UNDER	**THE COMMISSIONS OF INQUIRY ACT 1908**
IN THE MATTER OF	**ROYAL COMMISSION OF INQUIRY INTO BUILDING FAILURE CAUSED BY CANTERBURY EARTHQUAKES**
	KOMIHANA A TE KARAUNA HEI TIROTIRO I NGA WHARE I HORO I NGA RUWHENUA O WAITAHA
AND IN THE MATTER OF	**THE CTV BUILDING COLLAPSE**

STATEMENT OF EVIDENCE OF WILLIAM DAVID COATSWORTH IN RELATION TO THE CTV BUILDING

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STATEMENT OF WILLIAM DAVID COATSWORTH
IN RELATION TO THE CTV BUILDING

1. My name is William David Coatsworth and I reside at 211 Jeffs Drain Road, RD2 Kaiapoi.

2. I am employed as a Senior Associate, Structural Engineer by CPG New Zealand (**CPG**). I have been employed by CPG since 2008.

Qualifications and experience

3. I have been practising as an engineer specialising in civil and structural engineering for approximately 40 years. I am a Chartered Professional Engineer and an International Professional Engineer and a member of the Institute of Professional Engineers NZ.

4. By way of brief background summary, in 1971, I graduated from the University of Canterbury with a Bachelor of Engineering with Honours.

5. From 1973 to 1994, I worked as a civil and structural engineer for Sheppard Partners, becoming a partner in 1979. Sheppard Partners specialised in structural engineering and design with a particular focus on the health and education sectors. For example, between 1980 and 1994, I was responsible for much of the design for the Christchurch Hospital redevelopment.

6. In 1994, Sheppard Partners merged with another company to become AC Consulting Group. I was a shareholder and principal of AC Consulting Group until 2008, when the company was sold to the organisation that is now CPG. AC Consulting Group's principal focus was on the energy sector and, during those years, I performed structural engineering and design services for buildings and structures in that sector.

7. As a structural engineer, I have an understanding of failure mechanisms for structures – what can cause a building to collapse and why. Structural engineers are trained to design buildings to resist such failures, including failures induced by earthquake. In my career, I have designed many buildings.

8. With our emphasis on the health sector, seismic design was a particularly important focus during my work with Sheppard Partners. All of the hospital structures we designed had to meet stringent earthquake design standards. In addition to the Christchurch Hospital redevelopment, I designed buildings at Burwood Hospital, Wellington Hospital, Keneperu Hospital, Princess Margaret Hospital and at the Christchurch Training College.

9. New Zealand's natural propensity to earthquakes and improvements in the understanding of how buildings respond to seismic events have resulted in changes to earthquake design requirements. These changes have led to government authorities requiring ongoing building seismic assessment and strengthening.

10. Throughout my career, I have undertaken numerous projects of this nature. One such project (while I was working for Sheppard Partners) was the Christchurch Womens' Hospital, built in the 1940s, for which I managed a seismic assessment in the late 1980s and early 1990s. During my tenure with AC Consulting Group, I performed seismic assessments on numerous fire stations throughout Canterbury and Westland. Other projects included the seismic securing of Waitaki Boys High School Hall of Memories and the structural assessment and design of seismic strengthening works at many power stations for ECNZ and at many substations for power distribution utilities, such as Transpower. I have continued to perform seismic assessments during my employment with CPG. For example between February and May 2010, I inspected and prepared seismic assessments for approximately 60 commercial buildings in Kaiapoi and Rangiora for the Waimakariri District Council.

11. During the course of my career, I have also assessed and designed the repair of various damaged buildings and structures. One example is Burwood Hospital, where I designed repair and strengthening works for roof trusses on a building that had been damaged by snow loads. I have also designed remedial works for older buildings damaged by settlement at Christchurch Hospital and other places. The Christchurch Hospital work involved managing the underpinning and jacking of a two storey brick building that had suffered settlement caused by the construction of a new multi-storey building alongside. While I was with AC Consulting Group, my damage assessment work included investigating and replacing braces in several large power transmission towers that had fractured due to fatigue caused by vibration of the braces in the wind. I also managed strengthening of piled foundations to power transmission towers that were affected by land slips.

12. Prior to the 4 September 2010 Christchurch earthquake (**September Earthquake**), I had not undertaken any post-earthquake building assessment. However, I believe my training and experience (as summarised above) gave me a good understanding of structural failure mechanisms that could be caused by an earthquake and what to look for in assessing a damaged structure. As I shall detail in my evidence, I discussed some of my key conclusions with relevant colleagues and specialists before I finalised my report. This is standard engineering practice. In the present case, these inquiries confirmed my own opinions.

September 2010 Christchurch earthquake

13. At the time of the September Earthquake, I was on annual leave and travelling overseas. I returned to Christchurch on 19 September 2010.

14. In common with other structural engineers in Christchurch during the weeks following the September Earthquake, I became engaged in examining buildings for earthquake-related damage. The September Earthquake was – and is – widely considered in the engineering profession to be a "design event", that is to say an event which generated seismic loads that reached design loads for many structures.

15. One of my first inspections was of the CPG building in Armagh Street. Over the following week, I inspected a number of residential properties and the Papanui Substation buildings and equipment. Over the months that followed and after the 22 February 2011 aftershock, I inspected dozens of buildings and, indeed, am still continuing to devote significant time to ongoing assessment of damage to structures and design of remedial works.

Instruction to inspect the CTV Building

16. On or about 24 September 2010, I spoke by telephone with John Drew, the Building Manager of 249 Madras Street, Christchurch (**CTV Building**).

