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Abstract

Means are suggested by which a school district may incorporate low-cost fallout protection in a school construction program, through construction of an underground shelter beneath the concrete slab foundation. Ways of controlling distribution and filtering air are discussed. The author also suggests consideration of a completely underground school, leaving only large span units such as gymnasiums and auditoriums above ground. (RH)

Design of Schools to Incorporate Fallout Protection

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This discussion of how a school district may incorporate low-cost fallout protection in its new construction programs is not technical, in a research sense. It is a presentation of facts which may help a school district to select a method of building a new school or addition that will offer the greater protection for the least cost. The data regarding fallout are based on information furnished by the Office of Civil & Defense Mobilization; the remaining material is based on the experience of our firm in school construction in New York State.

With the development of the atom bomb and the use of atomic fission in commerce and industry, we have been aware of a hazard hanging above us like the sword of Damocles. Whether fallout occurs as an act of agression or whether it is due to accidental causes, its effects are just as deadly. The destruction by a direct hit is beyond imagination, and one cannot comprehend a means of protection against the heat, concussion and pressure. However, the hazards of gamma radiation brought by fallout are such that shielding can be provided. Although only 15% of the damage done by the bomb is radiation, it is this that will offer the most widespread hazard. The nature of man is to procrastinate in regard to his own safety and, even though he may spend $40 billion a year for defense, it is more than likely that he will not build a fallout shelter.

Before a man will convert his basement or dig up his yard, his mind will search for a convenient benefactor. He will consider how an agency of the government can be used to provide such protection, thus avoiding the problem. One such organization is the local school district, providing a substantial major structure, with continuing supervisory personnel, and centrally located with relation to the population load. Protection of our children is important to the future, psychologically and physically and therefore schools become our best areas of shelter.

If we study charts of wind drift based on bomb blasts of important targets, we find only a small percentage of the country will receive serious concentrations of fallout. However, due to wind changes, any location may receive a lethal dose, so full protection is the only safe consideration. Our early warning network indicates that adequate "take cover" warning can be given, providing approximately two hours' warning or enough time to get the school children into a shelter. Confinement may then last from several hours to as long as two weeks (Figs. 1, 2, 3).

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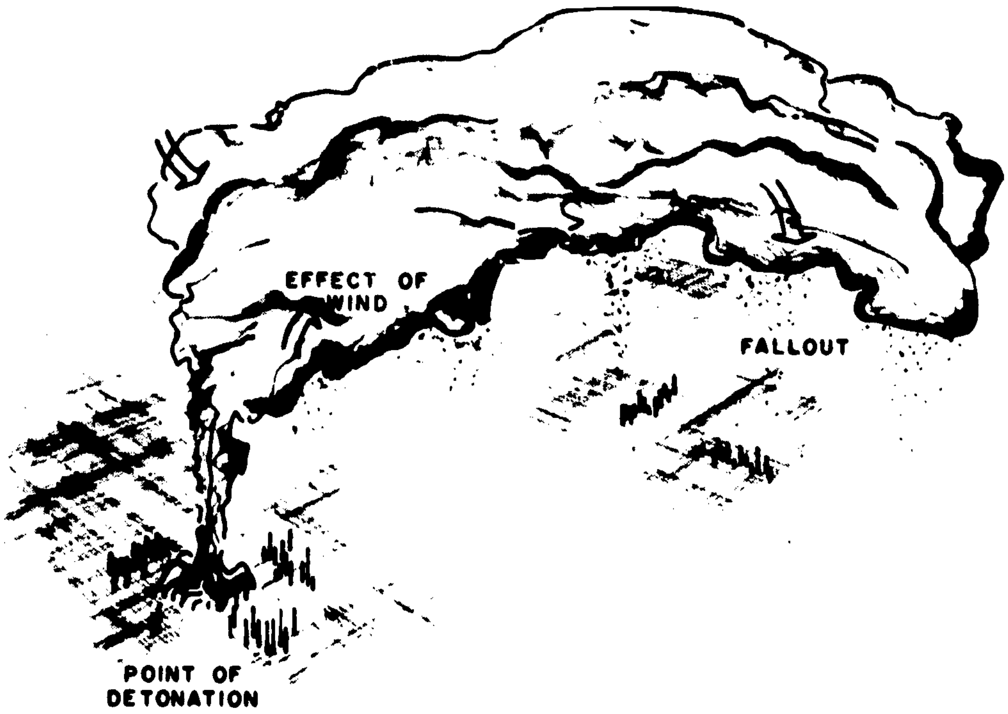


Figure 1. Distribution of fallout.

