5. LIGHT, STRONG AND FLEXIBLE FLOORS

The forces of an earthquake are directly related to the mass (weight) of the building. Heavy floors or roofs are therefore a source of large horizontal forces that are not at all desired. Floors and roofs in earthquake areas should be light and hang well together. The following are all disadvantages:

- Heavy concrete floor constructions (weight).
- Earth loaded roof constructions (weight).
- Roof insulation or waterproofing made with thick soil (weight).
- Roof constructions that absorb large quantities of water (weight).
- Roof beam constructions that are not well anchored into the walls (loose).
- Roof beams that are not nailed or tied together with the floor boards (loose).
- Roofs that are very stiff (this causes additional forces in columns and piers).

Floors (and roofs) must therefore be designed as light as possible. Modern insulation techniques allow for light floors to be warm, as well as safe (see other BACIP solutions[13]).

For schools and other public buildings, BACIP proposes a type of floor similar to that used in high-rise buildings, using a folded metal sheet. The adherence between concrete and floor sheet is very intense and no additional steel reinforcement is needed for spans up to 8 ft. These floors do not require form-work as the concrete can be cast directly onto the folded sheet. The floor is fully waterproof.

These floors are on an average only 4cm thick (1.5 inch) and therefore weigh only one-fourth of the commonly used reinforced concrete floors (6" thick). In addition, if the floor fails, the failure is very slow and cannot snap or break suddenly[14].

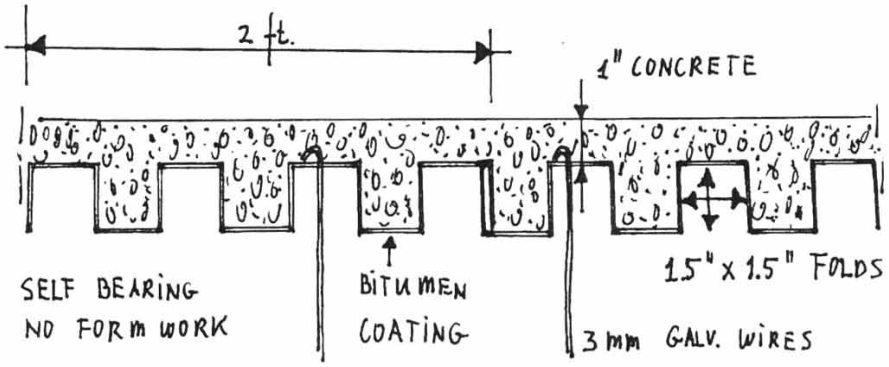

FIGURE 18. FOLDED METAL FLOOR OF 18-GAUGE (1.2MM) SHEET STEEL WITH AN 8 FT. SPAN

The possible disadvantage of the above-mentioned floor is that it requires a well-planned building design in which the elements can be precisely joined at 8-ft. intervals. This is possible in large or systematically built constructions, such as schools, office buildings, apartments and clinics. For house construction the design is not practical as too many different room sizes will require the sheets

[13] *BACIP House Improvements - An Overview of New Products (February 2000).*

[14] The so-called "slow failure characteristic" is an especially important feature in the event of long-lasting earthquakes as it allows people time to evacuate the building.

to be cut to size. The cutting of the metal sheet is not possible at the house building sites in the Northern Areas.
To overcome the above problem for private house construction, a similar design has been adopted using the 24-gauge corrugated galvanised iron roof sheeting as a basis. To enhance the adherence between the corrugated sheet and the concrete, an expanded metal wire-mesh has been fixed with "butterflies". The aggregates need to be sieved through a 3/4" sieve to allow the concrete to go through the wire-mesh (6 holes per 5 inches). The expanded metal enhances the strength of the floor as well.

The floor design illustrated below is supported at 2-ft. intervals with light wooden supports of 2" x 4" that carries over 6 ft. The average weight of this 3cm thick reinforced floor is only one-fifth of the traditional concrete floor and provides a full (waterproof) diaphragm function.

There exists a significant difference in the behaviour between heavy and/or stiff floors, and light and/or flexible floors. The heavy floor or roof will exert large horizontal forces on the walls during an earthquake and cause a larger sideways movement of the walls in the direction of the ground movement than light floors. Unattached floors or roofs will easily detach and collapse.