17. During the telephone call, we discussed a possible damage inspection by CPG of the CTV Building. I sent John Drew an email on 24 September 2010 setting out CPG's proposal for the building inspection. A copy of the email that I sent to John Drew is annexed at **Attachment 1** (**Proposal**) **(WIT.COATSWORTH.0001A.1-2)**.

18. As set out in the Proposal, CPG proposed to conduct a visual inspection of the CTV Building and determine whether there was any pattern to the damage observed that would explain any deficiencies observed in the performance of the building following the September Earthquake. We would prepare a report describing the building and the damage observed, comment on any reasons for the observed damage and briefly comment on possible remedial works. I quoted a price of NZ$3,000 for the services. As I shall explain in more detail, we did not propose to remove internal linings or to perform structural analysis.

19. We did not receive any written instructions. However, some time over the following few days, John Drew telephoned me and confirmed that the building owner, Madras Equities Pty Limited, wanted to proceed with the inspection as set out in the Proposal. We agreed that the inspection was to commence at 10am on 29 September 2010 and that I would be accompanied by Mr Drew and Leonard Pagan of Rawlinsons (Quantity Surveyors), who would assess the cost of repairs.

20. Other than the Proposal, no formal contract or other document set out the scope of work.

Attempts to obtain structural drawings

21. In the Proposal, I asked Mr Drew whether any structural or architectural drawings of the CTV Building were available. Mr Drew told me (I think during the second telephone conversation we had) that he did not have copies of the drawings. I then telephoned the Christchurch City Council to obtain drawings from them, but they told me that their records were in disarray following the September Earthquake and they did not know when drawings would become available.

22. I considered that the structural and architectural drawings would have been useful for me to familiarise myself with the structural systems in place at the CTV building in advance of undertaking my visual inspection. Also, I generally prefer to have more information rather than less. Having said that, I did not (and do not) think the drawings were required for me to be able to conduct a meaningful inspection of the building. I believe that I was able to identify key structural systems from my visual inspection.

23. After my visual inspection and subsequent report, I did not make any further attempts to obtain the drawings. If I had observed significant structural damage, I would have done so or recommended the client to do so, since information from the drawings would be necessary in order to perform a quantitative analysis of how the structure had responded to the loads experienced in the September Earthquake. However, as I shall explain, I saw no evidence of significant structural damage in the CTV Building.

24. I was able to obtain architectural plans of the ground and first floors from the CTV Manager during the inspection. CTV occupied these two floors. These plans identified the locations of the structural elements, including the shear walls and the columns.

Type of assessment carried out

25. In the immediate aftermath of the September Earthquake, civil defence and council inspectors did some rapid assessments and applied a sticker system to structures. A red sticker meant that the building was a hazard and could not be entered, green meant that the building presented no obvious structural damage or hazardous conditions and therefore could be entered and a yellow sticker indicated that there were some hazardous conditions or structural damage such that there should be only restricted access. The CTV Building was green-stickered.

26. My assessment – which occurred after the building was green stickered – included a visual inspection of the damage to the structure. In accordance with my Proposal, I reported on the damage observed, commented on the reasons for the observed damage and briefly commented on possible remedial works.

27. In my Proposal I said that I would not suggest removing internal wall linings unless there was some obvious reason to do this. Consistent with this, I did not remove wall linings during my inspection. However, as explained in more detail later, in my Report I did recommend, as a follow up procedure, removal of some linings on the ground storey south shear wall and the first floor west end wall.

28. I did not carry out an Initial Evaluation Procedure (**IEP**) assessment of the building. An IEP is a method of assessing the approximate capacity of a building as a percentage of New Building Standard (**NBS**). The procedure is described in the NZ

Society of Earthquake Engineers document "Assessment and Improvement of the Structural Performance of Buildings in Earthquakes" and is most commonly performed on buildings that are considered potentially earthquake prone, i.e. less than 33% of NBS. However, buildings designed to NZS4203 are not likely to be earthquake prone. Because the CTV Building was designed in the 1980s, after the introduction of NZS4203, I considered it unlikely that the building was earthquake prone and did not consider it necessary to perform an IEP assessment to verify this. I understand that the subsequent IEP undertaken by consultants to the Department of Building and Housing confirmed that the CTV Building was not earthquake prone. [**Refer page 30 of Hyland Report, Executive Summary.**]

29. I expressly excluded structural analysis from the scope of my investigation. Thus, I stated in my Proposal that we had not included an allowance "*for any analysis of the structure although in the event of significant structural damage it would ultimately be necessary to carry out structural analysis to determine strengthening and repair work requirements*". If as a result of my investigation, I had thought the building exhibited significant structural damage, I would have recommended further investigation, including structural analysis.

Conduct of the inspection

30. The inspection took place on 29 September 2010. At approximately 10am, I met John Drew and Leonard Pagan at the CTV Building. Peter Brown of CTV, accompanied us during the inspection of the first two floors of the CTV Building. These were the areas leased and occupied by CTV.

31. During the course of the inspection, I talked to a number of the occupants. I remember talking to two women on the top floor at the northwest corner of the building, who pointed out damage to partition walls and cracking. On the third floor, I talked to people from Kings Education concerning sagging in the floors. And, of course, Peter Brown pointed out damage he was aware of when we were going through the floors occupied by CTV. There were other people that we talked to as we progressed through the building, although I no longer recall the specific individuals.

