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Structural glazing in New Zealand: development and current status

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Structural Glazing In New Zealand; Development And Current Status

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SYNOPSIS

This paper gives some background to the introduction of structural glazing designs to New Zealand, in particular, external flush glazing where silicone sealant is the sole structural restraint for the glass. This technique is only used in limited applications in New Zealand with restrictions being imposed by local authorities on its use. The background to these restrictions is covered and future prospects for flush glazing mentioned.

INTRODUCTION

The history of structural glazing in New Zealand can be traced back to suspended assemblies and total vision systems. These were being developed in the United States in the late 1960s as a means of providing large, visually uninterrupted expanses of glazing. Typical applications were in grandstands at racing venues, then in the lower floors of corporate offices and in retail shopping complexes. In suspended assemblies, glass was suspended from its top edge and secured at the bottom in a glazing channel. Adjacent panes were butt-glazed with silicone sealants eliminating mullions. Glass fins were used to stiffen the assembly. The limitations of this system were that the self-weight of the glass meant assemblies could only span two floors, and the plates and bolts required were visible from the exterior. The Total Vision System was developed by PPG Industries. This utilised glass mullions which were fixed to the glass panes with high modulus silicone sealant. The glass mullions limited the deflection of the large panes of glass used in this system.

Both of these systems were picked up by the New Zealand building industry and are still being used in New Zealand today. They are typically limited to the bottom one or two levels of buildings.

These systems provide excellent vision areas and also present a relatively sheer appearance from the outside. The desire to extend this flush uninterrupted surface to more of the building envelope led to the development of systems in the USA where the glass was attached to the building by sealant alone. The first example of this appeared in 1972 in Detroit. The Smith Hinchman Grylls building was refurbished and silicone sealant used to stick glass panes to metal framing. Local building authorities, somewhat anxious about the prospect of large panes of glass falling on passing pedestrians, insisted that a mechanical restraint was included in the design. This was provided by a "spider" device that screwed into the backing mullion at corner points and held the glass back against the frame. These restraints were eventually dispensed with when they were found to be causing stress cracking of the glass panes.

Since then structural silicone glazing has become increasingly popular in the USA. In 1976 double glazed units were used in two-side sealant supported glazing, and in 1978 in four-side silicone supported glazing. A significant proportion of glass curtain walls now being built are structurally glazed.

USAGE IN NEW ZEALAND

Although the first example of external flush glazing appeared in Detroit in 1972, it was not until the early 1980s that any serious interest was shown in using it in New Zealand. The first recorded request received by BRANZ for design information on external flush glazing was in July 1983.

To date three buildings in New Zealand, all in Auckland, have external flush glazing as part of their cladding. Two of these were site-glazed with a stick system. The third used a PPG system where the glass was adhered to aluminium mullions in a factory in the USA. After a recommended curing period the units were shipped to New Zealand for installation, with only the weather-seal being site applied.

TYPES OF SYSTEM

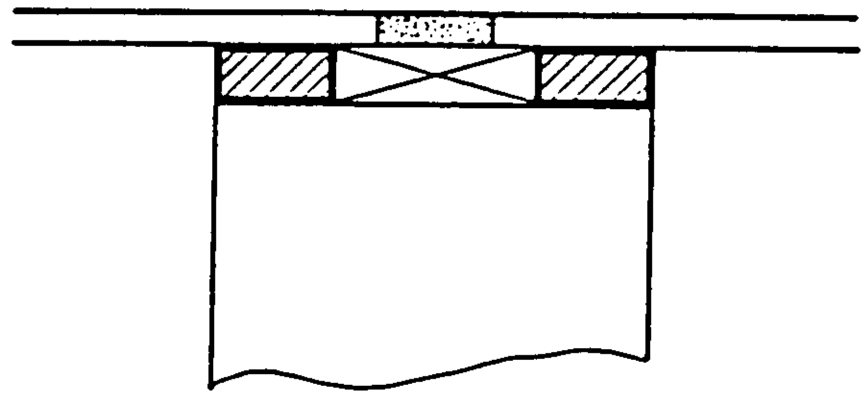
External flush-glazed systems with four side silicone support are generally described by two names, either stick or unitised. Stick systems are characterised by on site structural silicone application. The glass panes are held on to aluminium mullions by temporary supports and silicone sealant applied to the gap formed between the aluminium and glass by spacers. The width or bite of the silicone bead is controlled by backing rods. Figure 1 shows a possible stick joint detail.

