CASE STUDIES : EARTHQUAKE RISK BUILDINGS

1. THE UPGRADING OF MIDDLE SCHOOL : CNR JED AND DON STREETS, INVERCARGILL

F. N. Buxton*

INTRODUCTION:

Work on this building was done in line with Government policy of replacing or structurally upgrading recognised earthquake risk buildings of unreinforced brick masonry. The building has little of special architectural merit and is not of any historical significance, frequent reasons for strengthening rather than replacing. In that regard, it would be a special case.

The decision to strengthen followed considerable public debate, news media attention and controversy lasting some months and investigations carried out on behalf of the various interested bodies.

With regard to Middle School, the contract for upgrading was under the overall control of the Southland Education Board Architectural Branch with the Dunedin District Office, Ministry of Works and Development, Structural Division being responsible for the structural concept and design of engineering aspects.

DESCRIPTION:

The School building, built in 1925, (with alterations in 1964), is a single storey classroom block of about 500 m² in area and wall height of 3.7 m approximately. External walls were double skin cavity brick, topped with a rail iron reinforced concrete band. Internal walls were 225 mm thick solid brick. The roof with hipped ends, is slate clad over 25 mm square-laid close boarded sarking, supported by trussed rafters at 600 mm crs. Principle rafter members are 150 x 50 mm. Flooring is of T & G carried on 150 x 50 joists at 450 mm crs on concrete piles and with exterior concrete foundation wall approximately 600 mm wide. As with wall bands, the foundation walls are rail iron reinforced.

The building was free of chimneys, gables, parapets, etc, which are generally accepted seismic hazards, except for a small entrance structure on north frontage which had been blocked off for a number of years (photograph 1). This latter redundant feature, being superfluous to the proposed revamped structure, was removed, also enabling provision of added strength where needed in the up-graded construction (photograph 2).

PREVIOUS STRUCTURAL ALTERATIONS:

As earlier mentioned, alterations had been carried out in 1964. These

involved principally the removal of four large sections of internal load bearing corridor walls of between 5.8 and 7.3 metres in length. Latticed steel roof trusses with parallel channel section top and bottom chords were provided to carry roof loads. (These trusses were reused in the upgraded structure.)

Other alterations, involved internal wall removal in the short south wing, breaching of the north wall in four situations for fire egress doors, and later work in connection with a toilet block addition on the south side and entry/egress provision.

STRUCTURAL AND GENERAL BUILDING CONDITION

Concern was expressed as early as 1973 as to the condition of the building when it was reported that there was horizontal cracking in foundation walls due to corrosion of the railway iron reinforcing, and similar faulting in the concrete band topping external walls. Internally, horizontal cracking was evident between band and wall over the full length of north wall, and on a number of other walls in various parts of building at the 2.4 metre level. There were also faults in walls supporting trusses, some bad, close to truss seats. Lime mortar to brickwork was universally perished which was confirmed once work started on building upgrading. It could truly be said of this building that "gravity held the building together and the mortar held the bricks apart".

The timber framing to roof and floor was reasonably sound and little or no settlement faulting was in evidence suggesting adequate founding. While some of the faulting noted was of little significance structurally, overall the condition left much to be desired.

RESISTANCE TO LATERAL LOADS

The building because of its type and nature, did not lend itself to an accurate assessment of performance in earthquake. Clearly, it offered poor seismic resistance and would not comply with current codes.

UPGRADING CONCEPT

While a number of alternative approaches to upgrading were investigated and cost benefit studies done the scheme finally adopted basically involving the removal of interior walls and the inner skin of exterior walls, and the replacement of these elements with timber framed, 125 x 50 stud walls, plywood lined. The existing ceiling was replaced with sheeting of structural ply to form a seismic diaphragm. Concrete wall bands were removed with the internal walls, but

* District Structural Engineer, Ministry of Works and Development, Dunedin

Fig.1 General floor layout.

retained around the perimeter. Ties were provided to hold the exterior brick skin to the new timber framed walls.

In essence, the building was converted to a timber framed brick veneer structure. While some in-plane load could be expected to be initially transferred to the remaining brick veneer by way of the retained concrete band, calculation showed that with thickness of ply selected, this would be small with a maximum eaves level deflection of 5 mm. Generally, it was considered that the standard of protection for the outer veneer skin would be adequate, risk of damage at an acceptable level, and the resistance of the building as a whole against collapse would comply with the requirements of the then existing Code DZ 3603.

VENEER TILES

Ties were provided at 600 mm crs horizontally and every fourth course vertically. Anchorage into solid brick (not joints) was by way of 6 mm diameter proprietary anchors 50 mm long into predrilled holes. The anchors were laboratory tested with sample bricks from the building and met the requirement of 0.7 KN test load required by COP PW 81/10/1 Seismic Design of Public Buildings.

CONSTRUCTION ASPECTS

Demolition of the interior skin of the external cavity brick walls was done in sections approximately five metres in length, and timber wall framing installed as work proceeded with top and bottom plates fixed to band and foundation with expanding type bolts (photograph 3). It was a measure of the poor condition of the joint mortar to the brickwork that in many parts considerable areas of the inside face of the veneer needed remortaring in an effort to provide symmetrical bearing to brickwork. Studs at wall ends and openings were bolted down (photograph 4). Brackets of RHS were provided at ceiling level to perimeter walls with the object of (a) holding band in event of outer skin loss and (b), connecting wall to ceiling diaphragm when wall has face loads (photograph 5).

It is almost inevitable in work of this nature that some concessions need sometimes be made where necessitated by situations once exposed, and modified details substituted. This need for flexibility occurred at the junction of the ceiling and wall diaphragms where it became impracticable to carry the ceiling ply over a new inside bearer plate to the external band as originally envisaged.

Ply used was D-D grade throughout, 17.5 mm thick to outside walls and 12.5 mm to interior walls (both sides) and ceiling. Fixing was with flat head nails at 50 mm crs at edges and 150 mm crs to intermediate members.

SUMMARY:

The overall concept proved practi-

cable and did not create unreasonable demands on the contractor and the end result met the aim of the exercise within the limits of a strengthened building, eg, "veneer" mortar is very weak being perished lime mortar.

The cost of the work including new window frames, new wall linings, electrical rewiring, etc, was approximately 0.6 that of a new building of equivalent area.

Structural costs were slightly more than 35% of overall cost.

Photograph 1. North Elevation prior to upgrading.

Photograph 2. North Elevation during upgrading.

Photograph 3. Timber framing showing veneer ties and fixing to top band.

Photograph 4. Anchorage of studs at wall ends and openings.

Photograph 5. View of interior east end nearing completion.