32. During the inspection, I made notes and sketches of the damage that I observed and also took a number of photographs. This was my normal practice and it would assist

me in later preparing my report. A copy of my notes and sketches (**Notes**) are annexed at **Attachment 2 (WIT.COATSWORTH.0001A.3-19)** along with some diagrams of the north side shear walls (**Diagrams**) (**WIT.COATSWORTH.0001A.20-26)** that I made some days later to record cracks in the walls. The Notes are very abbreviated and were, of course, created as an aide memoire rather than for publication. On occasions they are somewhat cryptic and have what, on subsequent review when preparing my report, appeared to me to be the odd error. Accordingly, I have also included in **Attachment 2**, with reference to each note, a more detailed description of the damage that I observed and clarification of any ambiguities or errors in what I wrote down. A copy of the photographs (**Photographs**) are annexed at **Attachment 3 (WIT.COATSWORTH.0001B.1-20, WIT.COATSWORTH.0001C.1-20, WIT.COATSWORTH.0001D.1-20, WIT.COATSWORTH.0001E.1-20, WIT. COATSWORTH.0001F.1-20, and WIT.COATSWORTH.0001G.1-9**). I took a total of 109 photos during the inspection on 29 September 2010, numbered 1 to 109. I included some of these in my subsequent report and also sent Mr Drew a full set. In addition, I took two photographs of the south elevation of the building for use as "cover" photos for the report (**WIT.COATSWORTH.0001G.10-11)**. These were designated A and B. The results of my inspection are summarised in my report dated 8 October 2010 (**Report**). A copy of my Report is annexed at **Attachment 4 (WIT.COATSWORTH.0001H.1-20)**. In my following evidence I will refer to my Notes and Diagrams, the Photographs and my Report.

33. I began my inspection by walking around the outside of the building before moving inside on the ground floor and progressing to the roof on a room by room and floor by floor basis. The inspection took approximately 4 hours, concluding at about 2 pm. Although I asked Mr Drew, Mr Brown and others that I spoke to about areas of damage they had observed, I myself decided where I should look and what I should examine.

34. The most obvious form of damage that I was looking for was cracking, particularly in the structural concrete but also in other surfaces.

35. I was also looking for evidence of alignment divergences, settlement, and separations between structural elements. With respect to vertical alignment, although I made visual observations, I did not perform a vertical alignment survey. This is something normally performed where there are signs of settlement or liquefaction, which was not the case with respect to the CTV Building.

Building eccentricity

36. As a result of my investigations, I determined that the structure consisted of a reinforced concrete shear tower along the north side of the building and reinforced concrete coupled shear walls along the south side resisting lateral loads, reinforced concrete beams and columns resisting gravity loads and composite concrete topping and steel tray deck floors. I did not have any information about the foundations. I would have expected, however, that they were concrete strip and pad type. The drawings included in the DBH report show construction as described above.

37. I observed that there was some plan irregularity (eccentricity) to the building. I understood that the concrete block infill panels in the west wall were not intended to play any part in lateral load resistance since these panels were isolated from the surrounding concrete frame. This meant that for loads in the north-south direction, the centre of stiffness was in line with the finger walls in the north shear tower and the centre of mass was some distance to the west, nearer the centre of the building. This difference between the centre of stiffness and the centre of mass introduced some eccentricity.

38. The loads in the east-west direction were resisted by the north shear tower and the south side coupled shear walls. The north shear tower was stiffer than the south side coupled walls and this also introduced some eccentricity.

39. Because eccentricities apply torsional (twisting) loads to the structure, it is ideal to minimize these. However, it is unusual to have buildings with no eccentricities at all. Indeed, codes typically require designers to allow for some eccentricities. I did not do any calculations to assess the extent of the eccentricity in the CTV Building, but I was not alarmed by the amount of eccentricity that I perceived when inspecting the building.

North side shear walls

40. The two car lift shaft, stairwell and bathrooms projected from the north side of the building about half way along the north wall [**refer plan in Appendix 1 to Report (WIT.COATSWORTH.0001H.10)**]. A concrete shear wall extended across the north side of these facilities. Finger walls projected at right angles to the north side wall at each end and between the facilities – four finger walls in total.

41. The connection between the floor slabs and the north side shear walls was essential to the stability of the building. I understand it has been postulated that the retrofitted

drag-bars connecting some of the floors to the north shear walls failed in the February aftershock or, indeed, possibly failed in the September Earthquake. Although I was, at the time of my inspection in late September 2010, unaware of either the original or the retrofit detail, I was aware of the importance of the connection of the floor slabs to the shear walls. Any separation of the floors from the shear walls would have caused significant cracking/separation that would have been apparent. As I now explain, I expressly looked for such cracking.

42. With respect to the north core shear wall and the areas of connection between it and the floors, I looked for cracking in the shear walls and signs of separation between the floors and the shear walls. On the inside of the building, I made observations from the bathrooms, the stairwell and the lift lobby on each floor as well as in the tank and plant rooms. From the exterior of the building, I observed the north shear wall from the ground and from the roof.

43. I looked at the floors of the bathrooms where they extended out into the main part of the building. Had there been separation of the horizontal floor slab at this point, it would have shown up as a crack in the floor that I would have expected to see reflected in the floor coverings, or as a separation of the floor covering from the skirtings. I did not observe any of these signs.

44. In the stair well, in the bathrooms, in the tank room and the plant room, I was looking for cracking or misalignment in the walls. In the tank room, I observed minor cracking in the north and west walls [**refer Note 30 (WIT.COATSWORTH.0001A.8 and 18) and Photo 95 (WIT.COATSWORTH.0001F.15)**]. Some of these cracks showed efflorescence indicating that they had been there for some time and certainly predated the September Earthquake. None of them was structurally significant. The same was true for the plant room.

45. At most levels, there were some diagonal shear cracks in the walls surrounding the bathrooms and stairwell, for the most part measuring less than 0.2mm in width but with three measuring up to 0.3mm. For example, in the toilets in the north shear tower on the fifth floor, I saw a single fine diagonal crack on each of the east and the west walls [**refer Note 29 (WIT.COATSWORTH.0001A.8 and 18); Diagrams (WIT.COATSWORTH.0001A.20-26)**] . None of the cracks I observed in these areas was large enough to indicate failure or yielding of the wall [**refer Notes 18 and 35 (WIT.COATSWORTH.0001A. 6, 9, 15 and 19); Diagrams (WIT.COATSWORTH000. 0001A.20-26)**].

