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Sir M.Visvesvaraya – An engineer par excellence

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The district of Kolar in Karnataka state is well known all over the world for its gold mines. Muddenahalli is a sleepy small village in Chikballapur *taluk* of Kolar district. Mr Srinivasa Sastri and Mrs Venkatalakshamma residents of Muddenahalli were blessed with a boy on 15th September 1861, who grew up to be a golden treasure to India. Mr Srinivasa Sastri was a scholar who devoted most of his time to the study of Hindu scriptures and performing pilgrimages. Mrs Venkatalakshamma was a pious lady of strong character. The child was second among their six children and was named Mokshagundam Visvesvaraya. The family name Mokshagundam is attributed to the name of a small village hamlet in Giddalur *taluk* of Kurnool district in Andhra Pradesh from where the ancestors of Sastris hailed before migration to Karnataka in the late 15th or early 16th century.

The learned family of Sastris was short of resources and poor in material goods. They could not afford to send their six young children to the nearby school in Chikballapur. Education began at home. Later, as Mrs Venkatalakshamma was more concerned about the education of her children, the family shifted to Chikballapur where the children went to the government school for primary education. The teachers in the school were impressed by the intelligence and discipline of young Visvesvaraya and encouraged him to read by lending him advanced books. After his primary education Visvesvaraya moved to Bangalore and stayed with his maternal uncle Mr Ramaiah for further education and subsequent career. He joined the Wesleyan Mission High School in Bangalore and completed Matriculation as topper in the then Mysore State. The result encouraged his mother to continue the studies of her son in spite of financial and domestic problems. Visvesvaraya joined Central College for Intermediate Education, but life was hard and uncomfortable. He decided to earn by doing tuitions to meet his educational expenses. He undertook private tuitions in a Coorgi family. His schedule was hectic and tiresome because his college, the place of tuition, and his residence were spread out in different corners of Bangalore. The only mode of transport in those days was travelling by foot. Hence he slept in the house of the Coorgi family, woke up early in the morning to give tuition to their children and went to his uncle's place for food and then to the college. What he lacked in material comforts, he made up through his courage and determination.

Visvesvaraya was a brilliant student in the college and was easily noticed by the British Principal of the college Mr Charles Waters. The principal took keen interest in his progress in the college and admired his keen sense of duty and punctuality. Impressed by his student Mr Waters presented him with a *Webster's Dictionary*. This dictionary was a constant companion of Visvesvaraya almost throughout his life and can be still seen in the museum at Muddenahalli. Visvesvaraya passed his B.A. examination in 1880 with distinction. The Principal of the college, knowing the financial situation of Visvesvaraya, recommended him for a job in the Directorate of Public Instruction. However, Visvesvaraya wanted to continue his studies to become an engineer. By then, the Diwan of Mysore Mr Rangacharlu was instrumental in instituting scholarships for students from Mysore to pursue higher education outside.

Visvesvaraya met the Diwan of Mysore and was successful in obtaining a scholarship for himself to study Engineering in the College of Science in Poona. Visvesvaraya joined the college of Science in Poona (now Pune) in 1881. His professors took keen interest in him and helped him complete his course in two-and-a-half years instead of the usual three years. He passed his engineering diploma LCE (equivalent to B.E.) in 1883 and topped in the college. His brilliant success in the examination brought him the James Berkeley prize and his appointment as Assistant Engineer in the Bombay Public Works Department, the post being guaranteed to the topper among the successful candidates.

Engineering career

Visvesvaraya started his engineering career in February 1884 at an early age of 23 years after his engineering degree in Civil Engineering. The opportunity to work with the Bombay Public Works Department provided ample scope to him to prove himself as an engineer. Within a short span of 20 months he was elevated as first grade engineer and his job was confirmed. He worked in different regions in the Bombay province and was responsible for construction of different projects including construction of bridges. Later he opted to move to Poona, and was given charge of civil engineering works like buildings and roads. While in Poona during 1894 he was deputed to design and execute the project of drinking water supply for Sukkur in Sind province (presently in Pakistan).

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Collector wells

The project had multiple challenges – the area was hot and arid, and they had to manage with minimum funding. An initial plan adopted by the municipality of Sukkur was to pump water from river Sindhu (Indus) to a hill nearby, filter it and supply the water to the town through pipes. However, they did not have enough money for the filters. After visiting the site and studying the ground situation compounded with fund crunch, Visvesvaraya came out ingeniously with an innovation of digging wells in the river bed itself close to the river bank to obtain spring water through percolation. Thus filtering was achieved without having to install filters. To increase the supply of water, a tunnel was driven from the bottom of the well under the flowing river. This was a technique rarely seen in those days, but is now standard textbook material under the heading "collector wells". The technique of digging collector wells on river beds is one of the most efficient ways of extracting filtered water. In regions where rivers are not perennial or have low flow conditions during most part of the year, the wells are placed in the riverbed to obtain uninterrupted supply of naturally filtered groundwater through highly permeable saturated riverbed aquifers. Collector wells can provide moderate to large quantities of filtered water naturally.

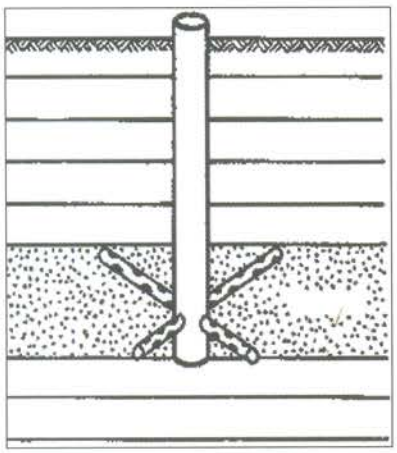

Fig. 1. Collector Well.

The design of collector well depends on parameters like river bed, surface water hydrology, study of geologic data like sand texture, density, size of grains, recharge potential of well, location of well and water demand.

Visvesvaraya was able to complete the work in a very short period. The then governor of Bombay, Lord Sandhurst inaugurated the drinking water facility built by Visvesvaraya in Sukkur in 1895, and in his inaugural addresses complimented Visvesvaraya as the most able engineer the project could have had.

After successfully executing several other assignments in other parts of the then Bombay state, Visvesvaraya was reposted in 1899 to Poona as executive engineer, Poona irrigation district. This was a turning point in his career. Now he had to manage politicians and farmers in addition to the management of irrigation works in Poona. The water from Fifa reservoir in Khadakavasla was drawn through Mootha canal for the drinking water supply of Poona city, Kirki military base, and farm lands surrounding Poona city. It was observed that water in the sharing canals was wasted in spite of water scarcity.

Rationing of water

Visvesvaraya's first challenge was to win public support for the system of rationing and regulating the supply of irrigation water. It was decided that water will be rationed for irrigation on a 10-day rotation period. The scheme was bitterly opposed by farmers backed by many prominent politicians like Lokmanya Balgangadhar Tilak and others. Balgangadhar Tilak wrote extensively in his newspaper *Kesari* opposing the water rationing action of the Irrigation Department. The scheme had to meet stiff opposition. However, the Government of Bombay expressed full confidence and backed Visvesvaraya. He then took an unusual step of inviting farmers and all those who were concerned for a public conference and debate organised at Fergusson College in Poona. The public conference was attended by interested parties. Visvesvaraya explained in detail the scheme of rationing the irrigation water. He even invited the farmers to take charge of the water management and offered them the Government support to meet incidental expenses. After hot debate the farmers were convinced that the system would be beneficial to them and agreed to adopt the system of water rationing. Thus the scheme of water rationing was introduced for the first time in the country, which was typical of Visvesvaraya's imagination and human approach, to the solution of problems in a democratic set up. The transparency, with which the scheme was implemented, was lauded by both farmers and politicians.

Block system of irrigation

Visvesvaraya devised innovative techniques that were well ahead of his time. One of his earliest contributions was the 'block system' of irrigation – designed to optimise, control and evenly distribute water supply to agricultural lands over a large number of villages.

In 1901, the Government of India appointed an Indian Irrigation Commission with Sir Colin C Scott-Moncrieff as Chairman to recommend measures to be adopted to conserve water and promote irrigation in India. Visvesvaraya prepared a report on irrigation with new schemes to be adopted in the Bombay presidency and handed it over to the Commission. The new scheme of irrigation was known as block system of irrigation. The object of the scheme was to distribute the water resources effectively among a large tract of irrigation land. This was an effort to concentrate the irrigation in each village within a block of specified units in selected soil so that there would be a crop rotation in each block once in three years for maximum utilisation of water and to reduce water wastage.

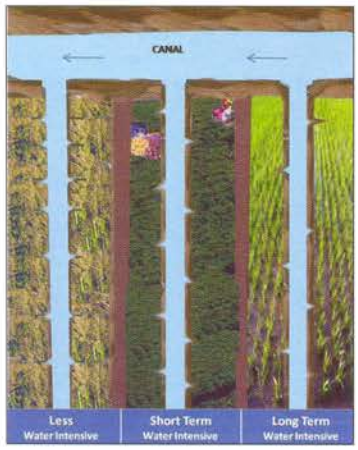

Fig. 2. Block system of Irrigation

According to the scheme the agricultural land in a village was divided into three different blocks. The three blocks would grow three different types of crops. The first block would grow short-term water intensive crops. The second block would grow less water-intensive crops. And third block would grow long-term water intensive crops. Once in three years the land was regrouped and rotated into blocks so that the farmers would get opportunity to grow all the above three types of crops once in three years and they were assured of the required quantity of water. The sowing time for the crops was also suggested keeping in mind the rainfall period in the region, so that the available water could be managed to meet the long term water intensive crops during summer. The Indian irrigation commission under the chairmanship of Sir Colin C. Scott accepted his report and termed the scheme as "very complete and well considered" and recommended that it should be given a trial and later implemented in the entire country.

The scheme was well ahead of its time to be accepted by the farming community. The Government of Bombay entrusted Visvesvaraya with the responsibility of introducing the scheme. Visvesvaraya made intensive efforts to implement the scheme in the Bombay province under stiff resistance from the farming community. He organised interaction groups between the farmers and irrigation officials to explain to the farmers the advantage of the block system of irrigation. The scheme began on an experimental basis. Slowly the farmers realised the potential of the system. The scheme assured them of required water for long term intensive crops. The scheme was effectively brought into force in the Bombay province and the benefits of the system were shared between the farming communities without further complaints. In 1908 the Bombay legislative council was informed by its spokesperson about the complete success of the block system of irrigation in Bombay province and the success of the scheme was credited to Visvesvaraya.

Automatic sluice gates

Having established himself as an able engineer of high reputation and capability, he went on to innovate and build automatic sluice gates for Lake Fifa in Khadakavasla during1901-1903. Lake Fifa had a weir and it was difficult to meet the drinking water requirements of Poona city from the water stored in the weir during non rainy seasons. Here it is relevant to mention what Visvesvaraya wrote on the necessity of gates for the weir at Khadakavasla: "The reservoir overflowed every year up to a height of six to eight feet above the crest of the surplus weir. A system of automatic gates was designed by me to raise the storage water level of the lake permanently by about 8 feet (2 metres) above the original surplus weir. The gates held up water in the lake till it rose to the full height of the previous floods but whenever water rose above that level the gates automatically opened and allowed the surplus water to escape. When water in the lake again fell below the 8 feet level over the surplus water the gates automatically closed and stopped further loss of water." The gates increased the storage capacity of the reservoir by about 25% without raising the height of the dam. The gates were manufactured by a European firm. Visvesvaraya obtained a patent for his invention but refused to accept any royalty for his invention.

Fig. 3. Patent agreement for Sluice gates

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Sluice gates control or regulate flow through an opening or sluice in the body of the dam where the upstream water level is above the top of opening The automated floodgates allowed flood water to enter a reservoir without the water level exceeding the full reservoir level, thereby reducing the risk of submerging surrounding land. The gates are automatic because they open and close with the rise and fall of water in the reservoir. This was the first time that thought was given to using reservoirs for flood control, in addition to irrigation and power generation. The wheels are mounted on the end girders. The bottom of gate is so shaped that satisfactory performance and freedom from harmful vibrations are attained under all conditions of operation apart from minimising downward pull.

The automatic sluice gates designed and built by M. Visvesvaraya served for more than half a century satisfactorily. The same pattern of automatic sluice gates was later used in the Tigara Dam in Gwalior, at Krishnaraja Sagar dam in Mysore, and in other large storage dams. The design of automatic gates has been copied all over the world including adoption in Panama Canal. Other notable works during his stay at Poona was the preparation of piped sewage scheme in 1904 for the city of Poona (probably first such scheme for a city in India). He was also deputed to Aden to advise and report on the problems connected to water supply and sanitary in the city. His two reports on the city of Aden was duly considered and executed.

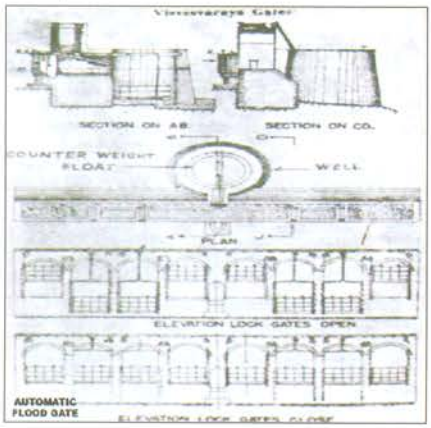

Fig. 4. Automatic Flood Gate drawing by Sir M.V.

Visvesvaraya by then had already superseded many of his seniors by virtue of his hard work and efficiency in the Bombay province. Discontentment among his fellow colleagues had started airing out. In 1908 the situation made Visvesvaraya to take a momentous decision of taking retirement from service. The Government of Bombay considered his resignation and although he was not eligible for pension, took a decision to grant him pension out of the way in view of his exceptionally meritorious service. Soon after his resignation he went on a foreign tour at his own expenses and visited many countries including Italy, Sweden, Holland, Denmark, England, Russia, Canada, and America and visited farms, factories, and irrigation works in those countries to widen his own knowledge about the new developments. His experience abroad benefited the future projects and economic developments which he took up subsequently in the country.

Services at Hyderabad

Soon after his return from abroad, Visvesvaraya was invited by the Nizam of Hyderabad to solve the problem of floods in Hyderabad caused by cyclonic rains and heavy water discharge from river Musi in to the city. Visvesvaraya took up this challenge in April 1909. He made a thorough survey of the catchment area and studied the flow of river. He submitted his recommendations to construct two dams across the river Musi and its tributary at a distance of about 12 km from Hyderabad. His proposal was duly considered and executed subsequently. During his tenure in Hyderabad he also planned the piped sewage disposal scheme for Hyderabad and Secunderabad cities. He was also involved in developing a system to protect Vishakhapatnam port from sea erosion. He left Hyderabad service in November 1909. But then he was once again associated with Hyderabad in 1922 and 1930 for planning a comprehensive scheme for the improvement of the twin cities including drainage schemes.

Visvesvaraya in the service of Mysore State

Visvesvaraya began his service as the chief engineer on 15 November 1909 in the state of Mysore. He initiated steps to build new railway lines and to take over the existing lines which were managed by the Madras & Southern Maratha Railway Company (British companies). He initiated action for various irrigation schemes including the distribution of water from Marikaniva reservoir. He became the chairman of Industrial Development Committee and Technical Education Committee. He was instrumental in establishing economic committees at district and *taluk* level in the Mysore province. He virtually initiated action for implementing development works in various spheres to ensure overall development of Mysore state. One of the major works was the design and construction of Krishnaraja Sagar dam, locally known as Kannambadi reservoir scheme, which began in 1911 and was completed in 1932.

Krishnaraja Sagar dam

The building of a huge reservoir across river Cauvery at Kannambadi to provide water for irrigation and electric power was inspired by his studies of the Aswan dam in Egypt and other experiences during his personal trip abroad. It did not take long to draw up the project to suit local conditions. The salient features of the dam are as follows. Type: masonry; maximum height above the lowest point of foundation: 43 metres; length at the top of the dam: 2,621 metres; gross storage capacity: 1,368,847 cum; type and number of gates: 161 lift gates.

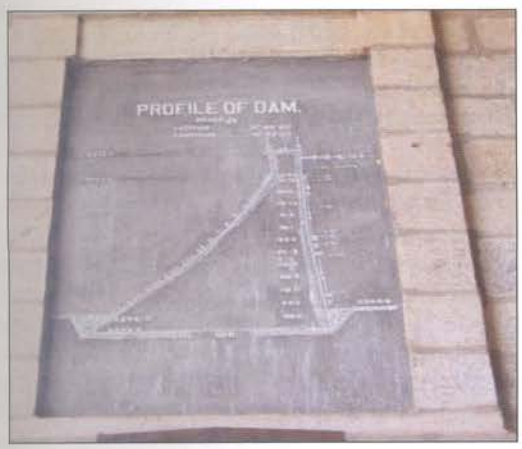

Fig. 5. Profile of KRS Dam

All reservoirs ought to have a device to pass excess inflows safely. Open spillways do this at the cost of a rise in water level. Visvesvaraya used his invention of automatic gates, which do this job without a rise in the water level. Such 48 automatic gates (out of 161 gates) in six sets of eight gates each were installed in the Krishnaraja Sagar (KRS) dam.

Fig. 6. Chain & Pulley arrangement for gate opening

Each set of eight gates are connected by means of chains and pulleys to a dead weight, which in turn is connected to a float working inside a masonry well, both situated on the rear side of the dam. The float and the counterweight balance each other and are located one in front of the other so as to have four gates on each side of it. When all the eight gates are closing the sluice vents, the counter weight is at the top of its run and the float at the bottom of the well. The well has an inlet pipe (1 ft diameter) from the reservoir to allow water into the well at full reservoir level. The well has also an outlet pipe. When the water level in the lake reaches the maximum permissible level, water rushes into the well and the float rises up.

The sluice vents then begin to discharge. When the reservoir level falls, the well gets emptied. The counter weight then comes up and the gates descend and discharge is stopped. (See the arrangement in the picture.)

Fig. 7. Skelton Gate of KRS Dam

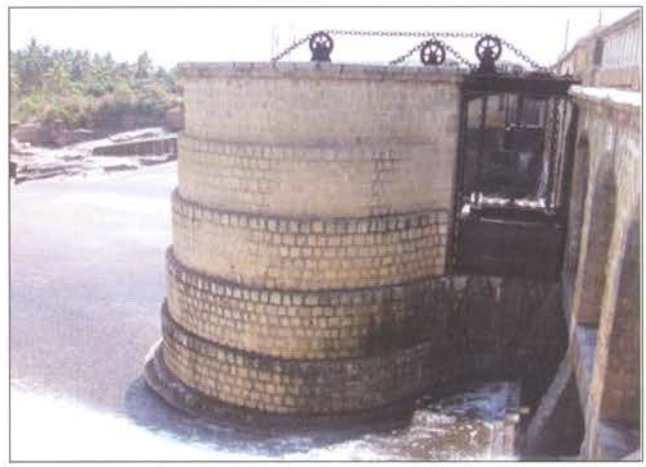

Fig. 8. Well with float and counterweight arrangement

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Each gate has the capacity to discharge at full reservoir level, about 1,000 cusecs (unit of measurement used to indicate the flow of one cubic foot per second of water). These gates are called "automatic gates" because they open and close at the rise and fall of water in the reservoir. The gates are made of cast iron and all the 48 gates were manufactured at the Mysore Iron & Steel works in Bhadravathi.

About sluice gates

A sluice is a water channel that is controlled at its head by a gate. Any gate that operates by allowing water to flow under it is termed as a sluice gate. There are many types of sluice gates, like the depletion sluice gates which are located at the lowest level in the body of the dam to empty the reservoir in the event of distress. It may be either wheel-mounted type or sliding type. The construction sluice gate is used for closing a construction sluice, which is normally plugged after construction. The crest gate which is mounted on a crest for the purpose of controlling the discharge flowing over the crest of the spillway of a dam. The fixed-wheel vertical lift gates comprise of, in general, a structural steel frame consisting of end vertical girders with properly spaced horizontal girders between them. The spacing depends on the design water pressure and on dimensions of the gate. The frame is held as a single piece by secure welding or riveting. Skin plate protects the structural framework from damage due to ice and heavy debris, minimises down pull, reduces corrosion and facilitates maintenance. However, in some cases as in the case of fixed wheel gates moving on track provided on the face of the dam, skin plate is provided on the downstream side. In exceptional cases, skin plate is provided on both downstream side and upstream sides, if the downstream water is above sill. In such cases the gates may be fully or partially buoyant. In case of fully buoyant gates, buoyancy is taken into account in determining the net balance of vertical forces and addition of ballast may be necessary to ensure lowering without difficulty. This problem is absent in the case of flooded gates but greater care against corrosion becomes necessary.

Diwan of Mysore

In November 1912, Visvesvaraya was invited by the Maharaja of Mysore to accept the office of Diwan. He was the first non-civil service member to occupy the post of Diwan in Mysore state. As Diwan of Mysore state, he was instrumental in galvanizing the state into progress. Soon after he assumed office he took into stock the prevailing situation with respect to general education and economic competence among the people. Only one in 16 was able to read and write; people were not fully employed. Visvesvaraya drew up a plan for improving the education and economic development of the region. He gave special emphasis to villages and mooted the idea of monitoring the progress in villages on a yearly basis. He urged people to take part in promoting progress of the region. He introduced constitutional reforms within the state with a large representative assembly to discuss budgets and a small legislative council with limited power of legislation. All the decisions were subject to the approval of the British.

Fig. 9. M.V. as Diwan of Mysore.

The Mysore economic conference started by him during his tenure as the chief engineer was further widened with three main committees for agriculture, industries, commerce, and education. The Committees collected statistical data at the micro level for evaluation and planning of development works. Education was given top priority. He passed a law for compulsory education of Harijans and girls. He was responsible for starting many educational institutions in the state. Some of the major educational institutions credited to him are the Agricultural College in Mysore, and Engineering College in Bangalore and Mysore, Sri Jayachamarajendra Polytechnic in Bangalore and the University of Mysore.

With the help of Industries Committee he was able to start various industries both in government and private sector. Notable industries among them are the Government Soap Factory in Bangalore, and the sandalwood oil factory in Bangalore and Mysore. A major industry which was set up due to his initiation was the Bhadravathi Iron and Steel Factory.

Finally he laid down the office of Diwan in December 1919 due to non Brahmin movement which rose to high level and was against the democratic views held by Visvesvaraya.

Post retirement

In his later part of life, Visvesvaraya was active by representing and advising in different committees all over the country for planning of economic policies and as an expert consultant for various irrigation works. He was the director of Tata Iron & Steel Company for 28 years from 1927 to 1955. In 1915, he was knighted by

King George V for his myriad contributions to the public good. The Government of India bestowed on him the highest civilian honour of Bharat Ratna in the year 1955 in recognition of his contribution towards the nation development. He was the founder president of the All India Manufacturers Organisation. He lived an active life throughout and was involved in advising many governments on various issues of irrigation and economic planning after independence. His works are spread out all over India and in present-day Pakistan.

Conclusion

Sir M. Visvesvaraya can be compared only with himself for all his achievements. His life remains an inspiration to people from all walks of life and stands tall as a legend in the history of India. He was an engineer, an economist, and a writer all in one of highest order. He imbibed a strict discipline and methodical attitude towards his work. He always planned his work with minute details. He had inexhaustible energy for work. His daily schedule noted in his diary remained the same throughout his entire life. His dedication and honesty towards work is unparallel. He lived a life of true human being and contributed to the development of the country.

Important milestones

* Designed water supply and sanitary system for Sukkur (Sind province).
* Established Deccan Club at Poona in association with Mahadeva Govinda Ranade and Gopala Krishna Gokhale.
* Designed a new system of automatic waste weir flood gate.
* Introduced the Block System of Irrigation.
* Usman Sagar and Himayat Sagar Reservoir project across the river Musi, Hyderabad.
* Prepared a scheme for flood protection work and underground drainage for Hyderabad City.
* Preparation of Project report for Kannambadi Anicut (KRS) across river Cauvery.
* Started the State Bank of Mysore.
* Started Mechanical Engineering School at Bangalore.
* Established Mysore University and the State Engineering College in Bangalore.
* Approved the plan to establish Bhadravathi Iron & Steel Works and several other industries.
* Established public libraries in Bangalore and Mysore.
* Automobile Industry Plan was prepared.
* Mahanadi flood control work in Orissa.
* Establishment of All India Manufacturers' Organisation as founder President.
* Established Sri Jayachamarajendra Polytechnic at Bangalore.
* Selected proper site for a new railway bridge on river Ganga in Bihar (Mokameh).
* Construction of Sharavathi Hydro-Electric Project.
* Establishment of Mysore Sandal Wood Oil Factory, Mysore Central Industrial Workshop, Chrome leather factory, etc.

Honours conferred on Sir M. Visvesvaraya

* Honorary Membership of London Institution of Civil Engineers
* C.I.E., (Companion of the Indian empire at Delhi Durbar)
* K.C.I.E., (Knight Commander of the Order of the Indian Empire)
* D.Sc., Calcutta University
* D.Litt., Banaras Hindu University
* Elected as an Honorary Life Member of the Institution of Engineers (India)
* D.Sc., Allahabad University
* D.Sc., Andhra University
* D.Litt., Andhra University
* Awarded the Honorary Fellowship of the Institute of Town Planners, India
* Bharat Ratna Award - Government of India

* D.Sc., Jadavpur University, Calcutta

* Durga Prasad Khaitan Memorial Gold Medal by the Royal Asiatic Society

* Fellowship of the Indian Institute of Science, Bangalore

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