

## 2. REDEVELOPMENT OF THE NORMAL SCHOOL CRANMER SQUARE, CHRISTCHURCH

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### INTRODUCTION:

This case study describes the strengthening work entailed in the redevelopment of the Normal School, an imposing Victorian stone building facing Cranmer Square, into luxury apartments.

### HISTORY:

The Normal School was founded by the Canterbury Provincial Council and intended as a large, centrally situated primary school in which student teachers might receive rudimentary training. It was designed by the architect S.C. Farr in the style of the early Victorian Gothic Revival and was completed in 1874 with a major extension to the Montreal Street wing in 1878. It was used continuously as a primary school until 1954, at which time it was taken over by the Christchurch Teachers' College.

In 1964 the Ministry of Works examined the school and concluded that the buildings should be placed on a priority list for replacement, and that their continued use be kept to a minimum as a calculated risk. The school was vacated by the Teachers' College in 1970 at which time further maintenance ceased. The disused buildings were then subject to vandalism and under threat of demolition, whilst various interested parties formed the Normal School Trust to determine the future of the buildings.

The main initiative for the preservation of the buildings came from I.C.O.N., a group of local residents committed to restricting commercial encroachment into what had essentially been a residential area. Various schemes for the use of the school buildings were forwarded by interested developers, and in 1981 a proposal by Berryman Properties Limited to convert the school buildings into luxury apartments was accepted. Messrs D. Sheppard and J. Rout of Kingston, Reynolds, Thom and Allardice were appointed Architects, and Halliday, O'Loughlin and Taylor were appointed Consulting Engineers.

### DESCRIPTION OF BUILDINGS:

The school is a two storey L-shaped structure, with wings facing Kilmore and Montreal Streets, and with a single storey octagonal shaped building at the junction. (See Fig. 1). The total area of the buildings prior to conversion was 2880 m<sup>2</sup>.

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Prime features of the buildings were the massive stone walls and high ceilings. Internally, the buildings were characterised by a long corridor along the courtyard side at both levels, and by large classrooms of up to 18 x 8 metres in size.

The walls were made of Halswell stone (basalt) laid in lime mortar with Castle Hill limestone facings. Generally, all internal walls were plastered. The ground and first floors were timber and the roof was slate and was supported by timber trusses. The site was on a swamp, with the foundations bearing on clay overlying a layer of peat. This caused problems for the original builder and the foundations once constructed had to be deepened and widened in order to be secure. Even so, cracking of the foundations and plastered walls and a difference in level of the ground floor corridor of up to 200mm indicated that substantial settlement had taken place over the years.

The northern half of the Montreal Street wing was built four years after the rest of the building and was somewhat different in construction. The walls were brick and the stone wall facing Montreal Street was a facade only.

The general condition of the buildings was reasonable considering their age. The timber first floor and the timber in the roof structure were generally sound except locally where the theft of roof slates and lead flashings had allowed water to flow into the building. Apart from the Octagon, the interior of the buildings was plain and austere with little detailing and little worth preserving. Almost all of the timber floors had been re-floored over the original at the time the school was taken over by the Teachers' College.

Many of the ornamentations, including the two tall towers, had been removed over the years and it was intended to replace these to restore the buildings to their original appearance. Loose stonework, particularly coping stones, constituted a danger and required proper anchoring.

### DEVELOPMENT SCHEME:

The approach to the structural strengthening of the buildings was evolved in conjunction with the formation of the redevelopment scheme adopted by Berryman Properties Limited, and was necessarily integral with it. Had it been necessary to retain the buildings as near as possible in their original condition throughout, then the strengthening