Figure 2. Fallout condition at D-2 days.

Figure 3. Typical fallout spread.

Fall-out is a dust in the range of 15 microns which falls like snow upon all horizontal surfaces and radiates penetrating gamma rays in all directions. Although the rays diminish rapidly, the initial fall, assumed to be in the vicinity of 3,000 Roentgens per hour, is extremely dangerous (Fig. 4). A shelter must provide a protection factor of 30 or more, or a minimum of 1/30 of the dose per hour that one would receive with no protection. A shelter, then, must have an interior exposure of less than 100 R/hr. (preferably less than 50) to offer adequate protection. A total lifetime exposure of 700 R is the assumed maximum a person can absorb without dangerous effects.

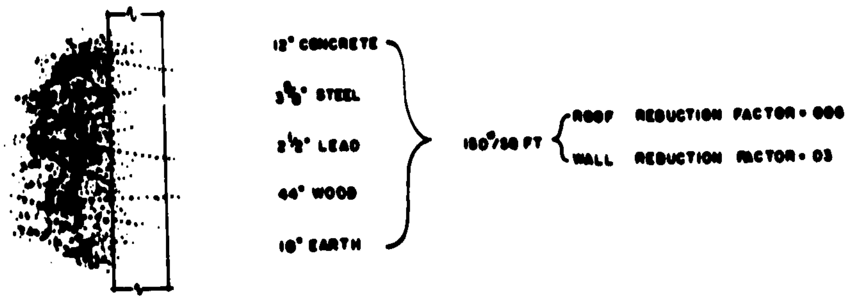
Figures 5, 6 and 7 show that the density and weight of construction materials are prime factors in protection from radiation. Therefore, a system of construction which best utilizes these properties will offer greatest protection. It is obvious that masonry systems are superior because of their weight-cost ratio. Underground shelters using the protection of the earth suggest greater shielding at lowest construction cost.

In our practice we have found that crawl space construction with flat slab concrete floors is both sensible and economical. This spacious area can be used for mechanical installations, as a moisture and temperature barrier, and for random storage. With a central air system, this space is ideal for fans and ducts. With only slight modification, portions of this area can be deepened for habitation. The below-grade effect offers excellent shielding, and the concrete slab overhead combined with roof and walls above provides a very satisfactory shelter with a factor of 40 Roentgens per hour, well within the safe limits.

Recently, at the request of a school district, we were asked to consider the installation of a shelter in a new high school. In surveying the plans, it was found that for 600 pupils at 12 sq. ft. per pupil we would require 7,200 square feet to house the entire school population (Fig. 8). In a building of masonry construction with a steel frame superstructure we are able to develop adequate below ground space adjoining the boiler room, food storage areas and service areas at almost no additional cost. At this time, we shall only excavate the necessary area and leave it unfinished for development when the urgency becomes more acute, or for immediate but not so comfortable use at once. Note the protected entrances and the areas for first aid, sanitation and emergency power (Fig. 9).

The BRI 1960 Spring Conferences presented a very timely and important conference on air purification. The papers presented brought out the fact that outside air no longer can be considered as "pure." Outside atmosphere today is dangerously loaded with infectious gases, pollen, bacteria, dirt and even fall-out. With today's engineered systems, it was reported to be more economical to reprocess the air than to take in large quantities of makeup air.

In the design of school heating systems, we attempt to control air-borne infection and thereby increase the average daily attendance by cleaning the air of its dirt, which also cleans it of bacteria attached to dust particles. A filter which will remove ordinary air dirt will remove fall-out particles. Because of the "hot" or radiant condition of the particles, the filter must eliminate the waste so as not to build up dangerous radiation. We have developed a central air system using an electrostatic self-cleaning filter. Although large quantities of air are moved, minimum outside air is admitted, as all air except in toilets and kitchens is recirculated through the filter. This quality system has been found to be no more expensive than other heating and cooling systems.



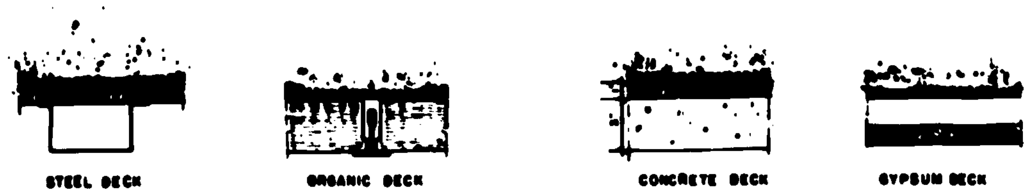
PROTECTION FACTOR $\frac{1}{.006}$ = 166.7

ROOF $\frac{\text{DOSE RATE (3,000R/HR)}}{166.7}$ = HAZARD 18 R/HR.