Unitised systems have panes of glass preglazed to frames or units which are then connected to the building. This system has several advantages over stick sysytems as it allows the application of the structural silicone under factory conditions. Figure 2 shows a possible unitised joint detail.

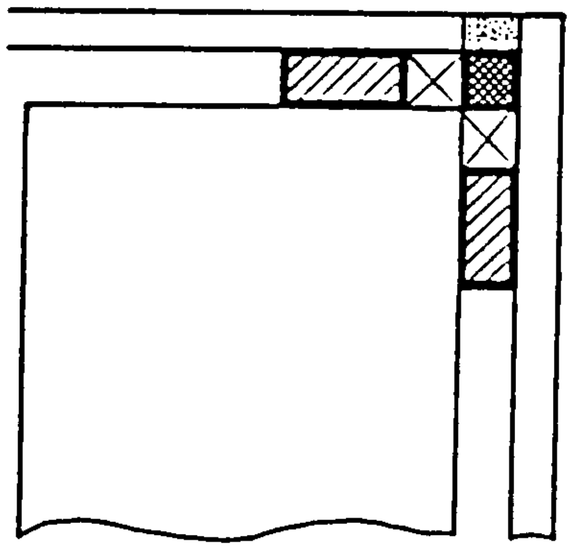
SEALANT MANUFACTURERS INPUT

As in the USA, some sealant manufacturers who recommend their sealants for structural glazing in New Zealand offer customer support. Local manufacture of structural silicone sealants is not carried out in New Zealand. Instead, local companies import and re-label sealants from Australia or the USA. Examples of this are the Dow Corning sealants supplied by Selleys Chemical Company and General Electric sealants supplied by Ados.

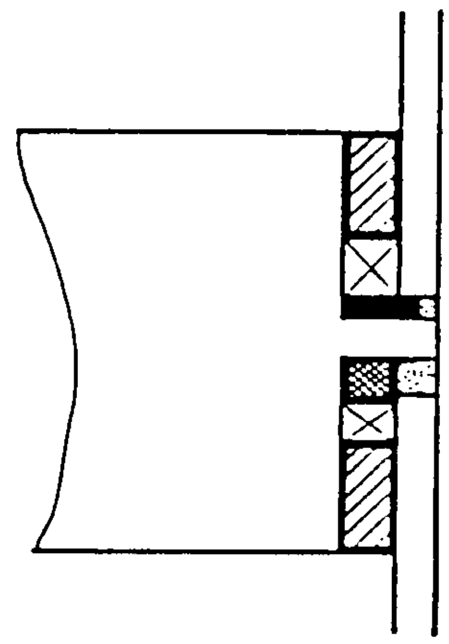
Typical sealant manufacturer customer support involves reviewing sealant joint design, specifying the sealant to be used and offering testing for adhesion, and compatibility between sealants and components such as spacers, backing rods and setting blocks. Under certain conditions a 10 year guarantee on the performance may be offered. Most testing is carried out in laboratories in Australia or the USA; however, typical test times are of the order of six weeks.