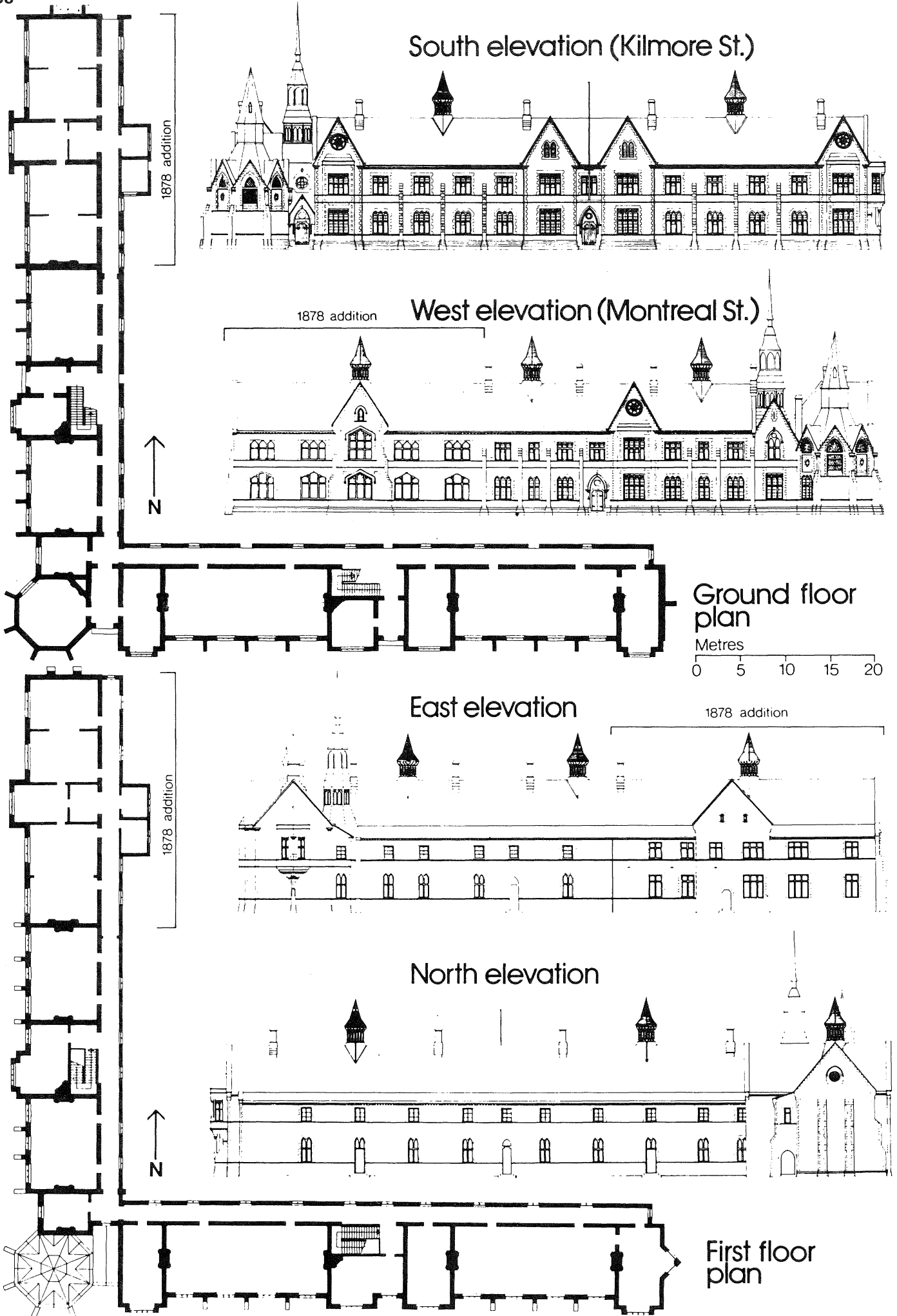


Figure 1

would have been a very different proposition.

The redevelopment scheme was basically to construct twenty two luxury apartments, two business suites, and a restaurant inside the school buildings and a further fifteen new townhouses plus ancillary buildings on the courtyard area behind the school. The apartments were to be sold as Unit Titles which meant that they had to be separated by concrete floors and masonry walls to comply with the Fire Code and local by-laws.

A conservation covenant was entered into by Berryman Properties with the Department of Lands and Survey to ensure that the architectural integrity of the buildings was preserved, which in essence meant that the Octagon and Montreal and Kilmore Street facades should be retained together with the roof line with its many towers, chimneys and ventilators. The retention of the two massive stone walls forming the corridor on the courtyard side was not a requirement and these were demolished to let light and air into the cavernous interior. The roof line was extended on the courtyard side and a modern facade provided. The original classrooms were sufficiently lofty to enable two storeyed apartments to be constructed between ground and first floors. Above this, at first floor level, the two storeyed apartments penetrated the roof space between trusses.

