FINAL REPORT

VOLUME 6
CANTERBURY TELEVISION BUILDING (CTV)

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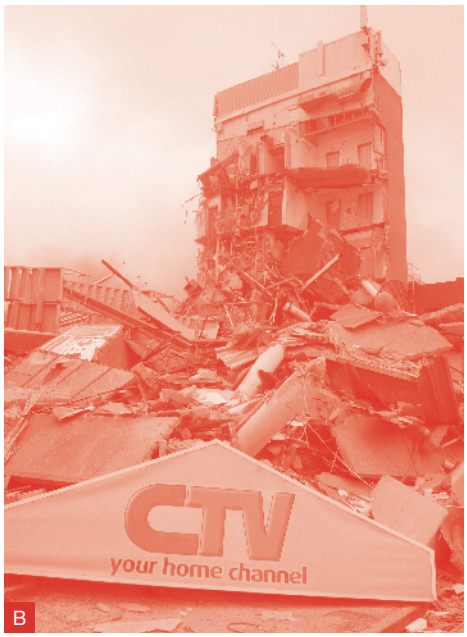

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A. The completed CTV building

B. The collapsed CTV after the 22 February 2011 earthquake (source: Geoff Sloan/The Star)

C. The CTV building under construction (source: Stephen Breach)

D. Floral tributes left at the former CTV building site (source: Dylan Taylor)

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Introduction

The CTV building at 249 Madras Street collapsed during the earthquake at 12:51pm on 22 February 2011. One hundred and fifteen people lost their lives and others were injured.

Figure 1: View of the south-east of the CTV building. Madras Street is in the foreground

Figure 2: An aerial view of the location of the building. Madras Street runs north towards Latimer Square

Those who died in the CTV building

Many parts of this report into the collapse of the CTV building are necessarily technical. However, throughout our Inquiry, we have not forgotten the 115 people who died, their families and their friends. Our thoughts have also been with the people who escaped the building after it collapsed, some of whom will carry serious injuries for the rest of their lives. We think particularly of the two 19-year-old Japanese students, Kento Okuda and Rika Iwakura, who both had a leg amputated following the collapse. Their lives have been changed forever. We appreciate the courage shown by those who retold their experiences during the hearing.

To honour and remember those who died, we asked their family members to tell us about them. The words that follow reflect what they said. We thank the families for their willingness to share this information publicly.

We also thank Mr Yucai Li, Consulate General of the People's Republic of China in Christchurch, Mr Yasuhide Sakamoto, Third Secretary: Protocol & Political section, Embassy of Japan in Wellington and Mr Tsuyoshi Shimbo, Chief of Family Liaison Team, Japanese Nationals Overseas Safety Division, Ministry of Foreign Affairs of Japan for their invaluable language support with this project and for always generously giving their time to support and liaise between the families and the Royal Commission. We would also like to thank Susan Urakami from the Toyama College of Foreign Languages in Japan and Liam Cai from the Christchurch Chinese community for all the support they have provided to the families and the Royal Commission.

Our thanks also go to *The Press* newspaper for biographical information from their supplement 'In Memoriam', which was published on 22 February 2012.

The biographies below all relate to people who were working or visiting in the building when the earthquake struck. Biographies of others who died in other parts of Christchurch as a result of the earthquake are published elsewhere in this Report.

Maysoon Abbas

Dr Maysoon Abbas, 61, was a medical doctor who graduated with a Bachelor of Medicine and Surgery from Baghdad University and Master of Medical Science from Sheffield University, United Kingdom.

She was working at The Clinic medical centre examining a patient in her office on the east side of the CTV building when the earthquake struck.

Maysoon enjoyed art, especially handcraft and painting. She was creative, loved travelling and was a great cook.

She was a very caring person who loved her family and was known for her infectious smile. When she loved, she loved with all her heart. She was strong, determined and passionate about her profession.

Maysoon is survived by her husband of 35 years, Maan Alkaisi, daughters Sarah Alkaisi, Marwa Alkaisi and Mariam Alkaisi, and granddaughter Sally, aged five.

Lalaine Agatep

Ms Lalaine Agatep, 38, was a registered nurse from the Philippines who was studying English at King's Education language school.

Lalaine enjoyed reading, surfing the internet and spending time with friends and family. She was a quiet, kind-hearted person who was obedient and loved her family.

She is survived by Linda Agatep (mother), Lee Agatep (father), Leelin Agatep (sister), Lorelie Agatep (sister), Leah Agatep (sister) and Leila Agatep (sister). Lalaine's sister Leila lives in Wellington, New Zealand, and the rest of her family live in the Philippines.

Husam Al-Ani

Dr Husam Al-Ani, 55, was a medical practitioner working at The Clinic medical centre. He was examining a patient when the earthquake struck.

Husam loved spending time with family, and playing and watching sport, soccer and tennis in particular. He enjoyed jogging, gardening and exploring new outdoor activities.

Husam was a loving husband and father, and a passionate, honest gentleman. As a loving family man, he was a role model and an exemplar for his daughters. Wherever he went his charming smile, his quiet calm and his ability to empathise ensured that he was popular with everyone. Since 1998 he had lived in Christchurch and he loved the city.

Husam was a very generous man who donated hundreds of hours of his time to the Youth Health Trust in Christchurch. His family feel that he died in service and he would not have wanted it any other way. His wife said: "Husam you are a man who lived as a hero, left as a hero and are survived by three young heroines".

Husam is survived by Dr Wasan Al-Ani (wife), Azza (daughter, aged 24), Aysha (daughter, aged 22) and Haya (daughter, aged 17).

Mary Amantillo

Ms Mary Amantillo, 23, was a Filipino nurse who arrived in New Zealand with close friend Valquin Bensurto just over a week before the earthquake. She was studying English at King's Education language school.

Mary sent text messages to her mother in the Philippines as she lay in the rubble of the building. Her first message said: "Ma, I got buried". Forty minutes later she texted: "Ma, I can't move my right hand". Mary's friend Valquin also died in the building.

Emmabelle Anoba

Ms Emmabelle Anoba, 26, was a Filipino nurse who was studying English at King's Education language school as an employment requirement. Emmabelle had been studying at King's Education for just two days before the earthquake.

Emmabelle had two siblings. Her younger sister, Aprille, posted on her Facebook page after the earthquake, "Wish I could hug you and tell you how much I love you".

Marina Arai

Ms Marina Arai, 19, was a Japanese student from Toyama College of Foreign Languages. She had arrived in Christchurch three days before the earthquake and was studying English at King's Education language school.

Marina's family describe her as a diligent student who wanted to improve her English. She had hoped to become a flight attendant or an animator.

Marina was a sincere and warm-hearted person with a delightful smile and a good sense of humour. She had a passion for Japanese tea coordination, and loved making sweets to match tea served in fine china.

Marina is survived by her father, mother, older sister, and a pet rabbit.

Matthew Beaumont

Mr Matthew Beaumont (known as Matty), 31, was a programme scheduler and movie reviewer for CTV. He was at work when the earthquake struck.

Matty was a keen movie buff and a big *Doctor Who* fan who for some time was a member of the *Doctor Who* fan club. Best of all he enjoyed being with his friends, having a laugh.

Matty was the adopted child of Jeannette and David Beaumont. He came to them when 10 days old and had a gentle, placid nature which he never lost. He was the epitome of laughter. His wit, intellect and cheeky smile were contagious and enveloped everyone who met, knew and loved him. He was also incredibly brave; although sensitive to an unkind word or review he would go on committing himself time and again to connect with and entertain people.

Matty had found the perfect partner. He loved his parents and friends and was loved in return. He was truly happy and optimistic about the future.

He is survived by Kelly Thorndycroft (partner), and Jeannette and David Beaumont (parents).

Dominic Bell

Dr Dominic Bell, 45, was working as a general practitioner at The Clinic medical centre when the earthquake struck. Dominic enjoyed jet skiing, snow skiing, watching rugby, cricket and movies, and he appreciated fine wine.

Dominic was an intelligent, loving, generous man who was a wonderful dad. His three sons were the greatest love of his life. He had a brilliant but often offbeat sense of humour and an ability to turn something seemingly ordinary into laughter to brighten anyone's day.

He is survived by Harrison (son, aged 18), Matthew (son, aged 14), Theo (son, aged 11), who were all living with their mother Vicki; Alison Bennie (partner) and her three children Tom, Porsche and Trinity; his sisters Virginia and Leonie, and his brothers Martin, Anthony, Damian and Matthew.

Valquin Bensurto

Mr Valquin Bensurto, 23, was a Filipino nurse who left for New Zealand with his close friend Mary Amantillo on February 12, 2011. They were studying English at the King's Education language school. Taking English lessons was an employment requirement for the nurses.

Valquin came from Jaro District in Iloilo City. He was a keen sportsman and enjoyed playing football and volleyball.

Heidi Berg

Ms Heidi Berg, 36, was teaching English as a foreign language at King's Education language school when the earthquake struck. Her class included many of the newly arrived Japanese students from Toyama College of Foreign Languages.

Heidi was a graduate of the University of Canterbury and had completed TEFL and TESOL qualifications in the United Kingdom and Australia. She was a dedicated and conscientious teacher who taught foreign language students from all over the world.

Heidi had travelled from the North to the South Pole and to many countries. She enjoyed touch rugby, swimming, cricket, walking her dog, driving, reading and spending time at the family holiday house in the high country.

Heidi was a loving, dependable, thoughtful, kind person with a great smile. She was the glue that kept her family and extended family connected throughout the world. She was loved by all her family members, including her granddad, aunties, uncles, cousins, and also by her friends.

She is survived by Alan (father), Julie (mother), Stephen (brother), Justine (sister), John (brother-in-law), Josh and Thomas (nephews), Chloe (niece) and her pet dog, Texas.

Andrew Bishop

Mr Andrew Bishop, 33, worked for CTV as a technical manager for the station. When the earthquake struck he was working with Jo Giles and editing a piece for Woodford Glen Speedway. He had returned from his lunch break and headed back upstairs to resume his work only a few minutes before the earthquake struck.

At CTV Andrew was involved with camera operating, editing, sound technician work, voice-overs, and other aspects of television production. He also worked at rugby games doing match communications and had his own editing company called Ribeye Productions.

Andrew was a fun person and loved to go on road trips with his partner Amber and the three boys they had between them. He liked fishing, camping and was a member of the Sumner Lifeboat crew. He also enjoyed practising on his electric guitar and ukulele and playing on his iPhone.

Andrew had a great personality and could get along with anyone. He had a cheeky smile, contagious laugh and was highly respected. He was a great role model, but also lots of fun for the children at the same time. Andrew loved creating an entertaining atmosphere wherever he went and having home barbecues with family and friends. The more the merrier.

He is survived by Amber (partner) and her two sons, Tyler (Andrew's son, currently aged 7), Karen (mother), Lyndsey (father), Anita (sister), Ben, Sam and Jake (half-brothers) and Nicole (niece).

Nina Bishop

Ms Nina Bishop, 32, was an administrator for Relationship Services in the CTV building. The staff at Relationship Services were like a second family to her. Nina loved her job and her workmates.

For Nina, her family was the centre of her world. She lived with her mother, Vivienne, and they were best friends. Nina was an optimist with a tight group of friends. It was impossible not to love Nina and she had an amazing capacity for giving and caring for those around her, from friends and family to workmates.

Nina loved books and movies and had a fascination with ancient Egypt. She made her dream trip to Egypt in the September before she passed away.

Nina was a loving daughter to Vivienne Bishop (mother) and a loving granddaughter to Enda Bishop (grandmother). Nina is also survived by Tracey, Nicole and Brett (siblings), and Sarah, Morgan, Brandon and Zeph (nieces and nephews).

Pamela Brien

Mrs Pam Brien, 54, had worked for the New Zealand Police for 17 years and was a member of the Christchurch child abuse unit. She was attending a work-related appointment with psychologist Ms Susan Selway at the CTV building when the earthquake struck. Susan also died in the earthquake.

Pam was a hard-working, loyal, dedicated and caring person. She always had an interest in other people and others would confide in her. Police colleagues described her as a very well-organised person who was dedicated to the cause, efficient, hard-working and a loyal friend and colleague.

Pam had started her career with the Police in New Plymouth as an assistant to an area commander in the Criminal Investigation Branch (CIB). New Plymouth CIB head Detective Senior Sergeant Grant Coward described Pam's death as an "absolute tragedy".

She is survived by Geoff Brien (husband) and Amie Booker (daughter, aged 30).

Rhys Brookbanks

Mr Rhys Brookbanks, 25, was a journalist for CTV. He was interested in working in investigative journalism but also had a great future ahead of him as a writer and poet. Rhys was busy preparing an article for evening broadcast on the day the earthquake struck.

Rhys loved travelling both within New Zealand and overseas, all sports, but particularly rugby and rowing, and he played in a mixed netball team. He owned a mountain bike and enjoyed the challenge of cycling through rough terrain as well as family weekend rides. He was well-read and a published poet. Rhys enjoyed pub quiz evenings as he had a wide general knowledge. He had a flourishing vegetable garden and loved to cook. He also played the guitar and enjoyed a wide range of music.

Rhys was a gentle, kind, caring, thoughtful man. He had a quirky sense of humour, loved practical jokes and terrible puns, and had a giggle that still rings in his family's ears. Rhys was very much a family man, always keen to visit his aunts, uncles and cousins, and was a good, amusing correspondent.

Rhys is survived by Fran Brookbanks (mother), Alan Brookbanks (father), Donna Brookbanks (sister) and Esther Jones (fiancée).

Ivy Cabunilas

Mrs Ivy Cabunilas, 33, came from Consolacion in the Philippines and was living in New Zealand with her husband and their 11-year-old twin daughters. She was studying English at King's Education language school and died alongside fellow Filipino students.

Cai Yu

Mrs Cai Yu, 31, was a nurse from Shanghai, China, who was studying English at King's Education language school.

Yu was fulfilling her biggest dream to study abroad when she left for New Zealand in April 2010. She always spoke with her husband about how one day they would have a wonderful life in New Zealand. They would sit together after dinner as a family and play with their daughter. They would drive to see the ocean, and the snow-capped mountains. They would buy a little house with a garden where she would plant her favourite tulips. Her husband says the earthquake of 22 February took away those beautiful dreams and his beautiful wife.

Yu had returned home to China for a two-week holiday in December 2010. Her husband says it was like a farewell arranged by God. They went to Hong Kong and visited Disneyland. Yu's daughter, who was three when her mother died, remembers going to the airport to meet her when she came home for the holidays. When she misses her mother she says to her father, "Daddy, let's go to the airport to get Mummy. She's waiting there for us".

Yu was a person who loved to laugh and was always compassionate to others. Everyone loved her and doctors and nurses called her 'little sister Cai'.

Yu is survived by her husband and her daughter.

Cristiano Carazo-Chandler

Mr Cristiano Carazo-Chandler, 35, was teaching at the King's Education language school when the earthquake struck. He was the son of Faye Chandler and Pedro Carazo. Known as Christian, he was born in Spain and came to New Zealand with his parents when he was three.

He obtained a Bachelor of Arts in Human Geography and Sociology and a Master of Arts in Geography at the University of Canterbury. The subject of his MA thesis was *Cyberspace – Another Geography:Territories, Boundaries and Space*. He then gained a Diploma of Teaching and started his career as an English teacher in South Korea, the United Arab Emirates and Spain.

Christian was a personable young man who loved to travel but had decided to spend time in Christchurch getting to know his young siblings before setting off overseas again. His ambition was to lead a fulfilled life and he planned to teach in less advantaged countries.

Chen Yang

Mrs Chen Yang (known as Sunny), 29, was a Chinese student studying English at King's Education language school. Yang had flatted with another earthquake victim, Wang Limin.

Yang was a happy, optimistic, positive woman who was like a ray of sunshine. Her smile always spread to the people around her and wherever she went she brought positivity with her. She loved to travel and cook. Before she left China she had developed an interest in Western cooking and made delicious pizza.

Yang deeply loved her parents, her husband and her little son and she always hoped they would soon be reunited. She is survived by her parents, her husband and her son (aged two).

John Chua

Mr John Chua, 23, was a Filipino nurse who arrived in Christchurch on February 20 and was studying English at King's Education language school. John, who was known as JK or Insik, lived in Cebu city in the Philippines.

John was a man who lived a simple life but touched a million lives. He was a tender-hearted gentleman who loved animals and children. His joviality and good nature attracted people to him and no one could forget his enthusiastic and contagious laugh.

John was adventurous and loved exploring the world. He was always there to pick up the pieces and sort things out. He was his wife's soulmate and her inspiration; her steadfast rock who helped her through thick and thin.

John is survived by Yoradyl Chua (wife) and Yojwan (his young son).

Susan Chuter

Ms Susan Chuter, 52, was an advertising representative for CTV. She had been with the company for only three weeks, after having left Mainland Press in The Press building. Susan had changed jobs fearing The Press building to be unsafe. When the earthquake struck she had just entered the building, making her way to her desk to complete some paperwork after having signed a contract with a new client for CTV.

Susan enjoyed being a mum and a homemaker. Cars were one of her passions and she liked going to Ruapuna Speedway in the weekends. She loved entertaining, socialising with the many friends who were part of her life, and travelling.

She was a vivacious person who lit up a room; a great communicator who made people feel at ease, was fun and always looked on the bright side.

Susan is survived by her father who lives in England, Gillian Chuter (older sister), three sons aged 37, 34 and 23 and a grandchild.

Tamara Cvetanova

Dr Tamara Cvetanova, 42, was a student at the King's Education language school. She was a former paediatrician in Serbia and had come to Christchurch to raise her family and register as a doctor in New Zealand. She arrived in Christchurch in 2000 and started studying English in January 2011 as an employment requirement.

Tamara was a devoted mother and wife who loved Christchurch and was a firm believer in the New Zealand system. She had spoken to her husband on the phone intermittently up until 1am on 23 February as she lay in the rubble. Tamara was a member of the Russian Orthodox Church of St Nicholas. Her husband will stay in Christchurch with their two children because Christchurch is where she wanted to be.

Tamara is survived by Alec Cvetanov (husband), Todor (son, aged 10) and Katerina (daughter, aged eight).

Joanna Didham

Mrs Joanna Didham (known as Jo), 35, was an advertising producer for CTV. She was in a meeting with CTV's managing director Murray Wood when the earthquake struck.

Jo loved her family, cooking and gardening. She was on the Parent Teacher Association for her daughter Madison's school. She also loved her orange Volkswagen Beetle.

Her family describe Jo as elegant, dedicated, beautiful inside and out, and an organiser. She is survived by Michael (husband of 13 years), Madison (daughter, aged seven), Jessica (daughter, aged three), Ashley and Brandon (brothers), Geoff (father) and Lorraine (mother).

Dian Falconer

Ms Dian Falconer, 54, was working as a receptionist at The Clinic when the earthquake struck. Before she joined the staff at The Clinic she had worked in a nursery growing native plants at Wai-Ora Forest Landscapes.

Dian grew up in Timaru and would visit her sister there, bringing baking with her. Dian went to church every week and also enjoyed being in her garden. She is described by her sister as so precious, caring, kind to animals, lovely and happy-go-lucky.

Dian is survived by Jenny (sister), Teremoana and Mania (children) and three grandchildren.

Jewel Francisco

Ms Jewel Francisco, 26, found New Zealand peaceful, clean and beautiful. She arrived in New Zealand weeks before the February earthquake and was studying English at King's Education language school. She came from Cavite City in the Philippines.

Jewel liked sport and was a competitive swimmer. She studied nursing and chose to come to New Zealand to improve her English and try to register as a nurse. She was aware of the September earthquake and her family had asked her to reconsider her decision to go to New Zealand but she had told them, "If it is my time to join my Creator, then it is my time to go with Him".

She is remembered as a strong, down-to-earth young woman who could take care of herself. She loved cooking and was also fond of dogs and owned three of them. Friends travelled from other countries to attend her wake and pay their respects as she had touched a lot of lives.

Jewel is survived by Ronaldo (her father, whom she adored), Robbie Leigh (older brother, who is also a nurse in the United States of America) and Renz (younger brother). Jewel was also a very caring aunt to Ronzer (nephew) whom she loved very much.

Samuel Gibb

Mr Samuel Gibb (known as Sam), 27, was a CTV news producer who was at his desk when the earthquake struck.

Sam was a bubbly person with a great sense of humour. He was sincere and dedicated to delivering good journalism. Sam's hobbies included playing guitar and listening to music, reading, playing football, brewing beer, fishing and the outdoors.

Sam is survived by Cindy (wife), Carol Gibb (mother), Laurence Gibb (father), Kristen (sister), Cameron (brother), Anna (sister-in-law to be), and Asreal (his cat).

Joanne Giles

Ms Joanne Giles (known as Jo) was a business development manager at CTV.

Jo represented New Zealand in pistol shooting at two Oceania Games and a World Cup. She was New Zealand's first female jockey to race against men, and competed in motor sport and rock 'n' roll competitions. Jo was a candidate for the ACT New Zealand political party in 2005 and was a mayoral candidate in the 2007 Christchurch local body election. Jo constantly challenged herself and liked to break down stereotypes by excelling in male-dominated sports or activities.

As someone with a very empathetic nature, Jo always had the time to listen to other people's problems, despite living a busy life. She believed that a problem shared was a problem halved. She always had time for her family and would have done anything for her children. Jo was constantly laughing and was often the life of the party. She always had something on the go and lived life to the fullest.

Jo is survived by her children Anna, Samantha, Olivia and James.

Elizabeth Jane Grant

Mrs Jane Grant, 51, was a practice nurse at The Clinic. She had been a nurse for over 10 years following a career with New Zealand Railways as a train controller.

Jane loved being at home and her hobbies included gardening, cooking, knitting and doing things with her family. She also loved dancing and playing her accordion. She liked going for trips in the campervan and loved animals, especially dogs.

Jane was generally a quiet-natured person but would stand up for herself when she had to. She was a loyal friend, loved her family and had compassion for other people.

She is sadly missed and survived by Murray (husband), Christina and Nickolas (daughter and son from her previous marriage) and Jenny (her much-loved Cocker Spaniel).

Yuki Hamasaki

Ms Yuki Hamasaki, 23, was having a lesson at King's Education language school when the earthquake struck. After graduating from a Japanese university she entered Toyama College of Foreign Languages and then travelled to New Zealand to study.

Yuki enjoyed listening to music from various countries and liked house parties. She was a person who always laughed and created a cheerful atmosphere around her. She was shy but had a strong will and was loved by many people.

Yuki is survived by her father (aged 57), mother (aged 45), three sisters (aged 21, 20 and 16) and one brother (aged 18).

Han Xiling

Ms Han Xiling, 25, was a Chinese nurse studying English at King's Education language school.

Xiling had dreams of becoming a registered nurse in New Zealand. Xiling was born in Jiangsu, China, and completed her undergraduate degree in 2008. She worked at Nantung Hospital until she decided to seek further education and she travelled to New Zealand in November 2010.

Xiling enjoyed singing and dancing, especially modern dance. She worked hard, was economical with money and was a friendly person.

Her parents said they had lost everything when Xiling died. When they first heard about the collapse of the CTV building they had hoped for a miracle. In Chinese culture parents rely on a child emotionally and financially a great deal, especially when they grow old. They explained that under the Chinese way a child has an obligation to look after their parents. They are sad and devastated, having spent everything they had on their daughter. They buried Xiling in Christchurch and want to return to New Zealand every year to visit her grave and be buried beside her when they die.

Xiling is survived by Han Siyin (father) and Wang Luxia (mother).

Tamara Harca

Mrs Tamara Harca (known as Lia), 59, who was originally from Romania, was an English teacher at King's Education language school. She had been an English lecturer at the University of Craiova and came to New Zealand in 2001. Lia was a senior teacher and teacher trainer at the language school and she had also trained teachers in Romania and Europe.

Lia's husband, Petre Harca, had joined her in Christchurch in 2003 but health problems prevented him from working. Their sons, Sebastian and Nicholai, joined them in 2004 but Nicholai has since returned home.

Lia was the breadwinner of her family. The money she earned went towards establishing a base in New Zealand, supporting her sons and getting her family to Christchurch. She was her husband's moral and financial support.

Lia is survived by Petre Harca (husband), and Sebastian and Nicholai (sons).

Yuki Hasumoto

Ms Yuki Hasumoto, 22, was from Toyama College of Foreign Languages in Japan. She was part of a group who arrived in Christchurch on 19 February on a three-week study and homestay programme.

Yuki had been interested in working abroad one day and had already visited England and Australia when she was a young student. At a young age Yuki became interested in cooking and later, as a student at a culinary school, she travelled to France and Italy, where she earned praise from a pizza chef. Yuki loved music and making sweets. She had many friends and enjoyed going for drives and visiting coffee shops and cafes with them.

Yuki was cheerful and outgoing with a positive attitude. She came from a large and loving family, consisting of her parents, grandmother, two brothers, a sister-in-law, a sister, a brother-in-law and three nephews.

Yumiko Hata

Ms Yumiko Hata, 29, was a Japanese nurse who was on leave from work to obtain an international nursing licence and study English at King's Education language school. She was probably having lunch with friends in the classroom when the earthquake struck.

Yumiko was always cheerful, lively and full of smiles. She cared about her friends and worked hard towards her goals. She loved books and would spend every spare moment reading.

Yumiko is survived by her father, mother, elder sister, elder brother and a younger sister.

Miki Hayasaka

Ms Miki Hayasaka, 37, was a Japanese nurse studying medical English at King's Education language school. After completing her training at the Nursing School of the National Centre for Global Health and Medicine in Japan, she worked as a nurse in Japan at the Cancer Institute Hospital, Yokohamashintoshi Neurosurgical Hospital, Suzuki Orthopaedic Clinic (Morioka City) and Yokohama Miyazaki Hospital of Neurosurgery.

Miki liked music and singing. She enjoyed singing with friends at a local gospel song club and singing at concerts. She also liked travel and photography and enjoyed taking snapshots while travelling. When she returned to her home town once or twice a year she organised family trips.

Miki was cheerful and lively, goal-oriented and had a strong sense of responsibility. She always wanted to improve herself in her work and was kind to everyone. She loved children and they loved her. She took good care of her nephew and niece.

Miki is survived by her parents (both 70 years old), two older sisters (both married) and an older brother.

He Wen

Ms He Wen, 25, was a Chinese nurse who was studying English at King's Education language school.

Wen came from Fuzhou in China where she had been working as a nurse in the neonatal unit in Dongguan Hong Wah Hospital. Colleagues said she was quiet, hard-working and a really good nurse, and her former boss described her as excellent, highly skilled and reliable. He also said her English was excellent and she could communicate with foreign patients at the hospital. Wen resigned in 2010 and came to Christchurch to study English. She had originally hoped to travel to Italy but discovered it would take too long to get the documents, so chose New Zealand instead.

Wen would send money home to China every month to put her younger brother through university. Her father was retired so Wen had become the support person for her brother. Wen had been in Christchurch for the September 2010 earthquake and felt that New Zealand's houses had come through quite well and passed the test.

Sandra Jen Jin Hii

Ms Sandra Hii, 34, worked as the administrator/receptionist at King's Education language school, registering and welcoming new students.

Sandra was a kind, gentle, loving and considerate person who was always willing to give a helping hand to those who were in need. She enjoyed reading the Bible in her spare time and also sharing her faith in the Lord Jesus with others.

She is survived by her parents and siblings.

Marion Hilbers, nee Berry

Ms Marion Hilbers, 49, was a receptionist at The Clinic medical centre.

Marion was a devoted and loving mother to sons Josh (aged 22) and Sam (aged 20). She has been described by her family as caring and extremely generous and she had a heart of gold that was for everyone.

Marion was born in Christchurch and has five brothers and one half-sister. She attended Aorangi Primary School, Cobham Intermediate, and Burnside High School. Her favourite colour was pink and she loved things that sparkled. Marion had a fascination with the stars in the night sky. She also doted on her two cats, Precious and Sylvia. She is sadly missed by her family and friends.

Yuko Hirabayashi

Ms Yuko Hirabayashi, 28, was studying English at King's Education language school. Her family felt she was probably chatting with her friends in the classroom when the earthquake struck. In Japan, after graduating from Kobe University, Yuko had worked as a midwife for three years.

Yuko was an easygoing, caring, thrifty person with leadership abilities. She was a very steadfast person who did not compromise easily, never spoke ill of others, made friends with everybody, worked hard towards achieving her dreams and loved small children very much.

Yuko was excellent at Kendo (3-dan) and while in New Zealand attended a Kendo club where she used her gear brought from Japan and was entrusted with teaching children. She always enjoyed socialising with her peers.

Yuko is survived by her parents, grandparents, younger brother and younger sister.

Yoshiko Hirauchi

Mrs Yoshiko Hirauchi, 61, was a former high school principal in Japan. She had retired in 2010 to study English and was at the King's Education language school when the earthquake struck.

Yoshiko loved and excelled at studying. After she graduated from university she became a high school biology teacher but continued to study and conduct research on soil creatures, eventually discovering a new type of soil bacterium. She later became principal at Namerikawa High School in Toyama Prefecture. After her retirement, Yoshiko wanted to return to university fulltime and continue her research. She wanted to study English first so she would be able to write her thesis in the language.

Yoshiko enjoyed travelling, gardening and watching Korean TV dramas. She was kind to everyone. The younger students at her school loved her and because of her warm and understanding heart they saw her as their second mother.

Yoshiko is survived by her husband, two daughters and a grandson.

Megumi Horita

Ms Megumi Horita, 19, from Japan was studying English at King's Education language school. She was having lunch when the earthquake struck. Megumi was about to embark on a career and had planned to enter university after graduating from Toyama College of Foreign Languages.

Megumi enjoyed table tennis and calligraphy. She loved wearing hats and took a white one with her to New Zealand, which was retrieved after the earthquake.

Megumi is described by her family as pure and innocent, open-hearted and kind to everyone. She had friends from junior high school who were deaf or had problems with non-attendance at school. She was described by her friends as a very truthful person who never told a lie.

She is survived by her father (aged 56), mother (aged 51) and two brothers (aged 20 and 22). She was particularly loved by her parents and grandparents as the youngest child. Her parents mourn her loss and feel empty without her.

Hifumi Hoshiba

Ms Hifumi Hoshiba, 41, was a Japanese nurse studying English at King's Education language school.

Hifumi had extensive experience in nursing at various general hospitals in Tokyo and other places and had been an ER nurse and a flight nurse. She was also an advanced cardiovascular life support provider. Hifumi studied English during her career in Japan and later participated in language training courses for medical professionals in both Oregon and California in the United States of America, before she came to Christchurch for further language training. She wanted to become a nurse who could work globally.

Hifumi enjoyed tennis, scuba diving and wind surfing when she was in her 20s and was practising flower arranging in recent years. She was a positive, forward-looking person who was hard-working and faithful to her principles. She was a thoughtful sister, personally handing out Christmas gifts to everyone in her family every year.

Hifumi is survived by three brothers and a sister.

Huo Siwen

Ms Huo Siwen, 28, was from Harbin in China. She had arrived in New Zealand in 2002 to get her Master's degree and was working as a journalist for CTV when the earthquake struck. She was engaged to be married in 2011 and her fiancé was also in New Zealand at the time of the earthquake.

Siwen had studied science at Heilongjiang University and her family supported her decision to study in New Zealand. She stayed with a Christchurch family when she first arrived in New Zealand and had maintained contact with them over the years.

Siwen was an intelligent and beautiful girl. She is survived by her fiancé, Li Xin, Zhilin Huo (father, aged 55) and Shuxin Liu (mother, aged 55).

Haruki Hyakuman

Mr Haruki Hyakuman, 27, was a Japanese nurse studying English at King's Education language school. He had worked as a nurse at Kanazawa University Hospital in Japan for four years before coming to New Zealand, and was having lunch in the classroom when the earthquake struck.

Haruki's hobbies were travelling, music and his PC. He was an independent, bright and cheerful person who had a strong sense of responsibility. He was kind and always cared about his friends.

Haruki is survived by his father (aged 59), mother (aged 59), sister (aged 30), and three pet dogs.

Rika Hyuga

Ms Rika Hyuga, 30, was a Japanese nurse studying English at King's Education language school.