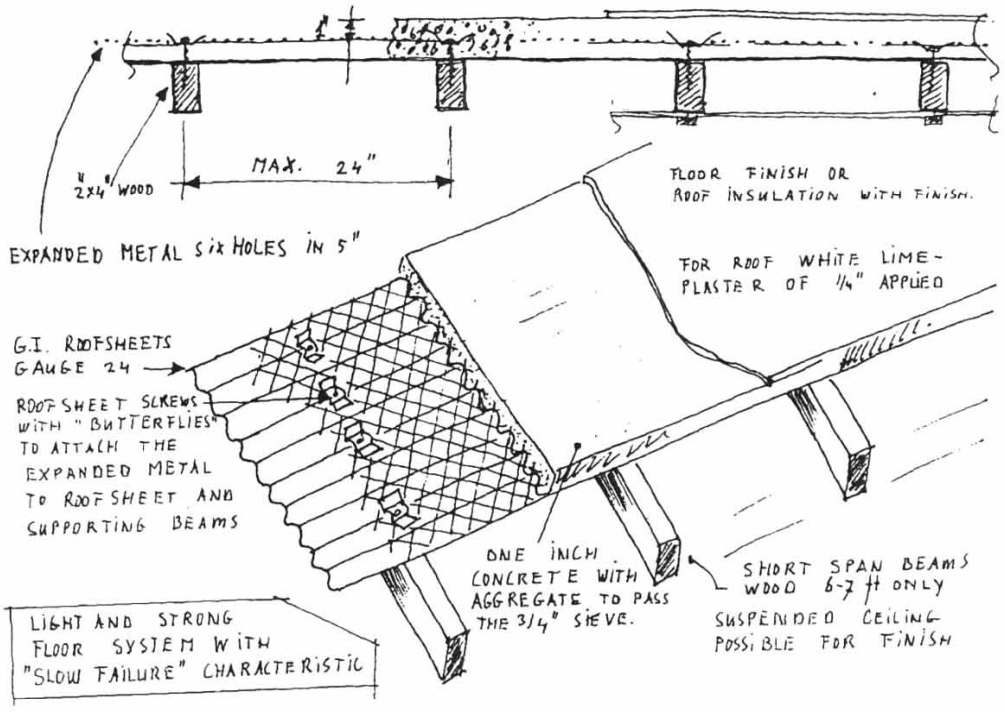

FIGURE 19. LIGHTWEIGHT AND STRONG FLOORS FOR HOUSING

Heavy (stiff) anchored floors or roofs will also exert the same large forces, but due to the stiffness and anchorage, the wall will tend to break below the anchoring point.
If these heavy floors are anchored to all four side walls, the horizontal force on the head walls in the direction of the ground movement will be considerably reduced (see Chapter 3).

The light floor will exert less horizontal forces on the walls than the heavy floor or roof. When the light floor is only 1/3 the weight of the heavy floor, the horizontal forces will be less than 1/3 as

compared to the heavy floor. Sideways deflection will be even less than 1/3 due to the resistance of the walls.

A flexible floor will tend to bend a little and with that absorb part of the forces, thus avoiding breaking damage in the walls as may be the case with a very stiff floor.

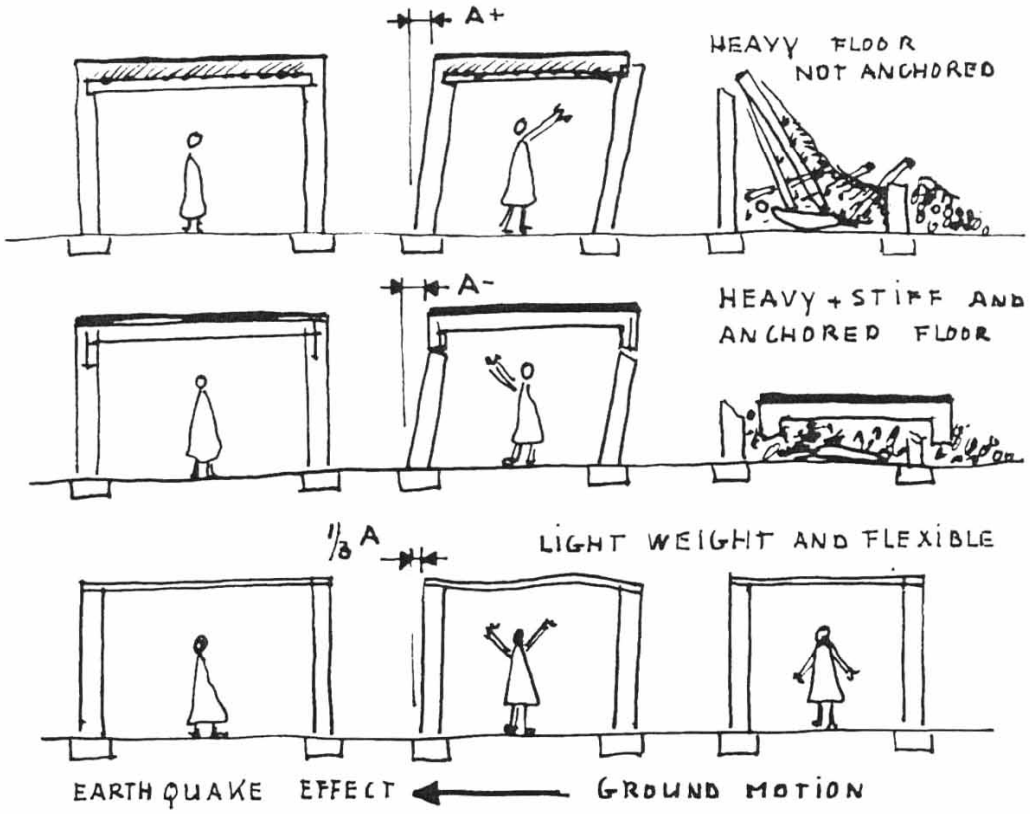

FIGURE 20. EFFECT OF HEAVY/STIFF AND LIGHT/FLEXIBLE FLOORS DURING AN EARTHQUAKE

When wooden floor constructions are used (also light), all members need to be tied together to make a full floor diaphragm. In addition, the sides of the floor need to be attached to the vertical anchors that come upwards inside the walls.

As vertical wall anchors, the 3mm galvanised wire can be used successfully and can be brought up into the wall from the level of the door and window lintels. To assure good anchorage between the beam and the wire in such a way that it cannot be pulled out horizontally, a V-shaped cut has to be made into the upper side of the beams.