BLOCK 15 HERITAGE REDEVELOPMENT VANCOUVER, B.C.

SEISMIC UPGRADING

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SUMMARY

Block 15, located in the heart of old Vancouver, consists of the Old Post Office, the R.V. Winch Building, and the Customs Examining Warehouse (all built prior to 1913), and the Post Office Extension (1936).

Recent development proposals for the surrounding area indicated that Block 15 would once again be placed in a strategic location and the four buildings have been designated as having heritage value worth preserving. For these reasons it was decided that all the existing buildings in Block 15 be retained, fully restored and extensively renovated. This paper will describe the structural and material aspects of the seismic upgrading which will be one of the largest undertaken in the Vancouver area.

INTRODUCTION - HISTORY OF BLOCK 15

The main Post Office for Vancouver was the first building to be constructed on the Block 15 site being completed in 1909. It contained four storeys and was topped by an ornate clock tower in the southeast corner. Once the building was completed the five storey R.V. Winch office building was commenced immediately to the west. Figure 1 shows the Post Office with the Winch Building still under construction circa 1909.

The Customs Examining Warehouse located immediately north of the Winch Building was commenced at about the same time and was completed in 1913. The final building in Block 15, namely the Post Office extension was completed in 1939 and was attached to the Post Office at the north end.

In 1977 a Heritage Report was commissioned by Public Works Canada which recommended that all the buildings be designated Heritage.

THE EXISTING STRUCTURES

Once a decision had been made to retain the existing structures on Block 15 it became necessary to evaluate them as far as their load carrying capacity was concerned.

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1. Old Post Office
   Very few existing drawings were available and the only structural information was contained on a few architectural sections. The structures appeared to consist of a concrete slab on steel beams and girders. Interior steel columns and exterior load bearing masonry walls carried the loads down to the massive granite foundations.

2. Winch Building
   Once again existing structural details were very sketchy. The framing appeared to be similar to that of the Old Post Office except that steel columns were embedded in the exterior masonry walls to carry the gravity loads to the foundations.

3. Customs Examining Warehouse
   Plans were available showing the layout of the steel beams, girders and columns. The structure appeared to be similar to that of the Old Post Office in that the beams and girders were supported directly on the exterior masonry walls.

4. Post Office Extension
   A complete set of structural drawings was available for this building. The structure consisted of a three inch thick concrete slab with closely spaced concrete joists supported by concrete encased steel girders and columns. The interior walls were of reinforced concrete while the exterior cladding was non-load bearing and appeared to be reinforced and attached to the structure. The foundations were of reinforced concrete.

Because of the incomplete nature of the information on the existing structures it was necessary to carry out an extensive materials investigation to provide supplementary details.

MATERIALS INVESTIGATION

It seems to be characteristic of heritage buildings that information regarding the main structural framing and load support systems is very sketchy. Thus, in order to be able to carry out a meaningful gravity load and seismic analysis it is necessary to conduct exploratory surgery. Materials investigation of the Block 15 buildings included the following:

1. Extensive diamond core drilling was conducted in all four buildings. This enabled typical through-the-wall and through-the-floor construction details to be established. Some remarkably complex composite flooring systems were encountered. e.g. a core profile through the floor in the Winch building revealed the following: 1/4 inch thick heavy-duty linoleum floor tile, on 1/4 inch thick ceramic tile, on 1 inch thick mortar bed, on 4 inch thick 700 psi., cinder concrete, on 5 inch thick 2000 psi., normal density concrete, on 1/2 inch thick plaster coat.

2. The type, location and depth of embedment of reinforcing steel, wire and mesh in floors was determined by means of a pachometer magnetic testing device, in conjunction with exploratory coring, cutting and drilling. A wide variety of metal reinforcements were detected. These varied from the use of a 8 inch x 4 inch diamond wire mesh to bundled pairs of 1/4 inch diameter steel bars, 4 inches apart, wrapped with 1/8 inch diameter steel wires in a diamond shaped configuration.

3. The complexity of such composite flooring systems defies conventional structural analysis and consequently the only meaningful manner in which to assess the structural capacity of the system is to conduct load testing. A load test was conducted on the third floor slab of the Post Office building. A floor load of 125 psf was applied to part of the floor area using sandbags and floor slab deformations were monitored. Structural framing and bracing was installed under the slab to provide support in the event of slab failure. As it turned out, the slab satisfied all the necessary load deflection and recovery criteria.