Rika was born in Tokyo and went to a private school in Yokohama. She majored in nursing at Jikei University's Faculty of Medicine. She had worked as a nurse at the university hospital from 2002 to 2010. While she understood the importance of sophisticated medical technology, her goal was to be a nurse who places more value on humanity and warmth, and being able to share a patient's anxiety and pains. Rika wrote a poem about working as a nurse and the last three lines read, "The world is like a jigsaw puzzle made of a thousand pieces. Smiles and trust are two small pieces next to each other. If these two do not stand by one another, then the whole world will shatter".

Rika was a keen football player and scuba diver. She used to dive at overseas locations six or seven times a year. She also enjoyed learning English.

Rika was an only child and is survived by her parents.

Toshiko Imaoka

Ms Toshiko Imaoka, 34, was a Japanese nurse studying English at King's Education language school. She had been working as a nurse at hospitals in Okayama and Osaka in Japan.

In Japan, Toshiko enjoyed travelling. She also practised flower arrangement. In New Zealand, she loved visiting different cafes and developed a liking for coffee. She ended up attending a training school in New Zealand to become a barista.

Toshiko was a kind-hearted person who expressed her emotions directly. She possessed the inner strength to carry out her intentions once she had made a decision.

She is survived by Tatsuji Imaoka (father), Haruko Imaoka (mother) and Kazuhiro Imaoka (younger brother).

Thanydha Intarangkun

Ms Thanydha Intarangkun, 36, was a nurse from Thailand who was studying English at King's Education language school. Her body was found in a search of the rubble on 24 February.

Tomoki Ishikuro

Mr Tomoki Ishikuro, 19, was a student from Toyama College of Foreign Languages who was studying English at King's Education language school. His English teachers praised his English pronunciation and said he had a great broadcasting voice.

Tomoki was a well-mannered and cheerful young man who loved heavy metal music. One of his prized possessions was his electric guitar and he spent many hours practising on it. He carried his guitar pick with him wherever he went, including to New Zealand. Tomoki was always kind and would go out of his way to help others or cheer them up without hesitation.

Tomoki loved cycling and often went on long-distance trips with his father and younger brother. He enjoyed watching local Japanese trains and was interested in American muscle cars.

Tomoki was raised in a large, happy family and lived with his parents, younger brother, grandparents and great-grandparents.

Kyle Jack-Midgley

Mr Kyle Jack-Midgley, 27, was the area manager for Ashley and Martin Medical Hair Centres (Christchurch and Wellington). Kyle had taken up his new position with Ashley and Martin and moved to Christchurch from Auckland three weeks prior to the February earthquake. At the time of the earthquake he was consulting with colleagues and clients.

Kyle enjoyed being with his family. He loved the outdoors including sun, sport and fishing. He liked travelling, meeting people, learning new things and exploring new adventures. He loved life. His favourite quote was, "Dream as if you'll live forever, live as if you'll die today", by James Dean.

Kyle enjoyed life for what it was, from relaxing in the sun to debating politics. He was an all rounder in sport and academic areas and was respected in all walks of life for his integrity, charisma and diligence. He had a big heart and a big smile. He had a special aura that attracted people to him. Kyle was very family-oriented and a people person who was always there for you if you needed help. Kyle's way was to "do it once and do it properly".

Kyle was the beloved partner of Olivia, cherished son of Suzanne Jack and Neil Midgley, much loved elder brother of Wade, Ryan and Nathan, and adored uncle of Nathan, Phoenix, Aaliyah, Trinity and Karma.

Jin Man

Ms Jin Man, 26, was a Chinese student studying English at King's Education language school. She came from Hebei province in northeast China. She came to Christchurch in September 2010 to study international management at King's Education.

After her death a message from Man Jin's family read, "You might not be anymore, but you've left us with endless memories. Everything's well at home; you don't need to worry. We'll always love and miss you".

Kayo Kanamaru

Ms Kayo Kanamaru, 19, arrived in Christchurch only days before the February earthquake. She was studying English at King's Education language school with her school friends from Toyama College of Foreign Languages. When she was at high school Kayo had gone on a two-week exchange to the United States of America. She had such a meaningful experience in the United States that she wanted to go abroad again to study English. She chose New Zealand because she wanted to follow in her older sister's footsteps.

Kayo enjoyed watching movies and dancing. She had been a member of the dance team for the Toyama Grouses men's basketball team and would perform during half-time. Kayo also dreamed of working in the film industry.

Kayo was a bright, friendly, kind girl with a radiant smile that warmed people's hearts. She is survived by her two sisters, parents and grandparents.

Kyoko Kawahata

Ms Kyoko Kawahata, 20, was attending the orientation at King's Education language school to prepare her for the three-week programme there when the earthquake struck. She was a student at Nara Women's University in Japan, majoring in English literature.

Kyoko enjoyed reading books, listening to music and playing the piano. Her family describe her as shy, cooperative, thoughtful and diligent. She made many friends both at her university and through a part-time job because of her good nature and sweet spirit.

Kyoko is survived by Kuniaki Kawahata (father, aged 58), Kuniko Kawahata (mother, aged 55), Naoko Kawahata (sister, aged 28), Tomoko Kawahata (sister, aged 26), Ikuko Kawahata (sister, aged 23), Hiroyasu Kawahata (brother, aged 18) and Sadako Kawahata (grandmother, aged 80).

Beverley Faye Kennedy

Mrs Faye Kennedy, 60, was the practice manager of The Clinic medical centre. As such, Faye was responsible for the efficient running of all its aspects.

Outside of work, her interests were her family, house, garden and tennis. Faye was involved in tennis for 50 years, including playing, junior tennis and administration. Faye is remembered as a bubbly person who loved life and was looking forward to her senior years.

She is survived by Brian (husband, aged 63), Karen (daughter, aged 32) and Megan (daughter, aged 31).

Saori Kikuda

Ms Saori Kikuda, 19, was a Japanese student from the Toyama College of Foreign Languages who was studying English at King's Education language school. She was enjoying lunch with her friends when the earthquake struck.

Saori enjoyed studying languages including Chinese and Korean. She also liked jazz and pop music. She was a kind, thoughtful, hard-working young woman with a strong sense of responsibility, but she also had a carefree side to her nature.

She is survived by her parents and a sister.

Yasuhiro Kitagawa

Mr Yasuhiro Kitagawa, 39, was a political journalist for 15 years in Japan. He had visited North Korea five times for work. When the earthquake struck he was in the classroom at King's Education language school where he was improving his English.

Yasuhiro was a hard-working, honest person who enjoyed reading and driving. He had driven to almost all the medieval castles in Japan.

He is survived by his parents and a younger brother.

Lai Chang

Ms Lai Chang, 27, was a Chinese nurse who came to New Zealand in February 2010 to improve her English. She was studying at King's Education language school when the earthquake struck.

Chang rang her father in China soon after the earthquake hit and said, "Daddy, I won't make it". He awoke to the call at just after 8am Beijing time. Chang's family, who live in Guangzhou in South China, contacted the embassy in New Zealand minutes after he received the phone call and they alerted a search and rescue team in Christchurch. Chang was never heard from again.

Chang had studied at Guangzhou University of Chinese Medicine and friends described her as a lively, passionate girl.

Hsin-Hung Lee

Ms Hsin-Hung Lee, 33, was a Taiwanese nurse who was studying English at King's Education language school. When the earthquake struck she was inside the building, preparing for courses in the afternoon. She was planning to eventually work as a nurse in New Zealand and join the Red Cross in order to help more people.

She enjoyed reading, studying English, singing, listening to music, and playing ball games. Her hobbies included watching movies and sightseeing.

Hsin-Hung was a kind, friendly person and very eager to help other people. She was also active and open-minded. At home, she was very kind and obedient to her parents.

She is survived by Mu-Yung Lee (father, aged 62), Chun-Hui Huang (mother, aged 58), Hsin-Yi Lee (sister, aged 35) and Xin-Mei Li (sister, aged 29).

Leng Jinyan

Mrs Leng Jinyan, 30, was a Chinese nurse studying English at King's Education language school. What made her happy was working hard for her family. She liked singing and cuisine. Most of all she enjoyed being a nurse because she felt she could help people to overcome their suffering from illness.

Jinyan was a sunny, confident and enthusiastic person who shared her happiness with other students and friends. She was a kind wife, dear mother and a grateful daughter. Her passing has left her family with great pain but countless loving thoughts.

She is survived by Cheng Xiange (husband, aged 42), Cheng Kesen (her husband's son, aged 18) and Chu Xingling (mother, aged 55).

Li De

Mr Li De (known as Lucas), 18, was a Chinese student learning English at King's Education language school. It was lunchtime when the earthquake struck.

Li De had a strong wish to succeed in life. His family says he passed away when he was just stepping into the age of adulthood and was anxious to discover more about life and this world. He told his mother many times that Christchurch was as beautiful as fairyland, but he missed his home town.

He had wide interests and sincere friendships. He enjoyed boxing, playing piano, guitar, singing and listening to music.

Li De is survived by Liao Luxia (mother).

Li Wanju

Mrs Li Wanju (known as Julia), 44, was a Chinese nurse studying English at King's Education language school.

Julia had come to Christchurch in 2010 to study English after studying nursing in Beijing and working in the emergency department of one of the local hospitals. She had also worked at a hospital in Kuwait.

She is survived by her husband and son (aged 12).

Li Xia

Ms Li Xia (known as Olive), 42, was a Chinese student studying English at King's Education language school. Xia's body was found during a search of the CTV building rubble on 27 February.

Phimphorn Liangchuea

Mrs Phimphorn Liangchuea, 41, was a Thai nurse studying English at King's Education language school. She was part of the Providence Education Group which, for four years, had helped Thai nurses study in New Zealand.

Phimphorn is survived by Sorasak Liangchuea (husband), her daughter (aged 13) and her son (aged 17).

Haruthaya Luangsurapeesakul

Ms Haruthaya Luangsurapeesakul, 32, was a nurse at a hospital in Bangkok, Thailand. She was studying English at King's Education language school. Haruthaya was on her lunch break with her classmates when the earthquake struck.

Haruthaya always had a smiling face. She was a kind, patient, responsible, hard-working woman who was strong in her Buddhist beliefs. She enjoyed singing karaoke with friends and going to retreats at temples to practise meditation.

Her family are Daranee Luangsurapeesakul (mother, aged 61), the late Kulachart Luangsurapeesakul (father), Kemruthai Luangsurapeesakul (sister, aged 35), Nopadol Luangsurapeesakul (brother, aged 34) and Tavadol Luangsurapeesakul (brother, aged 30).

Shawn Lucas

Mr Shawn Lucas, 40, was a production manager for CTV. He had probably just finished his lunch in the staff cafeteria and would have been hurrying to get back to his work when the earthquake struck.

Shawn was a member of the Sumner Volunteer Fire Service and Sumner Lifeboat crew. He enjoyed cricket, American football, war gaming and watching films. He was a loving, giving, funny and enthusiastic person.

Shawn is survived by Maree (wife, aged 40), Holly (daughter, aged 17), Jack (son, aged 15), three cats (Mog, Pippin and Hammersley) and a bird called Peter.

Donna Manning

Ms Donna Manning, 43, was a presenter for CTV who was at work when the earthquake struck.

Donna enjoyed family times, socialising, gardening, music, photos, camping, boating and walking; most of all she loved being a mum.

She is described as outgoing and fun to be with. Donna was very creative and could always make dull things seem interesting. She was loving and compassionate, clever and cheeky. Her presence would light up a room.

Donna's family are Lizzy and Kent (children), Betty and the late Vince Gardiner (parents), Jenny, Maurice, Jeff, Daphne, David, Pam and Andy (siblings) and Tigs (her cat).

Teresa McLean (nee Elms)

Mrs Teresa McLean, 40, was a registered nurse who was working as a practice nurse at The Clinic when the earthquake struck.

Teresa loved all sorts of crafts, listening to music of the 1980s and spending time with her boys and family. Teresa lived life to the full and was a caring, devoted wife, mother and daughter. She was always cheerful and helpful to others.

She is survived by Alistair (husband), Henry (son, aged two), Thomas (son, aged six months) and Tim and Mavis Elms (parents).

Heather Meadows

Ms Heather Meadows, 66, was at a medical appointment at The Clinic with Dr Maysoon Abbas when the earthquake struck.

Heather was born in England and her family moved to New Zealand when she was 11 because her father was transferred to the Royal New Zealand Air Force. Heather, a former private in the army, met her husband, Charles, at Burnham Military Camp. She lived at the camp for 15 years and raised her children there.

Heather loved watching television, listening to music, the Royal Family and loved to talk.

She was most comfortable wearing clothes such as jeans or track pants and did not wear make-up. She was also happy to sit at home in her dressing gown and slippers.

Heather is described as one in a million.

She is survived by three children, seven grandchildren and one great grandchild.

Ezra Medalle

Ms Ezra Medalle, 24, died alongside her boyfriend, Jessie Redoble. They were from Danao City, in the Philippines. They were both nurses who were at their first day of English classes at King's Education language school.

She was an only child but had not seen her mother for years as her mother had moved to Canada to earn money to pay for her education. Ezra had tried to apply to practise as a nurse in Canada and Jessie had tried for America, where his father lives. They both ended up coming to New Zealand, leaving for Christchurch on 19 February.

Ezra and Jessie have been described as inseparable, really in love and very sweet to each other. Ezra was kind, softly spoken, joyful, honest, respectful, smart, and a perfectionist. She had a high level of English and was completing the King's Education course to become registered as a nurse in New Zealand.

She enjoyed listening to music, reading, travelling and shopping. Ezra is survived by Arlene Medalle (mother).

Janet Meller

Ms Janet Meller, 58, was an osteopath working at The Clinic.

Janet was born in Jersey and was one of four children. Her younger sister, Pauline, was also her best friend. One of her brothers was intellectually handicapped and her family believe this triggered Janet to dedicate her life to helping others.

Janet went to school in South Africa and qualified in osteopathy when she returned to England. She joined a Christchurch osteopathic practice in 1987. She encouraged everyone to come to New Zealand, calling it paradise.

Janet and her partner, Denis Maddever, had been together since 1989 and raised their two sons, James and Henry, in Sumner, Christchurch. The boys were well informed about good posture, food and a healthy way of living.

Personal development was one of Janet's passions and she was described as energetic, outspoken and never boring. To be helpful and honest Janet couldn't hold back; she would tell friends and customers what she thought, hoping it might make a difference to their lives, even if it meant losing a friend or a patient. Janet has left a big mark in many lives.

Emi Murakami

Ms Emi Murakami, 19, was a Japanese student studying English at King's Education language school. She arrived in Christchurch on 19 February as part of a three-week study group from Toyama College of Foreign Languages in Japan.

Emi had an insatiable curiosity about things around her and wanted to know about everything. She is described as a hard worker and a diligent student who loved learning about new things.

She is survived by her mother and a younger sister.

Erica Nora

Ms Erica Nora, 20, was attending an ACE course at King's Education language school when the earthquake struck. She had completed a three-year nursing course in the Philippines and was working as a weekend harvester at Meadow Mushrooms while studying English.

Erica enjoyed playing badminton and had been given the award for most valuable badminton player while at Catholic Cathedral College, which she attended in Christchurch before studying at King's Education. Erica liked cooking and made lasagne, brownies and pasta; she also enjoyed playing computer games.

She is described as a mature thinker who was pretty, kind, very friendly and a very loving daughter; her faith was important to her.

Erica is survived by Arturo Nora (father), Luisa Nora (mother), Danica Nora (sister) and Jeffrey Nora (brother).

Noriko Otsubo

Ms Noriko Otsubo, 41, was a Japanese nurse, who was studying English at King's Education language school. She was having lunch when the earthquake struck.

Noriko had worked as a volunteer in Niger, Africa, for three years after she graduated from university as a member of the Japan Overseas Cooperation Volunteers (JOCV). She witnessed firsthand the dire need for medical supplies and saw many children dying without receiving sufficient medical treatment. This experience motivated her to want to help others.

After Noriko returned to Japan she became a professional nurse. During this period she also participated in medical and rescue activities in other countries as a volunteer for international medical non-governmental organisations such as the Association of Medical Doctors of Asia (AMDA) and Doctors of the World.

Noriko enjoyed travelling overseas, making miniature objects, playing er-hu (a two-string bowed musical instrument) and reading. She was an honest, mild, hard-working, positive person who never gave up and always saw things through.

She is survived by her father (aged 73), mother (aged 67) and a sister (aged 39).

Linda Parker

Ms Linda Parker, 50, was a compassionate carer of disabled adults and children. She was at a doctor's appointment at The Clinic when the earthquake struck.

Linda had a great sense of humour and was devoted to her daughter, Caitlin, and was inseparable from her Jack Russell dog, Maisey. She lived in Hoon Hay, Christchurch with Caitlin and Maisey. Linda was born in Greymouth but moved to Christchurch as a baby. She loved to knit and loved her animals, feathered, furry or in between.

She was heavily involved in different community groups around Christchurch, such as the Action Ministry at South City Christian Centre. Linda had always wanted to be a nurse and worked as a volunteer for the Timeout Carers Bureau, where she assisted with disabled adults and children for three and a half years before she died. Linda was last seen leaving a disabled client's home for her doctor's appointment at The Clinic.

Linda is survived by Cara (daughter, aged 32) and Caitlin (daughter, aged 12).

Wanpen Preeklang

Ms Wanpen Preeklang (known as Nok), 45, was a Thai student studying English at King's Education language school. Nok was last seen walking into the building with the other Thai students shortly before the earthquake struck.

A bangle from a temple in a central Thai province was found on Nok's wrist. She died alongside her friends, the other Thai students.

Jessie Redoble

Mr Jessie Redoble, 30, was attending the orientation and briefing for his first day at King's Education language school. He was with his girlfriend and classmate, Ms Ezra Medalle, when the earthquake struck.

Jessie was a registered nurse in the Philippines. He worked at Danao City Provincial Hospital as a floor nurse. He had also studied computer science and was starting an internet business in the Philippines.

Jessie and Ezra loved to go out together, shopping, going to the beach or fishing. Jessie liked going to the Kingdom Hall and associating with his brothers, sisters and other relatives. He liked going out on ministry work.

Jessie is described as a God-fearing man. He was a loving, caring person who was respectful of others. He loved to befriend children and he was reliable, dependable and trustworthy.

His father passed away in 2007 in the United States, where his mother is a permanent resident and works in the healthcare industry. Jessie had two brothers (aged 31 and 22) and a sister (aged 23).

Deborah Roberts

Ms Deborah Roberts (Deb), 39, was the accounts manager at King's Education language school. She had spent her lunch break with her fiancé, Brendan Baker, and had just returned to her office when the earthquake struck. She was talking on the phone to her sister, Kate Busson, at the time.

Deb enjoyed walking and watching the children play sport. She loved the outdoors and enjoyed weekends and bush walks around the family's holiday house at Lewis Pass. She also loved to go for weekend rides on her Harley Davidson motorbike and then relax in the evening with a wine.

Deb was a very practical, loyal, family-oriented person who loved catching up with family and friends whenever she could. She loved her two cats and spoilt them rotten. If the Crusaders were playing you would find Deb on the couch with a wine in her hand; she was a proud Cantabrian. Deb was due to turn 40 in June 2011 and was planning her wedding to Brendan later that year.

Deb is survived by Brendan Baker (fiancé) and his children to whom she was a stepmother, Stacy (aged 13), Loren (aged 12) and Jaimee-Lee (aged 10), Grant and Lorraine Roberts (parents), Nikki Colenso (elder sister), Kate Busson (elder sister), Jane (niece), Ben (nephew), Amy (niece) and Ella (niece). Deb had two cats, Mickey and Mallory; Mickey passed away a few months after Deb.

Saya Sakuda

Ms Saya Sakuda, 19, was a Japanese student from the Toyama College of Foreign Languages who was studying English at King's Education language school.

Saya was very kind to other people and had a strong sense of justice. She enjoyed playing tennis, was a dedicated member of her college drama class, and was described as a diligent student and a creative person.

Saya, who was quiet and friendly, admired foreign countries and wanted to improve her English; she had no firm plans for the future but had her own dreams. Travelling to New Zealand was a step towards improving her ability to make her dreams come true.

Yoko Sakurai

Ms Yoko Sakurai, 27, was a Japanese nurse studying English at King's Education language school. She was born in Liaoning province in north-east China and her family migrated to Japan when she was six. She grew up in Tochigi prefecture and was educated in Oyama.

After graduating from Oyama-Jonan High School, Yoko studied nursing at the Chiba National Medical Centre. After becoming a professional nurse, she worked in the centre's internal medicine ward for five years. In her spare time Yoko worked as a volunteer, using her sign language skills; she also liked cooking.

Yoko had a younger brother (aged 18).

Gillian Sayers

Ms Gillian Sayers, 43, was an English teacher at King's Education language school. She is described as a wonderful writer who loved teaching. Her students loved her and her family received many letters from her students when she died. She always made people a priority over material things.

Gillian was born in England and came to New Zealand with her parents and sister when she was seven. She attended Linwood College and studied linguistics and philosophy at the University of Canterbury. Gillian is remembered as an ethical person who had a fierce passion for animals. She thought through issues deeply. Gillian enjoyed collecting quotes and her favourite quote by Albert Einstein is a poignant reminder of her life: "Only a life lived for others is worth living".

She is survived by her family and partner (of 17 years), Matthew Boyce.

Susan Selway

Ms Susan Selway, 50, was a clinical psychologist who was working with a client, Ms Pam Brien, when the earthquake struck. Susan was only working in the CTV building until her new offices were available. She had lectured at the University of Canterbury and was in the process of building up her private practice, which was going very well as she was so highly respected by her clients and peers. Susan also gave her time to the STOP Trust aimed at reducing child abuse in the South Island; she was the chairperson and, with 12 years' service, the longest-standing board member. For a number of years, she was also on the board of directors for the COCA Art Gallery.

She enjoyed playing bridge with her mother and sailing in the Marlborough Sounds on the yacht she shared with her husband, Richard. She was also a good skier. Susan enjoyed catching up with friends and family. She liked travel, art and culture.

Susan is described as a people person. Her ability to empathise with people, no matter from what walk of life, was incredible. She was very caring, loving and totally straight and honest. She was a deep thinker, determined, an academic and a problem solver. She was charismatic and shone like a star in the crowd. She will always be remembered by her many friends as the life and soul of a good party. Susan was the rock of her family.

She is survived by Richard Austin (husband), Christine Selway (mother), Malcolm Selway (father), Karen Selway (sister), David Selway (brother), Helen O'Donnell (sister), Sally Kane (sister), Peter (half-brother), Katherine (half-sister), Sam and Matt Austin (stepchildren), Cosmo (her Jack Russell dog) and Minty (a West Highland Terrier).

Allan Sinclair

Dr Allan Sinclair, 45, was working as a general practitioner at The Clinic when the earthquake struck. He was respected deeply for his work ethic and his loyalty to his patients and colleagues alike.

Allan was a devoted husband and loving father. He is remembered as a man with a great sense of humour and a quick wit. He was intelligent, charming, gentle and kind. He was a good listener and an engaging conversationalist. Allan was much loved and will be greatly missed.

He enjoyed mountain biking and golf with his sons, and loved family holidays skiing and exploring New Zealand. He supported the Crusaders and the All Blacks. He was admired for his love of reading, his wide knowledge and his interest in the arts.

Allan is survived by Frances (wife), Alastair (son, aged 17) and Harry (son, aged 13).

Christine Stephenson

Ms Christine Stephenson (known as Trish), 61, was working as a relieving practice nurse at The Clinic when the earthquake struck.

Trish is described as social, adventurous and fun to be with. She was an animal lover who was passionate about the outdoors. She was also an enthusiastic tramper and a devoted member of the Peninsula Tramping Club.

Trish grew up in Gisborne and followed her older sister's footsteps into the nursing profession. She trained at Christchurch Hospital before travelling extensively around Europe, Africa, South America, Australia, Nepal and the Pacific. Trish then worked as an air hostess for the travel opportunities it offered, and had met her husband, Rob Stephenson, in flight. After their marriage ended she returned to Christchurch and gained an arts degree in social sciences before trying her hand as a real estate agent. She later returned to practise nursing on a casual basis and volunteered for St John Ambulance.

Trish had planned to travel to Europe in May 2011 to visit family and retrace her father's footsteps as a soldier in the Second World War. She is survived by George (son, aged 32) and Tom (son, aged 30).

Rhea Sumalpong

Ms Rhea Sumalpong, 25, was a Filipino nurse studying English at King's Education language school. She was trapped in the kitchen area with fellow Filipino, Jessie Redoble, when the earthquake struck.

Rhea enjoyed organising, watching movies, hanging out with friends and family, minding her little cousins and going to church. She is described as an obedient daughter, protective sister, loyal friend and supportive aunt. She was confident with an independent mind. She was a God-fearing person.

Rhea is survived by Marlene Sumalpong (mother), Mario Sumalpong (father), Rhizza Sumalpong (sister) and Zaielle Sumalpong (niece).

Yoko Suzuki

Ms Yoko Suzuki, 31, was a Japanese nurse studying English at King's Education language school. She was having lunch with her peers when the earthquake struck.

Yoko is described as a cheerful, active, positive person who enjoyed yoga, diving and Awaodori dance.

She is survived by Kikuo Suzuki (father, aged 64), Chizuko Suzuki (mother, aged 63) and Takeshi Suzuki (brother, aged 36).

Tetaki Tairakena

Mr Tetaki Tairakena (also known as Wally), 60, was working as an English teacher at the King's Education language school when the earthquake struck. He was probably in the resource room preparing for the afternoon lessons.

Tetaki had spent many years teaching Te Reo Māori before teaching English.

Music was Tetaki's passion and he also taught drums for many years, and worked as a drummer in bands such as The Velvettes, Steve Apirana Band, Gerardo Torres Latin Band and his own band, Svelte, for which he composed Māori waiata.

Tetaki was born in the Waikato and moved to Christchurch in his late teens. He loved Christchurch and, because of his strong belief in and love of God, he preached the gospel in Cathedral Square for many years.

Tetaki loved life, and was very joyful and passionate about everything. He gave 500 per cent to whatever he undertook and so always attained very high standards. His favourite quote was a Māori proverb "He aha te mea nui ki roto i te ao? He tangata, he tangata, he tangata".

This translates as, "What is the most important thing in the world? It is people, it is people, it is people".

Tetaki is survived by Donna (wife) and Chokki (his dog).

Hiroko Tamano

Ms Hiroko Tamano, 43, was a Japanese nurse who was studying English at King's Education language school when the earthquake struck. She had survived the 1995 Kobe earthquake in Japan only to be killed in the Christchurch earthquake.

Hiroko was working as a nurse at a municipal hospital in Kobe, Japan, when the magnitude 7.3 quake struck. Her apartment was flattened, 6400 people were killed and Hiroko helped care for the injured.

Hiroko, who was born in Osaka, Japan, has two older brothers. Her family said she took good care of people, was friendly and cheerful. She was popular among all her colleagues, regardless of age and position.

Hiroko enjoyed travelling and her dream was to gain a nursing qualification in Christchurch and immigrate to New Zealand with her skills.

Brian Taylor

Mr Brian Taylor, 66, was the managing director of King's Education language school. Brian had been a science teacher for more than 20 years before becoming the director of Science Alive for 11 years, then director of King's Education. He was first and foremost an educationalist.

Brian is described as larger than life in many respects. He was a survivor in lots of ways, he persevered and persisted and never gave up. To find that he had met something bigger than himself, something he couldn't do anything about was hard for his family to comprehend.

Prue, Brian's wife, describes him as outgoing, sociable and focused. He was the kind of person who was very easy to talk to; he was kind, caring and very approachable. Brian had strong opinions about many things that would get him into trouble at times.

Brian had an all-consuming passion for athletics and sport. He had played rugby at school and went on to represent both Otago and Canterbury in athletics. In his last few years he had started coaching athletics.

He is survived by Prue Taylor (wife), Hamish (son, aged 39) and Benjamin (son, aged 37).

Isaac Thompson

Mr Isaac Thompson, 21, was a sound operator and IT technician with CTV and was last seen sitting at his computer at 12.45pm. He had been working for CTV for three years and loved his job. In his spare time, he would often fix computers and solve sound and IT problems. From when he was a toddler, Isaac had been fascinated by technology and machinery. At the age of 10 he was learning to operate a sound desk at the Rangiora Baptist Church.

Isaac was a man of few words, but when he said something it was worth listening to. Isaac's sharp wit caught many by surprise. He was also generous with his time and talents. A talented musician who played bass guitar and drums, he was a member of the Christchurch band, Honesty, which he had formed with his two cousins. They had released their debut album in 2010.

His Christian faith was demonstrated through his loyalty and commitment to other people. He once wrote, "Lord, if I get nothing else done today, I want to spend time loving you and loving others, because that is what life is all about."

Isaac is survived by Rebecca Thompson (mother), Rod Thompson (father), and older siblings Christiana, Josiah and Ryan.

Lesley Thomson

Ms Lesley Thomson, 55, was visiting the osteopath at The Clinic when the earthquake struck. Lesley was a sector review coordinator at the Apparel and Textile Industry Training Organisation (ATITO). She enjoyed spending time outdoors in the sun, travelling the world and Toastmasters.

Lesley is described as a kind, generous, caring and loving person.

She is survived by David Thomson (father), Brian Hendry (partner), Olivia (daughter, aged 30), Scott (son, aged 28), Alex (son, aged 23) and grandchildren, Maya (aged two) and Cleo (aged 11 months).

Elsa Torres De Frood

Mrs Elsa De Frood, 53, was a Peruvian-born New Zealand resident working as a director of studies at King's Education language school. She wrote on Facebook, "Love my job!!! I meet interesting people all the time and the people I work with are great!! Who could ask for anything more??"

Elsa could speak five languages. She enjoyed listening to music, reading books, watching movies, dancing to Latin music and sharing with family and friends. She was an incredible person who was very friendly, generous, helpful, loyal and modest. Elsa was a great mother, daughter, sister and a wonderful friend who was devoted to her family.

Elsa's remains were never found, but her wedding ring and keys were discovered in the ruins of the building.

She is survived by John Frood (husband), Karen and Michelle Frood (twin daughters), Francisco, Gerardo and Edgar Torres (brothers) and Mika (her dog).

Asuka Tsuchihashi

Ms Asuka Tsuchihashi, 28, was a Japanese nurse studying English at King's Education language school. She was probably eating the lunch her host mother had prepared for her, when the earthquake struck.

Becoming a nurse had been Asuka's dream since she was a child. When she was at high school she went to Australia to study English for nearly a year. After graduating from high school, Asuka went to a school of nursing in Okinawa then worked as a nurse in Kyoto for over four years and in Osaka for six months.

Asuka was calm and mild, but she was firm in her beliefs about what she wanted to achieve – to be a nurse and work overseas. She had the strength to push her way towards her goals.

Asuka is survived by one older sister and one younger sister.

Tu Huiyun

Ms Tu Huiyun, 22, was a nurse from Christchurch's sister city, Wuhan, in China. She was studying English at King's Education language school when the earthquake struck.

Huiyun was a talented, considerate, loving and grateful person. In her parent's eyes she was the only one they could always rely on. She kept working as hard as a boy, which made her parents proud. She had donated blood from the age of 18. She was frank, straightforward and devoted to her friends. She was a passionate nurse who loved to laugh and because her laughter was particularly infectious Huiyun cheered her patients up and won the admiration of colleagues and patients alike.

Her parents describe her as having a boy's personality and a girl's pure heart and spirit. She was born into a poor family but she knew how to enjoy life. In her short life Huiyun won infinite love from her parents and friendship from a lot of people. Her parents say there is now one more angel in heaven.

Huiyun is survived by a disabled father and an elderly, ailing mother.

Yurika Uchihira

Ms Yurika Uchihira, 19, was a Japanese student studying English at King's Education language school.

Yurika is described as like the sun to all who knew her. She would make people near her feel bright, happy and warm. She was a happy girl who loved people and was good at making them laugh. Yurika had the ability to create a comfortable and calm atmosphere wherever she was.

One of her hobbies was fencing and she taught a children's fencing class in Japan. Yurika was also skilled at Japanese calligraphy and one of her works was awarded the New Face Award at the Toyama Prefectural Art Exhibition in 2009.

Yuriko enjoyed spending time at Tokyo Disneyland with her mother, shopping, eating and talking. She was studying English because she had dreams of living and working in a foreign country.

Amanda Uriao

Mrs Amanda Uriao (known as Mandy), 38, was working for CTV as a sales representative when the earthquake struck. She enjoyed bike riding with her family, travelling to South Bay for family holidays as often as possible, fishing and having long baths.

Mandy is described as caring, strong and very determined. She would be the first to organise and host a family event, the first to come to the aid of others when needed and was the kindest soul. Despite often being busy, Mandy would always cook or bake something for others and deliver it with a kiss and a cuddle in a flying visit before rushing off to do something else. She is remembered as a beautiful person inside and out.

She was completely dedicated to everything she undertook, whether it was work, sport or any other activity. This always resulted in a high level of achievement that she so deserved.

Mandy is survived by Ngati (husband), Samara (daughter, now aged nine), Jayden (son, now aged six), Brian (father), Carol (mother) and Tracy (younger sister).

Valeri Volnov

Mr Valeri Volnov, 41, was a Russian-born New Zealand resident who was working as an IT systems operator for CTV. Valeri moved to New Zealand from Ulyanovsk, a town on the Volga River to the east of Moscow.

Valeri is described as a good friend and a man of the future. There was no problem Valeri couldn't solve. He had a great personality and a very sharp mind. He was interested in history, politics, science, spiritual development, classical music and science fiction. He also loved to travel, document his adventures and make movies about his experiences.

Valeri did not have a television at home because he did not want to waste precious time. He would rather spend time reading books, listening to music or doing spiritual practices.

Valeri's wife, Anna, last saw him as he left for work on 22 February. At work he was last seen talking to Mr Matthew Beaumont and Mr Shawn Lucas at 12.20pm.

Jittra Waithayatadapong

Ms Jittra Waithayatadapong (known as Tarr), 40, was a Thai nurse studying English at King's Education language school.

Her parents had to submit DNA samples to the Royal Thai Police to confirm the identity of her body.

Wang Limin

Mrs Wang Limin, 32, was a Chinese nurse studying English at King's Education language school. Limin came from Liaoning, where her husband, Changlong, is a junior doctor at Shunkang Liaoning Hospital. In Christchurch, Limin flatted with another Chinese earthquake victim, Chen Yang.

Limin is survived by Wang Changlong (husband) and their son (aged five).

Wang Tao

Mrs Wang Tao, 29, was a Chinese nurse studying English at King's Education language school.

Tao came from Liaoning. She had been a nurse at the Beijing United Family Hospital before coming to Christchurch to study. Tao had planned to take up nursing in New Zealand but first she needed to fulfil the English language requirements. She had left for New Zealand on 4 January 2011.

Tao loved to laugh and sing and was a happy angel in the eyes of her colleagues. She is survived by her husband.

Siriphan Wongbunngam

Ms Siriphan Wongbunngam, 27, was a Thai nurse studying English at King's Education language school.

Siriphan came from Nakhon Pathom and is described as a lovely, sweet person. She had a keen interest in nature and travelling and enjoyed taking photographs.

Murray Wood

Mr Murray Wood, 56, was the managing director of CTV. His career included working as a professional musician, musical director for TVNZ, and managing director and owner of Magnum Mac, Natcoll and CTV. He was also on several boards including as chairman of the Christchurch Music Centre. Murray's own band 'The White Herons' was the resident band at Travelodge. When the earthquake struck he was at work at CTV, working on some music with Suzanne Prentice.

Murray was a gifted and talented musician who enjoyed sharing and making music and was a multi-instrumentalist. He also had a shared interest in and owned racehorses with his father, Jack. In the 1980s Jack and Murray had travelled to the United States together, including Los Angeles and Las Vegas where they acted like brothers. Murray was keen to go here, there and everywhere and when his father pointed out that money was running out he said, "Dad, what's money?"

Murray was always positive, caring, extremely generous, kind-hearted and had a keen sense of humour.

He is survived by Nicki (wife), Kimberley (daughter), Bradley, John, Mark, Adam and Ben (sons) and his father John (known as 'Jack').

Stephen Wright

Mr Stephen Wright, 46, was a marketing manager at CTV who was in a meeting on the first floor when the earthquake struck.

Stephen's hobbies included photography and cooking. He had a lovely personality, and was very kind, giving and generous. He also liked spending time with his family and friends. His great passion was photography and he had a real gift with landscapes.

Stephen is survived by June Wright (mother, aged 81) and Sue Rolston (sister, aged 45).

Paul Wu

Mr Paul Wu, 60, was a devoted husband and father and had just become a proud grandfather. At the time of his death he was the finance administrator with CTV, where he had worked since 1997. Paul was born in Malaysia but was a New Zealand citizen.

He was a passionate sportsman and excelled at badminton. To his CTV colleagues he will be remembered as their 'Hacky-sack King'. In the last year of his life, Paul became a keen and accomplished gardener and spent hours tending his rose, herb and vegetable gardens.

Paul was an unassuming man of many talents and strong faith. He will always be remembered for his smile, his kindness and his unflinching commitment to his family, his work and his God.

Paul is survived by his wife Nancy, three children and a granddaughter.

Xin Sisi

Ms Xin Sisi, 28, was accompanying her University of Otago friend to a medical appointment at The Clinic when the earthquake struck. Sisi was a dietetics student, studying to become a dietician at the University of Otago in Christchurch. Her course was due to finish in mid-2011.

Sisi loved baking and spent a lot of time trying out new cakes, biscuits and desserts for her friends and family.

Everyone who had their lives touched by Sisi remembers her for her very cheerful and bubbly personality. She had a sweet and beautiful smile, which will forever remain in the hearts of those who loved her.

Sisi is survived by Xin Yao Yin (father), Xu Yong (mother) and Dr Soon Jee Low (partner, whom Sisi planned to marry in 2012).

Xu Linlin

Ms Xu Linlin, 26, was a Chinese nurse who was learning English at King's Education language school. Her father describes her as a mature, outgoing person who enjoyed music and study.

Linlin is survived by Xu Donghai (father, aged 54).

Xu Xiujuan

Ms Xu Xiujuan, 46, was a Chinese nurse studying English at King's Education language school.

Xiujuan is described as eager to help people, outgoing and kind-hearted. She loved life, liked playing the piano and was good at drawing and singing.

She is survived by her father (aged 85), daughter (aged 19) and three sisters.

Ayako Yamaguchi

Ms Ayako Yamaguchi, 30, was a Japanese nurse studying English at King's Education language school.

Ayako loved travelling and had travelled by herself not only in Japan but also in Asia, Europe and Oceania. She had many friends from around the world and had 70 friends on her Facebook page.

Ayako enjoyed her life and made the most of her short 30 years. Her parents are proud of her.

Ayako is survived by Kazunori (father) and Yoshie (mother).

Didem Yaman

Ms Didem Yaman, 31, from Turkey, lived in Dunedin but was visiting her friend, Sisi Xin, on 22 February. Didem had a medical appointment at The Clinic and Sisi accompanied her.

Didem had been studying politics for five years at the University of Otago. She was the New Zealand representative for the Turkish think tank, the International Strategic Research Centre (USAK). Didem had worked as an academic in international relations at a university in Canakkale, Turkey. USAK had asked her to do a doctorate about relationships between Turkey, Australia and New Zealand. She was about to accomplish her goal and be awarded her doctorate.

Mina Yamatani

Ms Mina Yamatani, 19, was a Japanese student from the Toyama College of Foreign Languages who was studying English at King's Education language school.

She was a sweet girl who was always smiling. She was bright and cheerful with a strong sense of responsibility and a kind and gentle heart. Mina persevered and was diligent in everything she did.

Mina loved birds, drawing and music. She also loved learning English and practising Japanese calligraphy. Sometimes she gave her calligraphy to family members as gifts after choosing just the right words for them. After graduation, her goal was to transfer to university and get a job teaching English and Japanese calligraphy to children.

Mina is survived by her parents, older sister and grandparents.

Ye Caiying

Ms Ye Caiying (known as Cathy), 27, had worked as a midwife in a neonatal unit in China before moving to New Zealand to study. She was studying English at King's Education language school.

Cathy came from Guangzhou in China, where she had worked as a midwife for six years at the local hospital. A former colleague said she was always responsible and careful; even though the work could be tough, Cathy would always face everything with a smile and never lose her temper.

Saki Yokota

Ms Saki Yokota, 19, was a Japanese student from the Toyama College of Foreign Languages who was studying English at King's Education language school.

Saki was thoughtful, considerate and a hard worker. She had a great sense of humour. Wherever she was, there was sure to be a lot of laughter and smiles.

Saki appreciated music and played the piano. She also liked to go on drives or shopping with her family. As a language student, Saki was interested in the customs and culture of New Zealand. She put her heart and soul into everything she did.

With three older brothers, Saki was the beautiful princess of her family.

Gilhwan Yu

Mr Gilhwan Yu, 23, was a Korean student studying English at King's Education language school with his sister, Naon Yu. Both died in the building collapse where they were the only Korean casualties.

Gilhwan, who was born and grew up in Ilsan in the Kyungi Province, had dreams of becoming a university professor. He was the eldest of four children. He arrived in Christchurch with his sister approximately six weeks before the earthquake.

Gilhwan and his sister Naon were very close to each another and had a lot of fun together. He was a bright, positive and persuasive person. Both Gilhwan and Naon enjoyed spending time volunteering and supporting teenagers who came from broken families.

Naon Yu

Ms Naon Yu, 21, was a Korean student studying English at King's Education language school with her brother, Gilhwan Yu.

Naon, who was very close to her brother, is described as being full of energy and an outgoing person. She had wanted to become a nun.

Sang Chul, Naon's father, said his wife has not fully recovered from the pain of losing her children and he was trying to support his wife and two younger children.

Zhang Didi

Ms Zhang Didi, 23, was a Chinese nurse who was studying English at King's Education language school. Didi came from the historic city of Luoyang in Henan, China. She was a loving daughter and a very determined person.

Didi had attended Tianjin Medical School and was considered an excellent student. She came to Christchurch in October 2010.

On 26 October 2010, Didi wrote in her diary, "Yesterday, I treated myself and bought a loaf of sliced bread, and I felt lucky. But, no matter how hard it is, I have to weather it because nothing is easy. When no one else has faith in you, you have to have faith in yourself, because dawn will come one day."

Didi planned to bring her Chinese siblings to New Zealand after she completed her English course and was registered as a nurse. She had two older sisters and one younger brother. Her parents had struggled to provide for their four children and Didi had always wanted to help give her brothers and sisters a good life. Didi had also saved up money to buy medication for her mother, who had a cerebral embolism, and her diabetic father.

Zhang Hui

Mrs Zhang Hui, 34, had been a nurse in China. She was studying English at King's Education language school when the earthquake struck.

Hui liked English, studying and travel. She had a pleasant personality, was always ready to help others and was very generous; she was willing to challenge herself and keep moving forward.

She is survived by Chen Wu (husband), Chen Jinrui (son, aged five) and Zhang Cunxing (father).

Zhang Weiyu

Ms Zhang Weiyu (known as Cathy), 30, was a Chinese student studying English at King's Education language school. She had been attracted to New Zealand by the beautiful scenery.

Cathy was born to a Manchurian family in Hebei. She left China to study in Australia in February 2009 and moved to Christchurch in July 2010.

Cathy's parents had her late in life and her brother says they all were devoted to her. She had always been smart and was a hard-working student. She lived simply and sparingly and she loved life; she is described as happy, lively, generous and responsible.

Cathy had travelled extensively around New Zealand's South Island visiting Queenstown, Akaroa, the Pancake Rocks, Te Anau, the West Coast, Lake Wanaka, Oamaru, Mt Cook, Milford Sound and Dunedin.

Cathy's brother described her death as being "As if a flower wilted while in full bloom". He misses her vibrant smile and delicate bird-like silhouette.

Zhong Yantao

Mrs Zhong Yantao, 31, was a Chinese midwife whose work performance was highly regarded. She was studying English at King's Education language school when the earthquake struck.

Yantao is described by her husband as an "angel in white". She was a good wife and a devoted mother; kind-hearted, caring and refined with a cheerful character. She would always persist in her goals and never lose heart in the face of difficulties. Yantao was also a realist, believing in hard work and never making vain attempts.

She liked reading. After work, she kept learning and trying hard to improve herself. Yantao liked going window-shopping and often spent a whole day walking from shop to shop. She also enjoyed buying things and, seized by a whim, would bring a lot of things home. Occasionally, she would go to the cinema.

Yantao is survived by Zhuo Shaoyong (husband), Lily (daughter, aged five), an elderly mother and a younger brother and younger sister.

Zhou Xiaoli

Ms Zhou Xiaoli, 26, was a Chinese nurse studying English at King's Education language school. She was attending a class when the earthquake struck.

Xiaoli enjoyed travelling, playing sports, singing, dancing and making friends. She also liked animals and nature.

She is described as warm-hearted, generous, friendly, trustworthy and willing to help other people; she was a little shy.

Xiaoli is survived by Wang Wei (mother, aged 52), Zhou Bo (father, aged 54) and Le Le (pet dog, aged 10).

Terms of Reference

At the outset of this section of the Report it is important to record what the Royal Commission was directed to do in relation to the CTV building collapse. The former Department of Building and Housing (DBH) carried out a technical investigation into the reasons for the collapse. The Royal Commission's Terms of Reference contemplate a wider inquiry. Applied to the CTV building, the Terms of Reference directed the Royal Commission to inquire into:

- why the CTV building failed severely;
- why its failure caused such extensive injury and death;
- why it differed from others in the extent to which it failed;
- the nature of the land associated with the building and how it was affected by the Canterbury earthquakes;
- whether particular features of the building contributed to the failure;
- whether as originally designed and constructed, and as altered and maintained, the CTV building complied with earthquake-risk and other legal and best-practice requirements that were current, both in 1986 when the CTV building was designed and constructed and on or before 4 September 2010;
- whether prior to 4 September 2010 the CTV building had been identified as earthquake-prone or had been the subject of any measures to make it less susceptible to earthquake-risk and, if it had, the compliance or standards this had achieved;
- the nature and effectiveness of any post-earthquake assessments of the CTV building and any remedial work carried out on it after the 4 September and 26 December 2010 events; and
- any other matters arising out of or relating to these issues that came to the Royal Commission's notice that it considered it should investigate.

The Royal Commission was also directed to inquire into more general issues of legal and best-practice requirements in relation to building design, construction and maintenance and the managing of risks of building failure caused by earthquakes. While the CTV building is not referred to specifically in relation to these more general matters, to the extent that knowledge gained from the investigation into the collapse of the CTV building assisted the Royal Commission in its consideration of these wider issues, an inquiry into these issues was also within the Terms of Reference for this Report.

In preparation for the hearing, counsel assisting the Royal Commission gathered documents, interviewed witnesses, engaged experts, and directed written questions to a number of people about the design and permitting of the building in 1986, compliance with applicable building codes and best-practice, the construction of the building in 1986 and 1987, the circumstances in which work was done in 1991 to strengthen the connections between some of the floor slabs and the north wall complex, ongoing alterations to the building and changes in its use, and assessments of the building to determine its suitability for occupation after the September earthquake and ongoing aftershocks.

As required by its Terms of Reference, the Royal Commission has not inquired into, determined or reported on any questions of liability. However, this exclusion did not foreclose an inquiry into, and a determination of, errors or failings in design, permitting, construction, inspection or any other matter that might explain why the CTV building failed severely and why its failure caused such extensive injury and death.

Relationship to other sections of the Report

Many of the matters arising from this investigation into the collapse of the CTV building are common to other buildings and therefore other sections of the Report.

The discussion below covers:

- the history of the CTV building before the September earthquake;
- the performance of the building in the September earthquake and Boxing Day aftershock;
- the assessments of the building after those earthquakes;
- the reasons the building failed in the February earthquake; and
- lessons the Royal Commission considers should be learned from this failure.

It reflects information gathered from a variety of sources including:

- the investigation into the failure of the building by Dr Clark Hyland and Mr Ashley Smith for DBH (the Hyland/Smith report);
- the DBH Expert Panel review of the Hyland/Smith investigation (the Expert Panel report);
- a peer review of the Hyland/Smith and Expert Panel reports carried out for the Royal Commission by Mr William T. Holmes of Rutherford and Chekene;
- the panel of experts directed by the Royal Commission to confer and report back about non-linear time history analyses (NLTHA) and elastic response spectra analyses (ERSA);
- evidence given, and submissions made, to the Royal Commission at a hearing held from 25 June 2012 to 7 September 2012, including evidence from:
  - witnesses to the collapse;
  - a number of expert witnesses;
  - Dr Alan Reay, the principal of the engineering firm, Alan Reay Consulting Engineer (ARCE), which was responsible for the original structural design of the building and staff who worked for him on this project;
  - Mr David Harding, the engineer working for ARCE who carried out the original structural design of the building; and
  - the Christchurch CIty Council as the regulatory authority administering building controls in Christchurch.

A list of the people referred to in this Report and their role is set out in Appendix 1.

Section 1: The building

1.1 General description

The CTV building was six storeys high. On the original drawings, the ground floor was called level 1, the first floor was level 2, and so on up to level 6. The floors were referred to in this way in the evidence at the hearing and we adopt the same approach.

Figure 3: The CTV building in 2004. Shown in a photograph from the Hyland/Smith[1] report

At the time of the February earthquake, the western side of level 1 was an internal car park. The remainder of level 1 and the whole of level 2 were occupied by Canterbury Television (CTV), a community broadcaster that had been a tenant since 2000. Going Places Education had occupied level 3 of the CTV building, but moved out on 20 or 21 December 2010. This move was not related to the condition of the building. Level 3 remained vacant on 22 February 2011. The principal tenancy on level 4 was King's Education, which operated a variety of language and aged care education programmes. The Clinic, which was a medical centre, moved in to level 5 in January 2011 after a red placard was assigned to the building it had occupied in Gloucester Street. Relationship Services (now known as Relationships Aotearoa) occupied half of level 6 and had done so for some years. The other half of level 6 was unoccupied on 22 February.

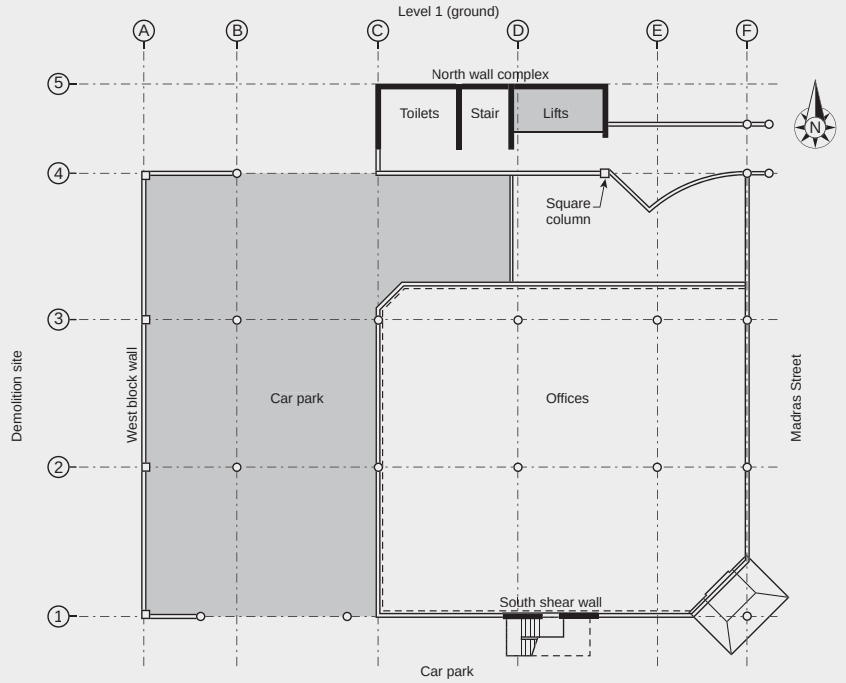


Figure 4: Plan of level 1, which was occupied by CTV at the time of the February earthquake. The finger walls in the north wall complex were shorter on level 1

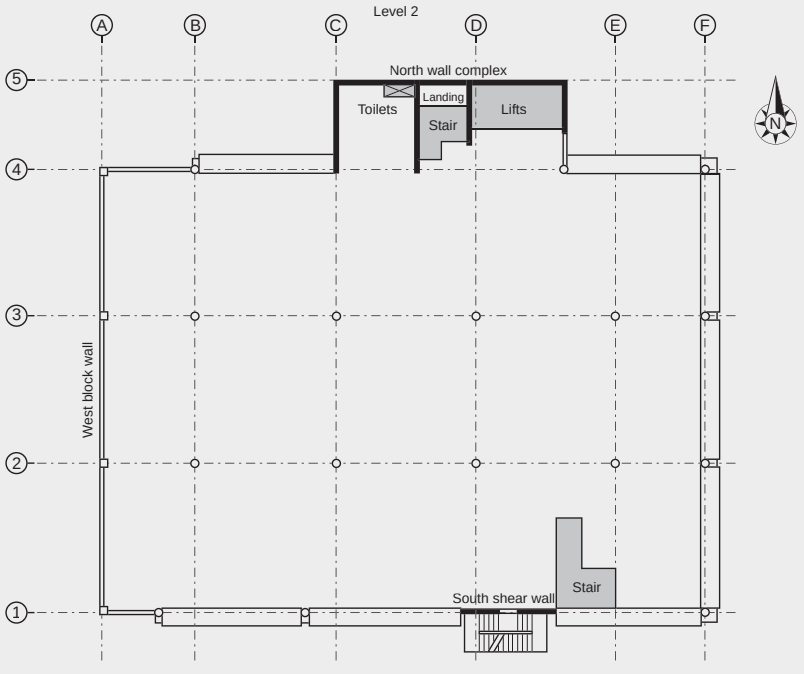


Figure 5: Plan of level 2, which was also occupied by CTV

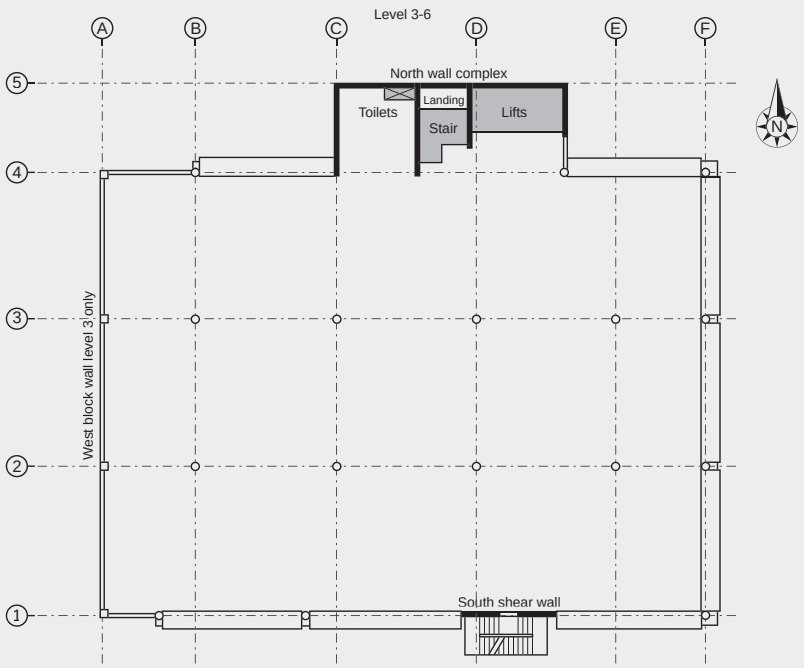


Figure 6: Plan of levels 3–6, occupied by King's Education (level 4), The Clinic (level 5) and Relationship Services (level 6). Level 3 was vacant at the time of the Boxing Day and February earthquakes

The owner at the time of the February earthquake was Madras Equities Limited, which is recorded on the Certificate of Title as owning the property from 25 March 1991. The building manager was Mr John Drew, who had entered into a contract to purchase an interest in Madras Equities Limited in April or May 2010 and was the owner of The Clinic.

1.2 Structure of the building

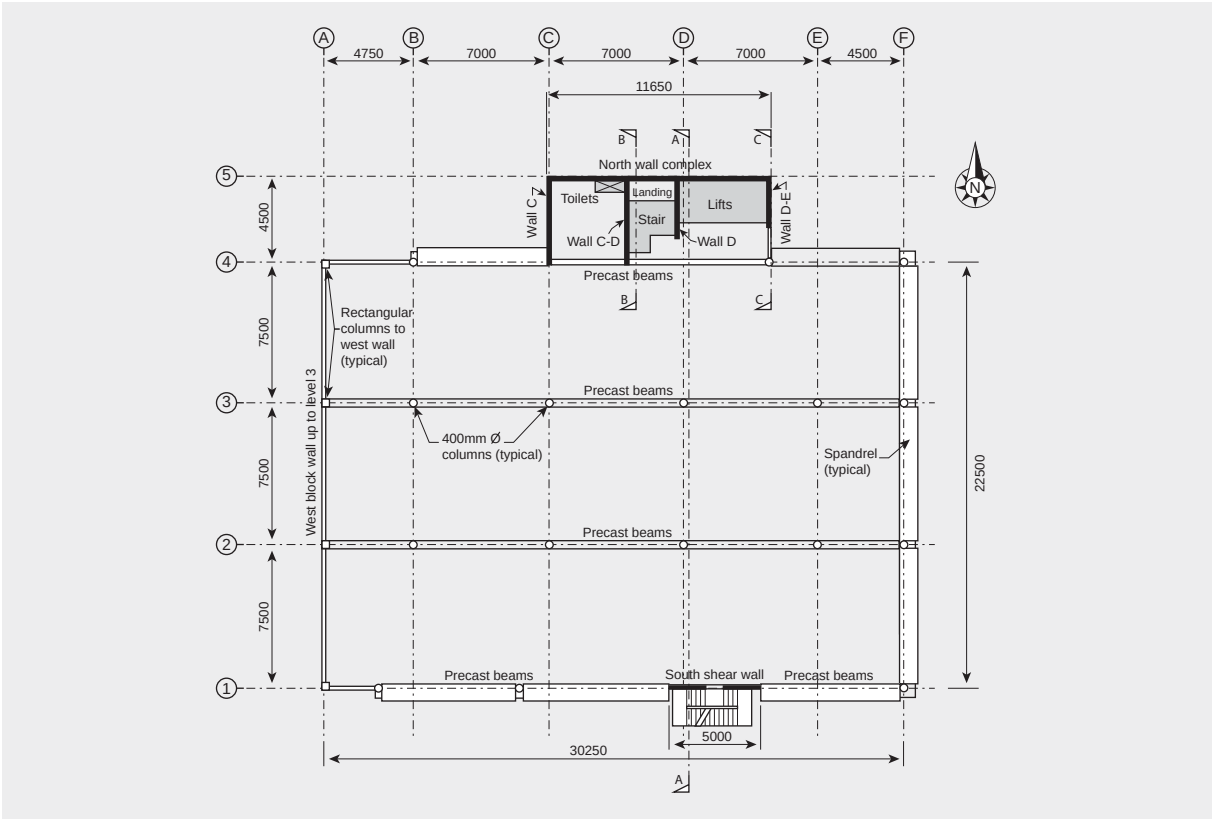


Figure 7: Typical upper floor structure

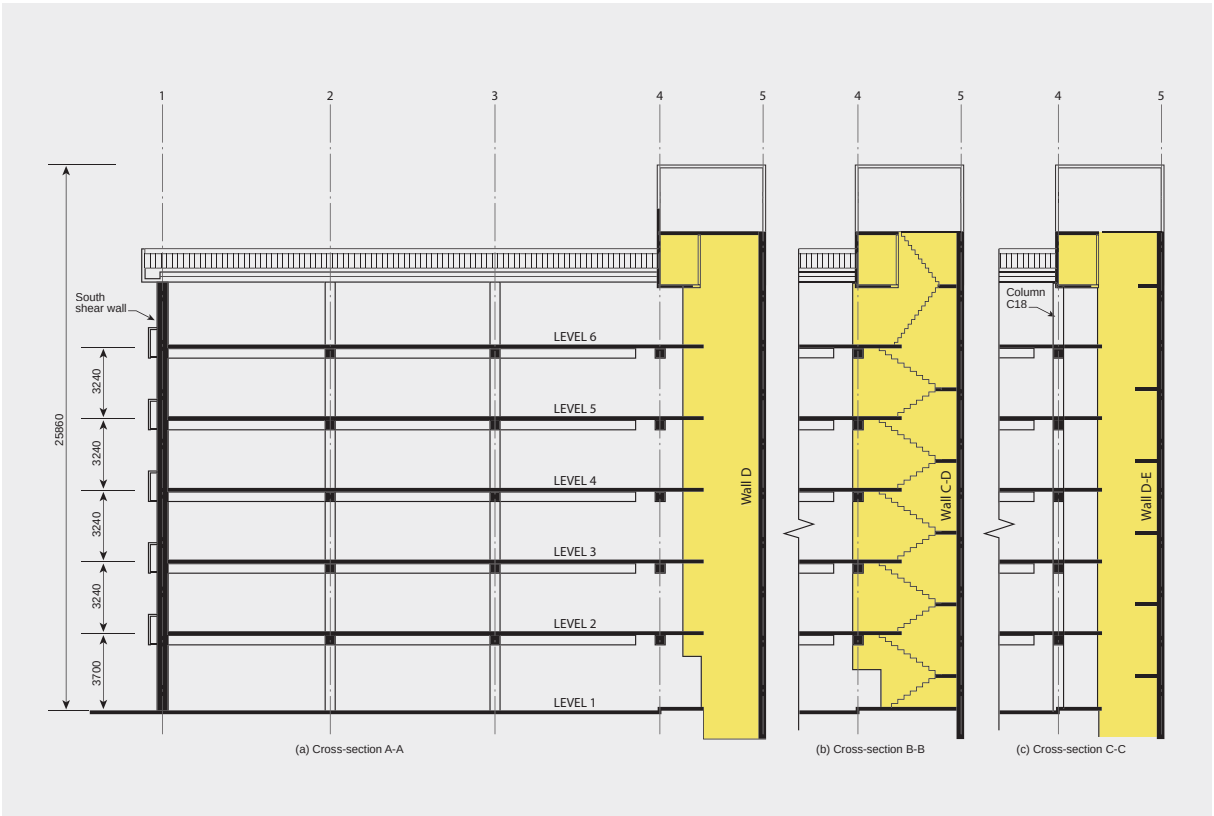


Figure 8: Cross-section looking west near grid line D

1.2.1 Original design

The plan dimensions of the CTV building can be seen in Figure 7, and cross-sections in Figure 8. The building was founded on pad and strip footings bearing on silt, sand and gravels. The above-ground structure was described in evidence as a "shear wall protected gravity load system". This means that the lateral load resistance in an earthquake was to be provided by shear walls. The columns were only designed to resist gravity loads as it was assumed that the shear walls would limit lateral deflections in the columns. This design approach received much attention during the hearing and will be referred to in detail in this Report.

The north wall complex consisted of an 11.65m long reinforced concrete wall on grid line 5 in the east-west direction with four reinforced concrete walls in the north-south direction. These surrounded the toilets, the stairs and the lifts. This was often referred to as the north core in evidence provided to the Royal Commission. However, the word "core" implies an enclosed structure (such as the shear core of the Pyne Gould Corporation building). As the wall arrangement in this building was not enclosed we have chosen to refer to it as the "north wall complex."

The south shear wall comprised two reinforced concrete walls joined together by coupling beams on the south face of the building. The beams crossed above the openings in the wall for fire escape doors. We refer to this as either the "south coupled shear wall" or the "south shear wall".

Reinforced concrete masonry walls were built between the columns and beams on the first three levels on the western side of the building. The floor slabs above level 1 comprised a profiled metal deck on which concrete was poured during construction to form the floors. The composite arrangement of metal decking and concrete was the proprietary product Dimond Hi-Bond. The floor slabs were supported by reinforced concrete beams. The internal beams were precast to the underside of the floor slabs. The external beams on the north, south and east sides were shell beams, which were filled with in situ reinforced concrete when the floor slab was cast. On the west side at levels 2 and 3 there were precast beams spanning between the columns in the north-south direction.