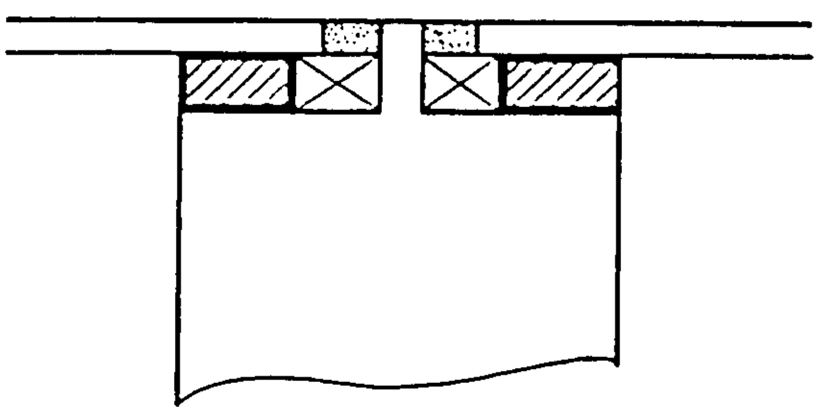
1(a) Cross section through a vertical joint



1(b) Cross section through a corner detail



1(c) Cross section through a horizontal joint



1(d) Cross section through an alternative vertical joint

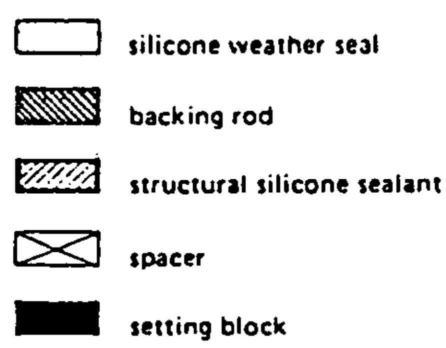
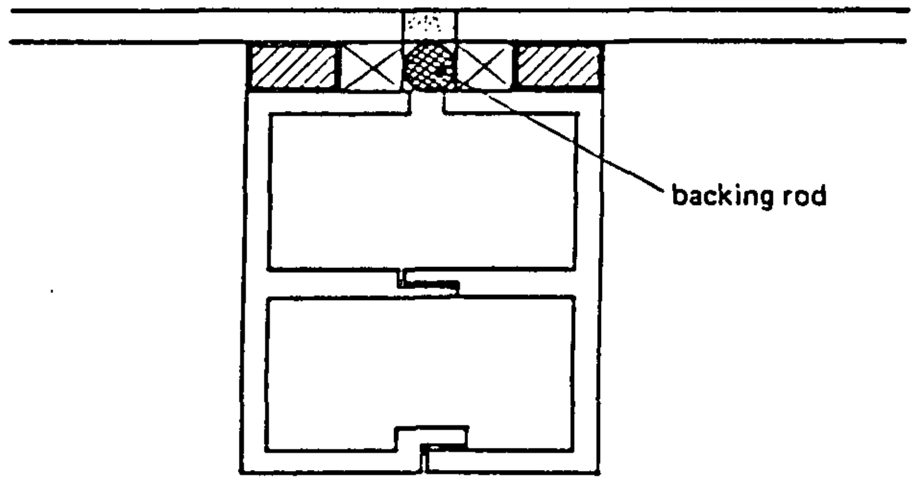
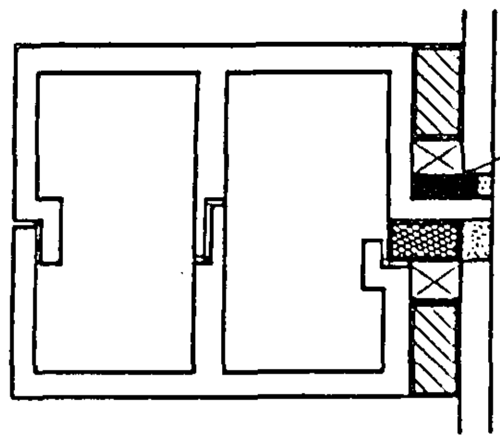


Figure 1. Examples of External Flush Glazing Joint Designs



2(a) Cross section through a vertical joint



2(b) Cross section through a horizontal joint

Figure 2: Unitised Glazing Joint Details

LOCAL AUTHORITIES AND FLUSH GLAZING

An important reason for the present lack of buildings under construction in New Zealand which incorporate external flush glazing, are the restrictions placed on its use by local authorities.

