic, determined and practical dreamer, planner of great vision, humane to the core, a philanthropist, friend of the under-privileged, believer in human dignity. He was an administrator par excellence. He was an inspiration to all who came in contact with him. His remarks in one of his speeches are worth quoting : "*In all scientific and technological advance, there is no substitute for thinking for one's self, for the habit of enquiry, for the drive for innovation, and for the gamble of experimentation". Accordingly—There can be no two opinions that an Engineer must remain a student all his life.*"

He passed away on May 29, 1984, full of years, every one of which was an year of achievement, full of honours, and fully deserved.

Jai Krishna