4. In order to assess the lateral stability of exterior walls it was necessary to establish the constitution, thickness and strength of the masonry materials. This was done by coring, cutting, drilling, removal and testing of masonry materials. The compressive strength of masonry mortars was established by the use of a Windsor Penetrometer, which fires a projectile into the mortar bedding layer. The depth of projectile penetration is related to the mortar strength.

5. The details of connection of the steel frame members to the exterior masonry skin of the Post Office, Winch and Customs Examining Warehouse were established by opening up the structures at appropriate locations. Typical bearing details were as follows:

   a) In the Post Office the main steel floor beams spanning into the exterior wall had no mechanical connection to the granite masonry blocks on the exterior face of the walls and only gravity and friction connections to the clay brick construction on the interior portion of the walls.

   b) While the steel beams in the Winch building were joined by a riveted connection to the vertical steel columns embedded in the inner portion of the exterior walls, there was no mechanical connection between the steel columns and the exterior granite blocks.

   c) The steel beams in the Customs Examining Warehouse, by contrast, were connected to the masonry wall through the use of shear keys, consisting of round steel bars penetrating the steel web and protruding into the wall.

6. The Customs Examining Warehouse contained a complex copper clad ornate box frieze at the roof level as illustrated in Figure 2. This frieze was 7 feet wide at the top and projected approximately 4.5 feet beyond the face of the building. In order to establish the details of construction of the frieze and the method of connection to the building, an inspection port was first excavated in the 28 inch thick masonry wall, through which a camera was inserted to photograph internal construction details. Selected sheets of copper were then removed from the top of the frieze for detailed examination of connection details.

7. The copper-clad ornate clock tower can be seen in Figure 1. The lower portion of the clock tower was comprised of a composite granite masonry exterior wall and clay brick interior wall, reinforced with vertical metal tie-rods connected to reinforced concrete floors at two levels. The dome portion of the tower was of wood construction. Deterioration over the years had permitted the ingress of water to the extent that there

was some rotting of structural wood components and deterioration of interior clay brick units and mortar. The shear capacity of the masonry mortar was determined by pull-out tests on clay brick units. The compressive strength of the mortar was ascertained by Windsor Penetrometer testing and finally the presence of dry rot in structural wood members was determined by incremental boring.

SEISMIC ANALYSIS

Using core sample data obtained in the materials investigation the weights of the existing structures were estimated and a static seismic analysis was carried out on each building in accordance with the National Building Code of Canada, 1980 Edition. This indicated the following:

1. Old Post Office
   The analysis showed that this structure could resist about 70% of the Code prescribed forces in the North-South direction and 90% in the East-West direction. There was inadequate seismic separation between this structure and the Winch Building and the tie between it and the Post Office Extension was not adequate to transfer the force required to connect them. Also the exterior masonry walls were unreinforced which was in non-conformance with the Code.

2. Winch Building
   According to the analysis the capacity of this structure in each direction was about 10% of that according to Code. In addition to the problems mentioned above regarding the separation with the Post Office and unreinforced masonry walls, this building had a high parapet wall which was not tied back to the roof at the top.

3. Customs Examining Warehouse
   This structure could only resist about 15% of the lateral force in each direction. The exterior masonry walls were unreinforced and the roof had a large cornice projection which needed to be braced (Figure 2).

4. Post Office Extension
   Since this building was of more recent vintage it was able to fully resist the Code prescribed forces. However, it was inadequately connected to the Old Post Office.

PROPOSED STRUCTURAL SOLUTIONS

Several types of elements are usually considered when providing seismic resistance in an entirely new structure. They are:

1. Moment Resisting Frames. These provide the greatest flexibility to the architect since movement through them is freely permitted. They are also the least stiff as far as resistance to lateral forces is concerned. Generally they are constructed of structural steel.

2. Braced Frames. These can accommodate openings at certain prescribed locations.

3. Rigid Shearwalls. These require careful integration with other disciplines since the locations of openings have to be carefully controlled. They are the stiffest means of providing lateral resistance and are usually economically built of reinforced concrete.

When considering renovations to an existing structure the most economical solution obviously involves the minimum disruption and new construction. For Block 15 there were several other considerations:

1. The buildings were clad with masonry walls which were fairly stiff. Therefore, if a frame was used to resist seismic forces much of the force would be absorbed by the walls before the frame could deflect.

2. Any frame system required the columns to be closely spaced in order to achieve reasonable sizes. The only building with closely spaced columns was the Winch.

3. The beam-column connections in the existing frames did not possess sufficient ductility to absorb the seismic forces so they would have to be substantially upgraded.

4. In general steel frames would require fireproofing except for seismic bracing on which the City of Vancouver has generally allowed a relaxation.

5. The frame solutions would require less foundation work.

6. Any bracing would have to be connected to existing beam-column connections of which very few details were available.

7. Large scale application of reinforced shotcrete to the inside faces of the masonry walls would be very expensive and also impossible in several locations because of the heritage designation of some inside walls.

8. New stairs and elevators were to be provided because of fire safety considerations. These provided locations for shear walls or braced bays.

After considering these factors it was decided that the seismic forces should be resisted by reinforced concrete shear walls located around the new stairs and elevators. The locations of the walls were coordinated with the architect to minimize torsional eccentricities.

Attention then turned to the problems of seismic separation of the structures. The proposed architectural scheme provided a central pedestrian way which dissected the block. This necessitated removal of part of the Post Office Extension thus disconnecting this building from the Old Post Office and simultaneously solving the problem of inadequate seismic separation. Further, new stairs and elevators were located at the junction of the Old Post Office and Winch Building so the two structures could be rigidly connected by means of these elements.

Frame-shear wall analyses were carried out on the upgraded structures which indicated that the exterior unreinforced masonry walls were stiff enough to attract substantial seismic forces. The stresses in the mortar due to out of plane seismic forces were found to be only 10 - 15 psi. Since the strength of the existing mortar varied from 200 to 400 psi it was decided

that distress in the exterior walls would be minor. The City of Vancouver indicated that it would concur with this conclusion. Further upgrading of the exterior masonry walls was complicated since both the interior and exterior faces of the buildings were designated as heritage elements. However, several steps were proposed to ensure satisfactory performance.

1. Additional steel columns and beams were to be embedded in the walls of the Old Post Office and Customs Examining Warehouse to support the vertical floor loads.

2. The floor slabs were to be connected to the walls at each level.

3. Parapet walls were to be anchored back to the roof.

4. Joints which were found to have deteriorated were to be re-pointed.

5. The clock tower atop the old Post Office was to be strengthened by removing the inside clay brick, adding reinforced shotcrete to the inside face and adequately connecting it to the roof structure.

The general arrangement of the structural solutions is shown in Figure 3.

CONCLUSIONS

This paper has discussed the renovations to the four heritage buildings comprising Block 15 in downtown Vancouver. Information on the existing structures was very sketchy so an extensive materials investigation was completed to determine the types and qualities of the construction materials. A seismic analysis was carried out in accordance with the National Building Code of Canada and several serious deficiencies discovered. Various structural solutions were explored and the constraints provided by the existing buildings discussed. Finally some proposed solutions have been presented.

ACKNOWLEDGEMENTS

CLIENT:	Public Works Canada Pacific Region Vancouver, B.C.

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FIGURE I. POST OFFICE AND WINCH BUILDING UNDER CONSTRUCTION (CIRCA 1909)

FIGURE 2. CORNICE ON ROOF OF CUSTOMS EXAMINING WAREHOUSE

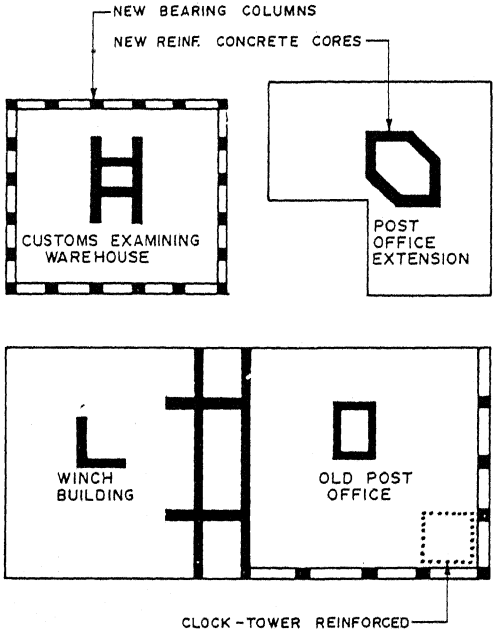

FIGURE 3. PROPOSED STRUCTURAL SOLUTIONS