THE EFFECTS OF SEISMIC ENGINEERING ON ARCHITECTURE IN NEW ZEALAND

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Introduction. The history of a people is the history of its architecture reflecting as it does, its cultural, religious, economic and sociological traits. This country being some 120 years since its first ordered colonisation, has not had time to develop positive architectural tendencies, but signs do exist of some three decades. Some of the Author's statements may indicate a bias, but if this paper is to be treated broadly (as is felt proper) the State's development works must figure prominently. Thus many individual opinions and works of architects and engineers are acknowledged but collectively are deemed not to show an architecture appreciably influenced by seismic engineering.

The paper develops the theme of earthquakes and the people, traces the architectural impulses and concludes with examples.

THE PEOPLE AND EARTHQUAKES C.1800 - 1964

Casual European occupation of New Zealand had begun early in the 19th Century, principally at the many good harbours of the northern ends of the Islands. Composed often as it was of runaway sailors, sealers, intermingled with some genuine traders and settlers, the early populace was not subject to much semblance of ordered communal life until Captain Hobson R.N. achieved the signing of the Treaty of Waitangi 1840 - thereby placing these lands under the impersonal and distant aegis of Queen Victoria.

The signing of the Treaty saw the immediate implementation of ordered colonisation, which already in its preparatory stages in England began to select the most favoured areas of the new colony. By 1842, at Wellington there was a township of some 3,000 inhabitants with smaller groups at Wanganui, New Plymouth and Nelson - minor groups were scattered through the Cook Straits. Thus at an early period there was a fair sprinkling of population over the latter-defined active seismic belt running through Wellington from the south west and north easterly to the Oceanic deeps. It is at Wellington that most of the following comment concerns, being the most populated area in the active areas.

The early township was flourishing - it had established, a Municipality, Post Office, and Courthouse, Stores and Churches, together with a jail to hold up to 60 inmates. The constructional media varied but principally were brick, wood and compacted clays used usually in combination with one or both of the others - wood being plentiful was used extensively. Quite a number of commercial enterprises were of two stories in brick with wood floors and roofs. Life was rather primitive, the degrees of comfort varying with the financial ability and cargo limitations placed on the early colonisers. The streets were often quagmires, but the limited household comforts were softened by candlelight and ruddy glows from wood fires burning in the popular brick chimneys.

In the early morning hours of 1848 an earthquake listed as mag. 7-7½ (1) shook Wellington. The initial damage was quite substantial; the majority of one and two storied brick structures had gables or end-walls

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cracked or demolished, brick and clay houses cracked or split with chimneys down by the score. Damage in terms of property was comparatively extensive but the death roll of 3 was very modest. The effect on the settlers after the initial main shock had passed was so described by Dr Thomson (2): "Settlers expected the earth to open; some slept in the bush and were panic-stricken. Business was suspended, a solemn fast was ordered and the churches were filled with penitent sinners (I have been told by an old military man that there was an extraordinary number of hasty marriages during those days of panic)." But though panic may have been exhibited, disciplined calmness was there too - so much so that in order to allay fears in England the Governor in his despatch stated inter alia .. "the danger - everyone who travels a hundred miles on a railway incurs a greater risk than he would do by living a life in New Zealand. Earthquakes, therefore, are nothing to people who are used to them." (3)

From the above, it seems that a slight jauntiness was being stimulated, that Wellingtonians were rather immune to seismic tribulations and that life could be made equitable. Though not too evident in the early despatches and writings, there was some recognition of continuing earthquake susceptibilities. The British navigator Captain Cook had recorded a shock in the Cook Strait area in 1769, sealers similarly in Dusky Sound and other sources disclosed the prevalence of major shocks. Evident too, was the firm belief widely supported, that the explanation of the numerous tremors lay in the volcanic belt extending from Lake Taupo north east to the sea. Consequently as the shocks were regarded as easings of molten pressures from within the earth, credence was readily established that a rather benign Divinity would see that no great build-up and thereby shock, would disturb the way of life.

By mid 1850 if the absence of ordered solemn fasts is conclusive, the township had recovered its various equanimities. A newly-established hamlet was at Hutt, trade was brisk, interest was mounting in communal affairs, land deals flourished and Governor's dinners were sought-for invitations. Many dispatches to England, asserted the good fortune of settling in New Zealand - the bitter Maori wars were yet to come. When another major disturbance of mag. 8 ± (1) hit Wellington in 1855, days of alarm shock and damage were experienced afresh. Though reckoned to be of greater magnitude than 1848, the shock caused lesser damage to the township, particularly among the now more prevalent wood-framed houses - chimneys were down again in plentiful numbers. The effects on the region were more severe - heavy tidal movements, extensive uplift of submerged areas, and widespread land slides. There were the usual despatches home and some settlers caused unenviable amusement when after shipping out of the township, they became wrecked at the harbour entrance. After rescue they elected to stay on. The shock was felt over a wide area about its epicentre in Wairarapa. At Wanganui, one observer modestly narrated the ability of which he skirted tumbling tables and shelves to reach the outside and heavy rain, but preserving intact throughout his glass of "Old Tom" (English Gin) - the same person adjured his reader in England to leave there - "there's no fear of earthquakes in Auckland; besides a man had better run the risk of being swallowed up here than to have nothing to swallow at home (England). Plenty to eat here, and always a bottle in the house and no man to call master". (4) A further excerpt of his despatch is felt warranted because it concerns a sentinel of the 65th Regiment, standing close to the ruins of Government House, and shouting "All's

well" (4) when addressed.