46. Except for a thin gypsum plaster coat applied directly to the concrete, the stairwell walls were unlined. The stair flights were of pre-cast concrete treads on steel stringers bolted under the landings. The mid-height landings were in situ concrete slabs cast against the shear walls. The floor level landings were part of the main floors of the buildings. There were construction joints in the walls, immediately above and below each floor level. From the stairwell, facing the wall that separates the stairwell from the bathroom, the construction joints were above and below the bathroom floor slab. For the most part, however, these were not visible because of the gypsum plaster coating.

47. I was looking to see if the construction joints had opened up or if there was any misalignment in the plane of the wall or at right angles to the plane of the wall that would have been indicative of shear (sliding) failure

48. I observed minor cracking along part of the length of the construction joints in the walls in the stairwells at several floor levels. However, these cracks measured generally less than 0.2mm in width but with a few up to 0.35mm in width. While this constituted minor structural damage, once again, it was not of an order that would signify yielding of the shear wall. [**Refer Notes 13, 14, 20, 26 (WIT.COATSWORTH. 0001A.4-5, 7-8, 12-13, 15 and 17); Photos 70-72 (WIT.COATSWORTH. 0001E.10-12), 83-86 (WIT.COATSWORTH.0001F3-6); Diagrams (WIT.COATSWORTH. 0001A.20-26).**]

49. I observed minor cracking in the stairwell walls at most levels. [**Refer Diagrams (WIT.COATSWORTH.0001A.20-26)**] For example, I saw horizontal cracking in three of the walls of the stairwell between the fourth and the fifth floors. There was also a minor diagonal crack in the northern wall approximately 500mm below the roof level. Although the cracking that I observed was indicative of minor structural damage, because the cracks were very fine I considered that the reinforcing steel had not yielded, that the aggregate in the concrete was still interlocking and that the general integrity of the concrete walls was not compromised. [**Note 26 (WIT.COATS WORTH.0001A8 and 17); Photos 83-86 (WIT.COATSWORTH.0001F3-6)].**

50. From the ground and from the roof, I looked at the outside of the shear walls. I was looking for misalignment or separation of the shear walls from the rest of the structure and for separations of windows or cladding materials from the underlying structure. I saw no signs of any such damage. [**Refer Photos 97-100. (WIT. COATSWORTH.0001F17-20)**]

51. In summary, none of the damage that I observed indicated yielding or other failure of the north shear wall or separation of the floor slab from the shear wall. I summarised these findings at page 4 of my Report.

Inspection of the columns and beams

52. The CTV Building had circular and square columns of reinforced concrete. The function of the columns and the beams was primarily to support gravity (vertical) loads, rather than to resist lateral (horizontal) loads. However, they did have some stiffness and, when the building moved horizontally, would attract some load.

53. In response to the lateral loads of the earthquake, I was looking for shear and/or flexural (bending) cracking in the concrete at beam-column joints or in the columns and beams themselves. The size of any cracking would reveal whether it indicated elastic or inelastic movement. I was also looking for signs of compression failure in the columns as a result of vertical loading.

54. I examined some columns on all floors. With a few exceptions, I observed very little damage. My findings are summarised on page 4 of my Report. I now expand on those findings.

55. The north east corner column immediately above the third floor spandrel exhibited some very fine, minor cracking. Similar hairline flexural cracking was evident in the north east column above the fourth floor spandrel panel. [**Refer Notes 19 and 22 (WIT.COATSWORTH.0001A.6, 7, 15 and 16) and Photo 68 (WIT.COATSWORTH. 0001E.8)**.] As a result of observing this damage, I further inspected the column in the north east corner at other floors but observed no damage. [**Refer Note 36 (WIT.COATSWORTH.0001A.9 and 19).**]

56. At the top storey, the first column west of the north-east corner of the building exhibited some cracking, the appearance of which was accentuated because the paint had chipped off at the cracks. I did not record the width of these cracks, but my recollection is that they were less than 0.2mm. I took photographs of the column and the cracks. [**Refer Note 27 (WIT.COATSWORTH.0001A.8 and 17) and Photos 87 and 88 (WIT.COATSWORTH.0001F.7-8)**.] The first column in from the south-west corner on the south side of the building at the top storey also exhibited some fine cracking. I recall these also as being less than 0.2mm and, again, I took

photographs of the column and cracks. [**Refer Photos 91 and 92 (WIT. COATSWORTH.0001F.11-12).**]

57. In a number of places, I observed gaps of approximately 7 to 8mm at ceiling level between the plaster board wall and structural columns. At floor level, however, there was no gap. The movement of the plaster board was in my view caused by building sway. At floor level, the plasterboard was fixed to the floor slab which was fixed to the column. When the column leaned during the earthquake it pushed on the plasterboard wall causing the gaps that I saw at ceiling level. [**Refer Note 23 (WIT.COATSWORTH.0001A.7 and 16) and Photos 25 (WIT.COATSWORTH. 0001C.5) (first floor), 63 (WIT.COATSWORTH.0001E.3) (third floor) 74 WIT. COATSWORTH.0001E.14) (third floor), and 82 (WIT.COATSWORTH.0001F.2) (fourth floor).**] Similar effects, but to a lesser extent, were evident where partition walls adjoined the shear walls. [**Refer Photos 31, 32, 37, 57 & 109 (WIT.COATSWORTH.0001C.11-12, 17, WIT.COATSWORTH.0001D17 and WIT. COATSWORTH.0001G.9)**.] This was not evidence of structural damage.