External flush glazing was reported in the press in an emotive fashion when interest was first expressed in its use by developers with terms like "stick-on" and "glued-on" glazing being used. The Standards Association of New Zealand (SANZ) issued a news release in April 1985 on "stick-on glazing systems" which advised councils to exercise caution before adopting any new materials, forms of construction and methods of design for which information on performance was not available in terms of the requirements of their "Model Building Bylaw", NZS 1900 (1976). This document consists of eleven chapters which set out performance requirements and refers to codes of practice and specifications which are an approved means of compliance with the bylaw. Where a material, form of construction or method of design is not covered in the model bylaw, an approval may be gained by application to the council's engineer. The engineer may refer to other organisations with expertise in the appropriate field to assist in reaching a decision.

Chapter 10 of the model bylaw (1964) refers to non-structural external wallings. For glass curtain walls, an approved means of compliance prior to 1985 was New Zealand Standard NZS 2258 (1969) "Recommendations for glass and glazing". Since 1985 the revised version of NZS 2258 known as NZS 4223 "Code of practice for glazing in buildings" (1985), has been an approved means of compliance with the bylaw. Neither of these documents covers external flush glazing. Approval to use this form of curtain walling therefore has to be gained from the council engineer in each case.

The reaction of the Wellington City Council to developers who planned to use external flush glazing on multi-storey buildings in Wellington has been to restrict it to the first two floors, and if it is used above this level to require mechanical restraint of the glass. This decision was made after assessing the available data on flush-glazed systems.

Their reluctance to accept the use of a system, which according to reports is widely used in the USA, is based largely on two reasons, quality control of construction and seismic movement concerns.