PROTECTION FACTOR $\frac{1}{.03}$ = 33.3

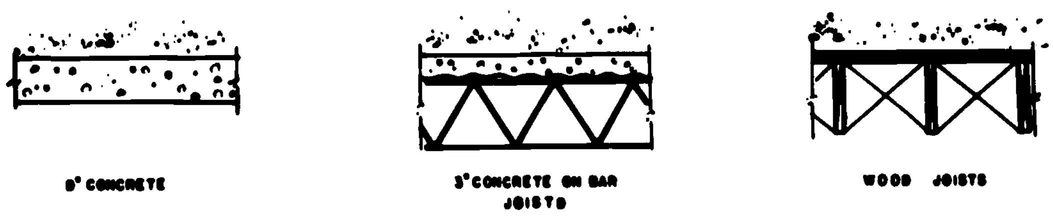
WALL $\frac{\text{DOSE RATE (3,000R/HR)}}{33.3}$ = HAZARD 90R/HR.

Figure 4. Shielding data.



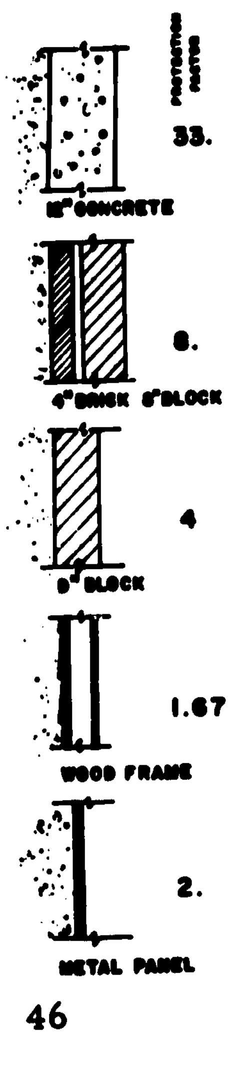
	STEEL DECK	ORGANIC DECK	CONCRETE DECK	GYPSUM DECK
PROTECTION FACTOR	1.67	2	10.	8.
	1800%m	1500%m	300%m	375%m
ADD STONE GRAVEL	1680%m	1360%m	295%m	365%m
ADD 2" SAND	1360%m	1150%m	282%m	350%m

Figure 5. Roof protection.



	CONCRETE	3" CONCRETE ON BAR JOISTS	WOOD JOISTS
PROTECTION FACTOR	50.	10.	3.3
	60%m	300%m	900%m

Figure 6. Floor protection.



	PROTECTION FACTOR	
12" CONCRETE	33.	90%m
4" BRICK 8" BLOCK	8.	390%m
8" BLOCK	4	840%m
WOOD FRAME	1.67	1,800%m
METAL PANEL	2.	1,500%m

Figure 7. Wall protection.

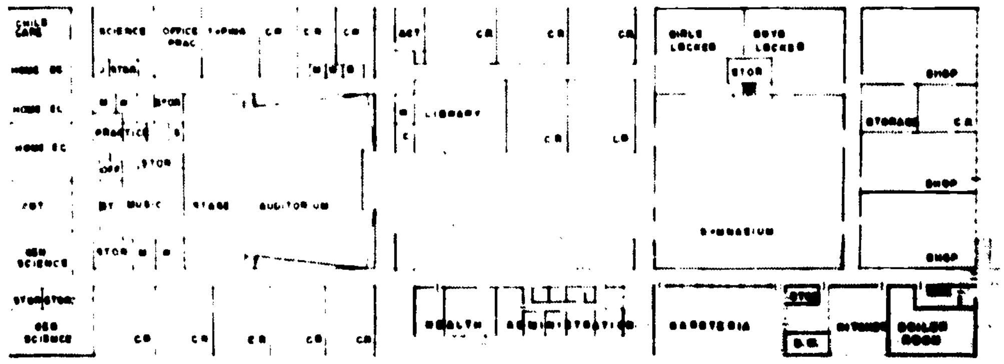


Figure 8. Plan of school.

