

- (3) Buildings with reinforced concrete frames :
- (4) Buildings with structural steel frames.

There was considerable overlapping of types, and there are in this area buildings which embody two and sometimes three of the above classes.

(1) BUILDINGS OF WOOD.

Generally speaking, solidly constructed wooden buildings stood the shock well. In dwellings the chief source of trouble was the foundation, particularly in Napier South, where the subsoil is silt and there was considerable earth-movement. Concrete foundations were seldom reinforced, and many cases of destruction of this type of foundation were observed. In timber-pile foundations there was often inadequate connection between the plates and piles, and the houses were thrown off the piles. Where high pile foundations were used there was often insufficient bracing to the piles.

At Port Ahuriri several timber wool-sheds suffered badly. Many of these had R.S.J. beams and columns supporting a second floor, the exterior walls being expected to take all lateral thrusts. These suffered extensive damage, and the necessity for the provision of adequate interior bracing is indicated.

With regard to wooden shops, there were no examples of a soundly constructed building suffering more than minor damage. There were a number of this type in the fire area about which all evidence has been destroyed. In large wooden buildings where wings had been used there was considerable damage at the junctions, owing to the tendency of the parts to vibrate in opposing directions.

(2) BUILDINGS WITH BRICK BEARING-WALLS.

There were many examples of brick dwellings of one or two stories which suffered practically no damage. Several examples of failure can be attributed to the site—*e.g.*, a house on the edge of the Bluff Hill face and another on a high spur at the other end of the island.

Out in the country on the foothills there were several well designed and constructed brick dwellings which were practically destroyed, but all of these were close to extensive earth-movements and must have suffered very severe shocks.

A dwelling, on account of its compactness and the light loading of the walls, is better able to withstand earthquake-shocks than other types of brick buildings, and observations in this area indicate that dwellings up to two stories may safely be constructed in brick, but the suitability of the site *must* be considered.

In the case of larger brick buildings there were many examples of failure, and, while many of these failures can be traced to faults in *details* of design and construction, the matter of *general* design must be taken into account.

With regard to general design, the evidence in Napier demonstrated the danger of erecting tall buildings, depending on brick bearing-walls for support, in which portions of different heights abut one another. Also, the dangerous wrecking effect of heavy concrete ceilings and heavy tiled roofs was very apparent.

With regard to faults in details of design and construction, the following factors were responsible for much of the damage :—

- (1) Insufficient footing-area in foundations :
- (2) The absence of ties across foundations :
- (3) The use of timber interior partitions inadequately secured to the walls :
- (4) Poor mortar and inefficient band-course reinforcement :
- (5) The support of heavy roofs on piers or walls too thin to withstand the racking effects produced :
- (6) The use of heavy brick shop-fronts with totally inadequate anchorage to the main body of the building.

Associated with the above, we have many examples of poor workmanship, but as a factor contributing to failure this must not be overstressed and the factors enumerated above lost sight of. The matter of poor workmanship can easily be taken in hand by enforcing stricter supervision, but the matter of design requires careful revision of what were hitherto in this town generally accepted principles, and the need for this is liable to be overlooked if too much of the damage to brick buildings is laid at the door of poor workmanship.

GENERAL OBSERVATIONS.

1. *Foundations*.—No serious foundation troubles were observed on the hills where the subsoil is limestone or in those parts of the flats where the subsoil is shingle. Where the subsoil is silt there were many examples of settlement, and in one case, where serious settlement occurred, the designed loading was 2 tons per square foot, indicating that for earthquake conditions this figure is too high. Trouble also occurred owing to omission of any foundation ties across the building, and the provision of some form of reinforced-concrete tie in such cases is essential.

2. *Mortar*.—Old lime mortar had perished badly, particularly in chimneys. The lime-cement mortar used latterly appears sufficiently strong to develop the full strength of the bricks. One of the chief troubles has been that the bricks here are very porous, and there is always difficulty in getting bricklayers to wet them sufficiently, with the result that the mortar does not bond well with the bricks. With regard to filling of joints, this has in many cases been poor, particularly in the case of vertical joints. Many cases of bricks laid with the frog down were seen.