Quality Control

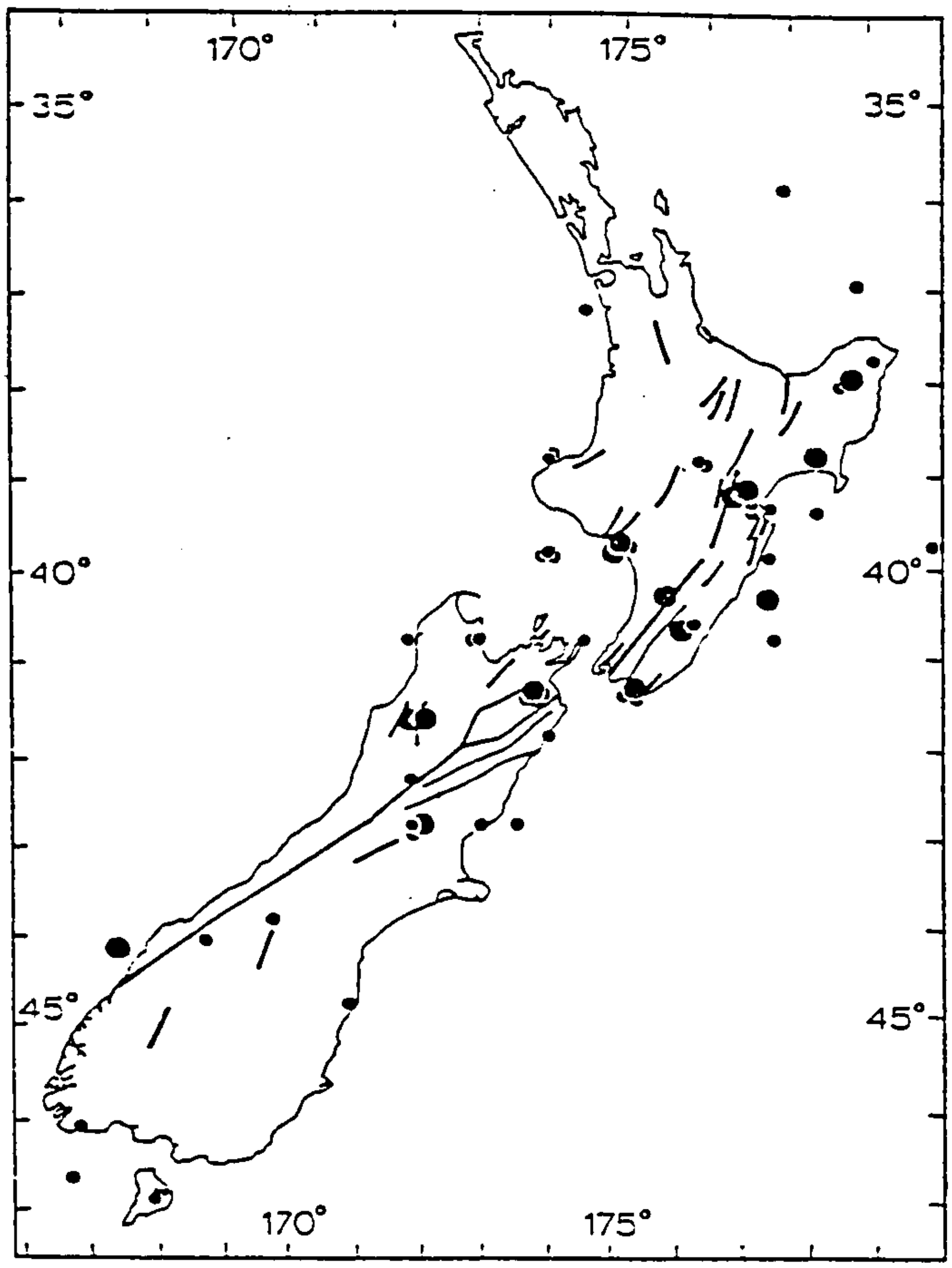
Experience in the USA has shown that external flush glazing systems can work well if the recommended procedures are followed rigorously. However, the system has the opportunity for many pitfalls. The integrity of flush-glazed systems is totally dependent on the adhesion of structural silicone sealant to both the glass and framing. As with any adhesive system, sucessful bond development requires meticulous substrate pretreatment. This will include cleaning with solvent and adhesion testing of the sealant with all substrates and each new batch of substrates. Priming may be necessary. To meet all the recommendations involved is extremely difficult on site. Condensation must be avoided, and under New Zealand conditions where the humidity is frequently in the range of 75-85% (Duncan 1985), this can cause problems. The absence of a pool of tradesmen skilled in structural silicone techniques is also a drawback. While many of these problems can be minimised by factory application of the structural sealant (where the environment can be controlled to optimise conditions for sealant application and cure) there still remains an element of uncertainty.

A further concern of local authorities is that they do not have staff conversant and experienced in structural glazing technology. This makes it extremely difficult to ensure that appropriate standards of design and workmanship are being followed during the design and construction process.

Seismic Activity

Undoubtedly the area arousing the most concern is seismic movement. New Zealand is situated on the boundary of the Indian and Pacific plates and is subject to earthquake activity. Figure 3 shows the principal active faults in New Zealand and places where large earthquakes have occurred. Figure 4 shows the Wellington city area. It can be seen that the city is built on an active fault. This does not necessarily mean that the city will be more prone to earthquakes than, say, an area 30km away, but historical records show that large earthquakes have occurred in Wellington.