58. The first floor beam on the north face of the building in the span between the north-east column of the building and the adjacent column had two fine diagonal cracks. [**Refer Note 13 WIT.COATSWORTH.0001A.4 and 12-13); Photo 45 (WIT. COATSWORTH.0001D.5) (photo 5 in my Report (WIT.COATSWORTH. 0001H15)).**] Because these were so fine, I did not consider yielding had taken place.

59. The interior beam-column joints were for most part behind the suspended ceilings. However, as I shall explain later in my evidence, I removed ceiling tiles from several locations and could observe the joints in areas where there was no suspended ceiling. The underside of the beam column joints around the perimeter of the building were visible from the ground and from the building through the windows. [**Refer Photos 004, 005, 006, 019 (WIT.COATSWORTH.0001B.4-6, and 19)**]. I did not see any signs of distress in the beam column joints that I observed.

60. In short, I saw no evidence of anything other than occasional minor structural damage to the columns and beams. This indicated to me that the steel in the columns and beams had not yielded and that the integrity of the beams and columns had not been compromised.

South shear wall and recommendation to remove ground storey strapping and plaster board lining

61. The south elevation contained a coupled shear wall. It had door holes in the middle of the wall at each storey providing access to the external fire escape. Beams across the door heads coupled the walls on each side of the doors together.

62. Coupled shear walls are designed to yield in the beams over the door-heads. I was accordingly looking for cracks in the coupling beams. I found no evidence of this.

63. I examined the southern shear wall from the ground floor and from the external fire escape at every other floor.

64. The inside face of the south shear wall was finished with a thin coating of gypsum plaster at all levels except the ground floor. At the ground floor, the wall was lined with plasterboard. The exterior of the shear wall was finished in a plaster splash.

65. The plaster splash surface of the exterior of the wall made fine cracking less obvious than on the gypsum plaster interior walls. However, in spite of the plaster splash, in my opinion cracks in the concrete wall that might have indicated yielding would have been visible. I did not see any.

66. During my inspection, I observed very fine diagonal hairline cracking in the gypsum plaster on the inside of the south shear wall at the first floor level of the building. [**Refer Note 11 (WIT.COATSWORTH.0001A.3 and 12).**] At the ground floor, I saw significant cracks in the plasterboard lining. [**Refer Note 6 (WIT. COATS WORTH.0001A.3 and 11).**] I was also able to identify a fine diagonal crack on the outside of the south shear wall at the ground storey. [**Refer Photo 51 (WIT.COATSWORTH.0001D.11) (photo 2 in my report (WIT.COATSWORTH. 0001H.13)).**] This crack was quite fine, so I did not consider it to indicate structural yielding. Given that the only crack I observed on the outside of the wall was of no structural significance, I considered it unlikely that the south shear wall behind the linings had been compromised.

67. However, I considered it prudent to remove a ceiling tile from the ground storey so as to inspect a portion of the inside of the shear wall itself. This also enabled me to inspect the first floor connections to the shear wall at that location. These areas

revealed no signs of distress. Secondly, I recommended that the ground storey plaster board linings be removed to provide further confirmation as to whether there had been damage to the structural shear wall. I anticipated that, if there were any cracks in the structural wall, these would be similar to the cracks on the inside of the shear wall at the first floor and to the single exterior crack I had observed on the outside of the wall at ground level, which were of no structural significance.

68. I do not specifically remember discussing my recommendation to remove the linings with Mr Drew or any other representative of the building owner but I think it likely that I did. It was included in my Report at page 3, in my discussion of the south elevation shear wall.

69. I do not know whether my recommendation was followed and, if so, what the results were.

Examination of floor-beam connections and removal of ceiling tiles

70. In the CTV Building, the floor construction consisted of composite concrete topping and a steel tray deck system spanning north to south between concrete beams. Because these types of floor systems are relatively light and flexible, it is common for them to exhibit some deflection and, indeed, most of the floors in the CTV Building had high points over the supporting beams and sags in between. This was not earthquake damage, but was a fairly normal and acceptable effect of this type of construction. [**Refer Report at pages 4-5 (WIT.COATSWORTH.0001H.6-7)**].

71. As I have previously mentioned, I remember talking with some of the staff at Kings Education about the deflections in the floor, and walking over the floor to see what they were talking about. I noticed the high points over the beams and the sags in between but I would have expected to have seen more significant deflections if the floor had yielded.

72. For the reasons I have just mentioned, I removed a ceiling tile from the ground floor ceiling adjacent to the south side coupled shear wall, which revealed no damage above the suspended ceiling.

73. In addition, I removed a ceiling tile from the ground storey ceiling in the CTV store room adjacent to the stair lobby. I did this in order to view the underside of the first

floor and its support beams and beam/column joints to check for damage. [**Refer Photos 16-17 (WIT.COATSWORTH.0001B.16-17).**] I observed no structural damage.

74. I was also able to observe the underside of the first floor slab, the support beams and the beam-column joints from the ground floor CTV studio and from the garage, neither of which had a suspended ceiling lining. [**Refer Photos 1, 2 and 50 (WIT. COATSWORTH.0001B.1-2 and WIT.COATSWORTH.0001D.10).**] Again, I saw no structural damage.

75. I also removed a ceiling tile from the second floor ceiling. I believe this was in the lift lobby. [**Refer Photo 30 (WIT.COATSWORTH.0001C.10).**] I did this for the purpose of viewing the underside of the third floor and its support beams and beam/column joints to check for any damage. Again, I observed no structural damage. I note that when providing responses to questions from the Royal Commission last year, I mistakenly identified this tile as having come from the first floor ceiling. That was an error.

