Architectural Design of a Nuclear Research Center with Radiation Safety Considerations, in North Western Coast of Egypt (Using AutoCAD and 3ds Max Programs)

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ABSTRACT

This research discusses the design of nuclear research centers to help architects and engineers who will design these centers. Also, the research covers the site characteristics which are used in site selection of nuclear research centers. It covers the principles and standards used in design and planning of nuclear research centers. The master plan of a nuclear research center should be designed based on the system of segregation according to the level of radioactivity. Radiation safety is an important aspect in the design of nuclear research centers. The Egyptian Atomic Energy Authority consists of three nuclear research centers, namely, the Nuclear Research Center in Inshas (Grid Planning Concept), the Hot Laboratories and Waste Management Center in Inshas (Grid Planning Concept) and The National Center for Radiation Research and Technology in Nasr City (Linear Planning Concept). The Radial Planning Concept is the best among all the Planning Concepts as regard radiation safety considerations. Therefore, an architectural design of a new nuclear research center was proposed in a suitable site in North Western Coast of Egypt (Radial Planning Concept) using AutoCAD and 3ds Max programs. This site is suitable and satisfies many of the site requirements. It is recommended that the architectural design of nuclear research centers should be supervised by an architectural engineer experienced in architectural design of nuclear facilities.

Key Words: Architectural Design / Nuclear Research Center / Radiation Safety Considerations / North Western Coast / AutoCAD Program / 3ds Max Program

INTRODUCTION

Nuclear sciences and technology have been developed to a stage which has a direct impact on the human needs for development. Most developments in nuclear sciences were carried out in special centers in which nuclear materials and radioisotopes are used in promoting medicine, industry and agriculture. The importance of the nuclear research centers for the continuous development of nuclear sciences and technology is well recognized since new fields of applications of nuclear materials and radioisotopes will remain always necessary. (1)

1. Design of Nuclear Research Centers

The nuclear research centers can be defined as research centers in which nuclear research can be achieved. The nuclear research center is normally similar to scientific research centers in its buildings. Additional facilities which deal with the nuclear research have to be provided. These include research reactors, accelerators, hot laboratories, decontamination facilities, health physics laboratories, waste disposal facilities etc. (1)

A nuclear research center may provide facilities for several research fields and operations. The activities in these centers involve basic and applied research, product development, material testing, applications, process development involving the use of research reactors, industrial irradiators,
accelerators, radioactive materials and radioisotopes. The activities and facilities included in a nuclear research center put constraints on the characteristics of the sites where it is located and on the design aspects which should assure the safety for people and environment. In these centers protection against hazards of ionizing radiations, is one of the basic duties of the administrations and the workers \(^{(2)}\).

2. Site Characteristics of Nuclear Research Centers

Site selection for a nuclear research center is a very important step. It includes site characterization and evaluation in terms of nuclear safety with the objective to protect the public and the environment from the radiological consequences of radioactive releases due to accidents or due to normal operation \(^{(3)}\). In the evaluation of the suitability of a site for a nuclear installation, the following aspects shall be considered \(^{(4)}\):

- The effects of external events (natural and human induced) occurring in the region of the particular site \(^{(5)}\).
- The characteristics of the site and its environment that could influence the transfer to persons and the environment of radioactive material that has been released.
- The population density and population distribution and other characteristics of the external zone in so far as they may affect the possibility of implementing emergency measures and the need to evaluate the risks to individuals and the population \(^{(6)}\).

The specific requirements for evaluation of the hazards due to external events include the following: Earthquakes and Surface Faulting \(^{(7)}\), Meteorological Events (Extreme Values of Meteorological Phenomena and Rare Events e.g. Lightning, Tornadoes, Tropical Cyclones) \(^{(8)}\), Flooding (Floods due to Precipitation, Floods due to Water Waves Induced by Earthquakes or other Geological Phenomena and Failure of Water Control Structures,…) \(^{(9)}\), Geotechnical Hazard (Slope Instability, Soil Liquefaction, Behavior of Foundation Material,….) \(^{(10)}\) and External Human Induced Events (Aircraft Crashes, Chemical Explosions,…..) \(^{(11)}\). The specific requirements for evaluation of potential effects of the nuclear installation in the region include the following: Dispersion of Radioactive Material through Atmosphere, Surface Water and Ground Water \(^{(6)}\).

3. Principles and Standards Used in Planning and Designing of Nuclear Research Centers

The architectural principles and standards of nuclear facilities differ from other research facilities. The nature of the radioactive material to be handled and the type of work to be carried out in the facility will determine the planning and designing of the facility. The main problem when considering the master plan for a nuclear research center is to provide effectively for future expansion. Therefore, in drawing up a master plan the methods used in town planning must be used. These methods are: centralized, linear, radial, clustered and grid.

Different aspects should be considered in the master plan of nuclear research centers. Traffic routes have to be established. Areas must be set aside for each of the departments of the center, large enough to provide for growth. The central focus composed of buildings such as the library, administration and the cafeteria, which may serve all other departments \(^{(12)}\).

Features of Nuclear Research Center Master Plan

The buildings in a nuclear research center should be segregated according to the levels of radioactivity in each of them. The radioactive buildings designed on the system of segregation should be planned from Cold to Hot areas. The types of buildings to be contained in each area are \(^{(12)}\):

- a) Cold areas should contain monitoring buildings, administration offices, conference halls, library, cafeteria, boiler building, fire station and guest house.
b) Warm areas should contain buildings for experimentation at low or warm level of radioactivity and should contain low level laboratories and mechanical workshops. Physics and chemistry laboratories should also be in these areas.

c) Hot areas are for experimentation at high level of radioactivity. Reactors, cyclotrons and accelerators are always placed in the hot areas. These areas should also contain hot laboratories, isotope production facilities and decontamination facilities.

4. The Proposed Nuclear Research Center

The proposed nuclear research center could be located in a semi-rural area in north western coast of Egypt. The center will function as a new focal point for conducting nuclear research activities for the northern part of Egypt because the only nuclear research centers are existing at Inshas (40 Km from Cairo) and at Nasr city. The topography of the area is typical of the north west coast. The coastal zone of the western desert has a rather special climate which differs from the climate of the inland desert area to the south. It is characterized by a high humidity and small diurnal temperature variations (13). The prevailing wind direction is north to north west. The prevailing northerly winds require that hot zones should be located in the southern portion of the site. On the other hand, cold zones should be located in the northern portion of the site. The site of the nuclear research center can be served by the main regional highway. The coastal road from Alexandria to Marsa Matruh and sallum connect the site with the national highway network (13).

It is assumed that the proposed center would include some basic facilities and machines that are necessary for developing the necessary research activities and different applications in the nuclear field. This is necessary for manpower development in the northern region of Egypt as well as for the necessary socio-economic development of that region. It is expected to place the following facilities in the site: research reactor, cyclotron, hot laboratories (hot cells), linear accelerator, boiler and power station, radio-isotope laboratory, waste treatment facility, water treatment facility, low-activity level laboratories, gamma rays units, nuclear physics laboratories, nuclear chemistry laboratories, nuclear chemistry educational building, nuclear engineering educational building, nuclear physics educational building, administration building, library, workshops, fire station, canteen and guest house. All these facilities were taken into consideration while developing a master plan of the center.

Master Plan of the Proposed Nuclear Research Center

The radial concept is the optimum one because it has big advantages over the others especially in terms of climatic conditions, security, function relation between the buildings and aesthetics factor. It could be observed in this concept that:

The center was designed based on the system of segregation according to which the different buildings were distributed in the site according to the level of radioactivity in these buildings. The different zones of the site are:

a) The cold zone is located in the northern portion of the site and includes nuclear chemistry educational building, nuclear engineering educational building, Nuclear physics educational building, administration building, conference hall, library, workshops, fire station, cafeteria and guest house.

b) The warm zone is located in the middle of the site and includes low-activity level laboratories, gamma rays units, nuclear physics and nuclear chemistry laboratories.

c) The hot zone is located in the southern portion of the site and includes research reactor building, cyclotron, hot laboratories (hot cells), linear accelerator, boiler and power station, radio-isotope laboratory, waste treatment facility and water treatment facility.
Fig. (1) Architectural design of nuclear research center.
Fig. (2) Layout and shots.
Fig. (3) Perspectives.
Fig. (4) Master plan (ground floors).
Fig. (5) Ground floor plans of accelerator, hot cells, reactor, cyclotron and laboratories.
Fig. (6) Plans (first floors, second floors and basements).
Fig. (7) North elevation, west elevation, section A-A and section B-B.
Because of the northerly prevailing winds, the hot zone is located in the southern portion of the site and cold zone is located in the northern portion of the site. A network of wide roads is provided inside the center. The site is surrounded by an exclusion zone. Around the buildings there is an area which is kept for future expansion.

5. Computer Programs for Architectural Design of Nuclear Research Centers

The proposed nuclear research center has been designed. It has been presented using AutoCAD and 3ds Max programs\(^{(14,15,16,17)}\), as shown in Figs. (1, 2, 3, 4, 5, 6, 7).

RESULTS AND CONCLUSIONS

An architectural design of a new nuclear research center was proposed in a suitable site in northwestern coast of Egypt. The nuclear research centers sites should not be located near a heavily built-area. The architects can design the different types of nuclear facilities. The master plan of a nuclear research center should be designed based on the system of segregation according to the level of radioactivity. Radiation safety is an important aspect in the design of nuclear research centers. Site selection for placing a nuclear research center is a very important aspect. So, many factors should be taken into consideration.

RECOMMENDATIONS

It is recommended to establish a new nuclear research center in a suitable site in northwestern coast of Egypt. This site has a highly suitable and satisfies many of the site requirements. It is recommended to use the proposed design of a new nuclear research center. It is recommended to leave an area in the master plan for future expansion. It is recommended that the architectural design of nuclear research centers should be supervised by an architectural engineer experienced in architectural design of nuclear facilities. The design of nuclear power plants is not covered in this research. It is recommended to conduct researches on these types of nuclear facilities.

REFERENCES