It is of interest to note that Dr.P.Marshall cited the 1855 shock as having put New Zealand on the seismic map as it were, because it was described by Lyell and included by Suess in his monumental work on earthquakes as being up to then the only known observed instance of elevation of the earth's crust. The area affected was of some 1,000 sq.miles with uplifts from 5'0" to 10'0". It seems that the most general lessons learnt from these two shocks were, the unreliability of brickwork unless heavily supplemented by timber framing, the resilience of wood framing and the damage susceptible to brick chimneys and clay-compacted houses.

Over the next 70 years or so, minor shocks and tremors appear to have persisted but the prevalence of non-damaging ones, caused relaxation of the concern after the two early major shocks. Further, the country was sparsely populated and no deaths were reported attributable to earthquakes. Life in the colony was vigorous, the Maori wars were finished, the turn of the century, a new liberalism of political outlook and the Boer War absorbing a great deal of public and political interests. The early 20th Century saw no increase of apprehension as regards damaging earthquakes, in spite of many pertinent observations by individual geologists and surveyors, who with competence had established fault lines. The evidence of these rather worked against a national acceptance of the problem, in that it helped to foster 'safe' areas. Few, if any, Local Bodies had restricting By-Laws and little public lead was forthcoming from Government, whose own works varied by recognising some of the dangers according to the views of the initiating designers.

In a sparsely-inhabited area about Murchison in 1929 an earthquake of mag.7.0 (1) caused some spectacular land failures with a death roll of 17. The most public result of this was the establishment of seismograph stations, but other than arousing greater speculative interest by a more perceptible awakening of Government and regional Local Bodies, there was no need deemed necessary to define a code of earthquake-resistant ordinances. But by February 1931, after the worst death roll (256) yet experienced, at Napier mag. 7½ ± (1), Government apart from its prompt relief measures acted swiftly in forming several Authorities to define new building codes, to rehabilitate the stricken areas and to settle claims arising from the disaster. Damage to buildings and property was severe particularly by the subsequent fires; railways and roads were disturbed, with extensive movements in the harbour or adjacent areas.

From this time onwards, there grew an appreciable public cognisance of the great uncontrollable potential of a major earthquake, but as time passed, so did the willingness to set controls. By 1935 the New Zealand Standards Institution published its Model Building By-Law which, though it formulated a code for national usage, lacked authority for compulsory acceptance, thereby allowing Local Bodies to reject in whole or in part design bases which, in their opinion were unwarranted in their areas. As Dr. Thomson shrewdly observed after 1848 "No kind of panic subsides sooner than an earthquake panic." (2)

The depression rolled away and life began to assume more of its usual hues, even though war now seemed imminent. Absorbed by the unique threat of war reaching these then lonely shores, Wellington in 1942 was jarred by a shake of mag. 7 ± (1) centred in the Wairarapa. The city did not fare so

badly in terms of major damage. There had been a tightening of By-Laws by the Local Body as regards large uncompartmented brick load-bearing walls with loosely tied wood floors and walls, heavy cornices and overhangs. But in smaller communities these restrictions were not so enforced, with resulting greater damage.

The engineering profession by inducing legislation to enforce the compulsory and annual registration of engineers, ensured that the structural carcase would be designed by competent people. Established as a democracy and peopled almost completely from one ethnic group, nearly a century had elapsed, punctuated by a persistent crop of annual reminders before the politicians, who theoretically should trigger off legislation to meet public animations, established a prohibition to control buildings designed by unqualified persons. Upon the conclusion of hostilities, an Earthquake and War Damage Commission was formed in 1945 to meet emergencies of a national nature with contributory finance supplied from fire insurance. Zoning now seems the last major problem to be resolved.

In concluding this short review, it may be contended that there were many ameliorating circumstances to defend the apparent apathy of the people towards a legislative control of building design and erection in a country with an established seismicity - the sparse population with a very strong pastoral background, the Maori wars of the North Island, the absence of rapid transportation, the isolation of the country and the scarcity of adequately-trained engineers and architects willing to accept the country's characteristics, may be a few. Perhaps, too, may reside the basic disinclination of colonists who, initially seeking the freedom and individualism of a new country, engendered unconscious resistance to the controls that would be inherent in reducing seismic damage, particularly when gauged against the urgency of establishing homes, industries and enterprises for sustenance. Rather contradictory do these latter reasons become when one assesses the comparative ease with which Welfare Statism has been promoted and accepted.

EARLY ARCHITECTURAL OBSERVATIONS UP TO 1954

The early settlers, except in their farmhouses particularly, showed little inclination to foster a regional style based simply on the functions to be performed, the materials available and the techniques to hand. The cultural roots were back in the British Isles from whence, filtered by long sea voyages, came the decaying remnants of the post-Revival Battle of the Styles, suitably pruned by local restrictions of labour and economic usages. The isolation of 13,000 sea-miles increased the nostalgia for the known forms and architectural idioms thereby making easier the acceptance of those who could emulate the familiar shapes, irrespective of the subject materials. In Wellington of some 80 years vintage or so, stands one of the largest wooden office buildings in the world, faithfully exhibiting in wood the attributes of a stone wall-bearing construction already then centuries old. As wood was plentiful, and further established in the central districts as a flexible medium to withstand damaging shock, it rapidly became the principal mode of construction for housing - bricks were used sometimes by the more affluent.

The two major shocks of the mid-19th century for some twenty years or so imposed a better system of tying heavy wood framing (floors and roofs) to brick load-bearing walls. But the lessons were gradually forgotten or

ignored particularly towards the end of the century which saw the introduction of cavity walls, cement mortar, and concrete encased iron members. The architecture had changed little. Victorian traits were quite the vogue, especially in the bland detachment of the ornamented street facade from its adjoining side ones. Plastered onto built-out supporting brickwork were placed the heavy cornices and paraphernalia of the style.