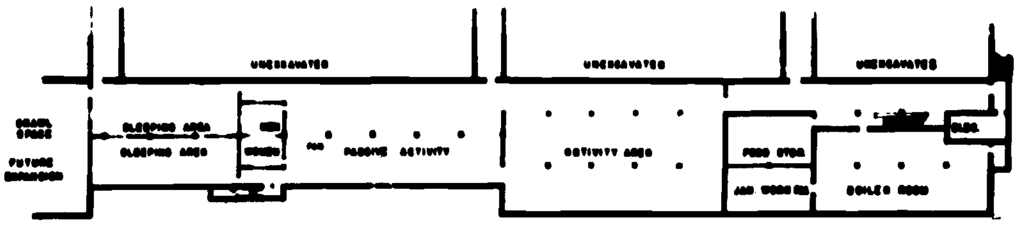


Figure 9. Plan of basement.

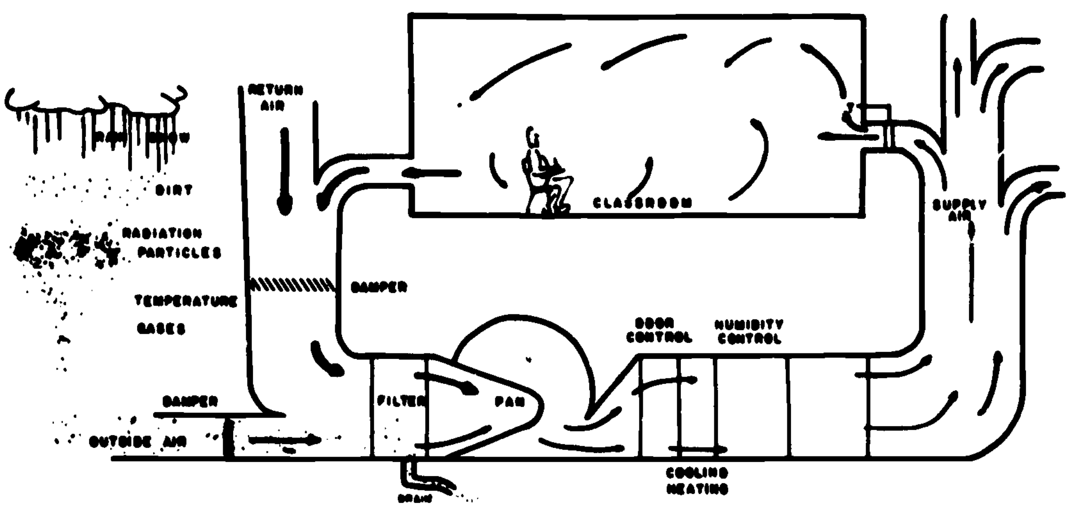


Figure 10. Air system diagram.

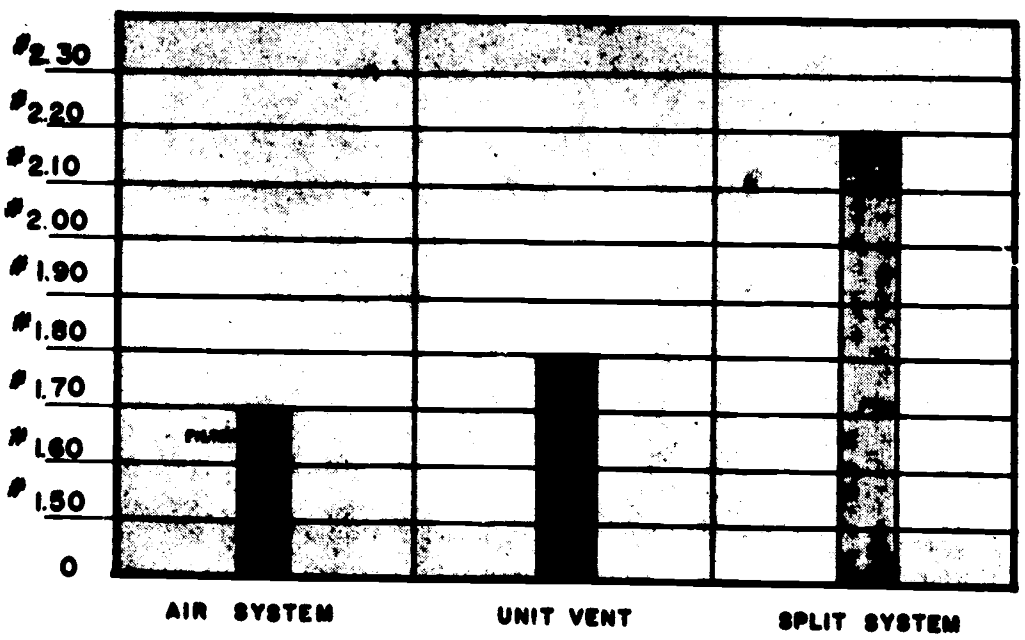


Figure 11. Cost analysis of heating systems.