The photographs in Figures 9 to 11 below were taken during the construction of the building. Figure 12 was taken after the building to the west was demolished between the September and February earthquakes.

Figure 9: View of the building from Madras Street while under construction. The north wall complex is to the right. The beam structure can be seen, along with the external round columns. The upper beams are "shells" at this point and were filled with concrete at the same time as the floor was poured

Figure 10: View from Madras Street before the installation of spandrel panels

Figure 11: View from Madras Street. The spandrel panels are now fitted, and the north wall complex can be seen covered in scaffolding

Figure 12: Photograph of the west wall after demolition of the building to the west, showing the block wall for the three lowest levels

The majority of beams were supported by circular cast in situ concrete columns of 400mm diameter. The columns contained vertical steel reinforcement surrounded by horizontal steel spirals. On the west face of the building the columns were rectangular, and one interior column on level 1 was square. The columns provided the bulk of the gravity support for the floor slabs, although the north wall complex and the south shear wall also contributed to gravity load support.

Figure 13: An interior column and beam on level 1

The roof was lightweight steel, supported on steel framing above level 6. Reinforced concrete spandrel panels were placed between the exterior columns at each level above level 1 on the south, east and north faces. These panels were not designed to provide any lateral or gravity load support.

1.2.2 Structural modifications after construction

Following a pre-purchase review for the Canterbury Regional Council by Holmes Consulting Group in January 1990, steel angle drag bars were fitted to the floor slabs and walls at grid lines D and D–E of levels 4–6 in October 1991 to improve the connections between the floor slabs and the north wall complex.

CCC records indicate that holes were to be drilled in floor slabs for plumbing installations. Holes would also have been drilled for other services. Holes were observed at locations where the slab pulled away from the north wall complex during the collapse. These would have had little or no effect on the structural performance of the building in an earthquake.

A stairwell penetration was cut in the floor of level 2 for installation of an internal stairwell during a fit-out in 2000. Steel beams and a steel post were added to replace the gravity load structure where necessary. This opening can be seen in Figure 5. The penetration did not affect the seismic performance of the building.

Although there were there other alterations to the building, these would have had little or no effect on the seismic performance of the structure. These included:

- the addition of block walls in some parts of level 1 in 1991, which were largely removed in 2000;
- the addition of a canopy to the south-east corner;
- alteration to the entry foyer and canopy on the north-east corner;
- telecommunication equipment added to the roof;
- the addition of a Lundia shelving system; and
- lightweight partitions on all floors.

The Royal Commission is not aware of any other modifications to the primary structure of the building.

References

1. Hyland C., and Smith, A. (2012). *CTV Collapse Investigation for Department of Building and Housing: 25 January 2012*. Wellington, New Zealand: Department of Building and Housing.

Section 2: The CTV building from 1986 until September 2010

2.1 Engineering design of the CTV building

The engineering design of the CTV building was undertaken by a Christchurch firm, Alan M Reay Consulting Engineer (ARCE) in 1986. We begin our discussion of the design of the building with an introduction to the key personnel at ARCE during the mid-1980s.

2.1.1 Alan M Reay Consulting Engineer

2.1.1.1 Dr Alan Reay

Dr Alan Reay studied at the University of Canterbury where he obtained a Bachelor of Engineering degree with First Class Honours in 1965 and a PhD in Civil Engineering in 1970. His PhD thesis was concerned with the dynamic characteristics of civil engineering structures. He is a Fellow of the Institution of Professional Engineers New Zealand, a Chartered Professional Engineer and a member of a number of engineering societies and organisations.

After completing his education and working for two years as a structural engineer with Hardie & Anderson in Christchurch, Dr Reay started his own firm, Alan M Reay Consulting Engineer in 1971. Alan Reay Consultants Limited (ARCL) was incorporated in 1988 and Dr Reay continues to practise, as a Director of that company. Mr Rennie QC, Mr Palmer and Ms Paterson appeared for ARCL and Dr Reay at the hearing and references to their submissions in the discussion that follows are to submissions that were evidently made on behalf of both parties.

Mr Rennie QC pointed out judicial recognition of Dr Reay's professional abilities and achievements. He was described in a High Court decision[1] about a dispute with a former co-director of his firm as "one of New Zealand's foremost structural engineers and lead consultants", whose work "has been acclaimed not only in New Zealand but also overseas". In 1995 Dr Reay was the engineering advisor to the Commission of Inquiry into the Collapse of a Viewing Platform at Cave Creek Near Punakaiki on the West Coast. In his report[2] to the Governor-General, the Commissioner, District Court Judge Graeme Noble said:

> Dr Reay has high academic qualifications, is a learned theoretician with very sound practical skill and is conservative and careful in his approach. Very substantial weight can be attached to his evidence, which was of great assistance. In cross-examination he demonstrated all the hallmarks of the expert witness, giving careful consideration to questions, providing balanced answers and being prepared to acknowledge that another expert might hold a different opinion.

Dr Reay's curriculum vitae states that he has 40 years' experience in the design of building structures throughout New Zealand. He said in evidence that in 1986 most of his work related to, and focused on, single level precast concrete factories and cold-formed steel design. He had been developing systems for the design of precast concrete, on site cast structures and the use of cold-formed steel in the light industrial and farming sectors throughout New Zealand and parts of the South Pacific. One of his former employees, Mr John Henry, described Dr Reay as "a very prominent designer" in the area of tilt-slab design and said that the systems he developed for those buildings were very efficient with regard to the use of materials and ease of construction. Dr Reay's work in developing the use of tilt-slab construction in New Zealand was recognised in 1997 when he was awarded the Engineering Achievement Award for outstanding design contributions that advance the application of tilt-up construction, by the Tilt-Up Concrete Association of America, the first time it was awarded outside of the United States. However, those systems were not present in the CTV building and were not relevant to its design.

Dr Reay referred to three multi-storey buildings he was responsible for designing before the CTV project came to the ARCE office. These were a six storey concrete frame building in Liverpool Street, designed when he was employed by Hardie & Anderson, and two buildings undertaken by ARCE: Kamahi Towers, an apartment building in Carlton Mill Road and Ibis House at 183 Hereford Street, designed in 1974. These buildings, and the knowledge and experience that they provided to Dr Reay relevant to the CTV building design, will be considered in more detail in section 2.1.2.1 below.

2.1.1.2 Structural engineers employed by Dr Reay

During the early period of ARCE, Dr Reay was the only structural engineer within the firm, but this changed as the business grew. Mr David Harding and Mr John Henry were subsequently employed and both gave evidence at the hearing.

2.1.1.2.1 Mr Harding's first period of employment at ARCE

Mr Harding was first employed by ARCE between 1978 and 1980 as a civil and structural engineer. He had graduated from the University of Canterbury with a Bachelor of Engineering (Civil) degree with Second Class Honours in 1973 and became a Registered Engineer in 1976. Like Dr Reay, he was employed by Hardie & Anderson for four years after he completed his studies. During that period Mr Harding was involved in the design of residential buildings and foundations, single-storey factories, offices, warehouses and school buildings and the structural strengthening of brick buildings. After joining ARCE in 1978 he undertook the design of structural elements of residential buildings and industrial and commercial buildings of one or two storeys particularly of precast concrete construction. He was responsible for the design of particular projects. Mr Harding left ARCE in May 1980 to gain experience in civil engineering.

2.1.1.2.2 Mr Henry

Mr Henry was employed by ARCE for around a year between 1984 and 1985. He graduated from the University of Canterbury with a Bachelor of Engineering with First Class Honours in 1979 before joining Holmes Wood Poole and Johnstone, where he was involved in the design of multi-storey buildings and trained in the use of the dynamic analysis computer program, ETABS. He became a Registered Engineer in 1982. Dr Reay said he employed Mr Henry primarily to undertake the design of medium height multi-storey buildings, which he had started to take on at that time. During his time at ARCE Mr Henry designed Landsborough House, which we discuss in further detail in section 2.1.2.2 of this Volume. He also completed the detailed design work for the Aged Peoples Welfare building, was involved to a limited extent in the design of the Bradley Nuttall House building, which largely replicated the Landsborough House design, and started to work on the design of the Westpark Tower. Mr Henry left ARCE in late 1985.

2.1.1.2.3 Mr Harding's second period of employment at ARCE

Mr Harding was employed by the Waimairi District Council at the time Mr Henry left ARCE. Dr Reay was advised that Mr Harding was looking for another job so contacted him and asked if he would be interested in returning to ARCE. The position offered the opportunity to design medium height multi-storey buildings. Mr Harding rejoined ARCE in November 1985 and became an Associate at some point[3]. He left ARCE in 1988 to establish his own consulting practice.

2.1.1.3 Structural draughtsmen employed by Dr Reay

ARCE also employed a number of draughtsmen, who were responsible for preparing structural drawings. The Royal Commission heard evidence from three of the draughtsmen employed by Dr Reay at the time the CTV building was designed and constructed, Mr Terry Horn, Mr Wayne Strachan and Mr Shane Fairmaid.

2.1.1.3.1 Mr Strachan

Mr Strachan worked for ARCE between 1979 and 1988. His main area of work during that period was tilt-up factories and he also worked on the design of kitset buildings for Fletcher Brownbuilt, one of Dr Reay's main clients. He had been involved in the draughting of structural drawings for multi-level shear core buildings in Wellington and Palmerston North in his previous employment but had not been involved in draughting any buildings at ARCE prior to the CTV project coming into the office. He was not involved in the draughting of Landsborough House or any of the other multi-storey buildings designed by Mr Henry while he was employed by ARCE.

2.1.1.3.2 Mr Horn

Like Mr Henry, Mr Horn came to ARCE from Holmes Wood Poole and Johnstone, having gained experience there in the draughting of multi-storey buildings. He worked with Mr Henry on the Landsborough House project and draughted the drawings for the Bradley Nuttall building.

2.1.1.3.3 Mr Fairmaid

Mr Fairmaid was employed by ARCE between 1981 and 1986. Mr Fairmaid referred to two teams operating within the ARCE office, one working on low-rise projects and the other working on multi-storey buildings. Mr Fairmaid worked primarily on the low-rise commercial projects and warehouses and worked closely with Dr Reay on those. Prior to the CTV building he had not been involved with any of the other multi-storey buildings that Mr Henry or Mr Harding designed.

2.1.2 Background to the structural design of the CTV building

2.1.2.1 Dr Reay's experience with multi-storey buildings and computer analysis

Counsel assisting submitted that the CTV building project should not have been taken on at all because Dr Reay had insufficient experience and competence in the design of complex multi-level structures. However, counsel for Dr Reay argued that he had in fact done such work in the past.

In section 2.1.1.1 we referred to three multi-storey buildings, the design of which Dr Reay was responsible for prior to 1986, when the CTV building was designed. These were the six storey concrete frame building in Liverpool Street, during his employment at Hardie & Anderson and two projects at ARCE, Ibis House at 183 Hereford Street, designed in 1974 and Kamahi Towers, an apartment building in Carlton Mill Road.

Dr Reay said he was responsible for the design of Ibis House in 1974. This was an eight storey building where the primary resisting elements consisted of ductile moment resisting frames and reinforced concrete block walls. The design process did not involve any response spectrum modal analysis. In closing submissions Mr Rennie QC noted that Dr Reay was 32 years old at the time he took responsibility for the Ibis House design and had three years' post-registration experience. We have reviewed the permitted drawings for Ibis House and note that the design of the columns, beams, slabs and blockwork was carried out by Dr Richard Sharpe. Dr Reay designed the foundations, stairs, the precast concrete fins and spandrels and the alternate precast concrete floor system. The drawings show that all of the structural drawings were checked by Dr Reay.

The closing submissions on behalf of Dr Reay also referred to Kamahi Towers as a multi-storey building, which gave Dr Reay experience in the design of complex multi-level structures. However he acknowledged in evidence that the Kamahi Towers building was a concrete block structure, which we heard was no longer an option for multi-storey building design in the 1980s as it could not be made ductile for earthquake loadings. We did not hear any further evidence about the relevance of the Liverpool Street building and it was not referred to in submissions.

Dr Reay said in evidence that competent, registered and experienced engineers can and are expected to work on structures that extend their basic knowledge and areas of experience. He pointed to his work designing the fibreglass trickling filter cover at the Christchurch City Council's (CCC) Bromley sewage plant in the mid-1980s. The cover was 54 metres across, which Dr Reay described as the world's largest span fibreglass structure at that time. He said that neither he nor Mr Henry, who was also involved, had experience designing fibreglass structures of that scale.

However, Ibis House was the only reinforced concrete framed building that could have provided Dr Reay with any experience in the design of a multi-level building at the time of Mr Henry's arrival at the firm.

Dr Reay said in evidence that he has never used the ETABS computer program. However in the 1960s he used software written by Dr Robert Donald for modal analysis of building structures.

2.1.2.2 Mr Henry and Landsborough House

In mid- to late-1984 Mr Henry took up a position as a structural engineer at Dr Reay's firm. Prior to that he had been employed for four years at Holmes Wood Poole and Johnstone. Mr Henry had worked on a number of multi-storey buildings during his employment at Holmes Wood Poole and Johnstone and had used the ETABS program.

2.1.2.2.1 Mr Henry's experience prior to joining ARCE

When he was with Holmes Wood Poole and Johnstone Mr Henry worked with (now Professor) Andy Buchanan on the design of the 13 storey Canterbury Savings Bank building on the corner of Cashel and High Streets, which had a poured concrete shear core in the centre. Mr Henry carried out the computer analysis of the shear core structure using ETABS, which at that time was only available on a computer at the University of Canterbury. Once the ETABS analysis had been completed, Mr Henry undertook the design of the building under the mentorship of Mr Buchanan and Mr Russell Poole, with Mr Buchanan sitting with him for about an hour each day to go through the steps involved. He said this was a major project at that time by Christchurch standards and involved constant overview and involvement from the senior partners and associates of the firm.

Mr Henry then designed several multi-storey shear core buildings, including the AA Centre in Wellington, a 14 storey building with an eccentric shear core and a perimeter frame. Mr Henry described this as a complex structure due to the interaction of the shear core with the perimeter frame.

Dr Reay prepared a brief of evidence in reply to Mr Henry. He said that the Canterbury Savings Bank building was a symmetric shear core building and the AA Centre's perimeter frame provided torsional resistance. For those reasons Dr Reay said Mr Henry had not designed buildings similar to Landsborough House prior to joining ARCE. However at the hearing, Dr Reay's position was that he had employed Mr Henry in a senior position to undertake the design of multi-storey buildings because Dr Reay was fully committed on other projects and he acknowledged that Mr Henry "certainly had more experience than Mr Harding".

2.1.2.2.2 Mr Henry moves to ARCE

Mr Henry's evidence was that he was attracted to an advertisement for a structural engineering position at Dr Reay's firm and thought that it might be an opportunity for career advancement. He attended an interview with Dr Reay, who was the only engineer in the firm at that time. His recollection was that Dr Reay indicated during the interview that there was a possibility Mr Henry would become a partner at some future point. Dr Reay also told him at this interview that he had some multi-storey buildings in the pipeline. Mr Henry understood that his expertise was required for these projects and Dr Reay accepted in cross-examination that he employed Mr Henry because he had started to take on multi-storey buildings and wanted someone experienced in this area to design them.

Mr Henry accepted the position. He said that at that point he expected to be working together with Dr Reay, not on his own.

2.1.2.2.3 Landsborough House

After Mr Henry started at Dr Reay's firm, Dr Reay told him the firm had been engaged to design two multi-storey office buildings. One of those, at 287 Durham Street on the north-west corner of Durham and Gloucester Streets, was referred to in the hearing as Landsborough House. The second, on the corner of Cashel Street and Cambridge Terrace, was for the Aged Persons Welfare Council (referred to in the hearing as both the Aged Peoples Welfare building and the Age Concern building).

The client for Landsborough House was the Amuri Corporation. Dr Reay was appointed as the lead consultant, so he engaged the architect and other professionals to work on the project. He said that he employed Mr Henry to undertake the structural design of the building and to prepare the documentation. However, Mr Henry did not have experience in project management so he was not the lead consultant.

It was Dr Reay's responsibility, as the lead consultant, to review the construction methodology and provide the permit documentation to the CCC.

Mr Henry remembered first becoming aware of the project when he was shown the preliminary design by Dr Reay. He recalled being surprised at the shear wall configuration: a single wall on the north side of the building adjoined by several short interior walls at right angles alongside the services area. Mr Henry said it was "immediately apparent" to him that this would not work. His reaction was to suggest a closed shear core as close to the centre of the building as possible, but he said Dr Reay rejected this. Mr Henry did some preliminary calculations and then proposed what he described as a compromise solution: that the shear core be enclosed with a further wall and offset to the north side of the building, but still within the building.

Mr Henry considered this would be an eccentric building and as it would be eight storeys high he considered that a model response spectrum analysis using the ETABS program was required by Clause 3.4.7.1(c) of NZS 4203:1984[4]. Whether the compromise solution would work depended on the results of this analysis, which Mr Henry carried out.

Mr Henry said he learned at Holmes Wood Poole and Johnstone that it was essential to calculate the relative displacements between storeys – referred to as "inter-storey drifts" – and to be satisfied with the proposed structural configuration before proceeding with the detailed design. He said that the results of his ETABS analysis of Landsborough House showed that the structural model worked but the corner deflections were at, or near, the maximum drift limits in the codes for the east-west direction of loading, the eccentric direction in this design. He noted that a limitation of ETABS at this time was that it only gave outputs reflecting the deflections of the building in a single location at the centre of mass for each storey. Hand calculations were required to calculate the inter-storey drift at other locations. As Mr Henry said, the largest deflections in an eccentric building are at the corners because of the twisting effects of an earthquake. This limitation in the ETABS program at this time led Mr Henry to express the opinion that a designer in the mid-1980s needed to have both experience using ETABS and an understanding of the design of multi-storey shear core buildings to ensure the deflections of a building had been determined accurately.

Mr Henry said that, before he undertook the detailed design of Landsborough House, he remained concerned about the proposed configuration of the shear walls and decided to seek comment from Professor Thomas Paulay. He recalled the Professor's lectures at the University of Canterbury on the poor performance of some structural configurations once ductile yielding commences under earthquake loading. He said he was not seeking a detailed review, rather he wanted Professor Paulay's opinion on the configuration of Landsborough House and possible effects of torsion. Mr Henry recalled that Professor Paulay did not raise any fundamental issues about Landsborough House but he did comment on the eccentricity of the building and the possibility of a loss in stiffness and consequent increase in deflections arising from diagonal cracking of the shear walls under earthquake loading. Mr Henry was already alert to this possibility and had used reduced member properties in his ETABS analysis to take account of loss of stiffness due to cracking in structural elements, but he said Professor Paulay nevertheless cautioned him about this issue.

Mr Henry then went to Dr Reay to discuss his lingering concerns and the comments made by Professor Paulay. He said that Dr Reay was dismissive of Professor Paulay's caution, showing no indication of acting on it. In his evidence Dr Reay accepted that Mr Henry raised Professor Paulay's caution with him but he did not accept that he dismissed it, saying instead he advised Mr Henry he was satisfied with the agreed solutions. He noted that Professor Paulay appeared to agree with his opinion that the eccentricity in the building was not a major issue. Mr Henry thought that the best interpretation he could put on Dr Reay's reaction was that Professor Paulay was coming from an academic perspective, not that of a day-to-day practitioner.

Despite Dr Reay's reaction, Mr Henry said he took heed of Professor Paulay's comments when it came to the detailed design of the building. He said he detailed the column hoop reinforcing in the end regions of the columns with a reasonable provision for some ductility demand just in case deflections greater than those he had calculated in the ETABS analysis occurred in an extreme earthquake. Although the interior columns were twice as heavily loaded as the exterior columns, he used a consistent column design throughout the building. He also did not scale down the loads used for the ETABS analysis (as permitted by NZS 4203:1984 where a modal analysis was carried out). He stated that these precautions "were buffering the structure against something unexpected".

Mr Henry said in evidence that Dr Reay's reaction to Professor Paulay's comments left him feeling that he was on his own and "it was a bit lonely to be honest". He gave the following summary of his role in the design of Landsborough House:

> I was very much in the driving seat in doing the structural design for Landsborough House. I had the sole responsibility for the ETABS work, including analysis of the output…I had no dealings with the client at all and few dealings with the architect in relation to project management over the Landsborough House job but carried out my role behind the scenes as the technical designer, specification writer and structural detailer.

Mr Henry said he believed he would have shown Dr Reay the results of his ETABS analysis. He recalled Dr Reay made some comments on the design and instructed him to use precast coupling beams to expedite the shear wall construction, which Mr Henry agreed with, as well as precast concrete fire separation walls between the egress stairs and the service core, which could be lifted in for each floor. Mr Henry said that Dr Reay liaised with him on a reasonably regular basis and that he knew what was going on. Mr Henry said he told Dr Reay the key parts of the design and they would be up on the drawing board as Dr Reay went past, so it was not a situation where he could not or would not have had a view on the work that Mr Henry was undertaking.

Dr Reay agreed that when he employed Mr Henry he wanted an engineer who was experienced in designing multi-storey buildings. He said that he did not envisage himself working on the multi-storey building projects "to any great extent", as he was fully committed on other projects. Dr Reay's involvement appears to have been at a conceptual level rather than the detailed design. He said that he understood the principles involved in the design of Landsborough House but relied on Mr Henry to ensure that the design complied with the legal requirements.

The CCC issued a building permit for Landsborough House on 9 August 1985. Mr Henry could not recall any involvement with the construction of the building or if that was underway at the time he left ARCE.

2.1.2.2.4 The Bradley Nuttall House building

The design of Landsborough House was used again for the Mair Astley building, which was referred to in the hearing by its current name, the Bradley Nuttall House building. This is a building at 79 Cambridge Terrace and is identical in plan to Landsborough House but one

storey smaller. Mr Henry and Mr Horn, who did the draughting for this building, both said that it was a copy of the Landsborough House structural design. Mr Henry's involvement was limited to the design of the architectural precast spandrel panels on the exterior of the building. A design certificate signed by Dr Reay and a Design Features Report were contained in the CCC file for this building. We infer therefore that this building was designed by Dr Reay but essentially copied from the Landsborough House plans. As Dr Reay has never carried out an ETABS analysis, he cannot have carried out one for this building. The CCC granted a building permit for the Bradley Nuttall House building on 23 October 1985.

2.1.2.2.5 The Aged Peoples Welfare building

The Aged Peoples Welfare building is a four storey reinforced concrete building on the corner of Cashel Street and Cambridge Terrace. Mr Henry's recollection was that he carried out the detailed design for this building at the same time as the Landsborough House design. It had a similar shear wall configuration, but the shear walls for the Aged Peoples Welfare building were full height tilt-slab walls, not cast in situ. Mr Henry said that the use of tilt-slab in this way was unusual for the time and extended the limits of this type of construction in Christchurch. He believed he did not carry out an ETABS analysis because NZS 4203:1984 only required this for eccentric buildings more than four storeys in height. A building permit for this building was issued by the CCC on 3 July 1985.

Counsel assisting asked Mr Henry whether the design work on the Aged Peoples Welfare building would have provided Dr Reay and his firm with experience and expertise relevant to the design of a multi-level shear core building on the scale of the CTV building. He said it would not, because no ETABS analysis was carried out and Dr Reay was not involved in the detailed hand calculations that Mr Henry had carried out for it.

Mr Henry said that Landsborough House, Bradley Nuttall House and the Aged Peoples Welfare buildings were all designed on the basis of the knowledge he acquired at Holmes Wood Poole and Johnstone and brought to Dr Reay's firm. He said:

> Although I believed the design of these buildings met the code at the time they were all at the limit of what could be achieved with eccentric shear cores and there was no margin for error. My personal view was that these were not desirable structures to be designing. However, I endeavoured to make the best of them given the constraints presented to me and to ensure that they complied with the code requirements.

In September or October 1985 Mr Henry resigned from Dr Reay's firm, having worked there for around a year. He said the role of backroom structural designer, carrying out designs but not being in control of projects, did not suit him and he thought it was unlikely to change. His view was that at the time he left, there was no designer at ARCE who was experienced in using ETABS or in multi-storey shear core building design. Dr Reay was the only other engineer at the firm at this time.

2.1.2.3 Mr Harding returns to ARCE

2.1.2.3.1 Mr Harding's level of experience when he returned to ARCE

After leaving ARCE in May 1980, Mr Harding worked at the Waimairi District Council as its design engineer. In that role he was responsible for the design office and supervised a traffic engineer, three civil engineering cadets and two draughtsmen. He was mainly involved in civil engineering, including the design of roundabouts and roads, but undertook some structural engineering related to annual surveys and maintenance of bridges. Mr Harding carried out preliminary investigation of, and then designed, the hydroslide and associated platforms and swimming pools for the Jellie Park swimming pool complex.

Mr Harding said that after five years of working at Waimairi he wanted to move on. He said:

> …I'd got to the stage at Waimairi whereas when I first got there the digger was down one end of the road and the theodolite was down the other end designing it. When I left I had a year's worth of work sitting in the drawer all designed ready to go and I, my next job there would've been deputy engineer or something and dealing with councillors all day, that wasn't being an engineer. So I decided that I'd rather get back to being a consultant again and [Dr Reay] must've got wind of that, and he said to me that he was now, he'd expanded his firm to go from the kind of thing we had been doing in the past to now be doing multi-storey buildings and I saw that as something new which I hadn't done before, I had no experience in, and an ideal opportunity to get experience in that realm.

Multi-storey building design was clearly an area in which Mr Harding was interested in gaining experience. He was asked by counsel assisting whether he would have agreed to return to ARCE if the role he was offered involved him designing "cutting-edge tilt-slab" buildings. He said he would not have accepted such a position because it would not have interested him. Nor would he have been interested in doing the kind of work he had done when previously employed there.

Mr Harding acknowledged in evidence that at this time he had never designed a multi-storey building and had never used the ETABS program. His evidence was that Dr Reay understood this when he approached him with the offer to return to ARCE. He said that Dr Reay told him he could gain experience in multi-storey design by working for the firm and referred to being offered the opportunity to "learn how to do multi-storey buildings".

Mr Harding said he gained the impression from his conversation with Dr Reay that there was experience in the office, apart from Mr Henry, in multi-storey building design. When questioned further, he thought this must have been a reference to the "accumulated knowledge in the office" between Dr Reay and the draughtsmen.

Dr Reay said that he approached Mr Harding after Mr Henry advised he was leaving ARCE, having heard that Mr Harding was looking to move on from his current position. He said he had not committed to designing any more multi-storey buildings at the time he approached Mr Harding. However, during a subsequent appearance before the Commission he acknowledged there were a couple of multi-storey buildings in the pipeline at the time but the design of those buildings was not a full-time job. In any event, Dr Reay disputed the suggestion that he had been working to expand the firm into the multi-storey building market but was simply responding to demand from existing clients who wanted to develop multi-storey buildings. Dr Reay did not agree with Mr Henry that the design of multi-storey buildings required a high level of expertise.

Like Mr Henry, the prospect of promotion within the firm also seems to have been discussed with Mr Harding prior to his return to ARCE. He said Dr Reay discussed him becoming an associate "in the near future". This was an attractive prospect to him, because he thought it would ensure he had more contact with clients. He said one of the reasons he had previously left ARCE was because he did not have that client contact, and was just "a backroom number muncher". However Mr Harding rejected the proposition that the potential to become an associate was a "lure" that was only on offer if he took on the design of multi-storey buildings. Mr Harding said the reason he went back to ARCE was the opportunity to be involved in the design of those buildings.

Mr Harding accepted Dr Reay's offer to return to ARCE but had to work out a three-month notice period at Waimairi. Mr Harding said Dr Reay contacted him and asked if he would shorten his notice period because Mr Henry was about to leave, which left the firm short-staffed for current projects. He could not reduce his notice period but after further discussion with Dr Reay about those projects Mr Harding offered to do the calculations for a low-rise residential building at 32 Cashel Street that ARCE had been engaged to design for the Hospital Board. This was a regularly proportioned concrete masonry building so it did not need to be analysed using a dynamic method, such as a model response spectrum analysis using the ETABS program. In the following sections this is referred to commonly as an ETABS analysis. Instead Mr Harding did the calculations for this building using the equivalent static method he had used before.

2.1.2.3.2 Design work undertaken by Mr Harding prior to the CTV design

Dr Reay produced monthly time records for 1986 that recorded the number of hours each staff member had recorded for each different project in a given month. These records appear to have been compiled from weekly timesheets that each staff member would fill out through the day. Counsel for Dr Reay and ARCL also provided a summary of the records showing the total hours worked by particular individuals on the CTV building. These documents were provided shortly before the hearing commenced and after a number of briefs of evidence had been provided to the Royal Commission, including Mr Harding's and Dr Reay's first statements of evidence. During the hearing, the accuracy of the time records was questioned by some witnesses and counsel, but not on any articulated basis other than memory of events 26 years ago. Accordingly we have no reason to doubt the accuracy of the time records.

Counsel for ARCL and Dr Reay also provided the Royal Commission with a list of the projects Mr Harding had worked on for more than five hours between November 1985 and December 1986, based on time records and other records held by ARCL. This showed the projects that Mr Harding had recorded time against before starting work on the CTV building. The buildings referred to in the course of the hearing were the residential accommodation building for the Hospital Board at 32 Cashel Street, Broadway at 62 Riccarton Road and the Westpark Tower, which was built at 56 Cashel Street.

Mr Harding described the Hospital Board building as a "well-proportioned building with a lot of block walls all the way around it…very straightforward to design". The time records show that Mr Harding spent 88 hours on that project between November 1985 and December 1986.

His next project was the Broadway building, a two storey commercial building at 62 Riccarton Road. Dr Reay was the principal consultant but Mr Harding undertook the structural design. Mr Harding said that he had designed a number of buildings of that type. The time records for this project show that Dr Reay recorded 1.5 hours of time in November 1985 but then Mr Harding appears to have taken over, first recording 42.5 hours in December 1985. Both the Hospital Board building and Broadway were designed using the equivalent static method so did not require Mr Harding to use the ETABS program.

Mr Harding was also involved in the testing of the fibreglass cover at Bromley but, while this contained structural elements, it was not a building.

Mr Harding took over the design of Westpark Tower, a nine storey building in Cashel Street, which had been started by Mr Henry. Dr Reay was the principal consultant for this building but did not undertake the structural design. Mr Harding initially maintained that he only worked on this building after the CTV building was under construction but after being shown the time records and his calculations, he accepted that he did work on it before CTV. Mr Harding said that Mr Henry had already done the preliminary calculations, created an ETABS model of the building, tested the inter-storey deflections and determined the size of structural elements. Dr Reay had a different recollection, stating that the calculations showed that Mr Harding had carried out his own ETABS analysis and used the output in his calculations for the design.

Dr Reay said that he gained confidence in Mr Harding's ability to design the CTV building from the fact that he carried out the Westpark Tower design. At another point he said that he could judge that Mr Harding's competence was greater than when he had first been employed by ARCE based on the work he did after his return to the firm. Dr Reay must have reviewed Mr Harding's work for this project because he signed a design certificate for the Westpark Tower. Provision of a design certificate was one of the means of compliance with Clause 8.2.5 of CCC Building Bylaw 105[5]. In signing the design certificate Dr Reay certified that he had "supervised the design of, and the computations for" the Westpark Tower. He also certified that the work had been designed in accordance with sound and widely accepted engineering principles, to support the loads specified in NZS 4203:1984 and that he had ascertained to the best of his ability that the stresses and combinations of stresses in the various materials of construction under the loads specified would not exceed the maxima to ensure the safety and stability of the structure if erected in accordance with the plans and specifications.

Dr Reay said that he would have reviewed the drawings and calculations for the Westpark Tower to the extent he considered necessary at the time and to a level of scrutiny that enabled him to be able to sign the design certificate. He was unable to give an accurate estimate of the time taken on the review.

2.1.3 The CTV project

2.1.3.1 Origins and concept

In 1984 Prime West Corporation Limited (Prime West) purchased three adjoining sections of land on the corner of Cashel and Madras Streets. At that time there was a building on the Cashel Street end and a car park where the CTV building was later erected.

In 1986 Williams Construction (Canterbury) Limited (Williams Construction) was invited to submit a design-build proposal to Prime West for an office building on that site. Mr Michael Brooks, the Managing Director of Williams Construction knew one of the directors of Prime West, Mr Neil Blair, as they had previously worked together when Mr Brooks was employed by Industrial Holdings. Mr Anthony Scott, the Quantity Surveyor and Project Development Manager for Williams Construction at the time, said that this was Prime West's first development project in Christchurch.

Both Mr Brooks and Mr Scott described the project as "speculative". There were no tenants for the building and the design-build contract did not include fit-out. Prime West required the building to cost as little as possible, subject to it achieving its intended function and having a reasonable appearance. Mr Scott's evidence was that the building was funded by Prime West with high levels of debt. However, Mr Brooks denied that Prime West put pressure on Williams Construction.

It was Mr Brooks' idea to have the lift shaft at the back of the building. This maximised the open floor area for leasing purposes. He recalled drawing the outline of the building on a piece of paper as a square box with the lift shaft out beyond the north wall. He then passed the drawing on to Mr Scott for costing and to Mr Alun Wilkie, an architect, to draw up plans.

Mr Harding said that the architectural design of the CTV building was based on the design of a four storey building at 299 Durham Street, referred to in evidence as the Contours building. He said he was advised by Dr Reay that the contractor had been impressed by the look and form of the Contours Building. This included the layout of the building, with the services core offset to the north and the façade details, namely circular columns, precast concrete spandrel panels, glazing set back behind the perimeter columns and the layout of the internal columns.

Figure 14: The Durham Street frontage of the Contours building at 299 Durham Street North, Christchurch

Mr Wilkie was the architect for the Contours building and was engaged to design the CTV building. He could not recall his instructions for the CTV project but did not dispute that features of the Contours building were replicated in the CTV design. He also acknowledged his preference for round columns for aesthetic reasons.

2.1.3.2 Engagement of ARCE

Mr Scott's evidence was that Dr Reay's firm was invited to be the structural engineer for the CTV building after the architectural design was underway. Williams Construction had previously worked with ARCE on the Aged Peoples Welfare building on the corner of Cambridge Terrace and Cashel Street. Mr Scott and Mr Brooks had liked the presentation, content and standard of drawings for that project and the fact that Dr Reay would also provide preliminary drawings for costing purposes without charge. Mr Brooks said that Dr Reay understood a developer's desire for maximising lettable space.

Dr Reay accepted he may have had an initial meeting with the Williams Construction management while the Aged Peoples Welfare building was still under construction about carrying out work on the CTV building on a "no job no fee" basis. This is consistent with the monthly time records he produced for ARCE staff for 1986 that show he recorded two hours on this project in February 1986. However, beyond this initial meeting Dr Reay denied any further involvement in the design of the building. He said his role was limited to checking that Williams Construction as the client had the knowledge and experience to undertake the proposed work. He was fully engaged on other projects when the project came to the office and did not have time to undertake the design. He denied having any input into the decisions about the design concept or materials used and thought that these matters would have been determined by the contractor in conjunction with Mr Harding.

Mr Scott recalled a meeting at Dr Reay's office where Mr Harding was introduced by Dr Reay as the engineer assigned to the project. He gave Mr Harding the preliminary drawings from Mr Wilkie and asked him to produce structural drawings. Mr Scott did not recall any further dealings with Dr Reay on this project after this meeting.

As part of this preliminary design process for the CTV building, Williams Construction asked Dr Reay and Mr Harding to come up with structural alternatives for the flooring system. Three options were discussed: using prestressed secondary beams supported by primary beams with a prestressed flat slab, a Stahlton floor system, or a Hi-Bond permanent metal formwork floor system. Mr Scott recalled that Mr Harding returned to the Williams Construction office with structural sketches for the building based on each of the three options. Mr Harding said that he would not have chosen to use Hi-Bond in the CTV building himself, but that it was something Dr Reay wanted to use. However, having considered the evidence from the Williams Construction witnesses and Mr Wilkie, we consider it likely that the decision to use Hi-Bond was made by Williams Construction as it was the best option financially.

Mr Harding maintained throughout his evidence that he did not have any contact with Williams Construction management or staff until the commencement of the construction of the CTV building, when he met Mr Scott and Mr Gerald Shirtcliff, the Construction Manager. He denied ever going to the Williams' office. He said it was Dr Reay who dealt with the client and architect, prepared the preliminary calculations and the concept design and arranged for the preliminary architectural drawings to be amended to meet his requirements. When Dr Reay brought the job to him he said he wanted the design to "work the same way as Landsborough House did". He said his first involvement in preparing preliminary design concepts was a couple of years after he returned to ARCE. Dr Reay said that it was Mr Harding's job to produce the structural designs but he was not restricted from dealing with contractors and architects.

Counsel for Mr Harding, Mr Kirkland, submitted that the monthly time records produced by Dr Reay for 1986 supported Mr Harding's evidence, as these show that Dr Reay allocated two hours to the CTV building project in February 1986 and Mr Harding's first time recorded is 22 hours in March 1986. However, the time records show that after an initial meeting in February, Dr Reay did not record any further time on the project until June 1986. The 22 hours recorded for Mr Harding in March 1986 are likely in our view to relate to the preliminary calculations and structural drawings. Although the accuracy of the time records was disputed by some witnesses and counsel, as we have said in section 2.1.2.3.2 we have no reason to doubt the accuracy of the time records. We have already recorded that Mr Scott recalled being introduced to Mr Harding and giving him the preliminary architectural drawings. Mr Wilkie had a limited recollection of the project but could recall meeting with Mr Harding. It is possible that Mr Harding did not record any time for his attendance at what was an initial meeting. We find that Mr Harding must have been involved with Williams Construction at a much earlier point than the commencement of construction.

2.1.3.3 Confirmation of the project

Mr Scott priced the project based on A2 architectural drawings provided by Mr Wilkie and A4 structural sketches provided by Dr Reay's firm. In April 1986 he submitted a preliminary estimate of $2,450,000 to Prime West, subject to building permit approval. This figure included architectural and engineering design fees of $100,000, a provisional sum for foundation piling of $100,000, a builder's contingency of $50,000 and a profit and overheads margin of $369,000.

In June 1986 Prime West approved Williams Construction proceeding to instruct Mr Wilkie's firm and ARCE to prepare drawings for permit and construction and both firms were engaged for a fixed fee. Mr Brooks and Mr Scott both recalled that the engagement of the architect and engineer would have been recorded through an exchange of letters rather than a written contract. Mr Scott then re-measured the architectural and structural drawings to check quantities, prices and subcontractors against his preliminary estimate.

A site investigation report dated 18 June 1986 was prepared by geotechnical engineers Soils & Foundations (1973) Ltd for Dr Reay's firm. The report concluded that either a shallow foundation or a piled foundation would be suitable for the building. Following that advice the building was built on a shallow foundation and the foundation piling originally budgeted for by Mr Scott was not required.

In October 1986 Williams Construction signed a building contract with Prime West for $2,450,000, the same figure as the preliminary estimate. Work started on the site later that month.

2.1.4 Design process

2.1.4.1 The respective roles of Mr Harding and Dr Reay at the start of the CTV design

We begin our discussion of the design process of the CTV building by recording the evidence Mr Harding and Dr Reay gave about the role each thought they played in the project and who was responsible for the design. It became apparent during the hearing that they had quite different recollections of their respective roles.

The monthly time records show Mr Harding spent 304.75 hours on the CTV project between March and December 1986. The only time recorded for Dr Reay is two hours in February 1986 and 1.5 hours in June.

Mr Harding regarded both himself and Dr Reay as the designers of the building. He said that his involvement with the CTV project only started after Dr Reay had met with the client, carried out preliminary calculations and the concept design and arranged for the architect's drawings to be amended to meet his requirements. He thought Dr Reay could not have recorded all of the time he spent on the project because his meetings with the client, the architect and the contractor during the preliminary stage are not reflected in the hours recorded. Mr Harding said that when the project came to him "it was already conceived and detailed and dimensioned and it was a case of putting numbers in boxes". Mr Harding then proceeded to carry out an ETABS analysis, the structural calculations and advised the draughtsmen as to the reinforcement to be shown on the structural drawings.

Dr Reay, by contrast, believed that once a professional services contract had been entered into with Williams Construction and he had verified that Mr Harding considered himself capable of undertaking the design, he handed over responsibility for the project to Mr Harding. He said he could recall making sure Mr Harding understood that the job was his responsibility.

Mr Harding could not recall any discussion where Dr Reay specifically asked him if he wanted to design the CTV building. He did not believe the responsibility for the design had been handed over to him by Dr Reay. He said he would not have taken the project on if he had been doing it on his own because it was beyond the limits of his competence. However he believed he was competent to design the building if someone was reviewing his work. He said:

> It was really just the fact that it, I hadn't done it before and there were, there's always some item of a design like that which an experienced engineer when casting his eye over it will say, well have you thought about this or, or why have you done it like that and when you haven't done something before there's always, you don't know what you don't know. You may think you know it all but if you haven't done it all, if you haven't done it before you can't afford to be confident that you can do it. So that's really part of this business of, it's a, it's a [sic] ethical thing. As an engineer you've got to feel in your own mind that you are confident to do it. You've done it before. You know what the traps are. If you feel that you don't have that confidence you seek someone to review it.

Dr Reay said it was Mr Harding's responsibility to say whether he could design the building or not. He said Mr Harding wanted to do the work and never communicated to him that he felt he would be working beyond his competence if he designed the building on his own. If he had, Dr Reay said he would not have agreed to Mr Harding undertaking the work and the job would have been turned away. Dr Reay rejected the suggestion that Mr Harding's chances of becoming an Associate would have been affected if he had said that he was not able to carry out the building design.

Dr Reay's position on supervising Mr Harding's work was that he had employed him in a senior role and accordingly "it was his responsibility to initiate with me any concerns…it was not my role to go and supervise him as I would a graduate". Dr Reay said he expected any qualified engineers he employed to seek advice from him if they needed it and he said he was available to Mr Harding if he needed help. However Dr Reay also acknowledged that he did not have the knowledge to be able to assist Mr Harding with the design in depth. He said if Mr Harding had needed assistance he would either have suggested that he approach someone else, or if he was struggling with the design as a whole, then Dr Reay "would have pulled the plug on the job".

Mr Harding said if he had any queries he would go and see Dr Reay but agreed he was not calling out for supervision or review. Both Mr Harding and Dr Reay could only recall one particular conversation between them about the design of this building, which was about the south wall. We discuss the evidence that was given about this conversation in section 2.1.4.3.

2.1.4.2 Mr Harding carries out an ETABS analysis

Mr Harding's evidence was that Dr Reay told him when he gave him the architectural drawings that the building would need to be analysed using the ETABS computer program. He said he had not used ETABS before returning to ARCE. Dr Reay agreed he was aware of this after Mr Harding came back. During his evidence we learned that Mr Harding had in fact used ETABS prior to starting work on the CTV building, because he had taken over the ETABS model for the Westpark Tower that Mr Henry had set up before he left ARCE. The calculations for the building show Mr Harding took over the ETABS analysis in February 1986 and Mr Harding's work on the CTV building, according to the time records, commenced in March. In any event, both Mr Harding and Dr Reay agreed that the CTV building design was the first time Mr Harding had been fully responsible for an ETABS analysis.

Dr Reay acknowledged he could not help Mr Harding with using ETABS because he had not used it himself. In order to assist Mr Harding with using the program Dr Reay gave Mr Harding the Landsborough House file, which contained Mr Henry's calculations and material from his ETABS analysis for that building. Mr Harding described the Landsborough House calculations as "a method template" for modelling the CTV building using the ETABS program. He recalled seeing the calculations for the gravity elements, seismic resisting elements and foundations for Landsborough House and input and output data from the ETABS analysis, but did not remember seeing the structural drawings. When asked whether he would have wanted to see the drawings to assist him with understanding the calculations, Mr Harding's answer was that the calculations were very clear. He acknowledged he was not expected to copy any details of the design of Landsborough House in the CTV design.

The ETABS analysis was performed on a computer at the University of Canterbury. An invoice from the University to ARCE dated June 1986 for $163.09 in computer charges was produced at the hearing. This had the ARCE file number for the CTV project, 2503, written on the invoice. Mr Harding could not recall seeing the invoice but did remember going to the University a number of times and leaving the input data for a staff member to load into the computer. He went back about a week later to pick up the output sheets and analyse them. He said he checked the inter-storey deflections of the building on each output run under the most severe combination of design loading.

Mr Harding recalled that the initial outputs showed inter-storey deflections that were beyond the limit in NZS 4203:1984 of 0.83 per cent of the inter-storey height. He tried to overcome this by increasing the wall thicknesses but this did not reduce the inter-storey deflections below the limit in the Standard. Mr Harding said he could remember discussing this with Dr Reay after the fourth or fifth run of the ETABS program.

Mr Harding said he did not calculate the corner deflections by hand as Mr Henry had done. He did not recall seeing that calculation in the Landsborough House file and said if he had seen it he would have followed that process for the CTV building. He said he was not aware of it at the time and that a more experienced engineer reviewing his work would have seen that he had not done the corner deflection calculation.

Dr Reay's evidence was that Mr Harding had a good introduction to ETABS and "had the time to go and work at it". He also noted that use of the 1984 version of ETABS was covered in a seminar Mr Harding attended in July 1986, although the invoice from the University, to which we have referred above, suggests that the ETABS analysis for the building was completed in June 1986. Because Mr Harding had used ETABS previously for the Westpark Tower, Dr Reay described this process for the CTV building as more of an extension of knowledge rather than a fresh start. He said Mr Harding never suggested he was struggling with ETABS, and Dr Reay had no recollection of Mr Harding coming to him with a query about the results he was getting. If he had done so, Dr Reay said he would have directed Mr Harding to one of the lecturers at the University or he could have approached Mr Henry or another engineer. He said it was Mr Harding's responsibility to come up to speed with ETABS and if he could not do that then ARCE would not have proceeded with the job.

Mr Harding's evidence on this point illustrates his lack of experience with the ETABS program and most significantly, his lack of knowledge about its limitations. He was reliant on following the Landsborough House calculations to the point that if a calculation was not in there, he did not do it. Because Mr Henry had been trained in the use of ETABS in an environment at Holmes Wood Poole and Johnstone where his work was monitored, he could carry out an ETABS analysis independently when he went to ARCE. Mr Harding did not have that experience. He should not have been doing this work without assistance. It is also evident that he did not call for that assistance.

2.1.4.3 The south shear wall

The way the south shear wall came to be included in the design of the building was also the subject of disagreement between Dr Reay and Mr Harding.

Mr Harding said he could remember sitting in ARCE's front office with Dr Reay discussing the fact that he could not reduce the inter-storey deflections produced by the ETABS analysis below the limits in NZS 4203:1984. He said they discussed options to reduce the deflections, including bringing the north wall complex back in within the four walls of the building and to close it like a box, as the core in Landsborough House was. Mr Harding said this was not an option as it would have required a redesign, which would not meet the client's wish for a building that looked like the Contours building. Mr Harding suggested that a shear wall be added to the south of the building. He said that his preference would have been for the south wall to have been of the same length as the main wall of the north wall complex, which would have made both shear walls symmetrical and eliminated the "torsional situation". Mr Harding recalled that Dr Reay was concerned that an additional wall on the south face of the building may not be acceptable to the client because there was not a wall there on the Contours building. He thought that Dr Reay then spoke with the client and the architect before relaying back to him that the wall could be added if it was no wider than the external egress stairs, which must have already been part of the design. Mr Harding said that this meant the wall had to be designed as a coupled wall with an opening at each level for a door to the stair landings.

Mr Harding said he then went back to the ETABS model, added in the coupled wall and adjusted the wall thicknesses. This produced outputs which brought the inter-storey deflection within the limits in NZS 4203:1984.

Dr Reay had a very different recollection of this conversation. His evidence was that, at the time Mr Harding received the preliminary architectural drawings from Mr Wilkie, he asked him what the layout of the building was. Dr Reay thought that the layout of the building could create excessive torsional response, which he said he could identify without having carried out an ETABS analysis.

Dr Reay said Mr Harding showed him an architectural drawing and said that there was going to be a south shear wall. He said on a subsequent appearance before the Commission that the south shear wall was already on the drawing when he saw it. Dr Reay said he assumed that Mr Harding had come up with the idea of putting the south shear wall in and had told the architect, who had put it on the drawing that he saw.

Dr Reay's evidence was that he initiated the conversation about the south shear wall, and that he was making sure that Mr Harding was not getting involved in "something that would be an undesirable outcome in terms of engineering". He said the structural layout was a major item of the building's design that he thought he should check. Counsel assisting, Mr Mills QC, then questioned Dr Reay:

> Q. So when you said previously that you had fully allocated responsibility to him, subject only to you having an open door if he had concerns, that's actually not entirely accurate I take it?
>
> A. Well I've always said that I asked him about this, the shear wall layout and it wasn't advice I was giving him at that point it was just me checking that, in fact, there wasn't something strange happening that he'd been asked to do.
>
> Q. In which case you would have given him advice.
>
> A. I would have.

Dr Reay said that the first time he saw the architectural drawings for the building was when he asked Mr Harding about the layout. He said that there was no discussion about the design being a gravity frame system but he anticipated it would be. We do not accept this evidence. Dr Reay knew enough about the building to know that torsion was a risk and to inquire of Mr Harding what he was doing about that. That would suggest Dr Reay knew that the north wall complex was to be outside the four walls of the building prior to this conversation with Mr Harding taking place. This knowledge would also have led Dr Reay to recognise that Mr Harding would be aided in referring to the ETABS analysis for Landsborough House because of the similarities between the two buildings.

Dr Reay said that his concerns about the layout of the building may have related back to the design of Landsborough House, which started as a shear wall system with an open wall configuration. He said he "wanted to make sure that we weren't going to waste a lot of time on another one of those" because he felt Landsborough House was getting towards the limit for a building with an offset shear core without a wall at the opposite end. Dr Reay could not recall whether he passed his concerns about repeating the Landsborough House layout on to Mr Harding. His view was that the inclusion of the south shear wall would lead to a more stable arrangement than Landsborough House.

A further difference between Dr Reay's and Mr Harding's accounts of this conversation is the point of the design process when it occurred. Dr Reay referred to seeing an architectural drawing only and thought that structural drawings were probably not in existence at the time.

Consequently, the conversation must have occurred at an early stage of the process. By contrast, the conversation Mr Harding recalled must have occurred later in the design process because he said he went to Dr Reay about the south wall after four or five ETABS runs. Dr Reay thought Mr Harding's account was unlikely because, if they had discussed the results of the ETABS modelling, Dr Reay would have seen what the shear wall layout was and would not have needed to ask. Counsel assisting suggested to Dr Reay that the conversation about the south shear wall took place in June 1986 because the time records show Dr Reay had 1.5 hours recorded against the CTV project for that month. This would support Mr Harding's evidence that they discussed the ETABS results and then Dr Reay spoke to the client and the architect about the length of the south shear wall because the University charged ARCE for use of the ETABS program in June 1986. However Dr Reay disputed this and said the conversation about the south shear wall would only have lasted ten minutes. He was uncertain what the 1.5 hours in June related to but said it may have been organising who would draught the project, planning it or providing a fee. When questioned why his version of the conversation was not recorded in his first or second briefs of evidence, but only appeared in his reply to Mr Harding's evidence, he said Mr Harding's evidence "must have jogged his memory".

Mr Wilkie was also called to give evidence. His recollection of the project was limited but he was clear that a wall was required on the south side from the outset to meet fire requirements. Mr Wilkie did not know how and when this wall became a shear wall. Counsel assisting put Mr Harding's recollection of how the south wall came to be part of the design to Mr Wilkie and asked him whether, from an architectural perspective, the wall could have been longer. Mr Wilkie said that walls were generally made no longer than they needed to be and it was desirable for office buildings to have as many windows as possible. However that was subject to the structural requirements of the building and Mr Wilkie said it was always for the engineer to determine the length of a shear wall.

Counsel assisting submitted that Dr Reay's evidence that he was unaware of the structural layout of the building before he spoke to Mr Harding was not credible. We have already found that Dr Reay attended an initial meeting with Williams Construction so we consider he is likely to have known about something as fundamental as the north wall complex at that point. We also find support for that conclusion from the evidence that Dr Reay gave the Landsborough House file to Mr Harding to assist him with the ETABS analysis of the CTV building. The decision to do that must have rested on Dr Reay knowing the structural layout of the CTV building and knowing that the design of Landsborough House was similar enough to be of assistance to Mr Harding.

We have no reason to doubt, and we accept Mr Wilkie's evidence that there was a wall on the south side of the building from an early stage because he knew the building would have to meet particular fire requirements. However we also find that at that point it was not a structural wall, and only became so after Mr Harding found through the ETABS analysis that he could not reduce the inter-storey deflections below the limit in NZS 4203:1984. Ultimately we are not able to resolve the exact content of the conversation between Dr Reay and Mr Harding. There could well have been a discussion between Dr Reay and Mr Harding about not making the wall any longer than it was already intended to be, which is consistent with the wall being designed as a coupled wall. Converting a fire wall into a shear wall would have necessitated the wall being made thicker, which would have increased the cost, which might have required approval from the client, although it is doubtful that the inclusion of a structural wall on the south of the building would have had significant implications for the availability of office space. We cannot take this issue any further.

2.1.4.4 The draughting process

After completing the ETABS analysis, Mr Harding proceeded with the detailed design of the building. A number of draughtsmen in the office worked closely with Dr Reay and Mr Harding to produce structural drawings at that time. We heard that the draughting process began with the engineer drawing the structural members on the architectural drawings, from which the draughtsmen would work out the dimensions. These drawings, referred to as carcass drawings, would then be printed and returned to the engineer who would direct the draughtsmen on the reinforcing to be detailed on the drawings. A tracer was often used to trace the drawings by putting translucent material over the top of the draughtsman's work. This was done to make the final drawings neater. A copy of the traced drawings would then go back to the draughtsmen for checking and then the complete set would go to the engineer for review.

The Royal Commission heard evidence from three of the draughtsmen who were involved in draughting the structural drawings for the CTV building: Mr Strachan, Mr Horn and Mr Fairmaid. The time records produced by Dr Reay show a total of 2.75 hours recorded for Mr Strachan between August and September 1986 for the CTV project, 141 hours for Mr Horn between July and September 1986 and 133 hours for Mr Fairmaid between July and November 1986.

The purpose of calling evidence from the draughtsmen was to see if they could assist with the account of the design process for the building and the roles of Dr Reay and Mr Harding. However none of the draughtsmen had a clear recollection of working on this project and it is difficult to draw any conclusions from their evidence, other than the fact that each of them was involved.

Dr Reay could not recall which of the draughtsmen he allocated to the CTV project but said he would have ensured that an appropriate draughtsman was allocated to the project before he handed it over to Mr Harding. Mr Harding remembered Mr Strachan being the main draughtsman for this project.

Mr Strachan prepared a statement of evidence before the time records were produced. He said that when he was first contacted by Royal Commission staff he had had no recollection of working on the building but after reviewing the permitted drawings he considered there was "no doubt" that he had done the majority of the draughting for the building. He noted the amount of detail on the drawings and the completeness of the dimensions as consistent with his draughting style and he recognised some of the handwriting. We heard during the evidence that a particular draughtsman may not be able to recognise his work from looking at the final drawings because these may have been prepared by tracers. However Mr Strachan noted that on occasions he had to do his own tracing or handwrite dimensions on the final drawings and he recognised his handwriting on Sheet 14 of the CTV building drawings. He could also see that he had not worked on every aspect of the drawings, and referred to the style of the steel reinforcing detail for the foundations, which did not have the dimensions recorded, something he said he would have done. He thought that Mr Horn may have drawn those sheets or supervised one of the other draughtspeople.

Subsequent to preparing that evidence, counsel for ARCL and Dr Reay provided Mr Strachan with a summary of the time records for 1986. This led to Mr Strachan providing a second statement of evidence. He said that when he was first contacted by Royal Commission staff he had had a "total disconnect" from the project, which continued after he had looked at the permitted drawings. He could not reconcile the time records, which recorded that he only spent 2.75 hours on this project, with the fact that the majority of the drawings looked like his work. He subsequently learned that 133 hours were recorded against this project for Mr Fairmaid, who was a senior draughtsman at ARCE in 1986 but who had been trained by Mr Strachan some years previously. Mr Strachan said he could then reconcile the fact that a number of drawings looked like his work because they had been done by someone he had trained in the office style. In explanation of why he initially claimed to recognise the handwriting, he professed that a tracer may over time have started to write like him.

Mr Strachan was sure that he could recall there being a rush to get a set of drawings of the CTV building into the CCC and Dr Reay being involved in that. We will refer to Mr Strachan's evidence on this point in more detail in section 2.2.3.4

Mr Horn also prepared a statement of evidence before he saw the time records. He said he had no memory of the CTV building project and did not recognise the drawings. However he acknowledged the possibility that he may have draughted the foundation reinforcing. Mr Horn subsequently viewed the time records, which showed 141 hours recorded for him on the CTV project between July and September 1986. He maintained that the time records were not consistent with what he remembered. He said when he heard that the building had collapsed in the February earthquake he was not aware that it had been designed by ARCE. He pointed to aspects of the drawings that were not detailed in the way he would have done it, such as the sheet that showed the columns detailed as individual items. After seven years of experience at Holmes Wood Poole and Johnstone and working with Mr Henry at ARCE, Mr Horn said he had learned a particular way of detailing buildings. He said he would have drawn the elements of the building showing how they fitted together, so that it could be seen whether a column connected to a beam or if there was a wall between two columns. This was not how the columns were drawn for the CTV building. However, Mr Rennie QC referred Mr Horn to his drawings for Landsborough House and Mr Horn accepted that the columns were depicted in the same way as for the CTV building.

Mr Horn recognised the reinforcing notes on the foundation drawings for the CTV building as being of a style he would have used but pointed out references to different floor levels on the column drawing that were not how he would have done them. He referred to the arrowhead next to the level that was half-filled with black ink and said he would not have done that or underlined the word "level 2". He said he would have simply drawn a small triangle and written the word "level 2" or simply "2" above it. Mr Horn pointed out that the levels on the Landsborough House drawings had been detailed exactly as he said, with just a triangle, not an arrow. He also pointed out his style for recording reinforcing details, for example, "R6 at 250 centres" was always to write the word "at", but he noted that the symbol "@" was used a lot on the CTV drawings.

A further part of Mr Horn's reasoning that he was not involved in the draughting of this building in more than a minor way was his belief that he would have questioned the engineer on parts of the design of the building. He said he would have asked why the spiral reinforcing in the columns did not close up at each floor level.

Mr Horn could not recall working with Mr Harding as closely as he did with Dr Reay and said that after Mr Henry left, he worked mainly on his own with some direction from Dr Reay. He did recall working with Mr Harding on the Westpark Tower.

Mr Fairmaid was the third draughtsman involved in the CTV building project who was called to give evidence. The time records show 133 hours recorded for him for the project between July and November 1986. At this time Mr Fairmaid was a senior draughtsman and had worked at ARCE since 1981. He could recall the CTV building passing through the office but was surprised to see he had spent 133 hours on the project because he could not recall having worked on it. He did not challenge the accuracy of the time records. Mr Fairmaid said he was not surprised to see that Mr Horn had spent 141 hours on the project because he usually undertook the draughting of the multi-storey buildings during that period, whereas Mr Fairmaid had not been involved in documenting any earlier multi-level buildings at ARCE. Mr Fairmaid had no memory of working with Mr Horn on the building.

Mr Fairmaid referred to Mr Horn's evidence that he only recognised his style in the foundation drawings, and Mr Fairmaid agreed that it looked like Mr Horn had detailed the foundations. However, Mr Fairmaid also suggested that the tracing process may remove some individual ways of detailing lettering or symbols in favour of a consistent house style. Mr Fairmaid said that the foundations for this building would only have accounted for between 20 and 30 hours of Mr Horn's recorded time. He agreed he had been trained by Mr Strachan but had for some years been working on projects as the lead draughtsman reporting directly to Dr Reay, and pointed out that Mr Strachan had also trained other draughtsmen in the office so they too could have been involved in the draughting work for the building.

We also heard evidence from Mr Paul Smith, a senior draftsman employed by ARCL and a director of the company. As Mr Smith commenced his employment with ARCL in November 1987, by which time the design of the CTV building was complete, we were not assisted by his evidence.

In the end, the only thing Mr Strachan, Mr Horn and Mr Fairmaid do agree on is that they have no recollection of working on the project. Their evidence as to the draughting process for this particular building was a relevant line of inquiry but one that has resulted in a dead end. We have not been provided with any reasons why we should not regard the time records as accurate, but equally we found Mr Horn to have been an honest witness who pointed to detailing that he did not recognise as his own. Counsel assisting submitted that the evidence supported a conclusion that Mr Horn did no more than the foundations. We consider, on the balance of probabilities that he must have done at least that work, and on the basis of the time recorded in the time records would have been involved in some other aspects as well. It is possible that, despite his evidence, the tracing process did result in the completion of some details in the "house style" rather than his own. We think it likely that most of the balance of the draughting was carried out by Mr Fairmaid, in accordance with the monthly time records. However, there is no suggestion that any draughtsman had any responsibility for the structural design of the building or ensuring that it complied with the Bylaw and the relevant codes.

2.1.4.5 Mr Harding's attendance at a seminar in July 1986

In July 1986 a seminar *Design of Concrete Structures* was held at the University of Canterbury. Mr Harding's name was on the list of registrants. Mr Harding could not recall attending the seminar but accepted in evidence that he did go and recognised his writing on some pages. It was suggested by Dr Reay that Mr Harding's attendance at the seminar should have enabled him to know whether or not he could complete the design. Mr Harding reviewed the seminar notes before giving evidence and initially said he could not see anything in that material which would have changed what he did in the CTV building design, but later said there was a page that showed a layout of walls very similar to what was used in the design and described it as an acceptable solution. He said that was one of the reasons he proposed the south shear wall.

2.1.4.6 Review of the design within ARCE

The issue of whether the design of the building was being reviewed within ARCE before it was sent to the CCC for a permit was another matter on which Mr Harding and Dr Reay gave conflicting evidence. Dr Reay said there was no review process within ARCE at that time and that as a small firm he relied on the CCC to review ARCE's work. Mr Harding, on the other hand, believed Dr Reay was reviewing his work both during the design process and before it went off to the CCC.

Mr Harding believed Dr Reay was reviewing his work, not by going through it with him, but by looking over the draughtsmen's shoulder at the work they were doing and at the details that Mr Harding had provided for his projects. He said that the ARCE office was small and generally quiet, so if Dr Reay was talking to a draughtsman about one of Mr Harding's projects, he would know Dr Reay would be coming to speak to him in the near future. He said Dr Reay would then advise him of any changes he required. Mr Harding said that this process gave him comfort that his work was being reviewed by Dr Reay. We note Mr Horn's evidence that Dr Reay was more concerned with making sure that the documentation for a particular project was going to be completed by the deadline, rather than the particular details that were being draughted.

Mr Harding said Dr Reay's evidence that there was no review procedure in place in 1986 was news to him and that if he had thought he was doing the project by himself he "would have bailed out right then".

Mr Harding said he believed that Dr Reay reviewed the design but based this on Dr Reay's usual procedure. He agreed that Dr Reay had not indicated on the CTV drawings that he had reviewed them. Dr Reay said that he did not review the drawings, calculations or specifications for the CTV building "and would not have expected to have done so". Dr Reay said it was Mr Harding's responsibility as the design engineer to ensure the design complied with the relevant codes and said on a number of occasions in evidence that Mr Harding would have been more familiar with the Concrete Code at that time than he was. Consequently, there was no reason to review Mr Harding's calculations for the CTV building.

We saw an example of Dr Reay having signed a design certificate, for the Westpark Tower, where the wording of the certificate specifically records that he had supervised the computations and the design. Dr Reay said that the extent of the review he carried out before signing a design certificate depended on the project and who had worked on it. In answer to a question from Commissioner Fenwick, Dr Reay said he could not recall how long he had spent reviewing the design for the Westpark Tower, saying that it would have been "clearly more than an hour or two and I wouldn't expect it to be more than a week". However, he said he did not make a similar check on the CTV building design because he "felt confident in the process that [he] was using" for that project.