In the larger communities, the great majority of the architects drew on their overseas training, the background of which attuned them to a continuity of those professional tenets held by their previous countries. Little appreciation of the country's characteristics nor its demands seemed evident except in street verandahs and the ubiquitous farmhouse, the latter usually built without professional assistance. Some very pleasing structures, readily associated with Old Country prototypes were built, assuring with more than some sentiment their cultural standing in the community. The scene remained static during the early twentieth century except for the introduction of concrete-encased steel, plate-glass and reinforced concrete or ferro-concrete to give it the then popular title. The architecture followed a sort of 'follow-on' to Renaissance traditions.

By 1931 architectural development was berefit of inspiration. The Napier earthquake with its demonstrated failure of brick load-bearing walls saw a rapid acceptance of reinforced concrete which, by its seemingly implastic nature (if based on economics) heralded in a very plain wall type of architecture, relieved by plastered frets and reliefs. The dominance of solid to void was significant even though early thinking of the impending 1935 Model By-Law postulated maximum resistance being taken by a frame. The superficial Napier style was borrowed largely from America and died quietly of its manifest weaknesses.

The depression of the mid-thirties rolled away and the first Labour Government was voted into power. As a vigorous housing policy was of major social priority, soon the building industry was being reunited from its enforced dissolution. The new housing, though it corrected many of the speculative builders' horrors operated almost entirely within the wood techniques. But more State enterprises were being designed and built with an interesting trend which set the pattern on architecture for several decades.

The influence of new State policies was felt noticeably under the new Government, which generally handled about 40% of its own works at that time, with the remainder being done by private practitioners. These latter people were aware that since the damaging Murchison and Napier shocks, the State had adopted the policy of designing its structures earthquake resistant to a good degree, thereby hoping as a side benefit, that a lead would be established for the country. But in areas remote from an historical sequence of shocks, the relevant Local Bodies in general did little to supplement State policy.

By the middle of the 1930s the principle of steel-frame for high-rise structures with reinforced concrete for low ones was used by the State which in retrospect had an inconsistency. When using reinforced concrete in low-rise buildings, because fire resistance measures established stiff walls about lifts, staircases etc., the great majority of all internal walls were in reinforced concrete too, so that a heavy and rigid compartmentation was introduced with minimal openings. This system worked externally

with the type of Georgian proportion elevations for the relation of solid to void in the external walls allowed easy two-way reinforcement, well-distributed, thereby producing walls of good stiffness. The full implications of these built-in rigidities were not applied to the steel-frame. Here there were the same stiff inner walls as well as those from a random pattern separating occupancies on one floor. The elevational character allowed the same type of stiff external walls to be developed in both directions but there seemed no conscious acceptance of these by structural designers. Planning was not compromised by the system of framing.

By the latter part of the 1930s, the principle of stiff members attracting heavier seismic loadings was being introduced by the State. The prototypes of shear-wall technique were being designed and of these the Dental Clinic Wellington (1939) built in reinforced concrete displayed many advantages over contemporary steel-frame structures. There was now a more orderly layout of stairs, lifts and internal bracing walls for this form of planning had advantages in resolving Egress Codes.

Second World War mobilisation was urgent and housed in wood which was rapidly expanded to all sorts of differing functions. Though it was engrossed with war, the Labour Government began designing and constructing multi-storey flats which had an impact, apart from the criticism of prosecuting political legislation during a major conflict. But these flats did help to sustain interest in the problem of seismic engineering, particularly as little construction work other than timber was being done. The most successful block was the Dixon Street block, being essentially a cellular load-bearing reinforced concrete structure on shear wall principles with simple exteriors relying almost exclusively on void to solid proportions.

With peace came rehabilitation urged on by desires to continue broken careers. Gone was the pre-war serenity enjoyed by the School of Architecture in teaching untravelled students; everywhere there were experienced ex-servicemen seeking new developments and firmly aligned against any return to the unquestioning adulation so inherent in historicism. For the first time conditions were favourable for the elements of a national architecture to be formulated. However, the Labour Government with considerable justification, imposed a rigid Building Control which was not uplifted by a new Government until 1952. Except for housing, hospitals and schools, building control was enforced with great severity. Of the large structures built during this period, as the majority were financed from State funds the early approaches to shear-wall design by State engineers were carried further; there were refinements of void to solid relationships, with internal planning and exterior orderliness being more noticeable. The style of the architecture was of severe Georgian proportions, with none of the character found in Swedish work which could have been studied more widely as a prototype.

With the 1952 freedom from controls, the only established continuity of design bases was that of the State's. The early 1950s saw a more liberal easing of the rigid shear-wall architectural strait-jacket. Information was now becoming available again from America and Japan - the glass curtain wall era was being first sighted in overseas publications.

The engineering legislation of 1942 was showing its benefits, for it induced a more receptive appreciation of likely shock damage by Local

Bodies. The Earthquake and War Damage Fund being applied nationally, irrespective of local support for zoning, was a persistent reminder.

AN ASSESSMENT OF ARCHITECTURE FROM 1954

Among the New Zealand national characteristics, individualism is not far below the surface - an attribute of our early colonisation conditions and isolation. These traits, inclined by academic teaching, have established a professional pattern composed largely of very small practices with a minority only, willing to serve in larger offices which are often better integrated by engineering associations. Thus the small practices, though numerically large, have not established any dicernible continuing development of an architecture conditioned by seismic engineering. Their structural consultants are hired job by job with very little likelihood of continuity of design development. It is to the larger associations of architects and engineers that developments can be traced, but War and Building Control restrictions had virtually halted progress for nearly two decades.

