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Shielding calculation for a linac bunker

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ABSTRACT

The cancer rate in India has more than doubled over the last 26 years. As per the Indian Council of Medical Research (ICMR) data, India had 14 lakh cancer patients in 2016 and this number is expected to increase. A machine is used to aim high-energy rays or beams from outside the body into the tumor. The machine most commonly used is called a linear accelerator or "linac." In this paper Shielding thickness calculation for 6 Mega voltage Radiation from accelerator will be carried out based on the ICRP (International Council for Radiation Protection) recommendation. Additional shielding materials, their thickness will be assessed.

Keywords— *Linac, Shielding, Concrete, Lead*

1. GENERAL

External radiation or external beam radiation is the most common type of radiation therapy used for cancer treatment. A machine commonly used for this purpose is known as a linear accelerator. The radiation beam used for treatment doesn't necessarily stop when it reaches the tumor. It can continue on through the wall/ceiling/floor and would continue out to the rest of the facility if we didn't properly block it. Radiation shielding is used to ensure that the radiation dose received by people outside the treatment room is lower than the regulated permissible levels. So the purpose of radiation shielding is to reduce the effective equivalent dose from a linear accelerator to a point outside the room to a level that is determined by individual states ie, this shielding is designed to prevent unintentional exposure of staff patients and the public.

1.1 Linear accelerator

According to Wikipedia A linear particle accelerator (often shortened to linac) is a type of particle accelerator that accelerates charged subatomic particles or ions to a high speed by subjecting them to a series of oscillating electric potentials along a linear beam line. The principles for such machines were proposed by Gustav Ising in 1924. Linacs have many applications: they generate X-rays and high energy electrons for medicinal purposes in radiation therapy, serve as particle injectors for higher-energy accelerators, and are used directly to achieve the highest kinetic energy for light particles (electrons and positrons). The design of a linac depends on the type of particle that is being accelerated: electrons, protons or ions.

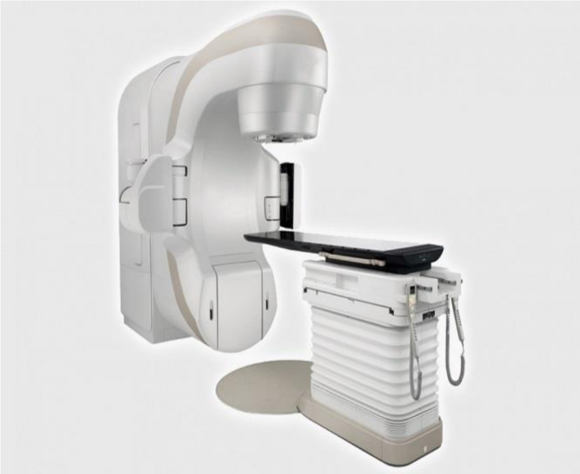

Fig. 1: A Linear Accelerator

1.2 Aim
The purpose of this work is to present the planning of a High Energy (6 Mega voltage radiation – photon energy) Linear accelerator bunker in an existing HDR radiation room of an oncology centre at Dubai.

1.3 Research methodology

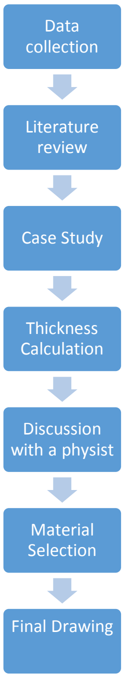

Fig. 2: Research methodology

2. LITERATURE REVIEW
K Parthasaradhi.et.al in their journal Aluminium, copper, tin and lead as shielding materials in the treatment of cancer with high-energy electrons says that transmission measurements are performed to determine suitable minimum thicknesses and to measure the transmission at this minimum thickness, for aluminium, copper, tin and lead for electron broad-beam field sizes 6×6, 10×10 and 20×20 cm^2 of energies 6, 12 and 20 MeV produced by a medical linear accelerator. The ratio of the measured ionization with and without the shielding material in percent is expressed as a measure of transmission.

Akkurt, H.et.al in their journal "Radiation shielding of concrete containing zeolite" in 2010 explained that The linear attenuation coefficient for concrete containing zeolite as an aggregate in different concentrations (0%, 10%, 30% and 50%) has been measured and the results are compared with calculation. The linear attenuation coefficient, measured with four concrete blocks, decreased with increasing zeolite concentration. It is concluded that the addition of zeolite as an aggregate in concrete is not an alternative option to be used for the purposes of radiation shielding.

3. CASE STUDY
A case study is done at the aster med city hospital Cochin. Here, the Linac room is a separate building near the main hospital building and associated annex building. Linac room consists of two floors in which the lower floor consist of linac room and upper room consist of a Brachytherapy room. This includes a total area of 3080 m2. The lower floor includes two linac rooms one with 85.10 m2 and other with the 84.59m2 floor area. Each associated with a control room of 21.95 m2 and 23.45m2 respectively. A waiting area is provided for patients near to the corridor with 15.52 m2 area. Other rooms are Equipment room, IP holds; A 2.4 m wide corridor is provided for free access to this area. A ramp is provided for the access of wheel chairs on one side of the corridor. An appropriate patient viewing facility is provided between these rooms which are the control room.

The construction team was a group of members consisting of architects, structural designers, contractors, project management consultancy, interior designers etc. Here the construction is based on the ICRP (International Council for Radiation Protection) recommendation. The material used for shielding is high-density concrete.

4. SHIELDING THICKNESS CALCULATION
The three important parameters that influence external radiation exposure are time, distance and shielding:
- The radiation dose received by individuals is proportional to the time they spend in the radiation field.
- The radiation dose generally follows an inverse square law, hence the dose is reduced substantially by increasing the distance from the source of radiation.
- The dose is reduced if shielding attenuates the radiation.

4.1 Equations reduction factor

$$B=Pd^2/WUT$$

Where,
B=Radiation dose limit for a person who is standing outside the shielded room (weekly limit).
d=distance from machine (radiation emitting accelerator) to the wall (outside).
W=weekly work load from the machine of the machine (depends upon no of patients treating per week and amount of radiation emitting by machine per week.
U=use factor outside the wall is fully occupied (if radiation is coming to a wall always then use factor is 1).
T=Occupancy factor (outside the wall is fully occupied or not. If it is an office room, then it is fully occupied. If it is a parting area, partially or occasionally occupied).

Tenth value thickness, TVT needed=1/ logB

4.2 Shielding materials

The various shielding materials used are lead, iron, steel, concrete, earth, bricks, concrete blocks, borated polyethene, and other composite materials. High-density radiation shielding concrete is produced by blending heavy weight aggregate, cement, water, and special additives Aggregates for high-density concrete for radiation shielding are iron shot and steel punching which is utilized to produce substantially high dense concrete. Other types of heavy weight aggregates that are used to produce medium to low-density concrete are barite, magnetite, limonite, goethite, and ilmenite. The following table shows the density and thickness of different shielding materials

Table 1: Shielding thickness for materials

Material	Density	1 TVT cm
Concrete	2.35	37
Steel	7.87	10
Lead	11.35	5.7

5. CONCLUSION

A linear accelerator is used for oncology treatment; it is providing external beam radiation which can be focused at a particular point affected by the disease. The purpose of providing radiation shielding is to reduce the effect of radiation outside the room to a minimum level so that it will not affect the public outside the room. Shielding thickness is calculated for a new linear accelerator Bunker based on the above equations and as per ICRP recommendations. Due to space constraints lead, steel, concrete are used as a shielding material.

6. REFERENCES

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