RUTGERS UNIVERSITY
NEW BRUNSWICK NEW JERSEY

DEPARTMENT OF
CIVIL ENGINEERING

December 11, 1941

Professor Norman C. Miller
University Extension
Campus

Dear Professor Miller:

Following is some information concerning bomb shelters and the design as well as some comments as to adaptability to existing conditions on the Rutgers campus.

1. From experience in Britain and elsewhere the tremendous expense involved for the construction of an absolutely bomb proof shelter makes this type of construction out of reach and it has been figured that the roof of such a structure would have to be 47' thick and the side walls much thicker to resist penetration of bombs and to take care of the accompanying vibrations. For this reason most bomb shelters are constructed to protect against falling debris.

2. It has been pretty definitely determined that shelters placed in existing buildings are of little protection except where definite changes, and alterations are incorporated such as construction of overhead burster slabs and strengthening and increasing thickness of side walls. In no case should shelters be placed in buildings which are not of fireproof construction. To find shelter zones offering comparative safety in most buildings under six stories in height is difficult unless they are of massive construction with independent structural frames of steel or reinforced concrete. It should be remembered that buildings of the wall-bearing type might be completely destroyed by direct hits or even by the concussion resulting from near-by explosion outside the building.

On the Rutgers campus there are no buildings which would approach the above specifications.

3. In view of the above in considering the construction of bomb shelters on this campus it would seem desirable and advisable to plan shelters that would protect only against falling debris and to some extent against concussion and vibrations. Based on British experience it would seem advisable that shelters should be designed for over-night occupancy; that reasonable space should be provided for sleeping accommodations and that space should also be provided to house sanitary and ventilation equipment.

4. The following is a resume of requirements as to space, volume and other design data. Shelters should be built in units, each unit to house not more than 50 persons. Floor area should be at least 30 sq.ft. per person plus an allowance for aisle space. This figure can be reduced if double tier bunks are used. The volume should be 50 cu.ft. per person and increased to 75 cu.ft. to provide for sleeping accommodations. Volumetric requirements would be satisfied by a room whose height bears a normal relation to the other dimensions. The total area of floor, walls and ceiling is another factor to be considered and this area would be dependent on climatic conditions. When a large number of people are closely confined, conditions quickly become unbearable unless there is sufficient surface area in the room to transmit heat to the outside. The cooling of a shelter becomes much more important than the heating. Careful attention should be given to the design of sanitary facilities. The number of fixtures may be determined in accordance with the requirements of the local building codes. Two or more sets of toilets should be provided with all toilet room fixtures preferably connected to regular house drains and sewers. The use of sewage ejectors is objectionable. Reserve chemical water closets should be provided in the event of damage to or destruction of existing sewers.

Decontamination centers should be provided for people exposed to poisonous gases. These centers consist usually of an undressing room with storage space for contaminated clothing, a cleansing room with hot and cold showers and a dressing room with a supply of fresh clothing. This space should be in excess of 500 sq.ft. All shelters should be provided with first-aid stations adjacent to decontamination centers where these are used. All large shelters should be provided with mechanical ventilation and an auxiliary method of operation in case of power failure. Each ventilating unit should be provided with duplicate intakes and a separate ventilating system installed for toilet rooms. A small heating plant for winter use is desirable.

5. Structural Requirements. On the basis of design for secondary effects of bombing the requirements for side walls protection are as follows:

Table 1 - Recommended Materials Thicknesses
To Protect Against Bomb Fragments+

Mild steel plates or plates of an aggregate thickness	1-1/2 in.
Solid brickwork or masonry	13-1/2 in.
Reinforced concrete	12 in.
Plain concrete	15 in.
Earth or sand	30 in.
Ballast or broken stone	24 in.
Wood, minimum	40 in.

+ Data if for a 500-lb. bomb exploding 50 ft. away

In general requirements for overhead protection are not as great except where overhead blasting can occur. These requirements are given in the

following Table.

Table 4 - Thickness Required For overhead Protection+

Mild steel plate	3/4 in.
Reinforced concrete	4 in.
Plain concrete	6 in.
Brick (arched)	8-1/2 in.
Ballast, broken stone or earth	1 ft. 6 in.

+ Recommended by British

For cases where the bombs may explode above a shelter roof the degree of protection given in Table 1 should be followed. Where umusually heavy parts of buildings are apt to fall as units, increase the tabular values given in Table 5 by 50 per cent.

Table 5 - Debris Loads+

Wall Bearing Construction

Stories above shelter	Static Load lb./sq.ft.
1-2	200
3-4	300
5 or over	400

Skeleton Construction

Unlimited	200

+ Recommended by British

Two or more exits should be provided in each shelter and for protection against poisonous gases lock should be provided in each of these entrances.

The cost of bomb shelters is rather difficult to ascertain but figures above indicate that costs will be as high as $150 per person with decreasing rates in accordance with the size of the shelter and the number of units per shelter. In Britain the costs were as low as $75 to $80 per person.

I have secured most of this information from "Protective Construction", Bulletin No. 1, prepared by the U.S. War Department, a copy of which accompanies this letter and some articles in the Engineering News Record of September 11, 1941 and of August 28, 1941; Civil Engineering, March, 1941; The Military Engineer, July-August 1941.

I hope that this information may be of some value and service to you.

Sincerely,

H. N. Lendall

H. N. Lendall
Head of the Dept. of Civil Engineering