#### STRUCTURAL SYSTEM:

Reinforced concrete lateral load resisting frames were constructed along the line of the inner of the two stone walls that were demolished (see Fig. 2 & 4). These, together with the existing stone walls facing the street, gave adequate seismic resistance along the wings. Lateral load resistance across the wings was provided by the existing stone cross walls. Concrete block cross walls were also built at the centre of the large classrooms to give added seismic resistance and to provide separation between Units.

A reinforced concrete floor was constructed at first floor level on top of the existing timber floor right throughout the building. This served a number of purposes; it gave the necessary fire resistance between Units, it gave increased vertical load capacity and it served as a rigid diaphragm distributing the seismic loads and tying the stone walls together.

Reinforced concrete columns were provided at irregular intervals to the inside of the stone walls facing the street to enable them to carry the face loads. The roof trusses were bolted to reinforced concrete bond beams running along the top of the stone walls at roof level. Steel cross bracing was provided in the plane of the roof to enable it to provide lateral support to the chimneys and gable walls. The gable walls were tied back to the roof framing and a team of stonemasons employed to make good the stonework and secure

any loose coping stones etc.

#### DESIGN LOADS:

The minimum level of strengthening acceptable to the Christchurch City Council was that specified in Section 624 of the Local Government Amendment Act 1979, i.e. a moderate earthquake calculated as one half as great as that specified in NZS. 1900 Chapter 8: 1965.

Due to the nature of the development, it was decided to strengthen the existing buildings to the full requirements of Chapter 8. This corresponded to a base shear coefficient of 0.10g.

All new structural elements were designed to NZS.4203: 1976.

As a further precaution against localised weaknesses in the stonework, an independent means of support was provided for the first floor and the roof trusses so that as a last resort, collapse of the roof and floors would not be initiated by a partial collapse of the stonewalls.

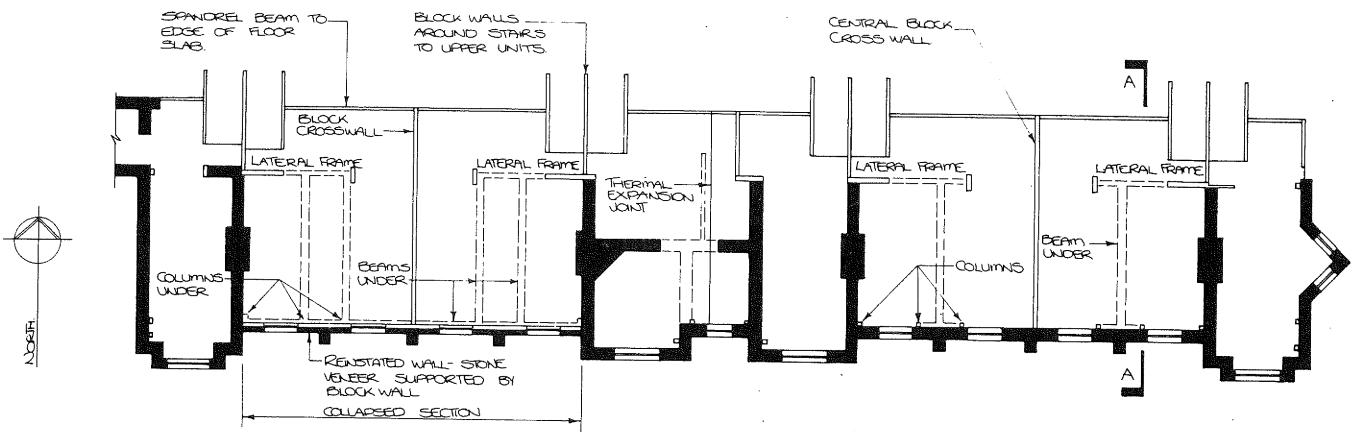
#### STONE WALLS:

The Halswell stone was extremely hard and undoubtedly the major factor governing the strength of the walls was the lime mortar, which tended to be very weak and powdery. This was offset to some extent by the interlocking nature of the irregularly sized and shaped stones. The maximum shear stress in the walls at ultimate was about 0.04 MPa which is the allowable load level specified in NZS.1900 Ch. 9.2: 1964.