76. I did not remove ceiling tiles from any additional locations in the building. This was a judgement call on my part. In the elements that were visible without removing ceiling tiles, e.g., columns, structural walls, non-structural walls and floors, I saw no evidence that damage at the upper levels was any worse than at the lower levels. In addition, I closely looked at the tops of columns at ceiling level and saw no evidence of any damage. [**Refer Photos 1, 2, 14, 15, 22, 24, 25, 48, 50, 69, 74, 78-80, 82 and 87-89 (WIT.COATSWORTH.0001B.1-2 and 14-15, WIT.COATSWORTH.0001C.2, 4-5, WIT.COATSWORTH.0001D.8, 10, WIT.COATSWORTH.0001E.9, 14, 18-20, WIT.COATSWORTH.0001F.2 7-9).**]

Other areas inspected

77. In addition to the structural elements described above, I also observed the spandrel panels, the non-load bearing concrete block walls, the internal framing and linings and the windows. Details of my inspection of these areas are set out at pages 4 to 6 of my Report.

78. The spandrel panels were on the north, east and south faces of the building, and weatherproofed the building under the windows. I observed the panels from the ground, from the fire escape and through the windows on each level. I could not

observe the connection of the panels to the structure since this was obscured from sight behind the panels themselves.

79. There were only two areas where I observed any damage to the panels.

80. First, at each side of the south shear wall, the ends of the panels had been plastered. The plaster was spalling off due to differential movement in the earthquake. Since this was a hazard to people below, I recommended that the spalling plaster be removed and a strong bonding epoxy plaster reapplied. [**Refer Report at page 4 (WIT.COATSWORTH.0001H.6); Photo 52 (WIT.COATSWORTH.0001D.12).**]

81. Secondly, at the fifth floor level, the end of the spandrel panel on the north elevation adjacent to the lift lobby showed signs of corrosion of the reinforcement. While this was not a structural problem (the spandrel panels were not structural elements) and had not been caused by the earthquake, I recommended that it be treated. [**Refer Report at page 4 (WIT.COATSWORTH.0001H.6); Photos 4, 90 (WIT. COATSWORTH.0001B.4 and WIT.COATSWORTH.0001F.10).**]

82. Apart from what I have just said, I observed no damage to the spandrel panels. I understand there is some suggestion that the columns may have impacted the spandrel panels at some locations. If this had occurred, I would have expected to see chipping at the corners/edges of the spandrel panels. I saw no evidence of this.

83. The west wall at the ground, first and second floors had concrete block in-fill panels between the concrete beam and column frames. As observed from inside the garage, there generally was a gap of approximately 30mm between the columns and the ends of the block panels. The back of this gap (recessed into the joint) appeared to be filled with sealant or possibly foam. [**Refer Photo 2 (WIT.COATSWORTH. 0001B.2).**] I do not believe there was a significant gap (if any) between the top of the block in-fill panels and the underside of the concrete floor beam above.

84. I understand there is evidence from workers, who observed the exterior of the building once the adjacent building had been taken down, that mortar rather than sealant filled the gap between the panels to the columns and horizontal beams. I have rechecked my photograph taken from inside the garage and it still appears to me to show sealant or foam. [**Refer Photo 2 (WIT.COATSWORTH.0001B.2).**] However, my view was limited since at the time of my inspection there was an old

brick building against the west wall, so I was not able to see the block-work from the outside.

85. As noted, I observed the block panels from inside the garage. If they had impacted the columns to any extent I would have expected to see some damage to the top corners of the block panels. I saw no evidence of this.

86. I also had some limited observation of the block panel separation from the north-west corner concrete column at the first floor. There was a gap between the internal framing/lining and the column at this point through which it was possible to see daylight. It appeared that whatever had been used to fill in the separation between the block and the concreted column (I believed sealant) had fallen out. I saw no evidence of impacting between the block panel and the column, although my notes reflect that in this location there was only an 8mm space between the column and the panel, so my view was limited. [**Refer Note 15 (WIT.COATSWORTH.0001A.5 and 13)**].

87. Because I had only a very limited view of this area, I advised that it needed further investigation (which would have entailed removing internal linings). I also advised that the gap needed to be repaired. [**Refer Report at page 5 (WIT.COATSWORTH. 0001H.7).**]

88. The non-load-bearing concrete block wall at ground storey in the stairwell exhibited some non-structural damage. Differential movement between the block wall and the structure had peeled off the gypsum plaster lining on the block wall. [**Refer Photos 35-36 (WIT.COATSWORTH.0001C.15-16).**]

89. There was damage to internal framing and linings on all floors, which varied from minor cracking in joints between plasterboard sheets to diagonal cracks in sheets. [**Refer Report at page 5 (WIT.COATSWORTH.0001H.7).**]

90. There was one broken window on the east wall at the third floor most likely due to the earthquake [**refer Photo 67 (WIT.COATSWORTH.0001E.7)**] and the rubber seal had come loose on another east wall window at the ground floor. [**Refer Photo 18 (WIT.COATSWORTH.0001B.18).**] I observed no other damage to the windows.

91. None of the damage to the spandrel panels, the concrete block panels, the internal framing and linings, or the windows was of structural significance.

Follow up to my inspection

92. Following my inspection I made some further notes to myself concerning my observations and preliminary thoughts. A copy of these is annexed as **Attachment 5 (WIT.COATSWORTH.0001H.21)**.

93. On or about 1 October 2010, I telephoned John Drew and advised him that a security fence should be erected around the bottom of the fire stairs on the south face of the building to prevent injury to people walking beneath the stairs should any of the plaster fall away from the damaged spandrel panels. I do not know whether this was undertaken.