The belief that engineers and architects should be integrated to the common objective of good building is not shared, of course, by all architects; some hold that to the architect lies the challenge to produce a structural concept, the details of which should be refined and resolved by the structural engineer. This seems more firmly held by those engrossed with form as the first objective in successful architecture, but it must be difficult to show positive advances unless the architect is equipped technically equal to the structural engineer. Because it has been fortunate in maintaining a permanent core, the Ministry of Works has over the last ten years definitely worked towards the closest integration, thus accepting the concept of coincidental architectural and structural themes - both professions can be completely committed without disparagement one to the other.

In the private field there is no parallel to the State's 30 years of endeavour broken though it was by war and controls. Few if any firms with engineering associations have been in practice more than say, 20 years and most of the principals have been associated with the State.

But progress is felt to have been made over the past ten years. A large State office building using shear-walls was built in Auckland and several aspects needed correction, such as the stiff walls about vertical services (lifts, stairs, etc.,) and the regular piercing, storey by storey, of internal bracing walls for circulation. In the next major office project the planning system was based on two cores, built up of bracing walls, unpierced, and enclosing the vertical services etc., Though this concept had many advantages in freeing subdivision and circulation, when carried to the logical end of using one core only, the gross floor area beyond the bracing system was not outstandingly productive. Core principles have been used by private practitioners in recent structures in Wellington, the freedom from deep-membered spandrels giving architectural freedom in cladding the exteriors.

In developing variations up to 6 storeys the State has expanded the core into an elongated centrally-positioned set of bracing walls, enclosing the lifts, lavs., and some circulation, thereby increasing the gross floor area beyond the bracing walls. Though this form of seismic planning gives unrestricted choice of cladding materials, secondary damage is liable to be

high unless adequate design factors for the claddings and inter-storey deflections are recognised. With its resources and continuity the State has a reservoir of design bases which private practitioners can seldom accumulate. Further, these design bases often resolve the project's needs to best advantage in short times - it is with satisfaction that one observes how coherent do resolutions come from this method of coincidental architectural and structural themes which is reflected in very economical carcase costs.

The private field has more difficult sites in city commercial work than the many island sites of the State. The small frontages to section-lots in conjunction with lengthy side boundaries dictate stiff side walls, with deep-membered spandrels front and rear, from which most of the natural daylight must come too. To clad these latter walls with glass-curtain walling is often too easy, and to many a retrograde step, reminiscent of Rococo philosophy. In the Wellington City, the Local Body is encouraging aggregations of sub-standard sections, upon which a new structure, if free on all sides to light and air, is permitted height relaxations to equivalent areas.

As noted earlier, the private consultant often operates under two systems of design, and with one - the Local Body system - there is less possibility of establishing a continuous development because the type of project varies from architect to architect. Hence it is difficult to illustrate in this field, specially if located in historically inactive areas (which influences Local By-Laws) any dicernible influence of seismic engineering on architecture. It is more discernible in State works, which irrespective of locality have been designed to a fairly consistent level of coefficients etc.,

At Christchurch there has been a marked regional style developed in reinforced masonry which to Wellington eyes is very venturesome. The architectural expositions are very uninhibited, for within this locality are the country's most 'compulsive expressionists', working admittedly with a virility seldom seen in Auckland, which never seems able to forego glossy-page architecture. The vocabulary of the Christchurch group is not extensive, nor must it be necessarily so, but intense preoccupation with form often overstimulates the designer to such a degree that, to other eyes, his work often seems a sort of volumetric joke - to be judged if it must more by rules of sculpture than of architecture.

Conclusions.

Though supplemented by recent precast techniques, as the choice of materials and constructional media has remained narrow in this country, some conclusions may be made as follows:-

1. Based on its performance, the wood-framed house has established itself as a logical form of construction. Even in exotic species it is plentiful, has technology behind it and seismically has a good record of light damage only, usually repairable by the handyman.

2. Brick and masonry are associated more as exterior linings to wood-framed houses; research is needed to make greater use of these materials for low-cost building.

3. The most economical form of permanent construction is reinforced

concrete for all its materials are nationally procurable - steel ingots excepted, being imported. Seldom does structural steel compete economically with in situ reinforced concrete and its monolithic qualities - precast work is often marginal with in situ reinforced concrete and tilt-up work should be encouraged more.

4. There is a fashionable trend to extend beyond the 102' in high-rise structures, but there seems little tried evidence upon which to fix ordinances to cover this relaxation.

Acknowledgements.

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Comments on Illustrations.

1. State Shear-Wall Developments

Dental Clinic Wellington 1939 Fig.1. Is the first known reinforced concrete prototype shear-wall building over 50'0" high. The building was designed with transverse shear-walls and deep longitudinal pierced walls and suffered no discernible damage in the 1942 shock (mag. 7 ±).

Dixon St. Flats, Wellington, 1942 Fig.2. The largest multi-storey flats in this country. The design is of reinforced concrete shear-walls with elevations relying entirely on proportions. This structure introduced a more contemporary State architecture. The engineer for this work was a consultant - the late Peter Holgate.

Flats, The Terrace, Wellington, 1957 Fig.3. A more refined reinforced concrete shear-wall structure, based on maisonette planning, thus allowing the major structural rhythms to be expressed elevationally.

Standard Police Station 1958 Fig. 4. A simply resolved structure utilising longitudinal spandrels, transverse end shear-walls with some internal bracing - the architectural expression is typical of those developed with this structural theme.

Government Printing Office 1959, Fig.5. With its industrial bias and heavy live floor loads (250 p.s.f. uniformly), this structure being in the Government Centre of Wellington needed to express a well-tailored industrial character. The vision strip windows set in precast facing panels are supported off projected floor slabs. The lightly-framed all-glazed top storey houses the Administration.

2. State Core Developments.

Bowen Street Office Building 1957, Fig.6. This was the first essay at a core structure which essentially has two towers shaped like an "H" with flanges, buttressed at the base into a raft foundation - core area to gross floor area - 21%. The metal exterior cladding to the end walls compromises the essential nature of the towers.

Aitken Street Office Building 1961, Fig.7.* The logical step from the Bowen St. with one core carried 16 storeys above ground - a steel frame used in conjunction with reinforced concrete made this the first composite structure of this type in the country - core area to gross floor area 24%.

Science School Auckland University. Fig. 8.* A large project wherein functional requirements were resolved into two main types - large span teaching areas and small research areas. The construction is designed for composite concrete (pre-cast and in situ) with precast claddings, sun controls etc., Design coefficients were lower for this area.

Science School Massey University of Manawatu. Fig.9. Functional requirements were for a standard block varying between three storeys and six with teaching areas peripheral to central service rooms with flexibility for future alterations. Structure is composite concrete.

Meteorological Office Wellington, Fig.10. The overhanging top storey was due to the Forecast Room being larger than any other suite combination. The structure, of composite concrete, has an elongated core accommodating vertical services etc., The sun controls are precast.

3. State Composite Framed Development, Fig.11.*

Postal Centre Wellington. The requirements were for major postal handling facilities (5 floors) and office facilities (7 floors). Several external treatments were tried more on exhibiting the functions of the areas enclosed - the scheme as illustrated returned to the principle of using structure as the co-ordinating theme of two differing functions.

The structure is of steel frame composite with reinforced concrete and precast claddings.

4. Private Consultants.

Arts/Library Victoria University of Wellington, Fig.12.

Kingston, Reynolds, Thom and Allardice
Architects and Engineers.

This structure is of considerable interest, being the only known multi-storey precast structure of this type. Structurally the aim was to ensure minimum construction time for a relatively light building of low earthquake response. The commanding site is sloping and functional requirements requested freedom of internal structural walls to facilitate expansion.

The columns are in situ, poured behind pre-cast forms, with high tensile deformed bars; floors are of ribbed construction, pre-cast pretensioned, 23" deep x 36" wide x 60'-0" long and weighing 9 tons. Apart from the continuity question, this project was a major step in attempting to shorten the chronically slow construction times prevalent in this country.

These structures are treated elsewhere in papers at this Conference.

Arts/Library, Massey University of Manawatu, Fig.13.

Kingston, Reynolds, Thom and Allardice
Architects and Engineers.

The functional requirements requested maximum daylight, solar protection and large open internal spaces free of walls. Bracing is had by two double longitudinal beams from stiff end walls passing through two small centrally-positioned stiff open cores in which are placed stairs etc., All shear walls, columns and connecting beams are in situ with pre-cast floors, spandrel panels and solar fins.

Flats, Christchurch, Fig.14.

Architect: Dornithorne.

An orderly example of reinforced masonry and flat concrete floors with three flats per floor.

Reserve Bank Building, Christchurch, Fig.15.

Architects: Trengrove, Trengrove and Marshall.

A reinforced concrete core structure attached to a podium of several floors, with no structural separation vertically. The core area to gross area of a typical tower floor is approximately 19%. The elevation makes use of reinforced masonry and pre-cast units.

Combined Office-Residence Christchurch, Fig.16.

Architects: Warren and Mahoney.

A structure utilising some of the entrenched traits of the area - a freely-handled and over-conscious form, reinforced masonry, and by Wellington standards, a startingly light bracing system. Within its concept, though, it does illustrate the commendable objectives attainable by thorough architect-engineer associations.

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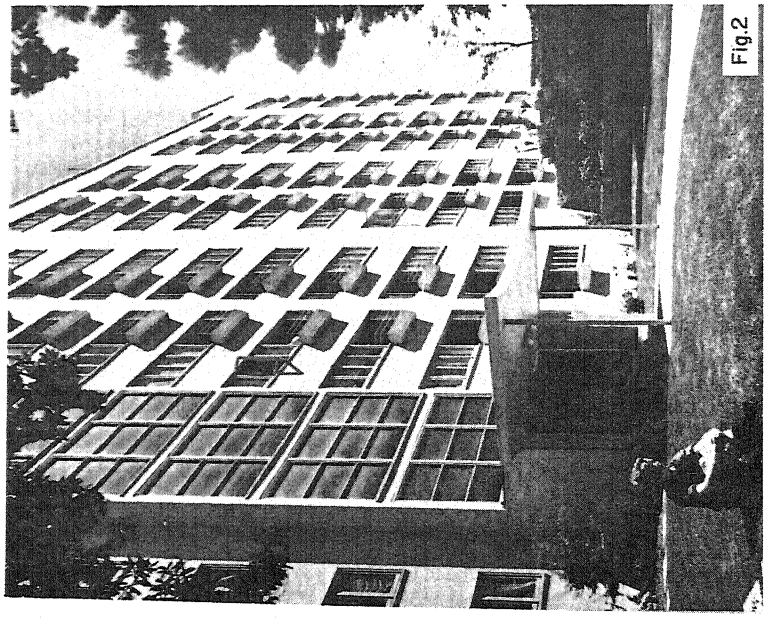

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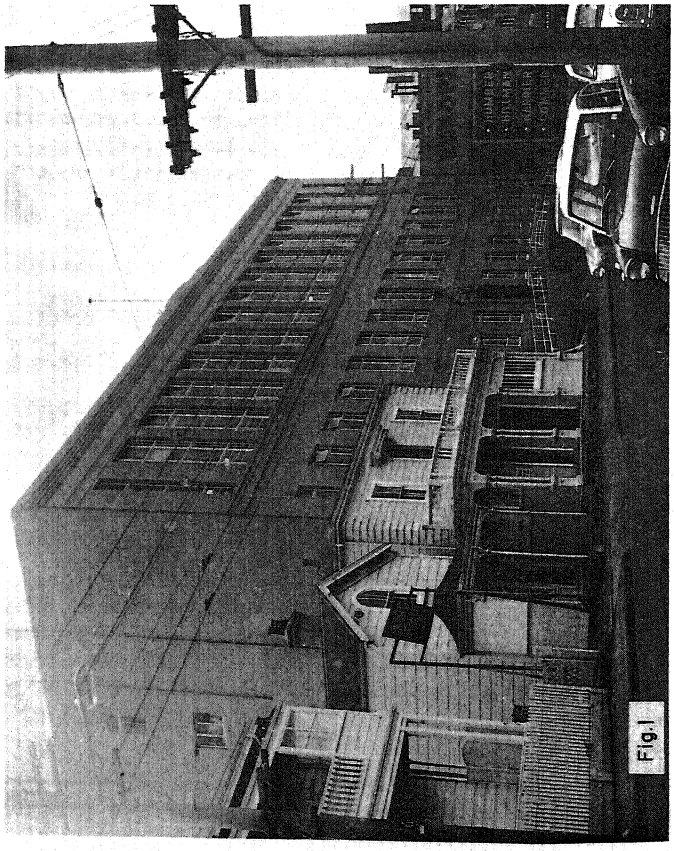

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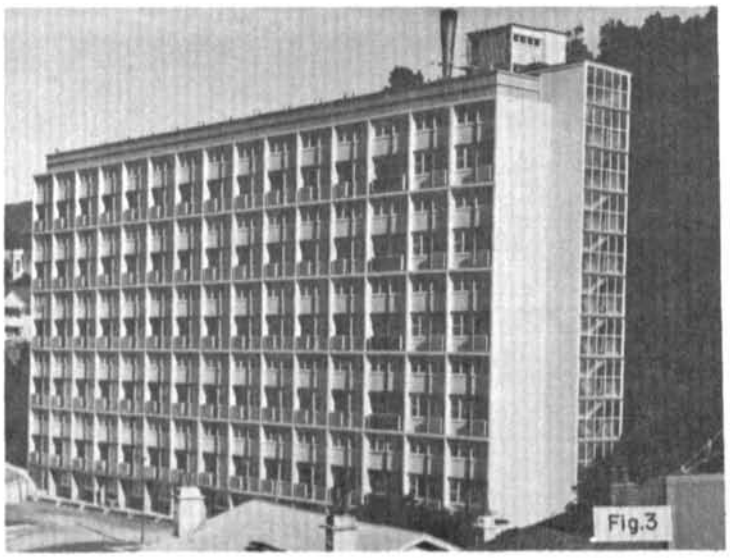

Fig.3

NEW CENTRAL POLICE STATION
DON STREET - INVERCARGILL

Fig.4

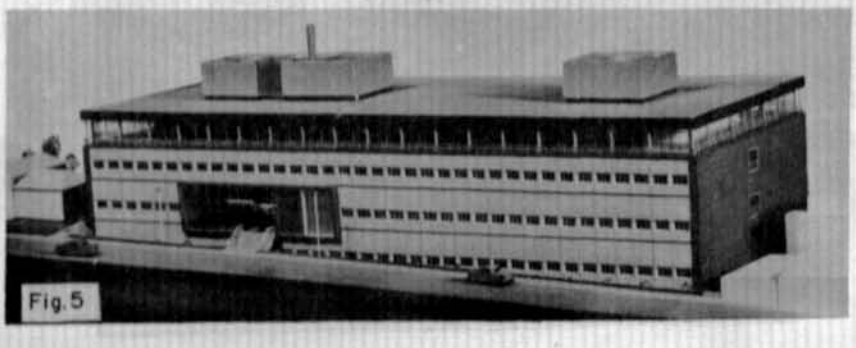

Fig.5

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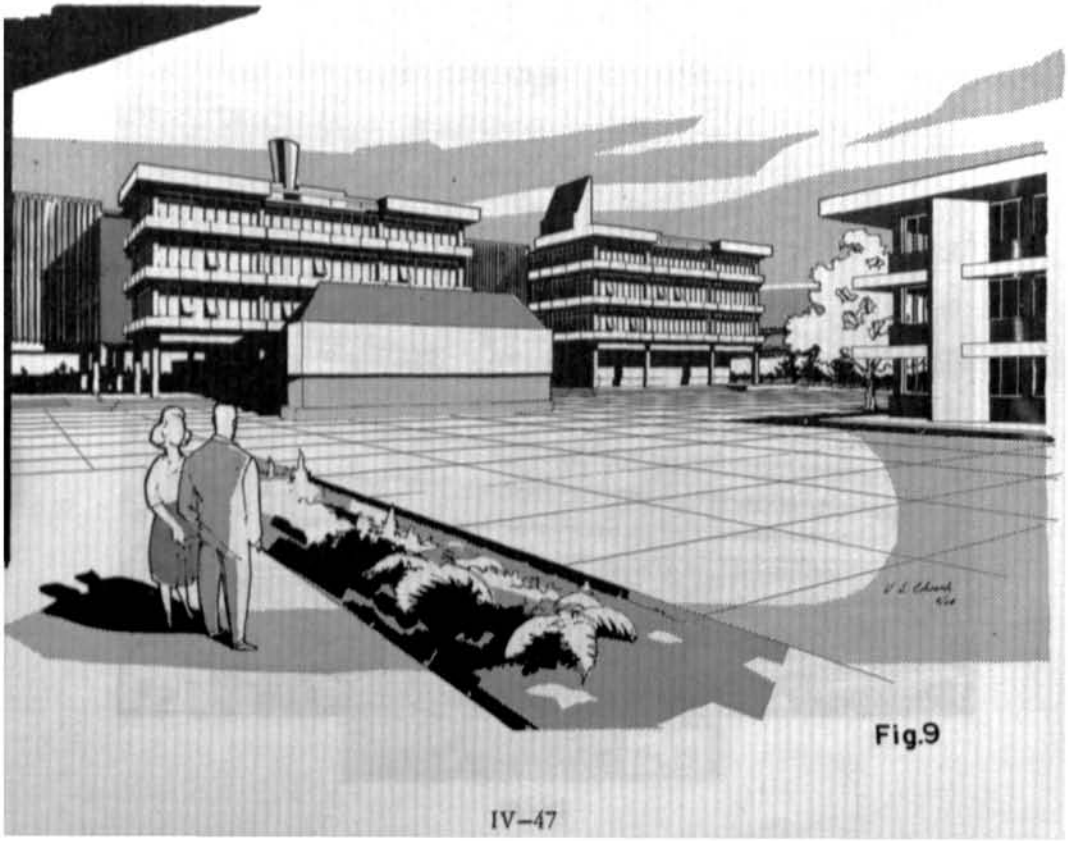

