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Need of Nuclear Power Plants for India and Quality Control during its Construction

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***Abstract*— Electricity is the most versatile form of energy and it has truly revolutionized the world. It is prime mover of economic growth of any nation. The demand of electricity goes on increasing along with population of world. So to cope up with this we have to make maximum use of nuclear energy to generate electricity. Nuclear power, as a safe, environmentally benign and economically viable source of electricity, can meet the increasing electricity need of the country. The construction of nuclear power plant is not an easy task as it consist of some important nuclear safety related structures. These structures are required to be of such quality that there is no any fall out of radiations from nuclear reactor. Also three significant accidents in the 50-year history of civil nuclear power generation have occurred, currently accident at Fukushima (Japan 2011). Hence Quality Management System is implemented in all phases and activities of nuclear power plant covering Design, Procurement, Manufacturing, Construction, Commissioning, Operations and Decommissioning adopting processes to meet the specified requirements for quality, reliability and safety. The objective of Quality Management System in construction of project is to ensure that civil works, erection, installation and associated testing of mechanical, electrical structures and components are carried out safely and meeting the specified requirements.**

Keywords—Electricity; Nuclear Power Plant; Construction; Quality Control

I. INTRODUCTION

Electricity is the most versatile form of energy and it had truly revolutionized the world. It is not only essential for industrial and commercial but also for daily needs of the people, such as for lighting, water supply, mass transportation, education, communication, hospital and related healthcare services. It is the prime mover of economic growth of any country. The well-being of a country's populace, which is reflected by its per capita Gross National Product (GNP), has always had a positive correlation with its per capita energy consumption. There is a big divide between developed and developing countries in per capita availability of energy.

India is not rich in traditional energy resources and our population is huge and growing. Power shortages are common and about one-third of population of India does not have access to electricity. Also, the demand supply gap is widening further. On an average Indians uses only about 880 kWh annually, compare to the worlds average of about 2800 kWh (WEA, 2012). Moreover India's need for electrical power is projected to jump by more than four times in the next 20 years or so, from the current 180 GW to 220 GW in 2017 and then to nearly 770 GW in the year 2032. Currently, the India's energy resource base status suggests the optimal mix of all the available energy resources to meet its growing demand of electricity.

A. Energy resources availability in India

The energy sources have been split into three categories: fossil fuels, renewable sources, and nuclear sources. The fossil fuels are coal, petroleum, and natural gas. The renewable energy sources are solar, wind, hydroelectric, biomass, and geothermal power. The nuclear-powered sources are fission and fusion. About 65.34% of the electricity consumed in India is generated by thermal power plants, 21.53% by hydroelectric power plants, 2.70% by nuclear power plants and 10.42% by Renewable Energy Sources. More than 50% of India's commercial energy demand is met through the country's vast coal reserves. The country has also invested heavily in recent years in renewable energy utilization, especially wind energy.

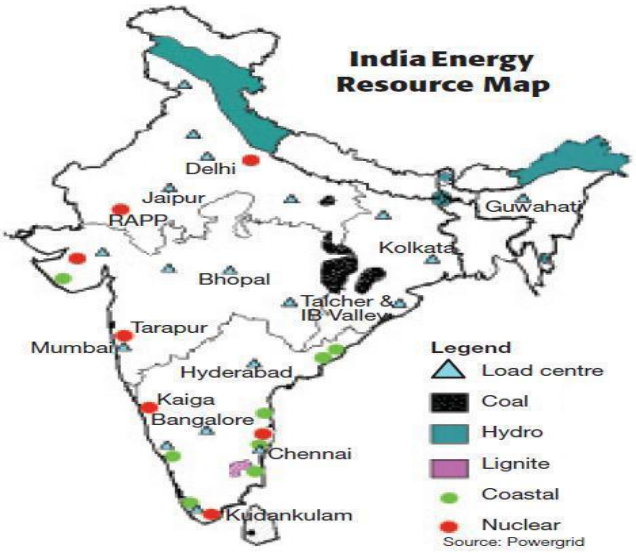

Fig -1: India's energy resource map

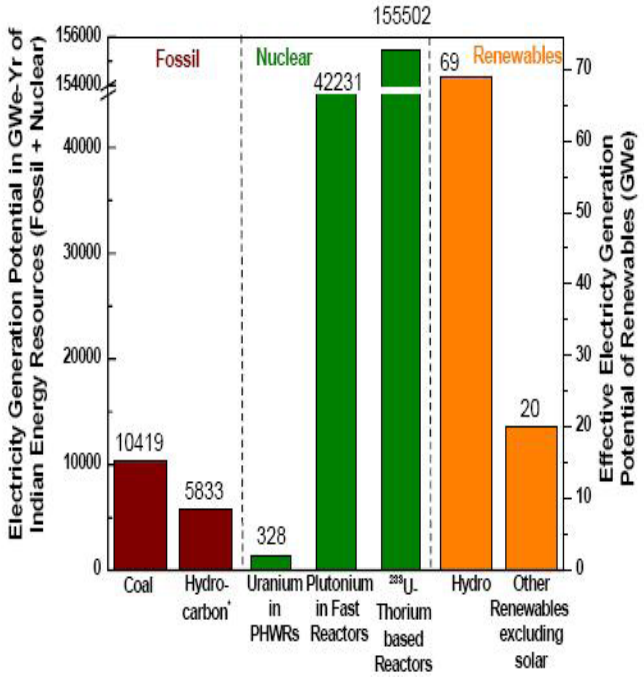

Fig -2: Current Indian energy resources and their effective energy generation potential

Though we got all these energy resources, but all has some pros and cons. Our major energy resource coal has limited availability and it is depleting fast. In fact, we are importing part of our coal requirement. Burning of coal causes global warming and fly ash pollution. There are many limitations to the power generation by using water dams. Dams cause submergence of forest and agriculture land as well as displacement of people. Solar and wind power look attractive but they requires much land. Solar power is not available during night time and on cloudy days. And wind does not blow all the time.

B. Why we use nuclear power plant?

Nuclear power plants provide about 13–14% of the world's electricity, with the U.S., France, and Japan together accounting for about 50% of nuclear generated electricity. In October 2011 the IAEA (International Atomic Energy Agency) report, there are 432 nuclear power reactors in operation in the world, operating in 31 countries

India has vast reserves of thorium. Using these reserves in the country, in future, reactors will provide electricity on a large scale for centuries even after coal and oil reserves are finished. From all the above discussions it is clear that in order to cope with increasing demand of electricity we have to make maximum utilization of electricity generated from nuclear power plants along with electricity generated from other energy resources.

Nuclear power plants have following advantages also:-

- Fights global warming: Nuclear fuel does not produce carbon dioxide (CO2), sulphur dioxide (SO2,) or nitrogen oxide (NOx) thus avoiding greenhouse emissions.
- Efficient: One gram of fissionable uranium can produce a million times more heat than one gram of coal. Thus very little nuclear fuel is required to produce huge amount of electricity.
- Clean: Nuclear power production does not cause pollution and thus it is "human-friendly" as well as environmental friendly.
- Less area: Nuclear power plant requires less land area as compared to other energy resources.
- Reliable: It is available 24 hours a day all the time.

As of now, India has 20 nuclear reactors in operation at six locations producing 4,780 MW while seven other reactors are under construction and are expected to generate an additional 5,300 MW by the middle of this decade.

II. QUALITY CONTROL ASPECT IN CASE OF NUCLEAR POWER PLANTS

Quality control system is implemented in all phases and activities of NPPs covering Design, Procurement, Manufacturing, Construction, Commissioning, Operations and Decommissioning adopting processes to meet the specified requirements for quality, reliability and safety.

Quality assurance can be thought of as a way of managing a nuclear power project to ensure that all project activities are accomplished in a planned, systematic, and controlled way. If such a system is operating well, there is a high degree of confidence that all project activities will be performed correctly and that failures, mistakes, and deficiencies in the design, construction and operation of the nuclear power plant will be avoided, or at least detected and rectified in time.

A. Quality control during site construction

Even a good design plant may not achieve the required level of safety if it is not constructed well. It is recognized that the level of quality assurance programmes needed will vary, depending on the site construction activity being performed. The most important factor to be considered in determining the extent of quality assurance efforts is the effect on safety of an error in service or the malfunction or failure of an item. Other factors for consideration include:

(1) The complexity, uniqueness or novelty of the item
(2) The degree of standardization of the item

(3) The need for special controls, administrative measures, and surveillance over processes, methods and equipment
(4) The degree to which compliance with design requirements can be demonstrated by inspection and tests
(5) The quality history
(6) The accessibility of the item, after installation in the plant, for maintenance, in-service inspection and replacement.

The NPP construction site head is responsible for establishing and implementing the management systems during project construction. He is duly supported by independent groups headed by competent personnel for the civil, mechanical, reactor, electrical, piping, control and instrumentation works and auxiliary systems. Independent Field Engineering and Quality Assurance Groups are also set up for overseeing design and quality aspects respectively during the construction phase.

B. Need of quality control during construction of nuclear power plants

- *For good quality concrete:*

Nuclear power plants show much more emphasis on quality in construction than on typical construction projects. This added emphasis is necessary because of the fuel that is used in a nuclear power plant. Since radioactive fuel is used, extreme care need to be taken to ensure that accidents are prevented from occurring during plant operation because the radiations produced are harmful to both human being and environment. So concrete has to protect the lives from danger of radiation. Another reason that makes difference between nuclear power plant construction and conventional building construction is the high temperature generated and to be handled during the operation.

In case of nuclear power plant very high temperatures is developed in modern fast breeder reactors. Normally temperature inside the reactor is thousands of 0C while outside temperature is close to atmospheric temperature. Hence concrete from which plant is built have to deal with this high temperature gradient. So it necessitates the requirement of least porous concrete. In short the high performance concrete has to fulfill following four major demands in case of nuclear power plant:-

i. Many concrete elements are required to undertake a shielding and secondary containment role in addition to structural duty.
ii. Concrete may need high structural strength and ductility requirements to resist seismic, thermal and other normal operating demands, plus fault and extreme environmental loading.
iii. The longevity of nuclear facilities requires continued strength, containment and shielding function often for many years beyond an operational life of 60 years or more.
iv. Many of the concrete structures become effectively inaccessible once the plant becomes operational.

In view of the above four points, concrete on the nuclear facility, including its design and installation, can become an integral part of the nuclear safety case necessary to justify plants operation throughout its life.

In conventional reinforced concrete construction, significant emphasis is placed on the assessment of concrete quality through inspection, cube strength tests. This approach operates on the traditional basis that if quality is not achieved, the contractor may be asked to 'break it out and start again'. However, the massive sections that are typical of the nuclear industry make this approach impractical for much of new build nuclear construction. More crucially, beyond the impracticality of such measures, failing to meet the concrete quality requirements will inevitably cause programme delay, dissatisfaction in client and contractor teams and critically, a loss of both regulator and investor confidence. Therefore, for nuclear construction, the emphasis must be moved from post-placement verification of quality, to pre-placement quality of design, specification and training to minimize the potential for defects.

- *For ensuring safety:*

Now another reason to have quality control during construction of nuclear power plant is safety. The safety of nuclear power plants becomes prime important due to three significant accidents in the 50-year history of civil nuclear power generation. Those accidents are:

i. Three Mile Island (USA 1979) where the reactor was severely damaged but radiation was contained and there were no adverse health or environmental consequences
ii. Chernobyl (Ukraine 1986) where the destruction of the reactor by steam explosion and fire killed 31 people and had significant health and environmental consequences.
iii. Fukushima (Japan 2011) where three old reactors (together with a fourth) were written off and the effects of loss of cooling due to a huge tsunami were inadequately contained.

The basic design philosophy followed world-over for assuring nuclear power plant safety is called "defence-in-depth" approach with multiple safety systems supplementing the natural features of the reactor core. Key aspects of this approach which can be summed up as Prevention, Monitoring, and Action (to mitigate consequences of failures) are

- High-quality design and construction so that the reactor operates with a high degree of reliability. The prevention of accidents is through intrinsic design features and stresses on quality control, redundancy, testing, inspection and fail-safe design.
- Equipment which prevents operational disturbances or human failures and errors developing into problems,
- Comprehensive monitoring and regular testing to detect equipment or operator failures,
- Redundant and diverse systems to control damage to the fuel and prevent significant radioactive releases,
- Provision to confine the effects of severe fuel damage (or any other problem) to the plant itself.

In all the above key aspects of "defence-in-depth" approach for nuclear power plant safety, High-quality design and construction underlines the necessity of quality control during construction phase of nuclear power plant.

- *For getting construction clearance:*

Clearance for start of construction of the NPP requires a detailed 'design review' of the plant design, by way of review of the Preliminary Safety Analysis Report (PSAR). The PSAR provides general information on plant design and details of the Design Basis of the reactor and all its auxiliary systems. Apart from the plant design, design basis and safety analysis, the Quality Assurance (QA) aspects during design and construction, construction schedule and the construction safety management aspects are reviewed in detail for compliance to the requirements specified in the relevant Code/guides/standards, before AERB considers issuing the construction clearance for an NPP.

Thus in order to achieve high quality concrete, safety, construction clearance etc. need of quality control during construction of nuclear power plant is essential.

CONCLUSION

From all above discussion it can be concluded that the demand of electricity goes on increasing along with population of world. So to cope up with this we have to make maximum use of nuclear energy to generate electricity. But recent accident at Fukushima (Japan 2011) mark question over nuclear power plant construction. So better quality control during its construction phase become a prime important.

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