94. On 6 October, I returned to the CTV Building in order to complete elevation sketches of the inside of the north shear tower walls as I did not complete a full sketch during my initial inspection. A copy of these seven sketches are included in the Diagrams at **Attachment 2 (WIT.COATSWORTH.0001A.20-26)**. I also rechecked the width of the cracking in the shear walls.

95. It is my normal practice to discuss my preliminary conclusions from an inspection with colleagues or other specialists in related fields. This form of peer review is useful in checking my own opinions and as a matter of risk mitigation. This is common across most engineering practices.

96. With respect to my review of the CTV Building, I consulted a number of people, in particular:

    a. On 1 October 2010, I telephoned Dene Cook of Firth Concrete. Mr Cook is an expert in concrete performance. I described the general level of cracking that I had seen in the shear walls. My notes of that conversation reflect that Mr Cook confirmed that, at 0.2mm crack width, the steel would not have yielded and the walls should be good for the same earthquake again. He also agreed that their stiffness might, however, be lower – that is, during a seismic event, the deflections would be greater in the pre-cracked section and the period of vibration might be a little longer than previously. A copy of my record of the telephone conversation with Dene Cook is annexed at **Attachment 6 (WIT.COATSWORTH.0001H.22-23)**.

b. On 6 October 2010, I telephoned Des Bull. Des Bull is a senior structural engineer and a lecturer at the University of Canterbury. He is also a key member of the Civil Defence response team in the Christchurch Earthquakes. During this telephone call, I discussed with Mr Bull my observations of the cracking present within the CTV Building and, in particular, the diagonal shear cracks in the order of 0.05mm to 0.35mm, as well as the cracking in the horizontal construction joints above and below floor slabs. Mr Bull advised that cracks of less than 0.4mm still retained aggregate interlock within the concrete and observed that code designs allow for some cracking. He was not surprised that there was cracking at the construction joints. He said he thought that cracks of the type I described should be fine, but agreed that, for peace of mind, cracks larger than 0.2mm should be injected with an epoxy resin. A copy of my note of this telephone conversation is annexed at **Attachment 7 (WIT.COATSWORTH.0001H.24)**.

c. I also telephoned Peter Higgins of Construction Techniques. The purpose of my call was to discuss injection of epoxy resin into the concrete cracks. Mr Higgins said he thought that the smallest cracks that could be effectively filled would be approximately 0.1mm. A copy of my note of my conversation with Mr Higgins is annexed at **Attachment 8 (WIT.COATSWORTH.0001H.25)**.

d. I discussed the matter with Jerry Kearney, a structural engineer in CPG's Dunedin office. Jerry recommended that I also speak with Steven Moody, of Adhesion Sealing, who were also experts in epoxy injection of cracks in concrete. I accordingly telephoned Mr Moody. He too confirmed that epoxy injection repair of these cracks was appropriate, but said that anything less than 0.1mm could not effectively be filled. A copy of my note of my conversation with Mr Moody is annexed at **Attachment 8 (WIT. COATS WORTH.0001H.26)**.

e. I also generally discussed the damage I had observed in the CTV Building and its effect on the structural integrity of the building with Jerry, as well as with Tony Crang, who is a senior structural engineer in CPG's Auckland office. I sent an email to both Tony and Jerry on the afternoon of 6 October 2010 in which I summarised the opinions of both Dene Cook and Des Bull, which confirmed my own views. This email is annexed at **Attachment 9 (WIT.COATSWORTH.0001H.27)**.

97. I started writing my Report on or about 6 October 2010. The report was emailed to John Drew on 8 October 2010.

Summary of conclusions and recommendations

98. Accepted design practice requires that buildings remain standing after a design event but it is expected that some damage will be inflicted. The CTV Building showed noticeable damage to non-structural elements such as linings and finishings. It demonstrated some minor structural damage as already outlined but no evidence of structural failure.

99. Based on my own knowledge and experience as an engineer as well as the checking I had done with other specialists, I concluded that the fine cracking I had observed was not indicative of yielding of the reinforcement in the shear walls or in the columns. I also do not believe that there was any evidence of separation of the floor slabs from the north or south shear walls.

100. However, the effect of the cracking would be to reduce the overall stiffness of the building slightly. I accordingly recommended that cracks with more than a width of 0.2mm should be repaired by epoxy injection. [**Refer Report pages 3 and 4 (WIT. COATSWORTH.0001H.5-6).**] In some places, this would also assist in weatherproofing the building.

Further attendance at the CTV Building

101. On 19 October 2010, there was an aftershock of magnitude 5.0. The aftershock was quite shallow, being 9 kilometres deep and, at 10 kilometres southwest of Christchurch, was quite close to the city.

102. The day it happened, John Drew telephoned and asked me to take another look at the building that same afternoon, which I did. Starting on the ground floor, I had a general look around the building, including walking up the stairs in the north shear tower. Peter Brown accompanied me on my inspection of the ground floor. I also spoke with the receptionists on the 5th floor. Apart from two cracks in the north stairwell shear walls being possibly slightly larger, I saw no additional damage to the building. I drew a sketch that reflected the damage I observed in the north shear tower, a copy of which is annexed at **Attachment 10 (WIT.COATSWORTH. 0001H.28)**. In addition, I took 9 more photographs, which I have numbered 19Oct10

001-009, a copy of which are annexed at **Attachment 11 (WIT.COATSWORTH. 0001H.29-37)**. Included among these, is the fifth floor column in the lift lobby that I had photographed during my initial inspection. [**Refer Photographs 87-88 (WIT. COATSWORTH.0001F.7-8) and Photograph 19Oct10 06 (WIT. COATSWORTH. 0001H.34)**]. As far as I could tell, the cracks in this column had not increased in size.