The stone walls were checked for face loads using a factor of 4 for the walls fronting on to the street, and a factor of 2 for all other walls. Only the walls facing on to the street were found to be incapable of spanning between floors and roof and so they were given additional lateral support in the form of reinforced concrete columns constructed on the inside face of the wall. These not only assisted the stone wall in spanning for face loads, but were also used to support the first floor concrete beams and in addition they provided an independent means of vertical support to the roof trusses in the event of a partial collapse of the stone wall. All columns were cast against the face of the stone walls rather than chased into them since attempts to cut a chase in the basalt resulted in the stones tending to pull out at they were being cut, rendering a neat cut impossible. The interior stone walls were left exposed in the finished state; any plaster present was removed, the walls were sandblasted and then re-mortared prior to glazing.

#### FOUNDATIONS:

A number of test bores and test piles were undertaken and these indicated the soil strata as being 1.5 m of clay overlying 0.35m of peat overlying silty clay with firm bearing not obtained until sandy gravel at about 4.0m below ground level.



KILMORE STREET WING : FIRST FLOOR

FIGURE 2

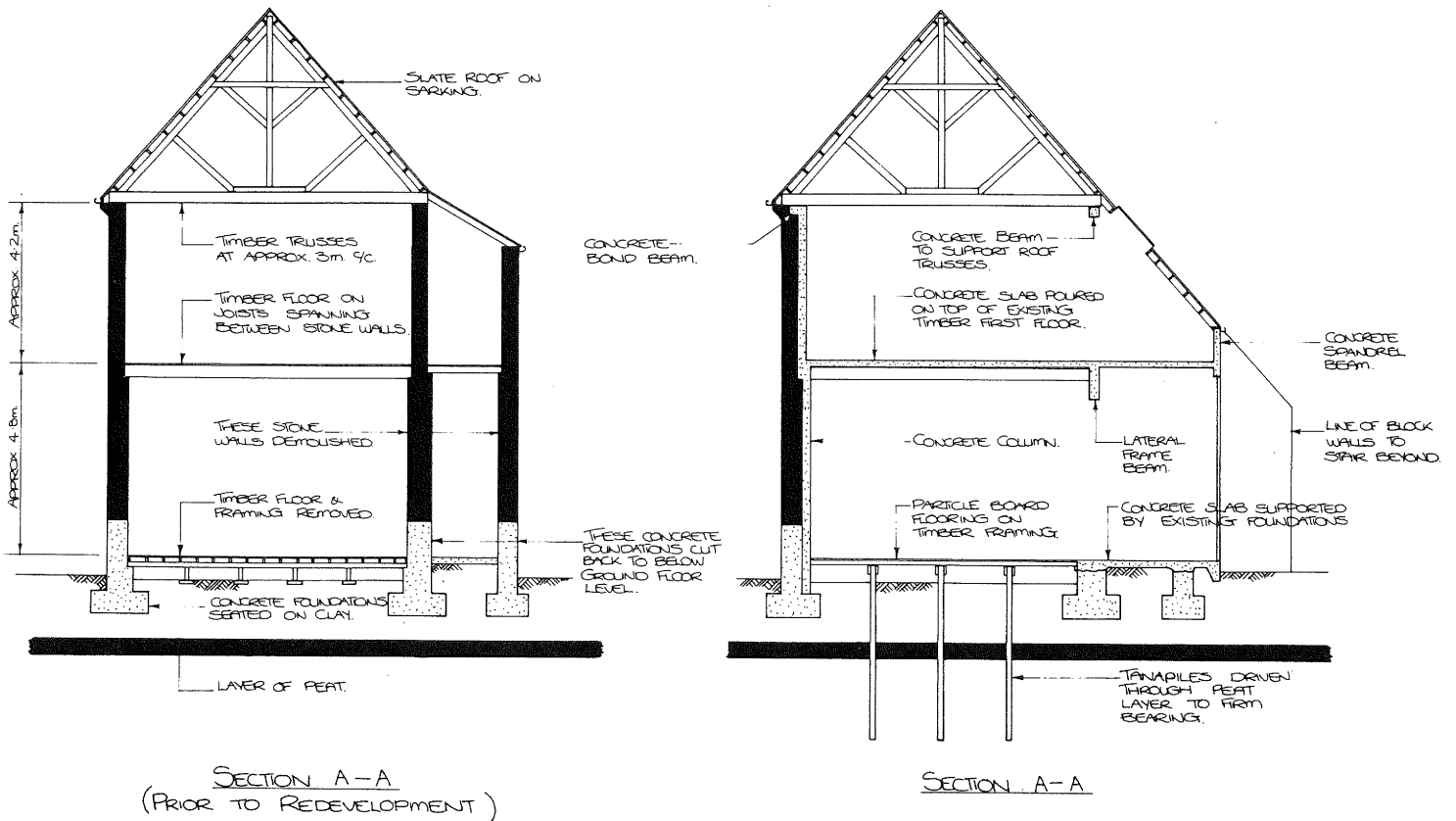


FIGURE 3

It was assumed that settlement of the massive concrete foundations due to the underlying layer of peat would have ceased, and further settlement was minimised by ensuring that any increase in foundation load (mainly from the concrete first floor), was kept to less than 10%. For this reason, the block crosswalls were founded on the existing foundations on the courtyard side, but on Tanapiles on the street side.

The ground floor sub-floor framing was rotten, and the floor was removed. A light weight floor was favoured rather than a concrete slab on backfill in order to minimise any further loads on the peat subsoil. After consideration of alternative framing systems, it was decided to replace the floor in timber supported on Tanapiles.

#### LATERAL FRAMES:

Reinforced concrete lateral load resisting frames were constructed along the line of the inner of the two stone walls that were demolished. The frames (see Fig.4) were of the half-frame and post type, a configuration chosen primarily to suit the architectural constraints. The frames were founded on the existing concrete foundations which had been cut back and reinforced to provide some hogging moment capacity.