We record that the set of structural drawings that were originally submitted to the CCC in late August 1986 were unsigned. The CCC raised the fact that this did not comply with the Bylaw requirement that the drawings be signed by the designer. However, Mr Harding did sign the drawings dated August 1986, which were held on the CCC file as the permitted drawings. He said he signed the drawings once he was happy that they were complete. There was no evidence that a design certificate was provided for this building.

We find on the balance of probabilities that the plans were not checked or reviewed by Dr Reay before they were submitted to the CCC for a building permit. We cannot accept Mr Harding's evidence that as the plans were being prepared by him Dr Reay was effectively checking on their content by discussing them with the relevant draughtsman. Mr Harding's evidence to that effect was unconvincing and it was too unspecific in nature to be of any value for our purposes. Apart from the discussions that took place about the south shear wall there was no evidence that Mr Harding took steps to raise any aspects of the design of the building with

Dr Reay. While the relevant events occurred a long time ago, we think it telling that Mr Harding was not able to point even in general terms to any process in which he sought Dr Reay's advice.

2.1.5 Issues arising from the design process

The issues that arise out of the design process are whether Mr Harding was competent to design the CTV building, whether he should have recognised the limits of his competence in 1986 and sought more assistance, and whether it was appropriate for Dr Reay to have left this project to Mr Harding to complete without supervision or review of his work.

We do not set out here the various deficiencies that we have found in the design of the CTV building. They are addressed in detail in sections 6, 7 and 8 of this Volume, and form part of the context for the discussion in this section.

2.1.5.1 Mr Harding

Counsel assisting submitted that Mr Harding was working outside his area of competence in designing the CTV building. Mr Harding's own evidence was that he was not competent to undertake the design of the CTV building without supervision by an engineer with experience in the design of multi-storey buildings. Counsel for ARCL and Dr Reay said that the CTV building was a "single mysterious error" because no other building designed by Mr Harding either before or after the CTV building had had any issues identified with its design. It was submitted by Mr Rennie QC that after 4,200 pages of evidence "we still do not know" why this occurred. Having examined this building in great detail and having heard eight weeks of evidence, we have reached the conclusion that Mr Harding was acting outside of his competence in designing the CTV building. This conclusion is largely based on the fundamental deficiencies of the design. However, we are also led to that conclusion by the evidence we heard about the design process.

The principal submissions made by counsel for Dr Reay and ARCL in defence of Mr Harding's competence were:

1. By 1986, Mr Harding was 35 years old, had seven years' experience as a structural engineer and four and a half years' experience as leader of the Waimairi District Council civil engineering team.
2. Mr Harding had been a registered engineer since May 1976. An important aspect of gaining registration was that an engineer should know what he or she does not know.
3. He was employed by ARCE in 1985 in a senior position, a role he wanted and considered himself qualified for. It was intended that he would become an Associate of the firm.
4. He was taken through the key elements of the building during cross-examination and asserted his competence to undertake the design of each. He stated that the elements of the structural design were all matters within his skills and expertise.
5. Mr Harding did not raise any issues or concerns with Dr Reay, other than the south shear wall. He agreed he was not calling out for supervision or review and never said to Dr Reay that he was not competent to do the work on his own without it being reviewed.
6. He had taken over the work started by Mr Henry for the Westpark Tower and completed the ETABS analysis and the design, with no known issues. He did not suggest that he lacked the skills to complete the Westpark design. Having completed the ETABS analysis on Westpark, Mr Harding believed he was in a position to proceed with the ETABS analysis for the CTV building.
7. Mr Harding had previous experience with the Concrete Code from his employment at Hardie & Anderson, his first period at ARCE and, in a civil engineering context, at the Waimairi District Council. Dr Reay's position was that, at the time of the CTV building design, Mr Harding was more familiar with the Concrete Code than he was.
8. Mr Harding had attended engineering seminars prior to rejoining ARCE, and went to a three-day seminar *Design of Concrete Structures*, prior to signing the CTV drawings. He acknowledged any issues arising from the seminar could have been taken into account in the CTV building design. He also recalled attending a seminar with Dr Reay about eccentrically braced frames.
9. Mr Harding was regarded as competent by other witnesses: Mr Scott of Williams Construction described him as competent and confident, Mr Horn described him as a "conservative engineer …[who] seemed to produce the right numbers", and Mr Peter Nichols, a former structural checking engineer for the Christchurch City and Riccarton Borough Councils, described him as a "very competent engineer".

10. Mr Harding was a near equal to Dr Reay in terms of experience. In 1986 he was entitled to practice on his own account and did so after leaving ARCE in 1988. It is only now that it is known that Mr Harding's experience and competence was not equivalent to Mr Henry's. The evidence is that Dr Reay and Mr Harding both thought the opposite in 1986.

Mr Harding's predecessor, Mr Henry, was an engineer who we consider was acting within his competence when he designed Landsborough House in 1985. The contrast between Mr Harding and Mr Henry and their respective design processes for Landsborough House and the CTV building was marked. Despite having worked as a structural engineer for less time than Mr Harding, Mr Henry came to ARCE in 1984 having been involved in the design of a number of multi-storey structures while employed at Holmes Wood Poole and Johnstone. He worked under supervision there and learned how to carry out response spectrum analyses using ETABS. During the design of Landsborough House Mr Henry recognised that the preliminary design was going to present issues in terms of torsion and pushed for it to be changed. He was aware of the limitations of the ETABS program and did additional calculations to ensure he accurately calculated the corner deflections. He sought comment from Professor Paulay, added additional reinforcement to his design beyond what the codes strictly required, and paid close attention to the detailing of structural elements. Leaving aside the question of whether it was appropriate for Dr Reay to leave Mr Henry to work largely unsupervised on this design as he did, it was clear that Mr Henry was knowledgeable and experienced in designing a shear wall gravity protected system building and was aware of the design challenges that this type of building presented. While counsel for Dr Reay submitted that Mr Harding's age and years of experience supported Dr Reay's position that he was competent to undertake the CTV design, we do not accept this. Mr Henry was younger and had been an engineer for much less time than Mr Harding but had been designing challenging multi-level buildings since he graduated. The type of experience is the appropriate indicator of skill and competence rather than age or the number of years practising or registered.

In contrast to Mr Henry, Mr Harding had not been involved in multi-storey building design prior to returning to ARCE in 1985 and had not used ETABS. Between 1980 and 1985 Mr Harding had been working as a civil engineer. During that period NZS 3101:1982[6] and NZS 4203:1984 were published. We do not accept that the structural engineering projects that Mr Harding was involved in while at the Waimairi District Council, the most significant of which appears to have been a swimming pool hydroslide, assisted with bridging the gap in his knowledge and experience between the one and two storey structures he had designed prior to 1980 and the challenges presented by the CTV building design.

Counsel assisting submitted that there were only two buildings that Dr Reay could point to as having prepared Mr Harding to undertake the design of the CTV building. The first was the four storey Hospital Accommodation building in Cashel Street. This design was carried out using the equivalent static method, not the modal response spectrum method, but did require Mr Harding to use the 1982 and 1984 Standards. Dr Reay also referred to the work that Mr Harding did for the Westpark Tower, which Dr Reay had reviewed in order to sign the design certificate. He said that gave him confidence that Mr Harding could carry out the CTV design competently. However the evidence suggests that Mr Harding was carrying out the design of the Westpark Tower just ahead of, if not at the same time as, the CTV building. We also heard that Westpark was a nine storey structure but was symmetrical rather than eccentric, so did not present the challenges that the eccentric layout of the CTV building did, particularly in relation to torsion. This meant that in undertaking the design of the CTV building, Mr Harding was venturing well beyond any work he had undertaken in the past.

A number of the deficiencies in the design of the CTV building were what Dr Reay described in evidence as matters of "fundamental engineering". Much was made in the hearing about Mr Harding's lack of experience using the ETABS program, but these fundamental mistakes were not dependent on an ETABS analysis. However we refer to the evidence we heard about Mr Harding's process for the ETABS analysis because it illustrates Mr Harding's lack of knowledge and experience in this area and the extent to which he was working beyond his competence.

Mr Harding had not used ETABS before, except in relation to the Westpac Tower, so to provide guidance Dr Reay gave him the Landsborough House file to follow what Mr Henry had done. The question of whether this was an appropriate thing for Dr Reay to do is discussed in section 2.1.5.2 below. It was submitted by counsel assisting that Mr Harding would have been encouraged by the fact that he could carry out an ETABS analysis by following the Landsborough House analysis and calculations. Mr Harding described this as "just a case of following the dots of the ETABS program". Mr Henry said he was concerned that Mr Harding had used his calculations in this way for two reasons. First, because his calculations were not

sufficiently detailed to provide guidance for a first-time designer to be able to understand the design processes followed and Mr Henry had not recorded all of his thinking processes or the decisions he had made based on judgement and experience. Secondly, he observed that the shear wall designs of Landsborough House and the CTV building were significantly different.

We also heard that in "following the dots" Mr Harding did not do hand calculations of the corner deflections. His evidence was that he did not know that he needed to do this but if he had seen those calculations within the Landsborough House file he would have done this for the CTV building. This illustrates his total reliance on Mr Henry's work. Counsel assisting submitted that if Mr Harding had properly calculated the corner deflections he would have seen that they were right at the limit of what was permitted.

As well as failing to properly calculate the inter-storey deflections Mr Harding did not look at the drawings for Landsborough House. He was asked whether he would have wanted to see the drawings to assist him to understand the calculations but he said he would not have because the calculations were very clear. Given how closely Mr Harding followed Mr Henry's calculations, it is surprising that he did not consider the drawings as well. If he had done so, then he could have seen where Mr Henry had added additional reinforcement to the design and this might have led Mr Harding to consider why he had done that.

Mr Harding's evidence about the ETABS analysis also suggests that he struggled with it. He said that he was "busy trying to get the computer program to work and to give any kind of result" and that when the analysis produced a result below the code limit he was grateful. He also said:

> …while I was giving it a go, I did struggle I must say because, yeah, doing something at the beginning when you're teaching yourself basically from someone else's example and working backwards is not the best way to do it.

However there was no evidence from Mr Harding or anyone else that he went to Dr Reay and said that he was struggling with ETABS. Mr Harding also said that his omission to calculate the corner deflections illustrated why someone more experienced needed to review his work, but again there was no suggestion that he asked Dr Reay or someone else to do this. Mr Harding said that Dr Reay told him he was not to contact Mr Henry for assistance but Dr Reay denied this, and we have no way of resolving that particular factual dispute.

Dr Reay's evidence was that if Mr Harding had come to him needing assistance he could not have been much help to him because he had no experience using ETABS. He said he would either have advised him to speak to someone at the University or to Mr Henry or to another engineer. As noted earlier, Dr Reay said that if Mr Harding was really struggling with the design the firm would have turned the job away.

Instead of seeking assistance it seems that Mr Harding simply pushed on and taught himself how to use the program. He said by the fifth or sixth run he was "reasonably proficient". Only then did he go to Dr Reay to discuss possible solutions to the excessive inter-storey deflection. Once the south shear wall was agreed as a solution Mr Harding then proceeded with ETABS, including it in the ETABS model. There was no evidence that Mr Harding consulted Dr Reay about any aspect of the design again.

The absence of any evidence that Mr Harding asked Dr Reay for help, other than the discussion about the south shear wall, conflicts with Mr Harding's position at the hearing that he was not competent to design those structures without review or oversight. As counsel for ARCL and Dr Reay submitted, if Mr Harding was in a position where he felt a review of his work was crucial he would have ensured that occurred. Instead he acknowledged in evidence that he was not calling out for review and described the rest of the design, apart from the south wall issue, as "pretty much routine". As noted earlier, we did not find credible or convincing Mr Harding's suggestion that he thought Dr Reay was indirectly reviewing his projects by looking at the work the structural draughtsmen were doing and at the details Mr Harding had provided to them. In any event, there was no evidence from Mr Harding that he ensured that this was occurring.

We accept the submission of counsel assisting and Mr Rennie QC that Mr Harding's position at the hearing that he was not competent to design the CTV building without review or oversight was not the view he held in 1986. If he had held this view, it was incumbent upon him as a Registered Engineer to tell Dr Reay that he could not do the design on his own and that he needed help but there was no evidence from him or from Dr Reay that he did this. Counsel assisting submitted that he did not do so because he wanted to become an Associate and this meant proving that he could do the design on his own. That is not something that we consider we need to determine. It is sufficient to note his sense of confidence and that Mr Harding was confident that he could carry out the design of this building on his own. As he said in evidence in answer to a question from Mr Mills QC:

Q. Yes. Did you know at this point that the work on Landsborough that you were being given as a template had been done by Mr John Henry?

A. Yes.

Q. Did you have any existing knowledge about his competence in the field of multi-level shear core building design?

A. Not prior to joining Alan's firm, no.

Q. And was anything said to you when you joined the firm about his levels of competence?

A. I don't recall anything particular but I, you can quickly draw a conclusion by looking at their, at the work that he had done. It was quite evident that he was very competent.

Q. So that was the view you formed when you looked at that material?

A. Yes.

Q. As a result of that I take it you had a high level of confidence that if you followed what you had done there then you too could design a good building.

A. Yes.

What was most telling about Mr Harding's view of his own competence was his defence of the design of the CTV building. He refused to accept the criticisms of Professor Nigel Priestley and Professor John Mander about the design and rejected criticisms of the diaphragm connection. As counsel assisting submitted, Mr Harding held firm to the view that exceptionally high vertical accelerations were the cause of the building's collapse. He was taken through each key element of the building's design by Mr Rennie QC and stated that all of them were matters within his skills and expertise. However counsel assisting submitted that, during questioning by Commissioner Fenwick, Mr Harding was shown to be seriously out of his depth and that the work he had done on the CTV building, in some critical areas, showed he was completely unaware of calculations that he should have made and code provisions that he needed to take into account. We accept this submission.

We find that Mr Harding was working beyond his competence. That is a conclusion which follows from the fundamental design errors and areas of non-compliance we have identified in sections 6, 7 and 8.1 of this Volume and is consistent with the evidence we heard from Mr Harding about the process he followed. This situation also illustrates some of the difficulties with the Institution of Professional Engineers New Zealand (IPENZ) Code of Ethics, which requires that engineers work within their area of competence but leaves it up to the individual engineer to identify and determine what their limits are. Mr Harding erred in his self-assessment of his competence and the confidence he had that he could design this building competently was unfounded.

Dr Reay said he considered Mr Harding to be "a very competent structural engineer who understood his limitations and knew how to work through them". It follows from our conclusion about Mr Harding's competence that Dr Reay was mistaken. This then raises issues about Dr Reay's decision to hand over the design of the CTV building to Mr Harding without having any intention of reviewing his work.

2.1.5.2 Dr Reay

Throughout the hearing Dr Reay defended his decision to give responsibility for the design of the CTV building to Mr Harding, without any supervision or review process in place. He was asked by Mr Mills QC whether he would make the same decision today, and he said that he would, based on Mr Harding's age, his "considerable experience in structural design" and in the knowledge that today there would be an external peer review of the building.

As we have discussed in section 2.1.5.1, Dr Reay rejected the suggestion that Mr Harding was an inexperienced designer in 1986. He pointed to Mr Harding's previous structural design experience and suggested on a number of occasions that he was more familiar with NZS 3101:1982 than Dr Reay was. Mr Harding disputed this and we note that his only previous experience with this Standard would have been while he was working at the Waimairi District Council, where he was not involved in designing multi-storey concrete structures.

Dr Reay accepted that the CTV building was a greater challenge for Mr Harding than any project he had undertaken before, but he said he relied on Mr Harding's judgement as to whether he was ready for that challenge. He said that Mr Harding's self-assessment was that he could carry out the design and Dr Reay accepted this. Mr Rennie QC submitted that this was a sufficient enquiry for Dr Reay to make because Mr Harding was employed in a senior position, was 35 years old, had worked in structural engineering for a number of years and was a Registered Engineer. The constant thread throughout Dr Reay's evidence was that it was for Mr Harding to come to him and say he needed help, not for Dr Reay to make enquiries about the design work Mr Harding was carrying out.

Dr Reay acknowledged that at the time he employed Mr Henry he wanted someone with experience in that area to design the multi-storey building projects he had

started to take on because he was fully committed on other work and did not envisage he would be working on those projects to any great extent. Mr Henry was employed in a senior role to undertake that work and his evidence confirmed that Dr Reay essentially left him to it. Mr Henry's evidence about the design of Landsborough House proved that he was competent to undertake the design of such a building and could do so without Dr Reay's assistance. But then he left ARCE and Mr Harding was hired as his replacement.

The evidence was clear that Mr Harding took over from Mr Henry and Dr Reay said he was employed in a senior role, as Mr Henry had been. It appears that Mr Harding was hired on the basis that Mr Harding was willing to fill the gap to be left by Mr Henry's departure. However it would not have taken much of an enquiry for Dr Reay to have realised that Mr Harding had had much less experience than Mr Henry with multi-storey buildings. In fact he had not had any such experience. Dr Reay knew what work Mr Harding had undertaken for him when he was first employed by ARCE, and there was no suggestion from Dr Reay that he did not know that Mr Harding had been working in civil (not structural) engineering for the past five years at Waimairi District Council. We accept the submission of counsel assisting that there was no basis for Dr Reay to conclude that Mr Harding could simply take over the level of work Mr Henry had previously been doing unless there was appropriate supervision and mentoring by someone else within the firm who had the requisite level of skill and competence.

When Mr Harding returned to ARCE in November 1985, the CTV project was not on the horizon, but it was only four months after he returned to ARCE that Mr Harding commenced the design. Dr Reay said that during the period between Mr Harding's return to ARCE in November 1985 and commencing work on the CTV building in March 1986, he was able to assess Mr Harding's work and considered him to be a very competent structural designer who understood what he was doing, understood his limitations and understood the codes. The projects that Mr Harding undertook during this period were the design of the Hospital Accommodation building, Broadway and the Westpark Tower. Dr Reay acknowledged that the Hospital Accommodation building did not involve an ETABS analysis but said it still required Mr Harding to understand structural design principles, including the transfer of forces from floors to walls and the design of floors to the code. Broadway was only a two storey building. Westpark was a nine storey building but was symmetrical rather than eccentric or irregular.

Dr Reay said that Westpark had already been partly designed when Mr Harding started working on CTV. He reviewed the final design for Westpark before signing a design certificate and said he felt that Mr Harding had handled that satisfactorily, which may have influenced his assessment of Mr Harding's ability to design the next multi-storey building. However we note that Dr Reay signed the design certificate for Westpark on 19 June 1986, while the time records he produced show that Mr Harding had started working on the CTV building by March 1986. This meant that the Westpark project could not have provided Dr Reay with a basis for concluding that by March 1986 Mr Harding was ready to design the CTV building without supervision. Dr Reay had not reviewed the project at that time.

However, once Mr Harding was employed, it may be that Dr Reay's confidence in his ability was enhanced by Mr Harding's failure to seek Dr Reay's assistance as he went about his work.

Dr Reay said he relied on Mr Harding's confidence that he could undertake the design and his belief that he could accomplish it. This was the only basis upon which Dr Reay could rely on Mr Harding, because he could not rely on his previous experience of designing multi-storey buildings. In the absence of that experience, we conclude that Dr Reay should have questioned the basis for that confidence. In any event, we do not accept that it was appropriate for Dr Reay to rely on Mr Harding's confidence that he could do the design and then leave him to it without putting any checks in place. As Mr Harding said in evidence, he did not know what he did not know, but if his work was being reviewed, some of the design issues that have now been identified may have been picked up while the design was being developed or at least before the plans left ARCE. While Dr Reay may not have been able to identify all of the defects in the building, counsel assisting submitted that he would have been capable of picking up the problem with the connection between the floor diaphragm and the north wall that was later identified, as he described this as "fundamental engineering" during the course of his evidence.

Dr Reay said in evidence that the only area where he thought Mr Harding was lacking was in using ETABS, which is why he gave him Mr Henry's work for Landsborough House to follow. But having recognised Mr Harding's limitations in that area, Dr Reay made no further enquiry of Mr Harding during his ETABS analysis and did not review, or arrange for someone else to review, his work.

The other area of assistance that Dr Reay said he provided to Mr Harding was in sending him to the three-day seminar in July 1986 that we have referred to in section 2.1.4.5.

It was suggested by Mr Rennie QC on behalf of Dr Reay that Mr Harding would have had the opportunity at this seminar to raise any questions he had about the CTV design with the presenters of the seminar, which included Professors Paulay and Park and (then) Dr Priestley. This was not accepted by Mr Harding, who said that he was not sufficiently experienced to raise issues in that way, but took the material home with the intention of digesting it over time. He was asked whether he could recall making any changes to the CTV plans in the light of what he learned from the seminar. His answer was:

> I don't, I think if anything it may have been, no I don't recall. I, I've recently had another look at those seminar notes since they were produced maybe three or four days ago and I can't see anything in them that, that would have changed what I did on that job.

While Mr Harding agreed that he was fully informed about the construction issues covered in the seminar, it was suggested by counsel for Dr Reay that after he attended the seminar Mr Harding would have been more informed about these issues than Dr Reay was. Again this was not accepted by Mr Harding, who referred to Dr Reay having a PhD and to the number of buildings he had designed previously.

Because structural drawings were not submitted to the CCC until 26 August 1986, there was opportunity for Mr Harding to have changed the design of the building after he attended the seminar. However, his evidence is that he did not make any changes as a result of attending it. We do not accept the submission of counsel for Dr Reay and ARCL that the seminar preceded the main structural design of the CTV building because between March and June 1986 there was already over 167 hours of work recorded against Mr Harding for this project on the time records. Even if part of the design had been changed following the seminar, we do not accept that sending Mr Harding to this seminar was a substitute for Dr Reay reviewing his work.

It was Dr Reay's position that Mr Harding was not "flying solo" on this project because if he had a problem he could consult with him. He said he did not think there would have been discussions about the design during morning and afternoon tea breaks because, if Mr Harding had started to raise concerns and ask questions, Dr Reay would have been alerted to an issue. However Dr Reay also said that he remembered making sure Mr Harding understood that he did not have the time or knowledge to be able to assist him in depth and that the responsibility for the design was Mr Harding's, and Dr Reay's assertion that he was there if Mr Harding needed him must be seen in that context. Dr Reay also said that he believed he would have found out fairly quickly if Mr Harding found he had difficulty with the design, but this premise relies on Mr Harding being able to recognise when he was in difficulty or making a mistake, and he was not able to do this.

We also find it troubling that on the one occasion when, on his evidence, Dr Reay did review Mr Harding's work on the CTV project, he wanted to satisfy himself that it was not going to be a repeat of the Landsborough House layout. He recalled the issues about torsion that Mr Henry had raised with him at the time Landsborough House was being designed but there was no suggestion that this led on to a discussion with Mr Harding about why he did not want a repeat of Landsborough, what Mr Henry's concerns were or what he had done to address these in his design. We have already found that Mr Harding's failure to look at the drawings for Landsborough House was a missed opportunity to notice the additional reinforcement Mr Henry had put into that design, and Dr Reay's enquiry about the layout of the building was an opportunity to refer him to that design. We also note that Dr Reay said that he had seen the south wall on an architectural, rather than a structural drawing. This meant he would not have seen any of the detail of the structural design. We conclude that Dr Reay realised that the layout of the building meant that the designer had to take a great deal of care, but the enquiry he says he made of Mr Harding was too superficial to ensure this occurred and may in fact have given Mr Harding a false sense of confidence that he was on the right track with the design.

Dr Reay did not review the drawings or calculations for the CTV building before they went to the CCC. Presumably this is explained by his comment that he had seen Mr Harding's work previously and was satisfied that he had a good understanding of the design of structures. He said he relied on the CCC to review the design during the permit process. In adopting this position, Dr Reay stood apart from other structural engineers who gave evidence during the hearing. All of them referred to processes whereby the work would be reviewed by persons in their firms other than the person who had actually carried out the design. Mr John O'Loughlin, a practising engineer since the early 1970s, was asked by counsel assisting whether he would have considered it appropriate to allocate the design of the CTV building to an

inexperienced structural engineer "with essentially no supervision but on the basis that [he] could rely on the Council reviewing engineers to pick up any deficiencies in that design". Mr O'Loughlin said that that would not be appropriate. Mr Henry referred to his experience working for a number of firms, of various sizes, all of which had some form of review in place. Mr Rob Jury of Beca and Dr Arthur O'Leary of Morrison Cooper Limited both referred to the importance of having a review process in place, particularly where the work is being carried out by an inexperienced designer.

Mr David Falloon, the principal of Falloon & Wilson, gave evidence in relation to engineering work his firm carried out for a fit-out of the CTV building in 2000. At that time he had four or five employees[7]. The design work was carried out by a recent graduate but was checked by Mr Falloon. He said he did that because "it's a small firm, that's my role". He was asked why he checked his employees' work and said:

> A. Well it's what we always do, I mean it's a daily event. You'd be keeping an eye on work that was done and finally when the drawing's complete I would sign it as checked.

Counsel for ARCL and Dr Reay submitted that none of these witnesses were in a position to comment on ARCE in the mid-1980s or on any firm of similar size, and that in a larger firm a person like Mr Harding, employed as an Associate, would be providing supervision rather than being supervised. Even if someone equivalent to Mr Harding was supervising others, in most firms, from the evidence we heard, he would still have had his work checked by someone else. Dr Reay should also have been aware of Mr Harding's lack of experience relevant to the CTV design and the need for his work to be checked. We do not regard the small size of Dr Reay's firm at the time as entitling him to rely on the CCC to have the role of checking plans that should have been completely designed before being submitted for a building permit.

2.1.6 Conclusion

Dr Reay expected Mr Harding to fill the gap created by Mr Henry's departure but at the same time he knew that Mr Harding was a novice when it came to multi-storey building design. Because of this, he could not simply continue the hands-off approach he had adopted with Mr Henry. It was not sufficient to rely on the fact that Mr Harding was a Registered Engineer of a certain age and number of years' experience. It was the nature of that previous experience that indicated what he could do unsupervised. There was insufficient basis for Dr Reay to believe that within four months of returning to ARCE, having come from a civil engineering position, Mr Harding was ready to design a challenging multi-storey building on his own, or that he would have known enough of the potential pitfalls and design issues to navigate his way around them without assistance.

Mr Harding was working beyond his competence in designing the CTV building. He should have recognised this, given that he had never designed a building like this before. We also consider that Dr Reay should have realised that this design was pushing Mr Harding beyond his limits given his past experience. The design process led to a building that was under-engineered in a number of important respects.

2.2 The building permit

2.2.1 Introduction

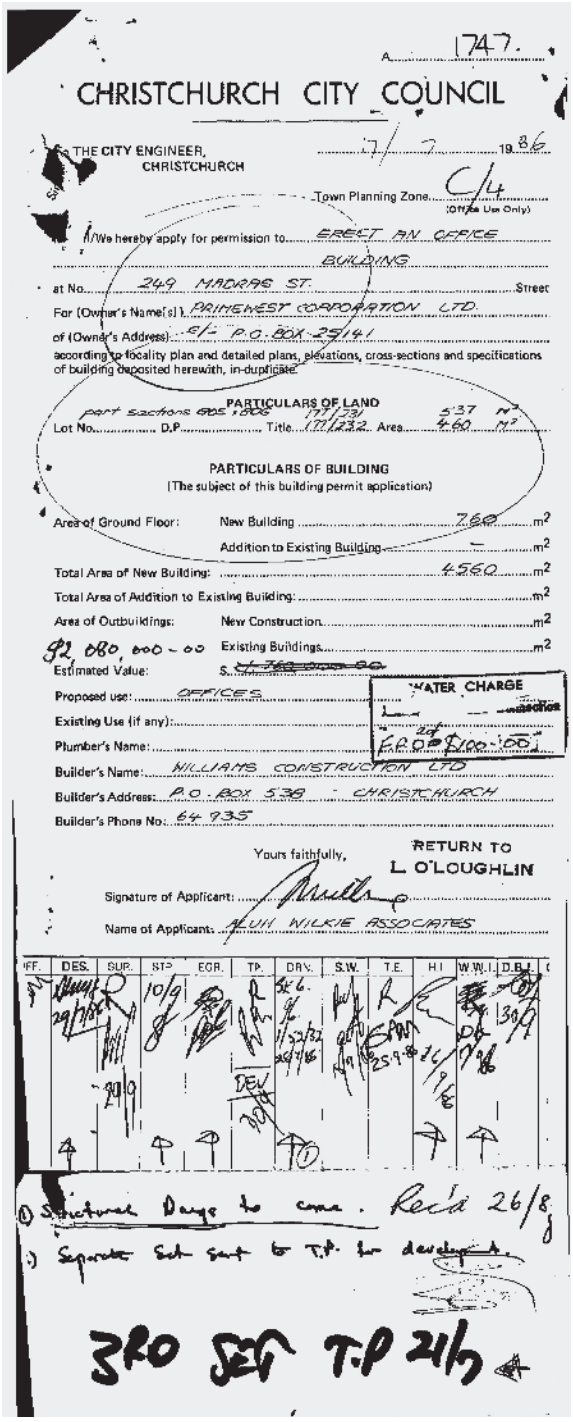
The Terms of Reference as they specifically relate to the CTV building require us to consider, amongst other things, whether the building complied with legal requirements current when it was designed and constructed. This section deals with the permitting process for the building, as part of addressing that issue and explains the circumstances in which the building permit was issued, despite the fact that it did not comply with the CCC's Building Bylaw 105, as discussed in detail in section 8.1. We have taken the view that it would be artificial to restrict the Inquiry to the facts that establish non-compliance and that we should go further and report on how the permit came to be issued. We think that such an approach is implicitly authorised by paragraph (b)(i) of the Terms of Reference and, in any event, may be reached under paragraph (e) of the Terms, which refers to other matters arising that the Commission considers it should investigate.

We are also required under paragraph (d)(iv) to consider the roles of, amongst others, local government, the building and construction industry and other elements of the private sector in enforcing current legal and best-practice requirements. The understanding we have developed of the circumstances in which the permit for the CTV building was issued has been of assistance to the Royal Commission in its consideration of the desirable future requirements for the issue of building consents for complex structures, addressed in sections 3 and 4 of Volume 7. The same issues have relevance for the purpose of recommendations which we are required to make about measures necessary or desirable to prevent or minimise the failure of buildings in New Zealand due to earthquakes.

2.2.2 Overview

Alun Wilkie Associates filed an application for a permit for the building with the CCC on 17 July 1986. The proposal was for an office building for Prime West, 4560m^2 in total area and at a cost of $2,080,000.

The structural drawings were not provided to the CCC when the application was filed: the words "Structural Drawings to come" appear at the bottom of the first page of the application form. There is a note next to that to the effect that the structural drawings were received on 26 August 1986, more than a month after the application was lodged. A further set of structural drawings was provided to the CCC on 5 September 1986.



A 1747.

CHRISTCHURCH CITY COUNCIL

To THE CITY ENGINEER, CHRISTCHURCH 17/7/19 86

Town Planning Zone C/4 (Office Use Only)

I/We hereby apply for permission to ERECT AN OFFICE BUILDING

at No. 249 MADRAS ST. Street

For (Owner's Name[s]) PRIMEWEST CORPORATION LTD.

of (Owner's Address) C/- P.O. BOX 25141

according to locality plan and detailed plans, elevations, cross-sections and specifications of building deposited herewith, in-duplicate.

PARTICULARS OF LAND

part sections 605, 606 Lot No. ... D.P. ... Title 177/231 177/232 Area 537 m² 460 m²

PARTICULARS OF BUILDING

(The subject of this building permit application)

Area of Ground Floor: New Building 760 m²

Addition to Existing Building — m²

Total Area of New Building: 4560 m²

Total Area of Addition to Existing Building: m²

Area of Outbuildings: New Construction m²

Estimated Value: $2,080,000-00 Existing Buildings m²

Proposed use: OFFICES

Existing Use (if any):

Plumber's Name:

Builder's Name: WILLIAMS CONSTRUCTION LTD

Builder's Address: P.O. BOX 538 CHRISTCHURCH

Builder's Phone No: 64 935

WATER CHARGE ... FEE $100-00

Yours faithfully, RETURN TO L O'LOUGHLIN

Signature of Applicant:

Name of Applicant: ALUN WILKIE ASSOCIATES

OFF. | DES. | SUP. | STR | ECR. | TP. | DRN. | S.W. | T.E. | H.I | W.W.I. | D.B.I.