103. I emailed John Drew that afternoon confirming my findings and my view that the CTV Building remained structurally sound. By this I meant that the capacity of the building to resist gravity and lateral loads had not been significantly reduced.

104. I emphasised, however, that it was inevitable that where cracks had been opened by the initial earthquake, subsequent shocks would work the joints and open them further. I accordingly recommended that arrangements to repair the walls by epoxy injection be made as soon as practical. A copy of this email is annexed at **Attachment 12 (WIT.COATSWORTH.0001H.38)**.

105. Following my inspection on19 October 2010, I had no further contact with John Drew. I was not requested to provide any further inspections of the building and did not provide any further inspections. So far as I am aware, I had no further contact with anyone in relation to the CTV Building prior to the 22 February 2011 aftershock.

Other questions

106. I have been asked to address whether my instructions included a request for any advice on whether the CTV Building was safe to occupy and whether my inspection amounted to stating this nevertheless.

107. The answer to the first question is no. To the best of my recollection, I was not asked if the building was safe to occupy.

108. However, I did state in my Report that there were no obvious structural failures. In my email to John Drew dated 19 October 2010, I said that the building was still structurally sound. I did not in either my Report or my email recommend that it be vacated. I saw no reason to do so – I considered that, with the limited damage observed, the capacity of the building to resist gravity and lateral loads had not been significantly reduced.

109. In my opinion, the building performed well in the September Earthquake, sustaining only minor structural damage. As an engineer, however, I do not use the term "safe" because it is too broad and imprecise. It is simply not possible to say a building will be safe under all circumstances. While I understand that a concern has been raised during the Royal Commission's hearings that a lay person might misconstrue a finding that a building had not been damaged as meaning that the building was safe in this broad sense, it was not my intention to imply this.

110. I have been asked whether in inspecting the building and coming to my conclusions I gave any consideration to:

a. The impact of the September Earthquake and any subsequent aftershocks on the structural integrity of the building and, in particular, whether the building's capacity to withstand future aftershocks was diminished as a result; and

b. That in the aftershock sequence, there could well be an aftershock of approximately one magnitude less than the September Earthquake, i.e., approximately magnitude 6.1, and the effect that might have on the structural integrity of the building.

111. With respect to part a) of this question, I did consider the impact of the September Earthquake and the aftershocks that had occurred as of the date of my inspections on the CTV Building, including the aftershock that occurred on 19 October 2010 after my Report was submitted. As I have said, I submitted a follow up email report to cover my considerations relating to that event.

112. I also considered the effect of future aftershocks as evidenced by my discussion with Dene Cook, whose conclusion with respect to the cracks in the shear walls was the same as my own – that the walls should be good for the same earthquake again, although their stiffness might be reduced leading to a longer period of vibration for the building. It was in part to remedy this reduced stiffness that I recommended the epoxy injections.

113. Given the limited amount of minor structural damage resulting from the September earthquake and given the minimal additional damage that resulted from the subsequent aftershocks up to the time of my final inspection on 19 October 2010, I

concluded that the capacity of the building at that stage had not been significantly diminished.

114. With respect to part b) of the above question, I did expect that there would be aftershocks and that one of these might have a magnitude of one less than the September Earthquake. What I did not expect (and I do not believe that anyone including the specialist seismologists expected) was an earthquake with the accelerations and resulting forces that accompanied the 22 February aftershock, which were substantially greater than those of the September event. [**Refer Hyland Report, Executive Summary at page 20.**] Having not done any calculations or structural analysis, I had no way of knowing how the CTV Building would perform in an earthquake or aftershock which exceeded the accelerations of the September Earthquake.

115. I have been asked to comment on whether in inspecting the building and reaching my conclusions, I gave any consideration to the following:

a. *Any information from GNS or any other source about the likelihood, location and extent of further aftershocks?* I was aware that aftershocks were likely. I did not, however, seek out information from GNS or others concerning the likelihood, location or anticipated extent of further aftershocks. As I have said, although I expected aftershocks to occur I did not expect (and I don't believe other engineers or seismologists expected) an aftershock to have the accelerations of the 22 February 2011 event.

b. *Any information from the Christchurch City Council relating to building standards or the inspection of buildings following an earthquake. If so, please provide details of this information*. Save for the fact that the CTV Building was green stickered, I do not recall having any other information from the Christchurch City Council at the time of my initial or follow up inspections of the building.

c. *Any information from any other party relating to building standards and the inspection of buildings following an earthquake*. I was aware of the requirements of the NZ Building Code and the various associated design and materials standards. I was also familiar with the NZ Society of Earthquake

Engineering document "Assessment and Improvement of the Structural Performance of Buildings in Earthquakes".

d. *Whether there had been any structural modifications or alterations to the building since its construction.* I was unaware of whether there had been any structural modifications or alterations to the building since its construction.

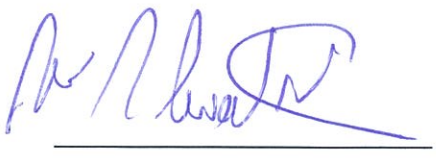
Concluding Comments

116. I along with everyone in Christchurch live with the consequences of the February 2011 aftershock every day.

117. It would be fair to say that I have relived the inspection that I did of the CTV Building over and over in my mind wondering whether there was anything I missed or misinterpreted. I have examined and re-examined the 120 photographs that I took and read and re-read my Notes and my Report. I have asked myself whether there was anything that I could or should have done differently that might have changed the outcome.

118. In the end, I have to fall back on my professional judgement as an engineer. I have told you what I did, the conclusions I came to and the reasons for those conclusions.

119. In closing my evidence I would like to offer my sincere sympathies to the families of the people who died in the CTV Building that day.



William David Coatsworth

Date: