معهد أبحاث البناء

٦٣٤٠ ١١ مارس ١٩٦١

تقرير عن

المنشآت الثقيلة الواقية من الإشعاعات الذرية

المركز القومي لبحوث الإسكان والبناء
Housing & Building National Research Center
Since 1954

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BUILDING RESEARCH AND TRAINING CENTER.

٦٢٤٠ ١٢ يناير ١٩٦١

معهد أبحاث البناء
المكتبة

تقـرير عـن

الخرسـانة الثقيلة الواقيـــة من الاشـعاعات الذرية

REPORT ON

HEAVY CONCRETE FOR RADIATION SHIELDING

المركز القومي لبحوث الإسكان والبناء
Housing & Building National Research Center
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جارى استكماله وصياغته باللغة العربية ،

المدير

دكتور عبد العزيز عبد الخالق صابر

P R E F A C E

The need for a summary of existing information on "Heavy Concrete For Radiation Shielding" has not, hitherto, been met by a publication readily available to engineers and others concerned in U.A.R. This bulletin has been prepared to meet this need and to give informations on such concrete using local materials for the construction of the Reactor Buildings.

Thanks are dedicated to Engineer M.Hamdy Abd-El Monem of the U.A.R. Building Research Centre for preparing this report and carrying out the experimental work.

Director General

Dr. A. Abd-El Khalek

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HEAVY CONCRETE FOR RADIATION SHIELDING

SYNOPSIS

The purpose of this paper is to provide the Egyptian Atomic Energy Commission with informations concerning heavy concrete of volumetric weights 3.2 gm/cm^3, 4.2 gm/cm^3, to be applied for use in the design and construction of the reactor building. Local materials were tried and investigated.

Introduction

The development of concrete shields for the protection of personnel from nuclear particles and radiations, has taken place due to development of nuclear power.

Concrete, because of the ease with which it can be cast into blocks, walls, and other desired shapes, is ideal as a shielding material.

Fortunately concrete is an excellent shielding material for large, permanent shields. It possesses good compromise thickness requirements for both neutron and gamma ray attenuation, sufficient mechanical strength, low maintenance and reasonable cost. Conventional concrete weighing about 2.4 t/m^3 is usually the cheapest type of shielding concrete, however, it is often desirable to use concrete of greater density to reduce the shield thickness.

Some tests were carried out by the Building Research Centre in the laboratories of testing materials, Faculty of Engineering, to obtain data on the properties of aggregates, and concrete for constructing new shielding structures. It is recognized that some of these aggregates would not be acceptable for use in concrete exposed to excessive weathering or abrasive forces, however, they are acceptable for use in shielding structures not subjected to these conditions.

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Magnetite, Limonite, Barite, and Himatite were tried to be used as concrete aggregates for their high density but tests showed that magnetite concrete and magnetite-steel concrete are only the acceptable.

Iron has excellent density as well as being a good absorber of thermal neutrons, for this reason higher densities were obtained by using steel aggregates in place of some of the natural aggregates.

In some applications such as to slow down fast neutrons, the concrete should also contain light materials such as hydrogen. Since max. density is incompatible with max. hydrogen content, a compromise between density and hydrogen content must be made to obtain the proper composition for attenuating both gamma radiations and fast neutrons.

In fact the effectiveness of a shield against penetration of neutrons is proportional to e (the base of natural logarithms) raised to the power of the density.

The water of crystallization in concrete can be considered as a reliable source of hydrogen as long as temperature does not exceed about 100°/C.

Factors Governing the Shield Design and Efficiency

I- Homogenity.

The major requirement for shielding effectiveness is homogenity. A radiation shield is only as good as its weakest point. If pockets are formed in concrete during placing or segregation occurs, the effective concrete thickness is lessened and the intensity of radiation passing these sections is greater than anticipated. Since it is not permissible to operate the shielded unit until such weakness in the shield are removed, the importance of homogenity, both in the concrete and the shield as a whole is readily seen.

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2- Mechanical Problems:

Shields are complicated by the presence of numerous openings required for operational or experimental purposes. These openings are of many sizes, widely scattered, and are required in large numbers. This requires accurate placement of formwork and skilful placement of concrete to avoid segregation. Additional thickness is required to compensate for these openings and careful design is necessary.

3- Space Requirements:

In places where space is somewhat valuable, the use of heavy concrete is better to be used rather than ordinary concrete since the reduction of thickness due to the use of heavy concrete will serve accordingly in reducing the space required for shield.

4- Economics of Shielding:

All the previous factors must be considered in determining the economics of concrete shielding. Due to the important differences between heavy and ordinary concrete, careful consideration of the cost factor involved is required. The increased cost of heavy concrete, due both to the need of obtaining and transporting heavy aggregates, and the relative unfamiliarity of contractors with regard to their concreting properties, are often compensated by the reductions in shielding thickness and space requirements.

5- Radiation Factors:

a. The possible deterioration of concrete shielding due to the activation, by radiation of atoms composing the concrete.

b. The gel structure of cement paste may be affected by irradiation, leading to changes in the mechanical properties of concrete, such as strength and cracking.