1) Structural Dwgs to come. Rec'd 26/8

2) Separate Set sent to T.P. for development

320 SET T.P 21/7

Figure 15: The application for a building consent for 249 Madras Street, dated 17 July 1986

A number of units of the CCC considered the application, including the structural engineers employed to review designs. The buildings engineer for the CCC at this time was Mr Bryan Bluck and his deputy was Mr Graeme Tapper. Both were deceased prior to the February earthquake. Mr Bluck and Mr Tapper were qualified engineers and we heard that both were highly regarded in the engineering community in Christchurch.

Mr Tapper reviewed the structural drawings and wrote a letter the following day, 27 August 1986, to ARCE requesting calculations to support the design, a foundation report and a specification. He listed a number of specific matters about particular sheets of the drawings. Mr Tapper also noted that the drawings had not been signed by the designer, as required by the CCC's Building Bylaw.

On 5 September 1986 Mr Harding completed a document transfer form, addressed to Mr Tapper, enclosing two sets of structural drawings, "including amendments as requested" and calculations "relating to Bondek structure after fire". These documents appear to have been hand delivered to the CCC.

Five days after those documents were delivered, Mr Tapper signed off on the structural aspects of the design. The permit itself was granted, subject to conditions, on 30 September 1986.

This summary suggests that the application for a permit for the building passed through the CCC in a reasonably uneventful fashion. However, evidence was called that suggested that Mr Tapper had identified a significant structural issue in the design, namely the connection of the floors (diaphragms) to the north wall complex, and raised this with ARCE in his letter. We were invited by counsel assisting to conclude that, despite Mr Tapper's concerns, the design of this connection was not amended by ARCE. Instead, it was submitted Dr Reay personally convinced Mr Bluck that Mr Tapper's concerns were unfounded and Mr Bluck instructed Mr Tapper to sign off on the design, despite his concerns. We set out the evidence we heard about this issue and the conclusions we have reached below, following a discussion of the relevant council processes in 1986.

2.2.3 The permit process

2.2.3.1 Bylaw 105

The CCC Building Bylaw that applied at the time was Bylaw 105, made on 20 November 1985, under the authority of the Local Government Act 1974. As discussed in more detail in section 8.1, the Bylaw adopted key New Zealand Standards for the design of buildings, including NZS 3101:1982 and NZS 4203:1984.

Part 2 of the Second Schedule of Bylaw 105 set out the legal requirements for a permit. Clause 2.2.1 provided, "no person shall erect or commence to erect any building without first obtaining a building permit from the engineer". Mr Bluck exercised the powers of the "engineer" under the Bylaw at the times relevant to this Inquiry.

Clause 2.6.1 specified that an application for a building permit was to be accompanied by:

> …detailed plans, elevations, cross-sections, and specifications which shall together furnish complete details of design, and the qualities and descriptions of construction materials and workmanship, and which shall be of sufficient clarity to show, to the satisfaction of the Engineer, the exact nature and character of the proposed undertaking and the provision made for full compliance with the requirements of this Bylaw and any other relevant bylaw in force at the time of the application.

In addition, under Clause 2.6.2.1, there was a requirement to submit to the engineer:

> such stress diagrams, computations, and other data as necessary to show that the design complies with all the requirements of this Bylaw and any other relevant bylaw in force.

However, this requirement was qualified in relation to concrete buildings by Clause 8.2.5:

> Design Certification
>
> The designer of any concrete element shall provide calculations which establish that the concrete element has been designed in accordance with the requirements of this Bylaw or alternatively certify in an approved manner that the design method conforms with the requirements of a recognised code of practice.

Clause 2.8 required that drawings, computations and other data submitted were to be signed by the engineer or designer responsible for their production. Where two or more parties were responsible, this was to be identified.

Under Clause 2.13 the engineer was empowered to withhold a permit where he considered that "deficient information" had been provided, or if he considered that the building did "not comply with the requirements of this Bylaw or any other relevant Acts, regulations or Bylaws." In that case, it was for the applicant to "make good such deficiency, or make such alterations in the documents as shall be necessary" to comply with the requirements of the Bylaw.

Under Clause 2.14, a permit would be issued where the engineer was satisfied that the "drawings and specifications" were "in accordance with the Bylaw and with other relevant Acts, Regulations and bylaws" and where he had no reason to believe that the "builder was not competent to carry out the work". It follows from this that the engineer had a legal duty to do what was necessary to be satisfied that a building which was the subject of an application for a permit complied with the Bylaw in all respects.

It is relevant also to record that section 693 of the Local Government Act 1974, as it was in force at the time that this permit was issued, provided that it was an offence for any person to act contrary to a bylaw and such offences were punishable by fine. Further, under this section the continued existence of any work or thing in a state, or the intermittent repetition of any action, contrary to any bylaw was deemed to be a continuing breach for the purposes of the section, subject to a recurring penalty. As is apparent from the extract of Clause 2.6.1 of Bylaw 105 the detailed plans and specifications required to accompany an application for a building permit had to be of sufficient clarity to show, amongst other things, "the provision made for full compliance with the requirements of this Bylaw". Reading the various provisions of the Bylaw together with the Act, it can be seen that only buildings that complied with the Bylaw should be granted a building permit and it was the CCC's duty to ensure that this was the case.

2.2.3.2 The building permit process

The Royal Commission heard evidence from Mr Leo O'Loughlin, who was employed by the CCC as a District Building Inspector between June 1985 and October 1986. During that period he was responsible for processing permit applications for buildings in the central city area. Mr O'Loughlin received the building permit application for the construction of the CTV building, and his name appears on the application form, which is stamped "Return to L O'Loughlin".

Mr O'Loughlin did not recall this application specifically but gave evidence about his general practice at the time. He said that the permit application for the building would have been handed in to the CCC's public counter. It would then have been assigned a permit number, in this case 1747, and a cover sheet attached.

Mr O'Loughlin said that his usual process was to review the documents provided with the application to determine whether any information was missing. He said that if he found any omissions or required further detail he would request this from the applicant. There is an example of this process in relation to the building in a letter dated 21 July 1986 from Mr O'Loughlin to Alun Wilkie Associates requesting further information. Mr O'Loughlin said that he would also review parts of the plans to ensure compliance with relevant bylaw requirements, but that this was limited to non-structural features, such as detailing for handrails, stair treads and ventilation. He would also check the siting of the building on the plans. He did not conduct any review of the structural design of proposed multi-storey or complex single storey buildings because this was a matter for the CCC structural engineers.

Mr O'Loughlin said he would then send the application and supporting documents to the relevant units of the CCC for consideration. The permit application form for the CTV building contained a number of boxes, each representing a different unit of the CCC. These were Administration (OFF), the Design Office (DES), the Survey Office (SUR), Structural (STR), the Egress Fire Safety Officer (EGR), Town Planning (TP), Drainage (DRM), Street Works (SW), Traffic Engineering (TE), Health Inspector (HI), Waterworks Inspector (WWI) and the District Building Inspector (DBI). A CCC officer in each unit would sign its box when satisfied with the application. Mr O'Loughlin said that if any of the units required further information from the applicant someone would usually write to the applicant directly. Once each unit had signed the processing check sheet the permit application would be returned to Mr O'Loughlin and he would prepare a handwritten list of draft building permit conditions. He said he would do this by selecting relevant conditions from a standard list and adding any additional conditions that had been recommended by the units that had checked the application. Mr O'Loughlin's handwritten list of conditions for the building was provided to the Royal Commission.

Mr O'Loughlin then prepared the application for review by the district building inspector. Once the application and draft conditions had been approved, the conditions would be typed up, the plans would be stamped and a permit approval and building permit prepared (in the case of the CTV building the permit, plans and conditions were signed by Mr Maurice Faulkner, who we were told was the chief building inspector at that time). The applicant would then be notified that the permit was available to be uplifted from the CCC upon payment of the permit fee.

Although the application was filed by Alun Wilkie Associates the permit itself dated 30 September 1986 was issued to Williams Construction Limited, noted on the application as the builder. The permit was copied to Prime West Corporation Limited, Alun Wilkie Associates and Dr Reay. The permit recorded that fees of $4,800 and a reserve contribution levy of $11,480 were required to be paid before the permit could be issued. The permit recorded that the application had been approved subject to conditions. Among the conditions was a requirement that the engineer responsible for the structural design confirm in writing that the intent of his design had been complied with before the building was occupied. Mr Stephen McCarthy, the Resource Consents and Buildings Policy Manager of the CCC, gave evidence that no such confirmation was held on the CCC's file for the CTV building and Dr Reay said that no confirmation was held on the ARCL file.

Mr O'Loughlin was asked whether it was usual practice in Christchurch at the time for building permit applications to be made on the basis that the structural drawings were still to come. He said that there were some instances where this would occur, usually when the design engineer was under pressure to get the project moving through the CCC. Some applications would be filed with architectural drawings only, allowing the design engineer more time to complete the structural drawings. This is despite Clause 2.6.1.1 of Bylaw 105 which required that:

> Together with every application there shall be submitted to the Engineer, in duplicate, detailed plans, elevations, cross-sections, and specifications, which shall together furnish complete details of design, and the qualities and descriptions of construction materials and workmanship, and which shall be of sufficient clarity to show, to the satisfaction of the Engineer, the exact nature and character of the proposed undertaking and the provision made for full compliance with the requirements of this Bylaw and any other relevant bylaw in force at the time of the application.

Mr Henry and Mr John O'Loughlin confirmed that submitting permit applications without a completed set of structural drawings was a practice that occurred in Christchurch in the 1980s.

2.2.3.3 The structural checking process

We also heard evidence from Mr Peter Nichols who was employed by the CCC between 1978 and 1984. He was employed as a structural checking engineer between 1978 and 1981 and then as deputy building engineer until 1984, second-in-charge to Mr Bluck.

Mr Nichols said structural checking engineers were responsible for checking the plans, specifications, calculations and other documents that were submitted with an application for a building permit. He said his usual practice was to review the plans, identify the critical points in the structure and the areas subject to maximum stress and do a general check for areas of concern.

Mr Nichols said calculations were not usually submitted with permit applications so he would carry out his own calculations on the principal structural elements of the design, essentially as spot checks, to verify that the elements were appropriate in size and detailed for the specific function they were required to perform in the overall structure. He would also check the bending, shear, torsional and axial stresses as well as deflections at these critical points to determine whether these were within the limits of the Bylaw. Mr Nichols said that when he was checking a multi-storey or otherwise complex building it was his usual practice to require the design engineer to provide full structural calculations. He said it was impossible, in his view, both in terms of time and resources, for the checking engineers to do their own independent calculations in the time available to them. By asking for a copy of the designer's calculations, Mr Nichols was able to review the design approach, the assumptions made, and follow the mathematical analysis as far as was necessary to verify that the requirements of the Bylaw had been met. Once he received the calculations, he would review them to ensure all of the important structural components were included, that the correct dimensions, material properties and formulae had been used and to check whether the calculations were correct. He said he would be looking for obvious errors or omissions rather than reviewing every number.

Mr Nichols had between a few hours to a few days to check large projects, depending on their size and complexity. All checking and analysis had to be done manually at this time because the CCC did not have computers. He said that with time he was able to develop an intuitive feel for different types of building design. While most designs that he encountered were conventional and required minimal assessment because they used familiar concepts and details, those that were more innovative or contained unfamiliar features would need further investigation.

Mr Nichols recalled that his time at the CCC was a demanding period, with a large volume of applications for building permits and a great deal of pressure "to get permits through and buildings up". Mr Nichols said that whenever Mr Bluck or his staff had a concern over a particular building permit application, Mr Bluck's standard practice was to invite the designer to meet with him to discuss the design. He described such meetings as sometimes lasting a whole day and usually ending with the designer completing a specifically worded design certificate. Mr Nichols said Mr Bluck believed that:

> …he, on the Council's behalf, was entitled to rely upon the expertise of a qualified professional engineer for assurance that his specific design met the required standard and if that was obtained to his satisfaction there was no reason to withhold the permit.

Mr Nichols produced a copy of a document authored by Mr Bluck which reflected that approach. The document was prepared by Mr Bluck and provided by him to his staff during the period within which Mr Nichols worked at CCC (between 1978 and 1984). The memorandum read as follows:

Guidelines for Structural Checking Engineer staff of the Christchurch City Council, to be applied in the assessment of structural compliance of BPA's with the provisions of the Building Bylaws.

1. All Applicants are legally entitled to be issued with an approved Building Permit provided that all relevant criteria in their particular application comply with the Building Bylaw provisions.

2. Do not attempt to rewrite the Bylaws, but administer them as they are written, or apply them as they may be interpreted in the context of each specific application. If ambiguity exists, then determine the intent of any applicable Bylaws and apply their provisions in the context of that intent.

3. You are entitled to rely upon the recognized expertise of a Professional Designer who is prepared to certify under his signature that a specific design for a conventional or innovative structure (or detail), complies in all respects with the intent of the provisions of NZS 1900 Chapter 8.

4. Do not amend the BPA drawings in any way (in order to expedite the permit process), as to do so could compromise the responsibility for the specific design which otherwise fully belongs to the Professional Designer.

B C BLUCK
BUILDINGS ENGINEER

Figure 16: Guidelines for CCC structural checking engineers authored by Mr Bryan Bluck, Buildings Engineer

Mr Bluck's approach of relying on the "recognized expertise" (sic) of the designer to certify that the design was compliant was pragmatic, on the bases that the designer should be able to show that the building complied with the Bylaw and that the CCC had limited time and ability to check the efficacy of the design. However, as the permit granted for this building shows, it was an approach accompanied by some risks, including the risk that a non-complying structure would be approved.

2.2.3.4 Mr Tapper's letter to ARCE

On 27 August 1986 Mr Tapper drafted a letter to Dr Reay's firm regarding the structural drawings submitted for the building the previous day. The original letter was provided to the Royal Commission by the CCC. We set out below a facsimile of the original, together with a typed version of the letter. We note that "Sh" and "S" are plainly abbreviations for a particular sheet of the structural drawings.

2503
rec'd 1/7/86

CHRISTCHURCH CITY COUNCIL

CITY WORKS & PLANNING DEPARTMENT

27 Aug 1986

Alan M Reay Consulting Eng
P.O Box 25-028
Christchurch

Dear Sir,

Re Your application Number 1747 to erect office building
at 249 Madras St is held up pending receipt of:

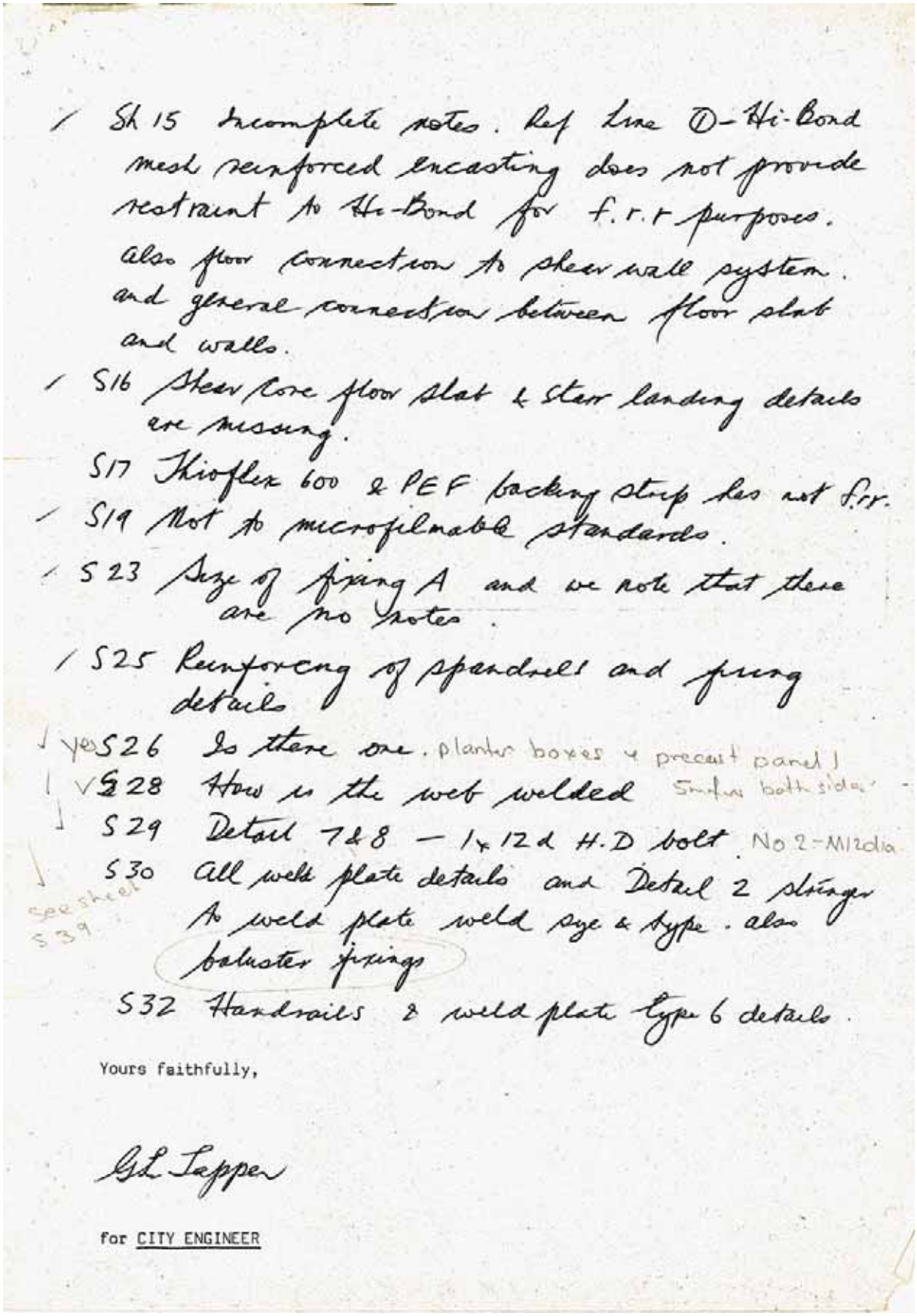
rec'd 2 days after letter sent off

Please provide the calculations to support the design. We also require a foundation report and a specification which describes the required quality standards for materials and workmanship. Please note that CCC Bylaw 105 requires in Cl 28.1. that "All drawings computations and other data submitted shall be signed by the architect, engineer or designer responsible for their production and shall clearly identify him and his firm or organisation" There is no indication of on the plans that they have been checked and approved for issue and construction.

Please attend to the following matters :—

/ Sh 9 — No subgrade information and the 125 slab is both unreinforced and unjointed.

/ Sh 14 Stirrups for Cols 4, 20, 10 & 16.



S15 Incomplete notes. Ref Line ①–Hi-Bond mesh reinforced encasting does not provide restraint to Hi-Bond for f.r.r purposes. Also floor connection to shear wall system. and general connection between floor slab and walls.

S16 Shear Core floor slab & Stair landing details are missing.

S17 Thioflex 600 & PEF backing strip does not f.r.r.

S19 Not to microfilmable standards.

S23 Size of fixing A and we note that there are no notes.

S25 Reinforcing of spandrels and fixing details

yes S26 Is there one. planter boxes & precast panel

S28 How is the web welded Single both sides

S29 Detail 7&8 — 1 x 12 d H.D bolt No 2 – M12 dia

S30 All weld plate details and Detail 2 stringer & weld plate weld size & type. also baluster fixings

see sheet S39

S32 Handrails & weld plate type 6 details.

Yours faithfully,

GL Tapper

for CITY ENGINEER

Figure 17: Letter from GL Tapper of the CCC to ARCE, dated 27 August 1986

> Please provide the calculations to support the design. We also require a foundation report and a specification which describes the required quality standards for materials and workmanship. Please note that CCC Bylaw 105 requires quality standards for materials and workmanship. Please note that CCC Bylaw 105 requires in Cl 28.1 that "All drawings computations and other data submitted shall be signed by the architect, engineer or designer responsible for their production and shall clearly identify him and his firm or organisation". There is no indication on the plans that they have been checked and approved for issue and construction. Please attend to the following matters:
>
> Sh 9 – No subgrade information and the 125 slab is both unreinforced and unjointed
>
> Sh14 Stirrups for Cols 4, 20, 10 & 16
>
> Sh15 Incomplete notes. Ref Line 1 – Hi Bond mesh reinforced encasting does not provide restraint to the Hi-bond for f.r.r purposes.
>
> Also floor connection to shear wall system and general connection between floor slab and walls.
>
> S 16 Shear Core floor slab & stair landing details are missing
>
> S 17 Thioflex 600 & PEF backing strip has not f.r.r.
>
> S 19 Not to microfilmable standards
>
> S 23 Size of fixing A and we note that there are no notes
>
> S 25 Reinforcing of spandrels and fixing details
>
> S 26 Is there one
>
> S 28 How is the web welded
>
> S 29 Detail 7 & 8 – 1 x 12d H.D bolt
>
> S 30 All weld plate details and Detail 2 stringer to weld plate weld size & type also baluster fixings
>
> S 32 Handrails & weld plate type 6 details

It became clear during the hearing that the drawings Mr Tapper was referring to in this letter were not the same as the permitted drawings that were exhibited during the hearing. He wrote that there was no indication on the plans that they had been checked and approved for issue and construction, whereas the permitted drawings, which were produced at the hearing, are signed with the initials "DH" for David Harding. There are no unsigned structural drawings on the CCC file and no earlier set of drawings was provided to the Royal Commission by ARCL.

Mr Strachan, one of the draughtsmen we have mentioned in section 2.1.4.4 who was employed by ARCE at the time the building was being designed, gave evidence of an initial incomplete set of drawings being submitted to the CCC. He could recall Dr Reay coming to him one afternoon and asking him to quickly detail the exterior staircase. He said he "wasn't prepared to do just a half-pie job on it and then have to come back later and re-do it" so another draughtsperson did the stairs.

Mr Harding did not have any particular recollection of a rush to get the drawings into the CCC and said he would not have submitted incomplete plans. However he thought the matters raised by Mr Tapper in his letter were consistent with him looking at incomplete plans: the matters he was raising were all omissions in draughting details. Dr Reay said it was not ARCE practice to send incomplete drawings to the CCC. He thought Williams Construction may have provided the CCC with the preliminary set of structural drawings that were used for planning the project.

Neither Mr Harding nor Dr Reay could recall having seen the letter from Mr Tapper. However Mr Harding said he wrote "rec'd 1/9/86" in pencil in the top right-hand corner of the letter. His evidence was that correspondence of this kind would go to Dr Reay first and then be passed on to the staff member working on the project. It was Dr Reay's position that he (or his secretary) may have simply passed it on to Mr Harding without reading it.

Mr Harding accepted that it was his job to respond to the letter after it was given to him. He did not think there was anything in the letter that would be worth arguing about from the ARCE perspective. He thought it was likely he referred the letter to Mr Strachan and left it with him to go through and complete the additional detailing required. He thought that the ticks on the second page of Mr Tapper's letter would have been made by Mr Strachan indicating whether he had dealt with each matter raised by Mr Tapper. He pointed to the comment about S17 relating to Thioflex and PET backing strip not being fire-rated and said that this was not a draughting detail, which is why Mr Strachan had not ticked it.

Dr Reay said that if the drawings were "visibly incomplete" it would only take a short time for Mr Tapper to assess them and work out if further information or completed drawings were required. Like Mr Harding, Dr Reay said he thought that the number of matters listed in Mr Tapper's letter was itself unexceptional given that they appeared to relate to drawings that were incomplete. He thought Mr Tapper had identified "obvious omissions or obvious incompleteness" in the drawings. He did not believe Mr Tapper would have analysed the building within a day.

The Royal Commission heard a different reaction to the letter from Mr Nichols and Mr Henry. Mr Nichols said Mr Tapper had meticulously listed an unusually large number of important details that had been omitted from the drawings. He said he had never dealt with a consulting engineer in such a fashion. Mr Henry, who had worked at the CCC with both Mr Tapper and Mr Bluck during the 1990s, said that a number of the issues raised by Mr Tapper would have concerned him as well. He referred specifically to the "shear core floor slab" issue, missing details for the stair landings, reinforcing of spandrel fixings, an absence of welding and the use of R6 spiral reinforcing. Mr Henry recalled that it was not unusual for Mr Tapper to put his communications in writing, recalling him saying that he "wanted to leave a paper trail".

2.2.3.5 ARCE response to Mr Tapper's letter

In his letter, Mr Tapper had requested "the calculations to support the design", a foundation report and a specification, which described the required quality standards for materials and workmanship. Neither Mr Harding nor Dr Reay could remember when or how the full calculations were sent to the CCC. The CCC file provided to the Royal Commission did not contain copies of the calculations.

The original of Mr Tapper's letter has the words "calculations" and "foundation" underlined in red ink and there is a note in the left-hand margin "rec'd a day or 2 after letter sent", also in red ink. At one point in his evidence Mr Harding said he recognised the writing in red ink as Dr Reay's handwriting, but Dr Reay disputed this. We think it is more likely that the note in red ink "rec'd a day or 2 after letter sent", together with the words "calculations" and "foundation [report]" underlined, also in red, were made by an officer of the CCC. While the calculations were not on the CCC file when it was provided to us, the Bylaw required that either the calculations or a design certificate be provided. In this case the calculations were specifically requested by Mr Tapper. We think it unlikely that Dr Reay or anyone else at ARCE wrote "rec'd" on the letter: it is the CCC that requested the calculations and foundation report. We also note that the calculations and foundation report could have been provided to the CCC by ARCE shortly after this letter was received because the calculations were complete and the foundation report is dated 18 June 1986. Therefore these would have been in ARCE's possession when the letter from Mr Tapper was received.

The original letter sent to ARCE must have been returned to the CCC at some point after 1 September 1986 because the original was provided to the Royal Commission by the CCC from its file. The original has both Mr Harding's note recording receipt of the letter in the top right-hand corner and the notes in red ink. Mr Harding could not recall having any dealings with Mr Bluck or with Mr Tapper in relation to this building and did not know how the letter may have got back to the CCC from ARCE after he had written on it. He said everything he did with the CCC was by telephone or letter and that he would not have gone to the CCC. Mr Harding said that Dr Reay might become involved in a permit application if there was something that the CCC was asking for which ARCE did not think needed to be provided. However he had no knowledge of whether Dr Reay had become involved in discussions with Mr Bluck or anyone else at the CCC about the CTV building in 1986.

Dr Reay's evidence was that consulting engineers and CCC staff would sometimes meet or speak on the telephone while a building permit application was being considered by the CCC. He said that Mr Bluck would have called him to talk on occasions about structural or other matters, but he could not recall having any discussions with the CCC about this building. He could not recall having anything to do with the letter from Mr Tapper or the response to it and or how it might have got back to the CCC. However, this was an issue which was addressed in other evidence and which we discuss in more detail in section 2.2.4.

There were two letters on the CCC file from August 1987 which referred to discussions between ARCE and the CCC at the time of the permit application. In a letter to Williams Construction dated 17 August 1987 Mr Bluck referred to a recent inspection of the building revealing that the Hi-Bond floor system had not been built in accordance with the permitted plans. He went on to state:

> At the time the building permit was being processed the Designers were reminded of the requirement to provide restraint in order that the Hi-Bond be fire rated.

Williams Construction must then have forwarded this letter to ARCE, because Mr Harding, in a letter to them dated 19 August 1987, said:

> The question of restraint was discussed in detail with the Council officers at the time of Building Permit Applications [sic] and at that time it was agreed that the Fire rating for the floor would be achieved by including additional "Fire Emergency" reinforcement in the floor slab, which would support the floor without assistance from the Hi-bond. Calculations in support of this proposal were submitted to the Council and were subsequently approved.

Dr Reay referred to these letters during his evidence and said that the discussions referred to would have been between Mr Harding and CCC engineers.

On 5 September 1986 Mr Harding provided "amended drawings as requested" and additional calculations, marked G76 and G77, to the CCC under a document transfer form. The calculations related to the fire resistance rating issue referred to in the August 1987 correspondence we have just referred to. The document transfer form was delivered by hand. Dr Reay thought that perhaps one of the junior trainee staff would have taken the plans down to the CCC and thought it was a reasonable inference that the plans reached the CCC at some point either on Friday 5 or Monday 8 September. The permit application was then signed off by Mr Tapper on behalf of the structural unit of the CCC on 10 September 1986.

There was no evidence that a design certificate was provided for this building, and we are satisfied that none was. Clause 8.2.5 of the Bylaw required that either calculations or a design certificate be provided with the design. Mr Tapper requested calculations, and the Bylaw would not have authorised a request for a design certificate in addition.

2.2.4 Issues about the building permit process

2.2.4.1 Did Mr Tapper identify that the floor connection to the north wall complex was non-compliant?

One of the aspects of the CTV building that attracted the most attention during the hearing was the connection of the floors to the north wall complex. In this section we consider whether Mr Tapper identified that this connection was non-compliant.

The floor connection is shown on sheet 15 and, in more detail, on sheet 16 of the permitted drawings. In the letter of 27 August 1986 Mr Tapper made the following comments about those two sheets:

> Sh 15 Incomplete notes. Ref Line 1 – Hi-bond mesh reinforced encasting does not provide restraint to Hi-bond for f.r.r purposes.
>
> Also floor connection to shear wall system and general connection between floor slab and walls
>
> S16 Shear Core floor slab & stair landing details are missing

Mr Laing, who appeared as counsel for the CCC together with Mr Reid and Ms Daines, submitted that, because we do not know what detail was on the structural drawings that were submitted to the CCC on 26 August 1986, we do not know what changes, if any, were made to the floor connection detail after ARCE received Mr Tapper's letter. Mr Harding thought that the details of the reinforcing in the shear core may not have been completed on sheet 15 at the time the drawings were first provided to the CCC and referred to the letter saying "shear core floor slab and landing details are missing" to support his contention. However, the words quoted related to sheet 16, not sheet 15. Mr John O'Loughlin said additional details must have been added to the drawings submitted to the CCC on 5 September because the permitted sheet 16, for example, shows the details that Mr Tapper had listed as missing on that sheet in his letter of 27 August. Again, that is a point related to sheet 16, not sheet 15. Mr Tapper's observations about sheet 15 were specifically related to the floor connections to the shear wall system and generally between the floor slab and walls.

Mr Tapper clearly raised a concern in his letter about the floor connections to the shear wall system and generally between the floor slab and walls. The connection detailed on the permitted drawings was inadequate and non-compliant, for the reasons that are discussed in section 8.1 of this Volume. If Mr Tapper had been unhappy with the adequacy of the floor connection as shown in the plans he was reviewing on 27 August, we consider that it is unlikely that what is shown on the permitted drawings (if different in this respect) would have satisfied his concerns. The floor connection issue was clearly one to which he had turned his mind, and other engineers who later reviewed the permitted plans also identified this as a concern.

Mr Laing submitted that, while it is clear that Mr Tapper was raising an issue about the floor connection, there can be no certainty as to the precise nature of his concern. While we accept that we cannot be certain, we consider it more likely than not that Mr Tapper would have identified that the connection was non-compliant, and this would have contributed to his concern about the building, discussed in section 2.2.4.2.4.

2.2.4.2 Why did Mr Tapper sign off on the structural design of the CTV building if a significant issue had not been addressed?

This question requires consideration of the hearsay evidence of Mr Nichols and Mrs Patricia Tapper which we discuss in sections 2.2.4.2.3 and 2.2.4.2.4 below. In brief, the effect of their evidence was that Mr Tapper was pressured by Mr Bluck to sign off on the CTV building permit because Mr Bluck had carried out a due diligence process and been convinced by Dr Reay that the concerns about the design were unfounded. We consider that evidence after referring to relevant, contextual evidence about the relationships between Mr Tapper and Mr Bluck and between Dr Reay and Mr Bluck.