Such a system is ideally suited for fall-out shelters. In the previously mentioned school, the air system is planned to be diverted to the shelter area for emergency use. An emergency standby generator can be used to power the unit, as well as for lighting. These generators can be obtained by the school from government salvage on a 50-50 basis. These two construction features are, by themselves, the major factors in providing a fall-out shelter. Such other amenities as food, water, sanitation and first-aid can be easily provided.

Research now going on indicates some new developments which may ease the burden of confinement. The concept of negative ions as beneficial to both the physical and psychological condition of the inmates may offer some help. The research and development necessary to build submarines and space vehicles with their self-contained atmospheres will provide useful data for the design of fall-out shelters. Reports also indicate that roof flushing and ground drainage away from the building may reduce the duration of danger from fall-out.

CBR, meaning chemical, bacteriological and radiological warfare, requires similar design features for safety and protection. Therefore, the shelter for fall-out may be adjusted when more detailed facts are known concerning future weapons. Here again is an instance where war research can be put to use to provide better atmosphere for learning in our above-grade classrooms.

After a school district has made the decision to construct a shelter, the previous suggestions will prove to be the least costly and will offer good school planning, with or without a shelter.

Solutions to above-grade protection are varied and depend on the type of building and site. Existing structures may offer a high degree of protection when masonry construction has been used. Multistory structures offer fairly good protection on the upper levels away from radiation emitted by particles on the ground or on nearby roofs. Some methods are shown in a brochure available to all entitled, "School Shelter" by Eberle M. Smith Assoc., prepared for the office of Civil & Defense Mobilization.

While the advantages of below-grade shelter construction are obvious, when considered primarily as a shelter, one has the feeling that this is not yet the answer. The problem of duplication of space and reserve systems, and the crowding which appears to be necessary, can be accepted if the duration is only a day or so. However, there remains the problem of dealing with children in confined areas for long periods of time. Try to visualize the problem of 600 children confined for two weeks. Add to this confusion the parents who have no home shelter, and who come to the school because it has shelter provisions. Experts in handling children, the teachers, advise a program of regular classroom activities with periods of diversionary exercise. When this program is analyzed, one realizes that a plan equal to the one used for everyday school, but with complete shelter protection, is necessary to carry on such a program.

Based on cost premises previously made, it would appear that a complete underground school program should be considered. In our present-day, above-ground schools, we have been aware that windows are not always required and have reduced them to a minimum, using a vision strip only large enough to provide eye relief, and providing better control of light, heat and air. With the advent of year-long classes, air conditioning has shown this to be even more advantageous.

With an air purification system, the interior atmosphere can now be maintained economically at a point where it will be superior to outside fresh air. New methods developed for space vehicles will make it possible to maintain correct humidity, odor purity and even ion content. Those who work in windowless offices and factories where visual space considerations have been taken care of, praise the attractiveness of the flow of interior space. The control of environment is appreciated more than the outside view. A school, being a functional structure with a definite performance requirement, should seriously consider any proposals improving its output. With the same view in mind, we have then a common solution to a better learning environment.

An underground school can be both functional and pleasant, and above all, economical. Its interior can be colorful and spacious with atmosphere controlled for best teaching conditions. Maintenance of plant exterior would be reduced to a lawn mower, and the school could have additional playground space because of this site utilization. Large-span units such as the gymnasium and auditorium could remain above grade, to enable their association with the play fields, or for public use for social activities.

In the face of "glass box" architecture it seems somewhat drastic to consider a return to cavelike structures, but this is a logical development. With the glass box, man proved he could lick the elements of nature by mechanical means. However, is it logical to fight nature when time has proven that if man is in tune with nature his life is more enjoyable? Man's progress along the face of the countryside has been anything but beautiful. With shortages of building sites, the consideration of subterranean development is logical regardless of atomic attack. The natural enhancement of the land by planting would be a welcome relief. The counteraction to the glass box is timely and sensible. Here, therefore, is an area for research. Can man, as a result of such data as will be compiled by research bodies, formulate an interior environment?

As with most progress, the difficult solution when tackled with a clear head can lead to a better result than that which has been accepted as the norm. Those of you involved in research, whether physical or psychological, should consider the possibility of earth-surrounded structures in the light of new knowledge available to us and develop better structures for the increasing human population.