A Treatise of Civil Engineering in Pakistan

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Abstract-The paper set up from a glance of civil engineering through the ancient ages to the twenty first century world. Nurturing of civil engineering all the way through the construction of pyramids in Egypt (2700-2500 BC) to the modern world civil engineering marvels. On its itinerary it passes through the different historic ages and it has detailed look on the civil engineering in perspective to Pakistan. Growth of Civil engineering education, employment of civil engineers, mega projects, civil engineering establishments, societies and civil engineering statistics are the major spotlights of this voyage. The field of civil engineering is being remodeled drastically to meet the challenges of public safety, health and welfare. With such evolvement there is a definite need to improve the high standards of civil mobility engineering e.g., sureness of presence of experts to ensure the distribution of knowledge and approach to the technology. Civil engineers are present on every level starting from public sector, municipal and national government to private sector, and individual home town firms through international companies. Pakistan is facing severe energy crises and new dams and energy resources are required to overcome this shortage of energy and the civil engineers are the one, who can contribute to achieve this goal. Civil engineering skills to optimize performance and efficiency of community systems are helping to balance safety standards. Despite of all its achievements, civil engineer is notorious for its rare failures as compared to usual brilliant success.

Keywords-Civil Engineering History, Civil Engineering Services, Mega Projects, Civil Marvels

I. Introduction

History of Civil Engineering is as old as the human life itself and that can be explained by looking at ancient structures. It can be assumed that the very early practices took place somewhere around 4000 and 2000 BC in ancient Egypt & Mesopotamia (ancient Iraq) [i]. The first large structures that were ever constructed are pyramids of Egypt (circa 2700-2500 BC). Imhotep is the first documented engineer; he is renowned for constructing a stepped pyramid located at Saqqara Necropolis for the king Djoser. He is supposed to be a courtier so he might have designed and then supervised the program of work. Some people call it engineer's high privilege when a civil engineer transforms his ideas from a brain wave to a plan on paper. Then this plan is turned into an actual non-abstract structure which provides shelter to people and elevates the standard of living & comforts of life.

II. Ancient Historic Civil Engineering Constructions

Some of the ancient marvels of Civil Engineering include Qanat water management system in Iran that is 1400 years old with a length of 71 Km [ii]. Some other outstanding reminders of Civil Engineering from the part of the world are;

One of the major reasons of the elevation of Roman civilization was the infrastructures they built. Romans built building, roads, bridges, aqueducts, harbours, dams etc. throughout their reign. Machu Picchu, Peru, was constructed in 1450 during the Inca Empire. It is one of the miracles of Civil Engineering. Some of the outstanding water resources engineers contributed in its construction in the Andes Mountains. Resident of Machu Picchu were highly advanced in using engineering techniques as their constructed structures, drainage system and food production sustained for more than 500 years.

If we look at engineering education, a book named Vitruvirus De archiectura was published in 1 AD in Rome. This book is an exportation on architectures that gives readers glimpses of the part. It is assumed that it was written by the Roman architect Vitruvirus. Somewhere around 15 BC he dedicated the book to his ruler, Caesar Augustus.

III. Civil Engineering History

A. Mega Projects

In the territory of the present Pakistan; the first Civil Engineering Project of its nature was the railway line built during 1847 from Karachi to Kotri. The Scinde Railway succeeded to connect Karachi and Kotri through railway line on May 13, 1861, just after 6 years of its creation, and it was the first railway line to handle public trains. The total length of track between these two cities was 108 miles (174 km). By the end of 1887 Railway lines to the Bolan Pass, Ruk to Sibi and Quetta had been completed. On March 25, 1889 the Lansdowne Bridge over the Indus was inaugurated to

connect Sukkur and Rohri and making the route for Railway connection between Peshawar and Karachi.

Sukkur Barrage was another mega project of Civil Engineering, built during 1923 to 1932 named Lloyd Barrage during the British Raj. The construction of this barrage opened new horizons for the civil engineering professionals by establishing the first institution in Pakistan for training of graduate Civil Engineers.

The construction of Karakoram Highway (KKH) was started in 1959 and the project reached to its completion in 1979. It is at the highest (Elevation of 4693 meters) paved road in the world. The construction of this project took the lives of about 1010 workers, including 200 Chinese. On its route from Pakistan to China it passes through Khunjerab Pass and is also referred as the "Eighth Wonder of the World".

Mangla Dam is a multipurpose dam constructed during 1961-1967. At the time, it was the 9th largest dam in the world. Another dam named Tarbela is the earth and rock filled Dam and was completed in 1976. It is one of the world's largest of its kind [iii]. Civil works contract of Tarbela Dam, amounting to $ 623 Million, was the world's largest single contract at that time. It was a Joint Venture comprised a group of three Italian and three French contractors.

B. Educational & Institutional History of Civil Engineering

The term 'Civil Engineering' has an interesting origin and it was used in the beginning to cover all terms that apposed military engineering. The National School of Bridges and Highways in France was the first engineering school, established in 1747. John Smeaton constructed Eddystone Lighthouse in 1759 and called himself for the first time a civil engineer.

In 1819, Captain Alden Partridge established first private college to teach civil engineering, it was named Norwich University in Vermont, USA. In 1835, Rensselaer Polytechnic Institute awarded the first degree in Civil Engineering, whereas in 1905, Nora Stanton Blatch Barney a woman was awarded first civil engineering degree by Cornell University.

In Pakistan, Mughalpura Technical College at Lahore was the first technical institute; established on November 9, 1921. Later in 1923, it became the 'Maclagan Engineering College'. In the year 1932, the classes of bachelor degree in engineering was started in affiliation with the University of the Punjab. At the time of Pakistan's independence (1947), the institution was offering well-established B.Sc. degree courses in Civil, Electrical and Mechanical Engineering [iv].

The Nadirshaw Eduljee Dinshaw (NED) University of Engineering and Technology was founded in 1922, as a technical project to train civil engineers working on the building of Sukkur Barrage [v], it was the institution for post graduate education in engineering in Pakistan although the bachelor degree program of the institution was started in succession to the University of Punjab. After British rule, it became the part of Sindh government management and it remained affiliated with University of Bombay, University of Sindh and University of Karachi respectively.

School of Military Engineering (SME) was established at Sialkot in April 1948. Organization was comprised of Administration Wing, Civil Engineering Wing, Field Engineering Wing and Combat Wing and. the institution was upgraded to Military College of Engineering (MCE), [vi] in 1952 and shifted to Risalpur.

North West Frontier Province (NWFP) University of Engineering and Technology Peshawar started Civil Engineering Department during 1953-54. It is the pioneer in Civil Engineering education in the province of Khyber Pakhton Khaw (KPK) and has produced thousands of engineers.

Civil Engineering department at Mehran University of Engineering & Technology initially established as constituent college of the University of Sindh in 1963. The Institutions offering the Degree in Civil Engineering in Pakistan have been enlisted in Table I, below;

TABLE I
INSTITUTION, OFFERING CIVIL ENGINEERING DEGREE

Sr. No	Name of University/Institutions	Civil Department Established
1	NED University of Engineering & Technology, Karachi	1923
2	University of Engineering & Technology, Lahore	1932
3	Military College of Engineering, Risalpur	1948
4	NWFP University of Engineering & Technology, Peshawar [5]	1953
5	Mehran University of Engineering & Technology, Jamshoro [5]	1963
6	Baluchistan University of Engineering & Technology, Khuzdar	1987
7	University of Engineering & Technology, Taxila (University College of Engineering and Technology was established in 1975 in Sahiwal and moved to Taxila in 1977)	1993
8	University College of Engineering and Technology, BZU, Multan	1994
9	Sir Syed University of Engineering & Technology, Karachi	1995
10	Quaide e Awam University of Engineering and Technology, Nawab Shah	1996
11	Gandhara Institute of Science & Technology, PGS Engineering College, Peshawar	2001
12	CECOS University of Information Technology and Emerging Sciences, Peshawar	2002
13	University of South Asia, Lahore	2006
14	Sarhad University of Science and Information Technology, Peshawar	2007

15	National University of Science & Technology (NUST), Islamabad	2008
16	Balochistan University of Information technology, Engineering and Management Science, Quetta	2008
17	University of Lahore	2009
18	Mirpur University of Science & Technology, AJ&K	2009
19	Wah Engineering College, Wah Cantt.	2010
20	National University of Computer and Emerging Sciences, Lahore Campus	2012
21	MNS University of Engineering & Technology, Multan	2012
22	The University of Central Punjab, Lahore	2013
23	COMSATS Institute of Information Technology, Wah & Abbotabad	2013
24	NFC Institute of Engineering & Technology, Multan	2013
25	University of Sargodha	2013

C. *Civil Engineering Societies*

ICE (Institution of Civil Engineering) is the first engineering society that was formed in 1818 in London. It got royal charter in 1828 that recognized civil engineering as an independent profession. According to the charter, the definition of civil engineering goes as: *"Civil engineering is the application of physical and scientific principles, and its history is intricately linked to advances in understanding of physics and mathematics throughout history. Because civil engineering is a wide ranging profession, including several separate specialized sub-disciplines, its history is linked to knowledge of structures, material science, geography, geology, soil, hydrology, environment, mechanics and other fields."* [vii]

Mechanical engineering came thirty years later after the creation of ICE. First professionals institute was established in 1847 under the name (IMechE). It was mainly a break away from the civil engineering (ICE) by George Stephenson who is termed as 'Father of Railways' and creator of the 'Rocket'.

Quaid-e-Azam took special interest in establishing Institution of Engineers, Pakistan (IEP) which was inaugurated on May 07, 1948. The institution was in succession to its predecessor that was Institution of Engineers. India, established by Royal Charter of 1937 and provides a forum for the professional, through a wide range of activities and programs. It covers majority of engineering discipline and has 14 major divisions to date.

The IEP members are round about 50,000 but interesting fact is that 20,000 numbers out of these are from corporate sector.

Pakistan Engineering Council (PEC) was established in 1976, as a body to regulate engineering education and profession in Pakistan. It is a federal government organization to grant accreditation to engineering institutions, enlistment of professional engineers, grant of license to contractors and consultants and provide services as a think tank to the government of Pakistan.

D. *Civil Engineering Statistics*

Civil engineers make up a significant proportion, about 50 per cent, of all engineers in the world [viii]. In Pakistan the proportion of Civil Engineers as compared to other branches of engineering has been shown graphically in Fig. 1.

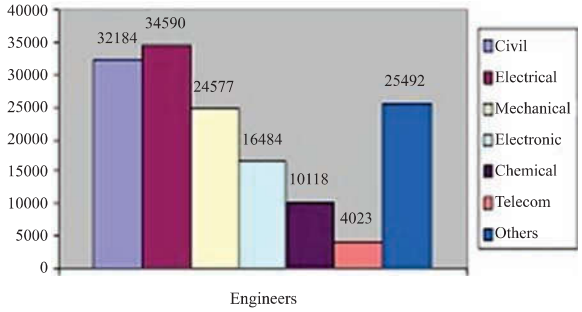

Fig. 1. Comparison with Other Engineering

At the time of independence there were only few civil engineers in Pakistan and the number has been grown to 32,184 as registered Civil Engineers with Pakistan Engineering Council out of 160,225 total engineers registered with it in various disciplines at the end of year 2013. Trend of increasing numbers of civil engineers since 1976 and their comparison with other disciplines have been shown in Fig. 2, 3, 4 & 5.