#### FIRST FLOOR:

The ceiling below and the flooring overlay above were removed to expose the original floor joists and flooring. Polythene was laid over the existing flooring which acted as formwork while the concrete was poured on top. Coachscrews were screwed into the top of the floor joists and cast into the concrete so that the exposed timber flooring would be supported by the concrete slab. The thickness of the concrete floors was generally 130mm although it did vary somewhat due to the out of level nature of the existing flooring.

In the large classrooms, the concrete floor spanned one way from stone wall to concrete beam to block centrewall. The concrete beam was supported by the lateral frame on the court-yard side and by the columns provided for face loads on the street side. The beam was formed between existing floor joists and cast integrally with the concrete floor.

In the smaller rooms, the concrete floor was supported entirely by the stone walls. In many cases the walls were stepped at first floor level which provided a lip to seat the slab onto. Reinforcing bars were epoxy grouted into the wall or stones were removed to create voids into which bars could be inserted. The slab reinforcing was detailed in such a way that the bars could be poked up into crevices between the stones as far as possible. Dowels were passed right through the walls and cast into the slabs on either side to ensure that the slabs were tied together.

#### STAIRS:

The existing stairs were removed and a new series of stairs constructed to provide access to the upper Units. New block-walls were constructed with lightweight stairs spanning onto concrete landings.

#### BOND BEAMS:

Concrete bond beams were constructed at roof level along the top of all of the walls, except the gable walls. Not only do these distribute the seismic loads at eaves level, but they provide proper anchorage for the roof trusses and cap the top of the walls, preventing loose stones from falling off.

The bond beams on top of the crosswalls, in many instances, had to dogleg around the existing chimneys. The gable walls were secured to the roof framing using wall plates and the framing itself was bolted back to the bond beams wherever possible.

It was calculated that in the event of a localised collapse of the stone walls, the bond beams would support the roof trusses as a last resort. In the few instances where this was not the case, RHS columns from first floor to roof were provided to support the trusses.

#### ROOF BRACING:

The steep pitch of the heavy roof and the consequent height of the gable walls and chimneys meant that a considerable seismic load would be generated along the roof planes. The sarking was inadequate to resist this and so steel angle roof bracing was provided between trusses in a number of bays.