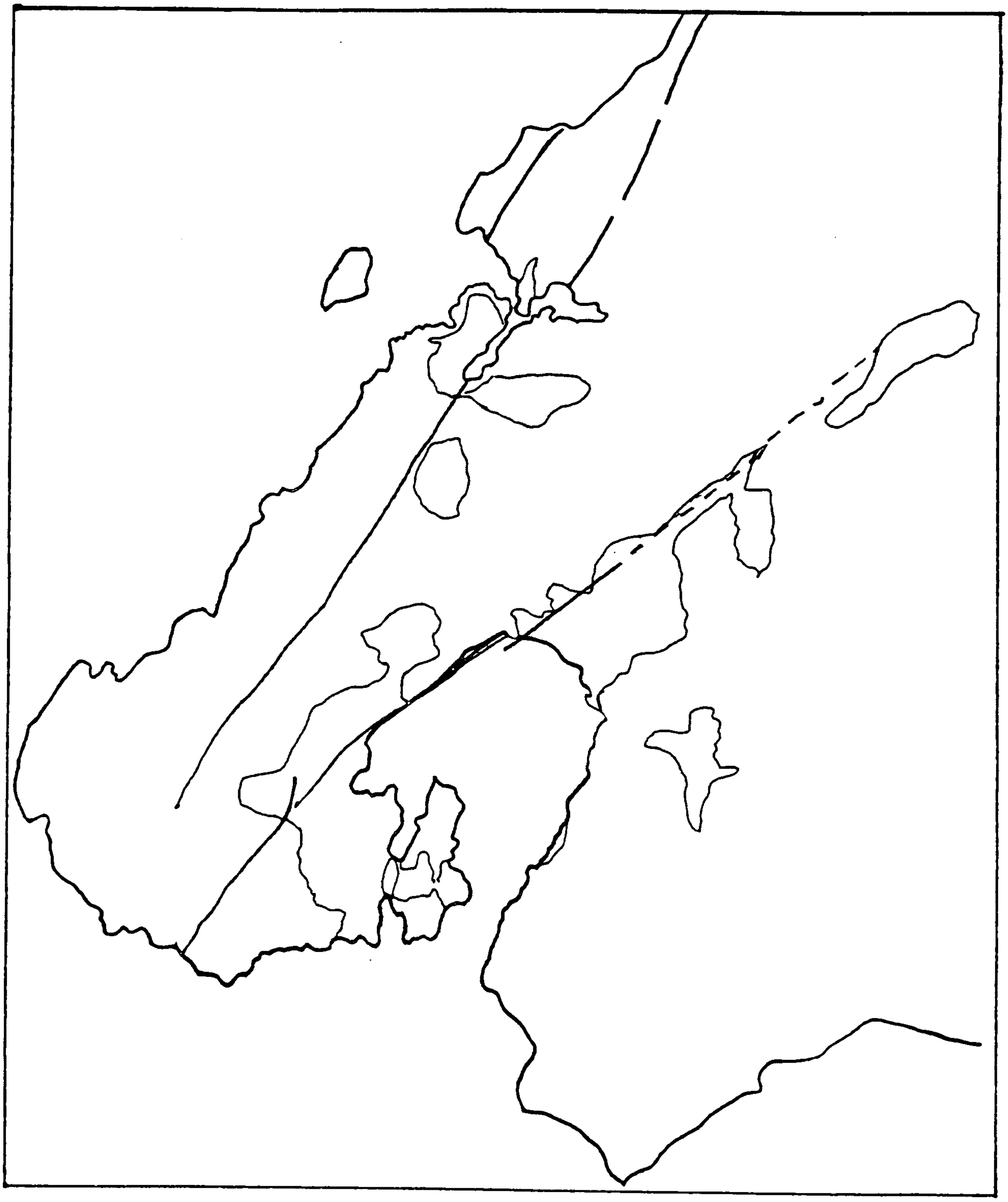
Figure 3 Principal Active Faults and Major Earthquakes Since 1840.



—— Principal active faults
● Magnitude ≥ 7
● Magnitude 6.5–7

(From Dowrick, 1983)

Figure 4 Faults in the Wellington Region



Built-up areas

Faults

Naturally enough, local authorites in New Zealand require buildings to be designed with some earthquake resistance. Chapter 8 "General Structural Design and Design Loadings" of NZS 1900 "Model Building Bylaw" (1976) states that the general structural design method and design loadings shall be approved as appropriate to achieve minimum non-structural damage in a moderate earthquake, and the avoidance of collapse and irreparable damage and loss of life and injury in and around the building in a major earthquake. NZS 4203 "General Structural Design and Design Loadings for Buildings" (1986) is one means of compliance with Chapter 8 of NZS 1900. This Standard attempts to limit non-structural damage by requiring separation of non-structural elements from the building structure where inter-storey deflections are greater than 0.0006 of the storey height. A maximum deflection of 0.01 of the storey height is allowed and elements such as precast units and glazing must be separated by the deflection distance. Where the element may alter the structural behaviour of the building (e.g., rigid partitions and stairways) the separation must be twice the allowable deflection. The commentary to the Standard notes that the required separation distances are significantly smaller than those which could result from a major earthquake.

Reports on the performance of structural glazing systems under imposed seismic loads (e.g., from racking tests) are not common. Racking is done in some cases in California on mockups which have been used for weather penetration testing and dynamic loading of the glass. These tests are in most cases privately sponsored and seem to involve a simple racking procedure using a hydraulic ram.

Conventional gasket-glazed curtain wall systems have some inherent movement capability resulting from the ability of the glass to move in the glazing channels between the gaskets. In many cases (particularly where appropriate tolerances are not maintained) this movement capability is insufficient to cope with inter-storey deflection and the designer must include additional separation provision by using seismic sub-frames or receivers. Flush glazing will obviously have some movement capability due to the elasticity of the silicone sealant. However, an 8mm bead of sealant cannot be expected to withstand an inter-storey deflection of 30mm. If the aluminium/silicone/glass bond is subjected to this degree of movement in the shear direction then the likely results are adhesive failure of the sealant, tearing of the sealant or breakage of the glass.

The silicone sealant in flush glazing is used to provide resistance to windloads and in some cases support the deadload of the glass. It should not be expected to withstand additional loads such as those imposed by earthquakes. The flush-glazed glass must be considered as part of one overall design process that includes fixing to the building frame, floor to floor separations and corner detailing.

In the absence of extensive test results to substantiate the claims of companies wishing to use external flush glazing, the Wellington City Council decision to restrict the use of this system remains. All other Councils with high rise building underway in the areas in their jurisdiction appear likely to follow this lead.

FUTURE DIRECTIONS

Designers and developers still remain interested in using flush-glazed systems. In one case a proposed cinema complex was designed with flush-glazed reflective glass on the street facade. This was modified to take account of the requirement for mechanical restraint.

One method of providing mechanical restraint for the glass in a flush-glazed system, while still maintaining a relatively sheer uninterrupted facade, is to use countersunk bolts at intervals around the circumference of the pane. These can only be used on toughened glass. However, the detail where the bolt connects with the mullion, or in some cases the building frame, must also be designed with seismic movement provisions in mind.

The New Zealand National Society for Earthquake Engineering has formed a study group which is presently looking at the question of non-structural elements in earthquakes. The group aims to publish their findings in a "state of the art" report which will serve as a basis for further work and assist those preparing building codes.

In its 1987/88 programme of work, the Building Research Association of New Zealand (1987) includes a project which will be investigating racking tests for glazing systems and the movement capability of some flush-glazed systems. The project will be looking at what happens to curtain walls in an earthquake and using this information to design a testing regime. This regime will provide local authorities and designers with data which will enable them to evaluate the likely performance of such glazing systems.

It is unlikely that blanket approval for external flush glazing will eventuate in the near future, however, it is possible that if each case is considered on its merit some approvals may be given. Before this can happen, developers, designers, engineers, curtain walling companies and all sub contractors involved in the curtain wall, will have to demonstrate to the local council's satisfaction that they have mastered the technology and have the appropriate levels of skill and quality assurance required in their operations. Detailed engineering analysis of the building behaviour and test results on the curtain wall under seismic loading would appear to be essential.

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