Fig.9

Fig. 10

Fig. 11

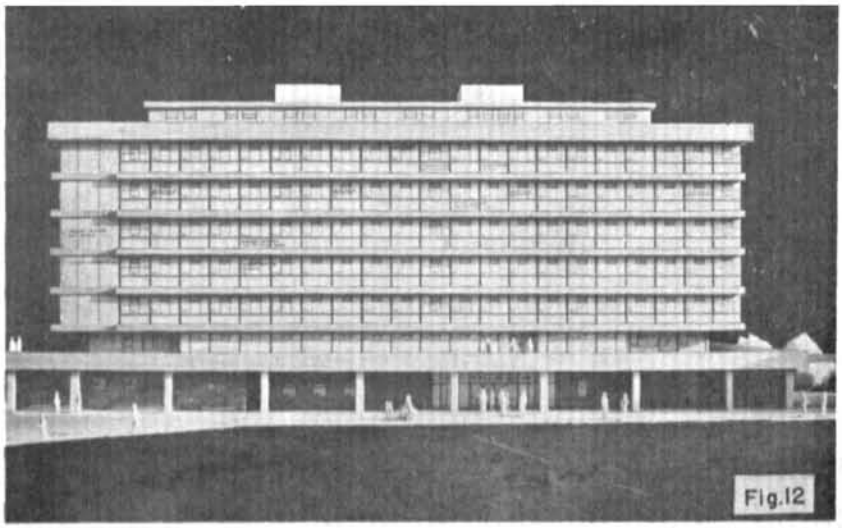

Fig.12

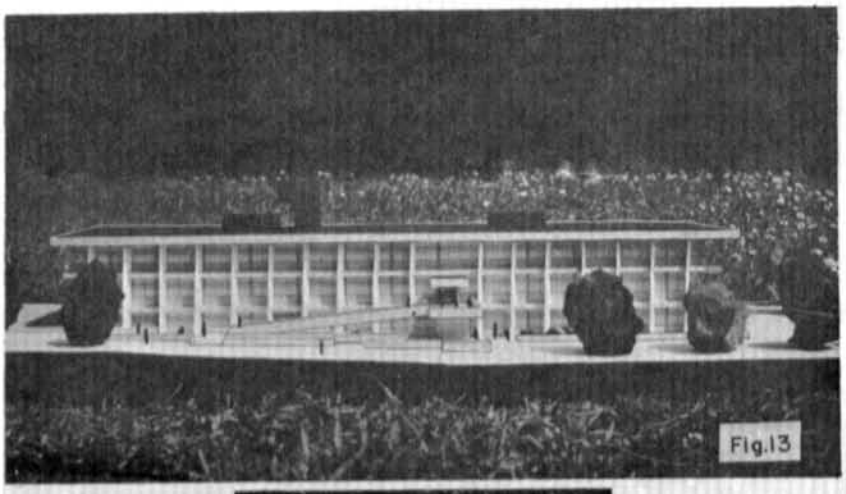

Fig.13

Fig.14

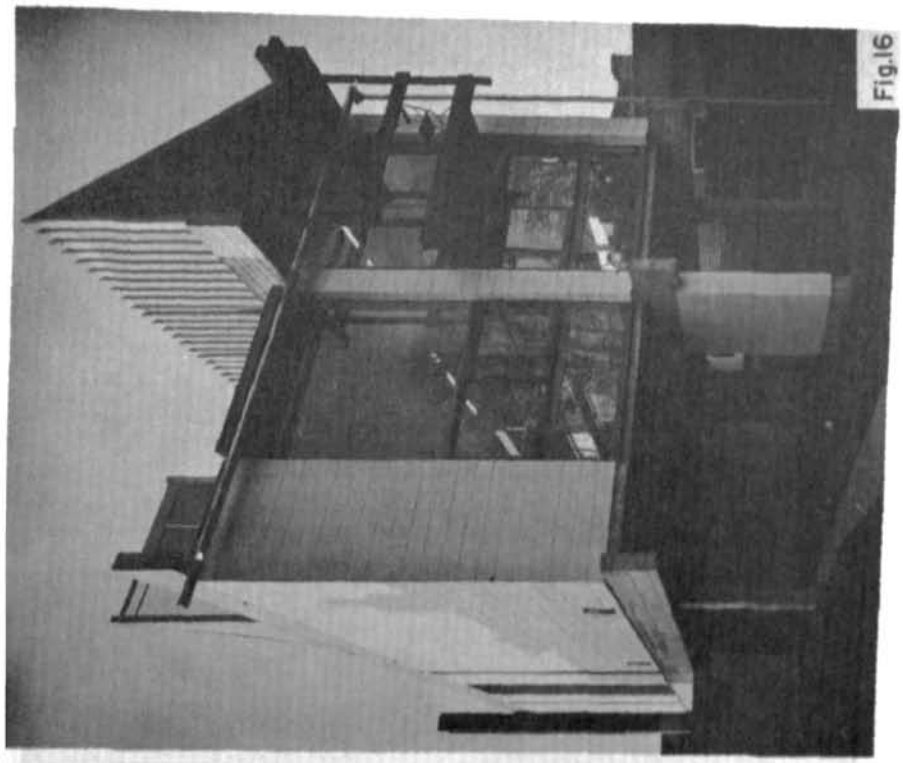

Fig.16

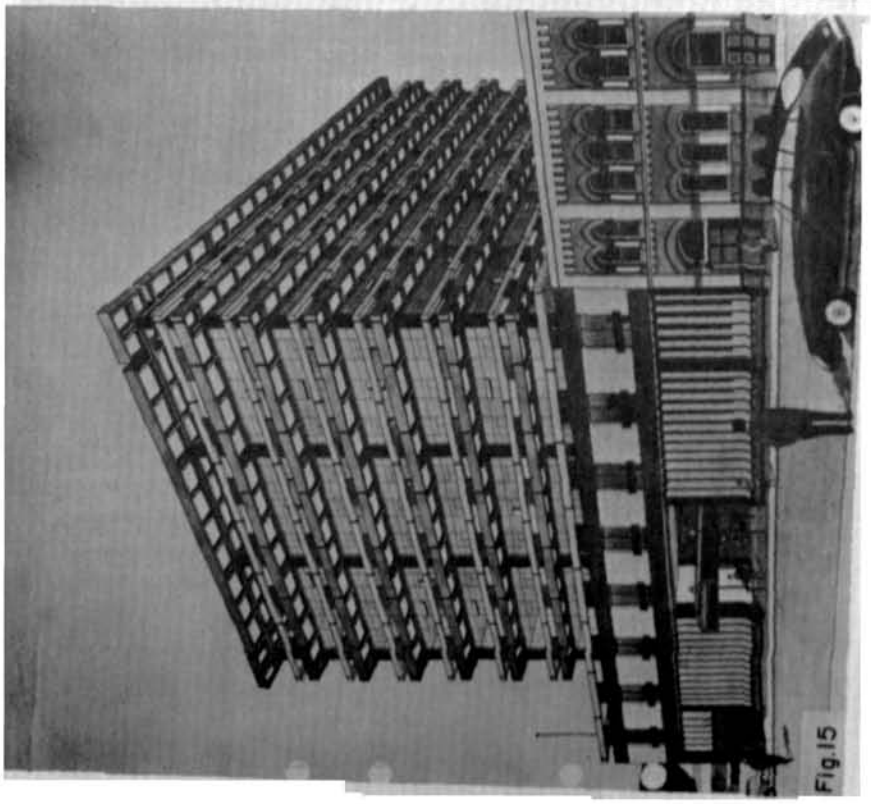

Fig.15

THE EFFECTS OF SEISMIC ENGINEERING ON ARCHITECTURE IN NEW ZEALAND

BY J. BLAKE-KELLY

QUESTION BY: A.W. SMITH - NEW ZEALAND

Could Mr. Blake-Kelly please indicate what actually are the effects of seismic engineering on Architecture in New Zealand. Presumably there is a loss in space from large members and it must be much more difficult to attain an optimum planning layout. Can a cost be assigned to this? Secondly what is the effect of seismic protection to architectural finishes etc. glazing, partitions and masonry etc.

AUTHOR'S REPLY: The paper comments on the lack of national acceptance of a uniform code for resisting seismic shock. Many Bylaws are years out of date and thus, contemporary architectural and structural idioms are appraised under pressure often without adequate precedence and not because of their stated merits. Further, there seems no unified seismic design philosophy for these new idioms, other than that of the Ministry of Works, who incidentally, have acknowledged in their works, that zoning could be an acceptable risk.

Because of its continuing interests the Ministry has shown over recent years developments of an architecture influenced by seismic engineering - in non-technical terms, to display buildings that look as though they can withstand earthquakes. This attribute, I believe, arises from our co-incidental architectural and structural concepts. In the private field, the differing architectural beliefs together with differing Local Body requirements, have noticeably restricted the number of architectural developments conditioned by seismic engineering.

In the main, seismic engineering has simplified planning and forced more regular structural forms, thus leading to economies in the carcase. Space has been lost and overall carcase costs have increased, but to what degree, I cannot state with confidence. To arrive at the increased costs it would be necessary to conduct surveys over a wide range of projects designed on two bases - gravity with wind resistance for one and seismic resistance for the other. Further, the type of project would influence the differences - a single storey office would show quite considerable reductions of cost margins as against a sixteen storey office building.

In answering the second question, the need to restrict secondary damage must be observed. On our large high projects we incorporate degrees of movement for external claddings, building services and vertical services, but in major items only. One often leads to another. For example, I believe that a building with glass curtain walling should have concrete verandahs along its street lines or over its principal egress areas - this introduces quite considerable structural problems. Another important service to safeguard is that of water for many new buildings have survived the shock but suffered fire damage because no water was available for fire-fighting. Thus as heavy water mains are vulnerable to damage, the sources of fire from within the building as well as those from any combustible adjacent structures needs investigation. Limiting secondary damage can be quite a large exercise to the designers.