#### CONSTRUCTION:

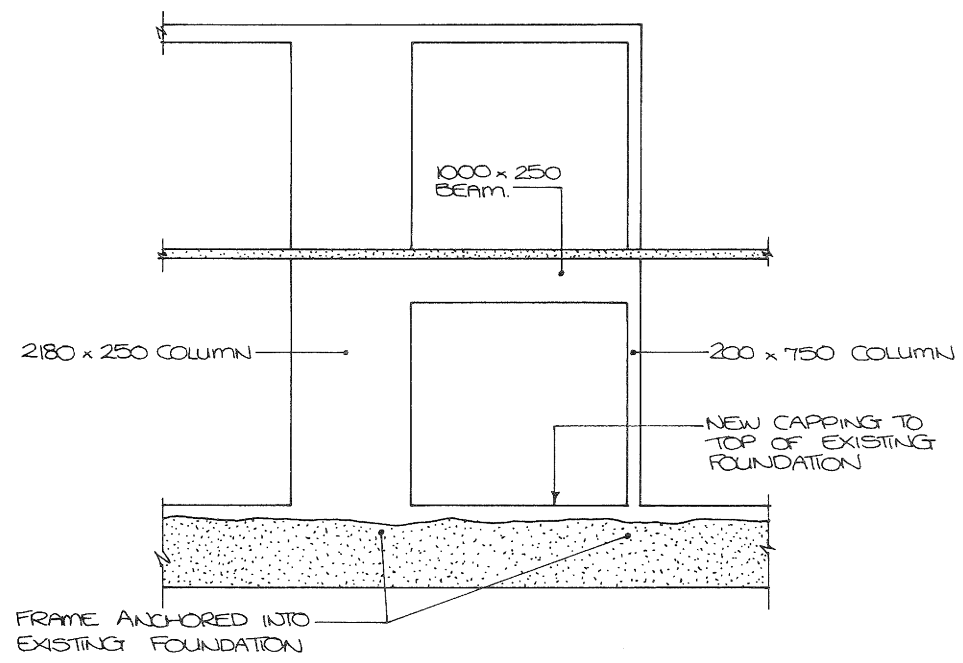
The construction work was undertaken by the developer, Berryman Properties Limited. Renovation of the Octagon was undertaken first and this was to be followed by redevelopment of the Kilmore Street wing, then the Montreal Street wing and finally the new townhouses and ancillary buildings. Further construction was to be financed by the sale of previously constructed Units.

Construction work was temporarily halted in early 1983 through lack of finance. At this stage the Octagon had been successfully renovated and almost all of the structural work, apart from a few items, had been completed on the Kilmore Street wing. Many of the Units had been completed and a number were occupied. Only preliminary demolition work and piling had taken place on the Montreal Street wing.

The structural part of the redevelopment of the Kilmore Street wing took place over a period of about six months. Construction work had been delayed by the collapse during demolition of an 18m section of the Kilmore Street wing due to the failure of some temporary props. The street wall had collapsed down to the first floor level and it was essential



NORMAL SCHOOL ABOUT 1880



TYPICAL LATERAL FRAME

FIGURE 4.

that it be reconstructed to appear identical to the original. The wall was rebuilt as a concrete blockwall with a veneer of original stones laid against this and tied to it. The wall was supported on a reinforced concrete bond beam at first floor level which in turn was supported by the columns provided to resist the face loads and by the block crosswall. The roof trusses were virtually undamaged and after the roof structure had been replaced, it was almost impossible to tell that this section was any different to the rest of the wing.

Ensuring an adequate bond to the stone wall when epoxy mortaring dowels proved to be a continuing problem. In many instances it was preferable to remove stones to create a large hole into which concrete could flow around the dowel although this was time consuming and involved a certain amount of making good. Other major problems centred around on-site measurements and levels differing from those assumed when detailing, and so sufficient allowance for this had to be made.

#### CONCLUSIONS:

This case study has described the strengthening of an historic stone school building and its conversion into luxury apartments.

The strengthening was achieved by the introduction of new reinforced concrete frames and blockwalls which, together with the existing stone walls, provided the lateral load resistance. Distribution of the seismic loads was effected by reinforced concrete bond beams at roof level, and by a reinforced concrete slab at first floor level. The roof was strengthened by steel cross-bracing and RHS columns were provided as a secondary means of support to some roof trusses in the event of a partial collapse of the stone walls.

Actual figures for the cost of the construction work are not available. The budgeted figures for the cost of the demolition and structural work (excluding reconstruction of the collapsed section of wall) associated with the redevelopment of the existing buildings, was assessed as 23% of the total cost of their renovation, or about \$120 per square metre of resultant floor area.

#### ACKNOWLEDGEMENTS:

Thanks are due to:

- (a) Christchurch City Council Town Planning Division for their booklet on the Normal School, from which Figure 1 was obtained.
- (b) Canterbury Museum for providing the photograph.
- (c) Berryman Properties Limited for their co-operation.