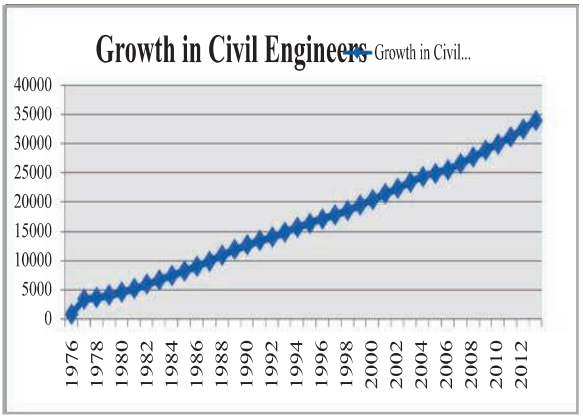

Fig. 2. Trend In Increase of Civil Engineers (1976-2013)

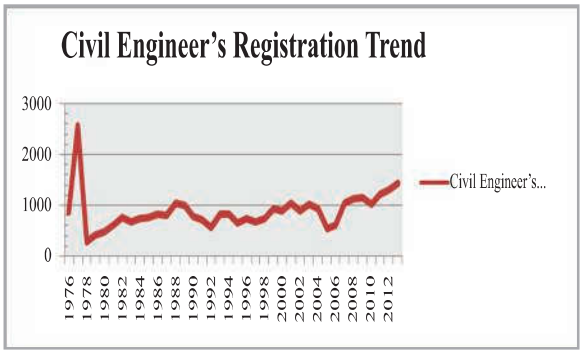

Fig. 3. Yearly Flux Of Civil Engineer's Registration (1976-2013)

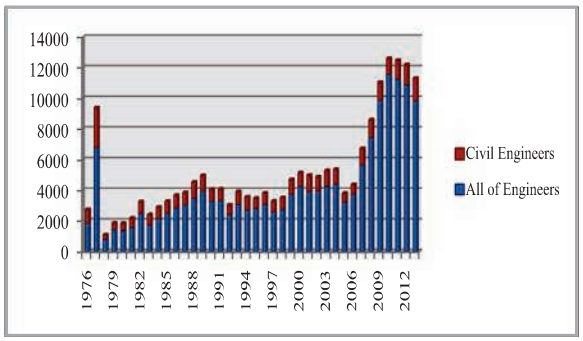

Fig. 4. Civil Engineers Boost As Compared To All Other Engineers (1976-2013)

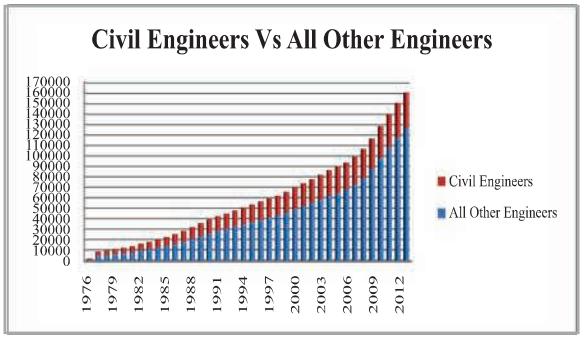

Fig. 5. Trend of Increase In Civil Engineer Vs All Other Engineers (1976-2013

Pakistan Engineering Council was established in 1976 to regulate the engineering profession and Mr. A.M. Akhoond was the first person who registered with PEC as a civil engineer while Mrs. Farzana Ali became the first female civil engineer getting PEC Registration, during 1976.

E. Civil Engineering Establishments

In 1849, British Government founded a Military Board to manage all basic infrastructures in the area of Punjab, North-West Frontier Province and the adjoining areas. Mr. Robert Napier was the head of the board. Later in 1854, civil, military and public engineering works were combined as a one department and Lord Robert Napier was selected as chief engineer. To address issues of irrigation, a separate directorate was formed. After some duration, PWD (Public Works Department) was formed at provincial levels and was under the central control. Due to increasing demand and burden, following three branches were established in 1866;

- Military Works Branch
- Civil Works Branch i.e. Irrigation etc.
- Railways Branch

In 1869, an improvisation was made to the administration and a separate Building and Roads (B&R) branch was founded. Achievements of PWD increased and many canal circles, sanitation and water supply, public health circles and divisions were formed in consideration with requirement and necessity of civil works. Later after independence, the B & R was given under the control of chief engineer and a secretary to manage all concerned matters. The matters were mainly focused on communication, building, sanitation, water works and electrification of government places. Administrative reorganization of government department during May 1962 altered this system as well. Old ways, suspended in 1955, were revived and communication and works (C & W) department was formed under West Pakistan government. Department of B & R and Town Planning were given under the administration of C & W department.

The previous post of provincial chief engineer was cancelled and a new order was formed with a team of five chief engineers. All of them were assigned full technical power, as each of them was in-charge of the relevant region. In 1972, the West Pakistan Housing and Settlement Agency was replaced by Housing and Physical Planning Department (H & PP) with a single attached department the "Directorate General Housing & Physical Planning" Lahore. Afterwards in 1973 H & PP was given control of Improvement Trust at Faisalabad, Gujranwala, Multan, Rawalpindi, Sargodha and Murree. Improvement trusts were transformed into development authorities except Sargodha & Murree.

One of the renowned and reliable construction firm FWO (Frontier Works Organization) was created on 31 October 1966. Purpose behind its creation was to build something that seemed an impossible project. The firm was supposed to make a way out of the highest mountain ranges of the world, the Karakoram Highway.

Near the completion of KKH, the authorities weighed the talent and potential of FWO in completing such projects full of ordeals. So government decided to keep FWO not only for civil engineering projects but expand it throughout the premises of country.

National Engineering Services Pakistan (NESPAK) is government owned private limited company. It was established in 1973 to achieve indigenous pool of competent consultant engineers to

minimize the dependence on the foreign consultants. NESPAK has not only achieved this but it has also gained recognition in the international market of engineering consultancy services by getting registered with a number of international funding agencies such as Asian Development Bank (ADB), International Bank for Reconstruction and Development (IBRD), and Islamic Development Bank (IDB), and it is providing services in as many as (37) countries of the world including Azerbaijan, Afghanistan Bangladesh, Chad, Comoros Island, Cameroon, Ethiopia, Ghana, Iran, Kazakhstan, Libya, Nigeria, Qatar, Kingdom of Saudi Arabia, Senegal, Somalia, Syria, Tanzania, Turkey, Turkmenistan, United Arb Emirates, Uzbekistan, and Yemen.

F. Civil Engineering History: Employment

Total number of civil engineers registered with Pakistan Engineering Council at the end of year 2013 is 33,986 being 21.21 % of the total engineers of 23 disciplines. Ministry of Defense is the largest employer of civil engineers in Pakistan, having approximately 2400 civil engineers; National Highway Authority is the second largest employer having 1500 engineers and Water & Power Development Authority has employed 901 civil engineers. The other major employers of Civil engineers have been shown in the Table II:

TABLE II
MAJOR EMPLOYERS OF CIVIL ENGINEERS

Sr. No	Employer	No. of Civil Engineers
1	Communication & Works Departments	1485
2	Irrigation, P & D, Housing, Urban Development & Public Health Engineering Departments	1165
3	National Engineering Services Pvt. Ltd	715
4	Ministry of Railways	171
5	Others	16250

G. Famous Civil Engineers of the World

Among many following are the prominent Civil Engineers,

Yasser Arafat	Former Palestinian President
Mahmoud Ahmadinejad	Ex-President of Iran
Leopoldo Calvo Sotelo	Spanish Prime Minister
H.D. Deve Gowda	Former Indian Prime Minister
Hu Jintao	Ex Chinese President
Gabriel Narutowicz	The 1st President of the Second Polish Republic.
Fidel V. Romas	Ex President of Philippines

IV. CIVIL ENGINEERING CHALLENGES

With rapid increase in population, responsibilities have increased as well. The discipline of engineering has to fulfill higher standards. The field of civil engineering is being remodeled drastically to meet the challenges of public safety, health and welfare. With such evolvement there is a definite need to improve the high standards of civil mobility engineering e.g., sureness of presence of experts to ensure the distribution of knowledge and approach to the technology.

World Council of Civil Engineers (WCCE) was established in July 2006, to communicate with engineers on a global level. Usually the engineering graduates are tempted at well earning jobs in sector like management sciences, computer sciences, information technology, financial services and civil services. However, much of the ambitious young civil engineers are lured into medium sized construction firms. Two to three decades ago, bright and talented engineers went to foreign countries in pursuit of high income. Over this gigantic "brain drain", the president of Federation of Indian Chamber of Commerce and Industry (FICCI) commented, "Talent has to be compensated."

V. CIVIL ENGINEERING MARVELS

The Civil Engineering remained ahead of all the branches of engineering throughout the historic age and it is a matter of pride for civil engineers that almost all of the Seven Wonders of ancient ages [ix] belong to civil engineers. Their writings have not survived, except as references. The classic seven wonders are:[x]

1. Great Pyramid of Giza
2. Colossus of Rhodes
3. Lighthouse of Alexandria
4. Statue of Zeus at Olympia
5. Hanging Gardens of Babylon
6. Mausoleum at Halicarnassus
7. Temple of Artemis at Ephesus

To meet the challenges of their work, Designers rely less on formulas learned in graduate school than on the kind of improvisation learned in practice [x]. As per American Society of Civil Engineers, wonders of the modern world have been shown in Table III.

TABLE III
THE WONDERS OF THE MODERN WORLD [xi]

Sr. No	Wonder	Location
1	Channel Tunnel	Between France and the UK
2	CN Tower surpassed by Burj Al-Khalifa	Toronto, Ontario, Canada
3	Empire State Building	New York, U.S.A
4	Golden Gate Bridge	North of San Francisco, California, U.S.A
5	Itaipu Dam	Between Brazil and Paraguay (Paraná River)
6	Delta Works/Zuiderzee Works	Netherlands
7	Panama Canal	Isthmus of Panama

Following is the brief description of the modern world wonders.

It was an old dream to link Britain with rest of the Europe. The thirty one-mile channel tunnel made that dream come true. It is a splendid marvel of civil engineering that unites infrastructure and machinery to form an underwater passage of unmatchable innovation.

Fig. 6. Channel Tunnel

Fig. 7. Burj Al Khalifa

Burj Khalifa (Arabic: برج خليفة, "Khalifa Tower"), is the tallest man-made structure in the world[5]. The building is a blend of diversity. About over 828 meters (2,716.5 feet) and more than 160 stories, Burj Khalifa holds the following World Record:[xii]

- Tallest building in the world
- Highest number of stories in the world
- Highest outdoor observation deck in the world
- Tallest free-standing structure in the world
- Highest occupied floor in the world
- Tallest service elevator in the world

Before Construction of Burj Khalifa, CN Tower was the highest building at 1,815 feet above the sidewalks of Toronto. The CN Tower was erected at an incredible rate of 18 feet per day.

The Empire State building is one of the best-known skyscrapers in the world. It held the record of being the tallest building ever constructed for more than four decades. The distinguished feature of this 1,250 feet high building is that it was constructed in a year and 45 days, without any overtime.

Fig. 8. CN Tower

Fig. 9. Empire State Building

The Golden Gate Bridge in San Francisco was declared by ASCE as a movement of millennium and is considered to be a land mark in civil engineering, completed in just four years. A number of ordeals were faced by the crew during its construction including intense cold weather, 70-mph gusts and dizzying heights during the brief span of four years of its construction.

Fig. 10. Golden Gate Bridge

Itaipu Dam, five miles wide was constructed by shifting the course of the seventh largest river in the world; 1.3 mile by pass was dug to accomplish this goal.

Fig. 11. Itaipu Dam

The hollow concrete segments are used to construct the main dam removing approximately 50 million tons of earth and rock; flanking wings of the dam comprise of earth and rock fill. The quantity of steel and iron used in the construction of Itaipu dam is enough to construct as many as 300 Eiffel Towers. The power house of Itaipu dam is another marvel of engineering, it measures one half mile in length and it is partially submerged. It has 18 hydroelectric generators producing 12,600 megawatts of power that is enough for the most of California [xiii]. This power is more than 60 % of total power demand of Pakistan

Fig. 12. Netherlands North Sea Protection Works

Inhabitants of Netherland made a number of attempts to protect themselves from flooding but could not succeed. Netherland North sea protection works, unique vast and complex system of dams, floodgates, and storm surge barrier are the literal reasons behind Netherland existence.

Fig. 13. Panama Canal

Panama Canal opened in 1914 and still functional is a miraculous combination of geotechnical, hydraulic, structural, and sanitary engineers. The canal has reduced the maritime distances by 13,000 km between the American East and West coasts [xiv]. Panama Canal has been declared as the Monument of the Millennium and an International Historic Civil Engineering Landmark by the ASCE [xv].

The world's largest flood prevention projects named as Tide Barrier Project, constructed in Venice, Italy, to protect the Venetian lagoon from the sea water during high tides and storms. It consists of 78 rotating gates, blocking the sea from the lagoon.

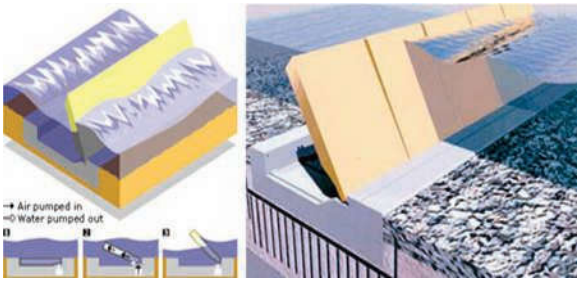

Fig. 14. The Venice Tide Barrier Project

A massive irrigation system in Egypt “The New Valley Project” conceived to reclaim a half-a-million acres of desert is one of the five most outstanding civil engineering achievements of the year by the American Society of Civil Engineers. The First phase was completed and opened for operation in year 2005, second Phase is scheduled to be completed in 2017. It will provide about 3 million jobs, a foremost contribution to help manage the increasing growth of Egypt's inhabitants.

Fig. 15. The New Valley Project

The Three Gorges Dam is one of China's largest construction projects since the Great Wall. It is almost 400 miles long, over 600 feet wide and produce electricity equal to 18 nuclear power plants.

Fig. 16. Three Gorges Dam

Fig. 17. Palm Islands

The Palm Islands, located off the coast of the United Arab Emirates in the Persian Gulf near Dubai, are outstanding examples of engineering achievement. The islands, formed by filling the seabed with sand, in the shape of a palm tree with a crescent-shaped rock encircling the top of each island as shown in Figure 17, are the largest man made islands.

VI. Conclusions

American Society of Civil Engineers define Civil Engineers as "Civil Engineers serve competently, collaboratively, and ethically as: constructors, planners, designers and operators of society's economic and social engine; the built environment; stewards of the natural environment and its resources; integrators of ideas and technology across the academic, public and private sectors; innovators and managers of risk and uncertainty caused by accidents, natural events and other threats [xv]. Civil engineer is present on every level starting from public sector, municipal and national government to private sector, individual home town companies to international companies.

- Civil engineers carry the responsibility as they influence the lives of people around them, as professionals they are managing the built environment.
- To ensure human life safety and prosperity, reliable, safe and high quality measures need to be ensured. A flaw on part of a civil engineer can result into disruption and many other dire consequences like sickness, injury and potentially death of a large number of people.
- Civil engineers bring unique services to society – services that involve creative skills and personal decisions that carry substantial responsibility.
- In the early ages of Pakistan, civil engineering rose to high altitudes. Projects like Karakorum Highway, Mangla & Tarbela Dams and Irrigation networks showed new horizons to Pakistani civil engineers. Interaction with world fame civil engineers enhanced their capabilities, and civil engineering remained on highest merit in the engineering institutions of the country. The statistics shows that registration of Civil Engineers at the time of creation of PEC in 1976 was more than 50 % as compared to all other disciplines. Civil engineering faced a downfall in the early nineties, consequently graduating civil engineers in that era faced problems to find suitable jobs and many of them switched their professions due to lack of opportunities. After 2003, civil engineering profession in Pakistan started resurgence and it is striving to get back to the past glory. Today's statistics of opportunities for civil engineering graduates are very encouraging.
- An interesting fact is that despite of all its achievement, a civil engineer is notorious for his/her rare failures as compared to usual brilliant success.

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