2.2.4.2.1 Mr Tapper and Mr Bluck

Mr Henry, who had worked with Mr Tapper at the CCC between 1992 and 1995, described Mr Tapper as a "competent senior engineer" who had developed "a good sense of the potential weak points" in a structure. Mr Henry said that Mr Tapper's experience and training was evident in the way he carried out his work, maintaining high professional and ethical standards and having "little tolerance for consulting engineers who submitted poor details or incomplete work". Mr Henry said that this would often result in difficult situations, which Mr Bluck then had to deal with.

Dr Reay described both Mr Tapper and Mr Bluck as "dedicated and competent engineers". Mr Leo O'Loughlin, who had worked with Mr Tapper and Mr Bluck in the 1980s, described Mr Tapper as a "very thorough person". Mr Nichols said he did not know Mr Tapper well but knew he was "a very forthright person who held strong views and could be hard to move from those views". Mrs Tapper described her late husband as "an old school engineer" who was "very rigorous and very honest".

Mr Henry joined the CCC as an engineer in 1992 and observed the relationship between Mr Bluck and Mr Tapper at that time. He said that there were often arguments between them, sometimes "extreme". Mr Leo O'Loughlin said that he too had heard "heated debate on the pros and cons of jobs" between them.

We have already expressed the view that it is unlikely there was any change to the floor connection as detailed on the plans submitted on 26 August 1986 and those delivered to the CCC on 5 September 1986. Further, we consider that Mr Tapper, given his experience and his reputation for thoroughness, would have detected the inadequacy of the floor connection apparent in the permitted plans, at the time he was considering the design. This gives rise to the issue of why Mr Tapper signed off the plans in the form they were permitted.

2.2.4.2.2 Dr Reay and Mr Bluck

We heard evidence from Mr Henry that on a number of occasions during his time at the CCC, disagreements between Mr Tapper and Mr Bluck over ARCL building consent applications ultimately led to Mr Tapper being overruled by Mr Bluck. Mr Henry said that it was "not uncommon for Alan Reay to go directly to Bryan Bluck to obtain the release of a building consent when he could not get approval from Graeme Tapper". Mr Horn said he was aware of Dr Reay's practice of resolving issues with Mr Tapper by effectively going over his head to Mr Bluck.

Dr Reay did not agree that he had had arguments with Mr Tapper but rather characterised them as "debate" and "disagreement over certain aspects". He accepted that, generally, Mr Tapper stood firm on what he thought was correct. Dr Reay said he did not agree with the evidence of Mr Henry and Mr Horn to the effect that he would go over Mr Tapper's head to Mr Bluck if there was any disagreement. He said that he had dealt with Mr Bluck for many years and respected him and his views. Since he was used to dealing with him, he preferred to do so, but Dr Reay denied going to Mr Bluck to override Mr Tapper.

We consider that there would be many engineering consultants who might prefer to deal with a territorial authority's chief engineer. Dr Reay appears to have had such a preference at this time. In itself there is nothing untoward about this.

We consider the evidence in sections 2.2.4.2.1 and 2.2.4.2.2 supports the following conclusions:

- Mr Tapper was a competent and thorough engineer;
- he was principled and difficult to move once he had formed a view;
- this led to arguments between Mr Tapper and Mr Bluck, which sometimes resulted in Mr Bluck overruling Mr Tapper;
- however it is characterised, Dr Reay did deal with Mr Bluck over issues that Mr Tapper had raised on other applications; and
- Mr Bluck's general approach was to rely on the expertise and assurance of the design engineer.

The above discussion is important as background to consideration of the evidence of Mr Nichols and Mrs Tapper relating to the CTV building.

2.2.4.2.3 Evidence of Mr Nichols

In 1986 Mr Nichols was working for the Riccarton Borough Council. He said that he heard through the "engineers' grapevine" that a new building in Christchurch had been the subject of some contention in relation to the issue of a building permit. In particular Mr Nichols said he had heard that Mr Tapper and Mr Bluck had been involved in "another of their fairly regular fracas, this time concerning assessment of the structural design content of the proposed new building". Mr Nichols said he heard it had been "particularly trenchant" on this occasion.

He was curious to know what the issue was with the building and as a result, some six months after he had heard about the "fracas", he took the opportunity when he was in the central city to have a look at the building under construction. He said he was standing on the footpath on the south side of Cashel Street looking at the building, which was then under construction, when Mr Bluck came up to him. Mr Nichols assumed Mr Bluck was taking his "usual midday constitutional walk" as had been his habit when Mr Nichols had worked with him. Mr Nichols commented to Mr Bluck that he had been studying the building and was trying to "get [his] head around how its structural mechanism worked" as it was not a system with which he was familiar. In his opinion "it superficially appeared to lack substance". He said he referred to the "lack of any substantive lateral load restraint system in the south wall vertical plane", which he felt should have been there. Mr Bluck's response was that he had shared Mr Nichols' concerns when he first saw the concept depicted on the plans. According to Mr Nichols, Mr Bluck said he agreed that it still gave "that superficial appearance as the construction proceeded".

Mr Nichols recalled Mr Bluck telling him that the building design "incorporated a novel technological approach and that he initially had misgivings about aspects of the design". Mr Bluck assured him that he had carried out "due diligence and had been convinced by Alan Reay that his reservations were unfounded". In cross-examination, Mr Nichols said that he understood that the "novel technological approach" to which Mr Bluck had referred was the way in which a shear wall gravity protected load system had been used in the building. In re-examination he clarified his opinion that a shear wall gravity protected load system was not in itself novel, in cases where the shear walls were symmetrical.

Dr Reay said he could not recall a conversation with Mr Bluck in which he had allegedly convinced Mr Bluck about the building's design, nor could he recall any involvement with the permit process for this building. He did not believe that he had had a conversation with Mr Bluck about it, because he would have remembered it and would have involved Mr Harding. He said he was not in a position to discuss the details of the building with the CCC because he was not involved in its design. Dr Reay was unable to recall whether Mr Harding visited the CCC about this project.

2.2.4.2.4 Evidence of Patricia Tapper

We also heard evidence from Mr Tapper's widow, Mrs Patricia Tapper. Mrs Tapper said that her late husband was a person who never talked about his work at home. The one exception to this was the CTV building. She said he went "on and on about the CTV building". In cross-examination, counsel for Dr Reay and ARCL elicited evidence from Mrs Tapper that the events she was referring to took place over about a week or so and afterwards her husband did not really speak about the building again. In fact, he went into it some years later to be filmed by CTV.

As Mrs Tapper noted, the building to which she said her husband had referred was not known as the CTV building at that time. She identified the building discussed as the CTV building because it was in Madras Street near St Johns Church (in Latimer Square) where she and her husband were married.

Mrs Tapper said that at first she thought her husband's concerns related to Alan Reay as she thought there was a personality clash between the two. However she soon realised that Mr Tapper was unhappy about the building itself. She said that she recalled her husband's view was that there were "earthquake risks" and "it was not a question of if, but when, and when it happened he was concerned the CTV building would not prove to be strong enough".

Mrs Tapper said that her husband told her he did not want to sign the building off but was under "huge pressure from Bryan Bluck who was above him in the Council hierarchy".

Mrs Tapper also said that on a particular day her husband said to her he might not have a job when he came home that night. However, we note that in cross-examination by Mr Laing, Mrs Tapper agreed that her husband's comment about his job may have been a "throw away comment". Because we do not know on the evidence the manner in which Mr Tapper's comment about his job was made, we do not think we would

be justified in finding that Mr Tapper was seriously concerned about the loss of his job. However, the fact that the comment was made supports the evidence that there was a difference of opinion between Mr Tapper and Mr Bluck about the structural integrity of the design. We also accept, on the basis of the evidence of those who worked with them, that the relationship between Mr Bluck and Mr Tapper was a strong one, well capable of surviving differences of opinion, even on important matters.

2.2.4.2.5 Hearsay evidence

The evidence of what Mr Bluck said to Mr Nichols and what Mr Tapper said to his wife is hearsay.

The critical hearsay evidence is:

- Mr Nichols recalling Mr Bluck saying he initially had misgivings about aspects of the design but he had carried out due diligence and had been convinced by Dr Reay that his reservations were unfounded; and
- Mrs Tapper's evidence that the building her husband spoke to her about was the CTV building and that he told her he did not want to sign the building off but was under pressure from Mr Bluck to do so.

We should record at this stage that we accept the evidence of both witnesses that the conversations occurred. Mr Nichols said he was curious to know what the issue was with the building, having heard on the "engineers' grapevine", at another council, that there was a "particularly trenchant" fracas between Mr Tapper and Mr Bluck about it, and this interested him enough to go to the site of the building where he had a chance meeting with Mr Bluck. We also accept that Mr Tapper spoke to his wife regarding his concerns about this building and, for reasons which we refer to below, we are satisfied that it was the CTV building.

The conclusion that we were invited to reach by counsel assisting was that Dr Reay became involved in the permit process for the CTV building, met with Mr Bluck who was carrying out "due diligence" and persuaded him that his concerns about the CTV building were unfounded. Mr Bluck then instructed Mr Tapper to sign off on the CTV building, which he did on 10 September 1986. This evidence, if we were to accept it, would explain how the building came to be permitted despite the floor connection being non-compliant and Mr Tapper having recognised this. However, given the potential prejudice to Dr Reay of such a finding and because it would principally be based on hearsay evidence, we have carefully considered the submissions of counsel assisting, counsel for ARCL and Dr Reay and counsel for the CCC about the evidence of Mr Nichols and Mrs Tapper.

Under the Commissions of Inquiry Act 1908, section 4B(1), the Royal Commission has power to admit such evidence as it considers appropriate. However, because of the significance of this evidence for both Dr Reay and the CCC we have considered the way hearsay evidence is treated in the Evidence Act 2006. While the approach that a court would take under that Act is not binding on the Royal Commission, it is a helpful guide.

The fundamental principle is that all relevant evidence is admissible: section 7. This includes hearsay evidence. Evidence is relevant in a proceeding if it has a tendency to prove or disprove anything that is of consequence to the determination of the proceeding: section 7(3). Even if evidence is relevant a judge must still exclude it if its probative value is outweighed by the risk that the evidence will have an unfairly prejudicial effect on the proceeding: section 8(1). The other limbs of section 8 are not relevant here.

Hearsay is dealt with specifically in sections 16, 17 and 18. Section 17 provides that a hearsay statement is not admissible except as provided for in subpart 1 of Part 2 of the Act. The general rule about the admissibility of hearsay statements is set out in section 18. A hearsay statement is admissible if the "circumstances" relating to the statement provide reasonable assurance that the statement is reliable: section 18(1)(a). The other provisions dealt with in section 18 are met here because both Mr Tapper and Mr Bluck are deceased.

The meaning of the word "circumstances" as it is used in section 18 is defined in section 16. Relevant "circumstances" in considering whether they provide a reasonable assurance that the statement is reliable are:

- the nature of the statement;
- the contents of the statement;
- the circumstances that relate to the making of the statement;
- any circumstances that relate to the veracity of the person; and
- any circumstances that relate to the accuracy of the observation of the person.

Counsel assisting, after referring to the relevant principles above, submitted that the relevant circumstances in this case do provide a reasonable assurance that the hearsay statements are reliable in terms of section 16 and 18 of the Act, namely:

- the circumstances for both Mr Nichols and Mrs Tapper were such that the conversations were clearly recalled;
- Mr Nichols had heard about a disagreement between Mr Tapper and Mr Bluck and had decided to look at the building he understood to have been the cause of this disagreement. It was as he was doing this that Mr Bluck appeared and the conversation occurred;
- Mrs Tapper said her husband never discussed his work at home and the CTV building was the only exception to this. He mentioned it a number of times because of the particular concerns he had;
- there was no issue taken with the veracity of Mr Nichols or Mrs Tapper; and
- there did not appear to have been any suggestion of embellishment in the recounting of the conversations.

We also note at this point that, although not itself an indicator of reliability, there was no challenge to Mr Nichols' evidence that Mr Bluck said it was Dr Reay who convinced him that his misgivings about the design of the CTV building were unfounded.

Mr Laing submitted that it was unfair to admit the hearsay evidence as affected parties were unable to test the "underlining factual matters". In the course of his careful and well-organised submission, Mr Laing relied on a number of points which he said meant that there was a lack of clarity about important issues arising from Mr Nichols' evidence, due to the absence of direct evidence from Mr Bluck and Mr Tapper. The uncertainty created in this situation was such that he submitted it would be inappropriate for the Royal Commission to draw the conclusions for which counsel assisting contended. In this respect Mr Laing raised the issues which we italicise below, followed in each case by our response:

a) *What exactly were the precise design issues in contention between Mr Tapper and Mr Bluck that led to the "fracas"?* We accept that we cannot be satisfied about what the "precise issues" were. However, we are satisfied that the issues are likely to have related to the structural integrity of the building because it was Mr Tapper's responsibility to ensure that the building complied with the Bylaw. His letter of 27 August 1986 had raised issues about the floor connection to the "shear wall system" and the "general connection between floor slab and walls". These were issues that we are satisfied related to the ability of the building to resist lateral forces.

b) *What initial misgivings did Mr Bluck have in terms of a design involving a "novel technological approach" and how were these misgivings first raised with Mr Bluck?* Again, we are satisfied that the misgivings that Mr Bluck had about the building would have related to the system used for resisting lateral forces. We cannot know the circumstances in which Mr Bluck formed doubts about the building's structure and we do not think that matters for present purposes.

c) *How did Dr Reay's involvement not recalled by him) come about? Did he or some other person in his office make the first contact with Mr Bluck, Mr Tapper, or some other Council officer*? We do not consider this to be a matter that we can resolve or that we need to resolve. It is of little consequence for our purposes how contact between Dr Reay and the CCC was initiated.

d) *What was the precise nature of the discussions between Mr Bluck and Dr Reay if any)?* We do not know the precise nature of the discussions between Mr Bluck and Dr Reay but we do know that the result was that Mr Bluck was "convinced" that his concerns were unfounded. That is what he told Mr Nichols.

e) *What factors led to Mr Bluck being persuaded that his initial reservations were unfounded?* This covers the same point as d) above. We do not know what factors Mr Bluck was persuaded by but we can infer, on the balance of probabilities, that he was assured that the methods employed in the design for resisting lateral forces were sufficient to meet the requirements of the Bylaw.

f) *Was Mr Tapper in any way involved in the discussions, and if so, was he also ultimately persuaded that his concerns whatever they were) were unfounded?* On the balance of probabilities we are satisfied that Mr Tapper would have become involved in the discussions, at least with Mr Bluck, but we cannot conclude that he would have been present at any discussion between Mr Bluck and Dr Reay. It is possible that he too was persuaded that his concerns about the floor connection to the "shear wall system" and the "general connection between floor slab and walls" were unfounded. However, we are not prepared to make a finding to that effect for three reasons. First, Mr Tapper picked up these issues originally; secondly, as we have already found, it is unlikely that there was any significant redesign of the details in the permitted drawings that would have overcome his concerns; and thirdly, the connection as depicted in the permitted plans was non-compliant.

Mr Rennie QC also made a number of submissions in relation to the reliability of Mr Nichols' evidence, which we italicise in the following discussion, again giving our responses:

a) *It was unclear whether Dr Reay convincing Mr Bluck in relation to the "innovative" design related to the CTV building or some other building, such as Landsborough House*. We consider it is clear from the evidence of Mr Nichols that the design which was being discussed by Mr Bluck and him was that of the building in front of them, which was the CTV building. There is no reason to doubt Mr Nichols' evidence on this point and none was suggested to us.

b) *Mr Nichols was mistaken in his belief that there was no shear wall at the south end of the building*: We accept this is so. However, the significance of Mr Nichols' evidence is what Mr Bluck said to him about the building at the time, not what Mr Nichols may have thought about the design when he was looking at it.

c) *The evidence of Mr Bluck's character and experience was that he was not someone who would be "overridden".* We accept that evidence but Mr Nichols' evidence was that Mr Bluck said he was "convinced" by Dr Reay, not overridden. This is an important distinction, especially in the context of Mr Bluck's memorandum stating that a structural checking engineer was entitled to rely on the expertise and assurance of the designer.

d) *When Mr Hare spoke to Mr Bluck in January 1990 Mr Bluck identified four issues with the building, but none of them structural or related to the permit process.* We accept that is so, however if Mr Bluck had been convinced by Dr Reay that any concerns were unfounded, and accepted that the building permit should be issued, he would presumably have accepted from that point there was no longer any issue with the design. It is inherently unlikely that Mr Bluck would have raised an issue in this discussion about matters on which he had been satisfied, leading to the issue of a permit for the building.

e) *There was a narrow window of opportunity between 5 and 10 September 1986 within which any meeting could have taken place*. We do not accept that two or three working days is too brief a period to have allowed for a meeting between Mr Bluck and Dr Reay.

f) *In a letter from Mr Harding to Williams Construction Limited dated 19 August 1987 he made reference to discussions with the CCC at the time of the permit application*. We are not clear about the point being made by this reference. The discussions referred to in the letter were in relation to the issue of fire restraint of the floor slabs. Mr Harding could not recall any contact he might have had with the CCC at that time. However it does not follow that there could not have been the discussions between Dr Reay and Mr Bluck, as recounted by Mr Nichols. In fact Mr Rennie QC appeared to accept that there could have been a meeting. He submitted:

> It is quite possible that that meeting took place on the 8th, 9th or 10th of September. What we do know is that both Mr Bluck and Mr Tapper were satisfied because Mr Bluck told Mr Nichols that and Mr Tapper signed the papers and ceased talking to his wife about it.

We note that this submission is consistent with the fact that Mr Nichols was not challenged at all on his evidence recounting Mr Bluck's statement that Dr Reay had given him an assurance about the CTV building design.

We found Mr Nichols to be a reliable witness because of the detail he clearly remembered about the reasons he went to look at the building, the coincidental arrival of Mr Bluck, Mr Nichols' own misgivings about the design and what he remembered Mr Bluck saying to him about the concerns he had. It is the totality of this evidence that paints a convincing picture that there was a discussion with the essential elements recounted by Mr Nichols.

Submissions were also made by counsel about Mrs Tapper's evidence. We accept that we cannot make findings about certain matters raised by Mr Laing in respect of the evidence she gave, such as:

(a) Did Mr Tapper and Mr Bluck finally have a meeting of the minds on whatever the precise design issues in contention were?

(b) If Mr Tapper had reservations about approving the structural design, did he document his concerns?

(c) Did Mr Bluck in fact put pressure on Mr Tapper to sign off on the structural design?

These matters could only be resolved by evidence from Mr Tapper or Mr Bluck, or some form of documentary evidence which has not been produced to us. However, we also find Mrs Tapper to have been a reliable witness with an accurate recall of what her husband said to her. This conversation stuck in her mind because her husband had departed from his usual practice of not talking about his work at home to tell her about his

concerns. In written submissions counsel for ARCL and Dr Reay suggested it was possible that the building discussed by Mr and Mrs Tapper was not in fact the CTV building. However in argument Mr Rennie QC conceded that in fact it was "more probably" the CTV building. We are satisfied that their discussion was about that building. Mr David Hutt, working for the Royal Commission, searched CCC records to ascertain if there were any other buildings in Madras Street designed by ARCE in 1985 or 1986. The only building was the CTV building. A memorandum from counsel for the CCC expanded on those inquiries to include the whole of the period in which Mr Tapper was employed with the CCC. The only building, other than the CTV building, also designed by ARCE (or ARCL) was a supermarket on the corner of Madras Street and Moorhouse Avenue. This building received a building permit in 1990. We do not accept that it could have been this building, some 650 metres from the CTV building, to which Mr Tapper was referring when he spoke to his wife.

2.2.4.3 Conclusions

We are satisfied that the evidence of both Mr Nichols and Mrs Tapper, about their conversations with Mr Bluck and Mr Tapper respectively, was credible and reliable. Insofar as their evidence was hearsay, we are satisfied that the circumstances relating to that evidence provide reasonable assurance that it was reliable, so that the general requirements for admissibility of hearsay evidence in a court of law, were they applicable here, would be satisfied. Despite the considerable time that has passed since both conversations, both witnesses gave their evidence in a measured fashion, without apparent embellishment, and accepting that there were matters they could not remember. However, they were able to give details of the circumstances which made the conversations memorable for them.

Having heard the evidence of Mr Nichols and Mrs Tapper and considered the submissions of all counsel, we make the following findings:

- following receipt of the letter from Mr Tapper of 27 August 1986, Dr Reay became involved in the permit process, likely between 5 September (when the document transfer form was provided to the CCC by ARCE) and 10 September 1986 (when Mr Tapper signed off on the structural aspects of the design);
- he spoke to Mr Bluck, who had become aware of the application and the concerns that were raised by Mr Tapper;
- it is likely that there was a meeting called (as Mr Nichols said was Mr Bluck's practice), which resulted in Dr Reay convincing Mr Bluck that the concerns over the building were unfounded. We note that we cannot make any finding about the extent to which Mr Bluck required convincing and, therefore, about the extent to which Dr Reay was influential; and
- Mr Tapper was either persuaded that his concerns were unfounded, or more likely was directed to sign off on the structural design, which he did on 10 September 1986.

These findings must be read alongside our conclusions, set out in section 8 of this Volume, that the building did not comply with the Bylaw in a number of respects.

Mr Harding said that he could not recall further involvement in the permitting process following provision of the signed structural drawings. Dr Reay said that he could not recall any involvement in the permitting process whatsoever. However, it is quite possible that any dealings with Mr Bluck over the CTV building permit would not have stood out among a number of dealings that he would have had with Mr Bluck while Mr Bluck was CCC's buildings engineer. We have already noted in section 2.2.4.2.2 Dr Reay's evidence that he had dealt with Mr Bluck for many years, had been used to dealing with him and indeed preferred to do so. By contrast, Mr Nichols and Mrs Tapper were giving evidence about particular conversations that were plainly memorable for them for reasons that they gave: in the case of Mr Nichols, because he had met Mr Bluck by chance, having specifically gone to the site of the CTV building when it was under construction, because of what he had heard about arguments in the building permitting process and the two of them had had a discussion about the efficacy of the building's structure. In the case of Mrs Tapper, her husband's concerns stood out in her memory because this was the one occasion on which he spoke about a problematic building. We prefer their clear memory to Dr Reay's lack of memory of the events discussed.

As to whether Dr Reay was in fact involved in the discussion on the day referred to by Mrs Tapper in her evidence, we think that it is likely, but it does not matter. It is not a point of significance for present purposes to determine whether Dr Reay's involvement was in a discussion in which both Mr Bluck and Mr Tapper were involved or whether Dr Reay met with Mr Bluck alone, and Mr Bluck subsequently spoke to Mr Tapper.

Mr Laing submitted that there was no evidence to show that Mr Bluck did not apply himself in a professional manner. We agree. The same of course applies to Mr Tapper. Mr Bluck appears to have been applying the approach (set out in the memorandum to which we have referred in section 2.2.3.3 above) of relying on the design engineer for assurance, although it did not in this case culminate in a requirement for the provision of a design certificate. However, the result of the process followed was the issue of a building permit for a design that did not comply with the CCC's Bylaw 105 (as discussed in section 8.1), a state of affairs that should not have eventuated. It is clear from the evidence, in particular from Dr Reay himself that he knew very little about the structural detail of the building. On the evidence he only had one substantive conversation with Mr Harding about the design, concerning the south shear wall, when reference was made to architectural drawings. Dr Reay said he had not seen the structural drawings at all before looking at them in January 1990. It is therefore difficult to understand how he was in a position to give any proper assurances in relation to the design. In fact had Dr Reay looked at the structural drawings before they were sent to the CCC, he might have seen, as he did in 1990, that there was a fundamental defect in the floor connection. Nevertheless, Mr Bluck told Mr Nichols that he had been convinced by Dr Reay that his reservations were unfounded. We conclude that Dr Reay's involvement in the permitting process contributed, at least to some extent, to the wrongful permitting of the building.

We discuss in section 8.1 the various respects in which the building failed to comply with the Bylaw. We have already described in section 2.2.3.1 the provisions of the Bylaw and the Local Government Act which collectively had the result that a building permit for a non-complying building should not have been issued by the CCC. While, for the reasons we give in section 8.1, we accept that in some cases the instances of non-compliance could not have reasonably been discovered by the CCC reviewing engineer, that is not the case with respect to all of them.

We conclude that the building permit should not have been issued.

2.3 Construction

2.3.1 Introduction

The CTV building, as we have noted, originated as a speculative design-build property development. Prime West, which owned the land, asked Mr Brooks of Williams Construction to submit a proposal in early 1986.

Early decisions about the characteristics of the building were influenced by a desire for maximum lettable space and the requirements of the district planning scheme. As referred to above, Mr Brooks said it was his idea to locate the lift shaft external to the floor plate of the building.

The key personnel during the construction of the CTV building were all employees of Williams Construction. When construction started in late 1986, Mr Brooks was Managing Director, Mr Scott was Quantity Surveyor and Mr William (Bill) Jones was the Site Foreman. Mr Brooks described taking steps to employ someone with structural and construction experience to strengthen the management structure. This led to the appointment of Mr Gerald Shirtcliff around September or October 1986 as Construction Manager.

On 3 April 1986 Mr Brooks and Mr Scott submitted architectural drawings and structural sketches with a preliminary cost estimate of $2,450,000 plus GST to Mr Blair of Prime West. In May Mr Brooks received approval to instruct the consultants to prepare drawings for permit and construction. A permit was issued by the CCC on 30 September 1986. A formal building contract was signed by Prime West in October 1986. Mr Scott said the contract was for an "empty shell" building and did not include a fit-out.

Construction began in late 1986 with the building completed early in 1988. Mr Brooks gave evidence that Williams Construction became the subject of a takeover in late 1986. Mr Scott explained that Williams Property Holdings Limited, the parent company, was sold to Smart Group Limited around late 1986 to early 1987. Council inspection records show that the foundations and first floor of the CTV building had been completed by early 1987.

Mr Brooks, Mr Scott and Mr Shirtcliff resigned in a letter to the Chairman of Williams Construction dated 18 March 1987. The letter stated that a new construction company would begin trading from 1 May 1987. Union Construction Limited (Union Construction) was established with Mr Brooks, Mr Scott and Mr Shirtcliff each holding a 10 per cent stake, and Angus Group Limited holding the balance of 70 per cent. Mr Brooks' employment with Williams Construction was terminated early on 9 April 1987 and Mr Scott recalled moving to Union Construction on 1 May 1987. Mr Shirtcliff continued to work for Williams Construction until about September before going across to Union Construction.

Figure 18, which was included in a Williams Construction report dated 30 June 1987, shows that all elevated floors slabs had been constructed by that date. The report also noted that, due to the major tenant cancelling his space requirements, a delayed completion date would be accepted if required. The completion date was noted as 1 October 1987.

Union Construction completed the CTV building around late 1987 or early 1988. It appears that soon after completion of the CTV building, Union Construction became insolvent and was also wound up.

Figure 18: Williams Construction report as at 30 June 1987

The workers on the construction site were directed by Mr Jones. He said there were 8–14 staff on the CTV site at any given time, plus himself. According to Mr Jones, at any one time some would be working on shear walls, others on the south wall and others on the columns. He said that it was hard at that time to get good staff and that some were hired on a daily or weekly basis. If they were good they were kept on, otherwise he would get rid of them.

Both Mr Shirtcliff and Mr Scott described the building as a straightforward job. Mr Scott stated that there were no variation orders issued during construction and the building, when completed, complied precisely with the permit drawings that were approved by the CCC.

A number of construction issues were identified in the Hyland/Smith[8] report. These issues were explored at the hearing with the former Williams Construction employees, Mr Brooks, Mr Scott, Mr Shirtcliff and Mr Jones. Their evidence highlighted financial and management difficulties as well as inadequate supervision. Expert witnesses also expressed opinions on the significance of the construction issues.

The failure to roughen the faces of precast beams where they connected with in situ concrete, in particular at the ends of the beams where they met the circular columns, was a critical omission that may have contributed to the failure of the building. This was both a construction and a design issue.

The "bent-back" reinforcement in the precast beams that connected to the western side of the north wall complex was a significant construction fault. The structural drawings required this reinforcing to be embedded 200mm into the wall with a 90° hook. However, it is unlikely that this error alone led to the collapse as there was some connectivity provided through the top 24mm diameter reinforcing bars.

The omission of the specified spiral reinforcing through the beam-column joints, poor cover control of column longitudinal reinforcing and the absence of a reinforcing bar at the attachment of column C18 to wall D–E (see location of columns in Figure 62(a), section 5.1.3.1) were also identified as construction issues. However, these would have had little or no effect on the failure of the building.

The seismic separation between columns and spandrel panels and between columns and the western block wall, along with the concrete strength, were the remaining construction issues identified in the Hyland/Smith report. For reasons that are explained later in this section, these issues assumed less significance during the Royal Commission's hearing.

2.3.2 Construction defects

2.3.2.1 Roughening of construction joints

The CTV building was a combination of both precast and cast in situ concrete construction. Any interface where fresh concrete is cast against hardened concrete is known as a construction joint. If the joint is not prepared so as to ensure monolithic behaviour, it presents a potential plane of weakness, which may influence the shear strength. Construction joints perform well when they are adequately reinforced (with reinforcement crossing the joint) and with a clean and rough interface to the freshly placed concrete. The surface can be roughened in several ways: by applying a chemical retarder and water jetting the surface, by scrabbling, providing keys, or brushing the surface while the concrete is still plastic.

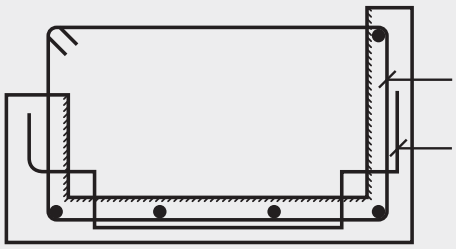
There were construction joints between the shell beams located around the perimeter of the building and their infill concrete, in the shear walls (horizontal construction joints) and between the ends of the precast beams and the in situ concrete columns (vertical construction joints). Mr Jones said he used a product called Rugasol C to paint the shear wall joints as soon as the concrete was set and washed it off the next day to achieve a roughened joint. The precast beams, which were made by a supplier arranged by Mr Scott, arrived at the site ready to be installed. There was no roughening at the ends of the precast beams where they joined with the column concrete that was cast in situ (Figure 20). Mr Jones said he never thought of roughening them.

Mr Graham Frost, an experienced engineer who was on site during Urban Search and Rescue (USAR) activity after the earthquake, identified the smooth and curved surfaces of the joints as potential weak interfaces that may have been critical (as discussed in section 5.1.3.3).

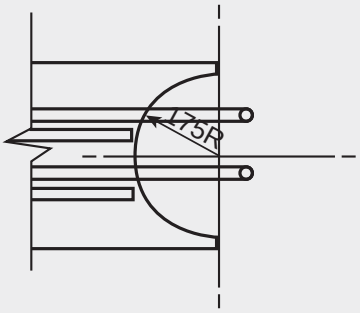
As we have noted, the lack of roughening to the precast beam surfaces was both a design issue and a construction issue. There was inconsistency and a lack of detail in the way this requirement was detailed by Mr Harding on the drawings and in the specifications. The structural drawings included notes directing the roughening of surfaces (as shown in Figure 19(a)). Roughening was required on the inside of most shell beams (Figure 19(b)) but was not shown at the critical region where the precast beams met the in situ concrete of the circular columns (Figure 19(c)).

Areas indicated thus should have the surfaces roughened before the beams are erected. A suggested method would be to apply a retardant locally to the inside of the boxing before pouring, and washing down after stripping.

(a) Notes for roughening



(b) Roughening specified inside shell beam



(c) Plan view of precast beam end with no roughening specified

Figure 19: Details for roughening on structural drawings

The specifications, on the other hand, stated, "all surfaces against which concrete is later to be cast shall be roughened by brooming while the concrete is still plastic". They also specified that the surface of precast shell beams "shall be roughened to ensure good bond to the infill concrete". There was evidence that this was not carried out, for example Figure 20. Dr Robert Heywood, a USAR and forensic engineer, observed a number of internal and edge beams in the rubble. He said that there was no surface roughening and no evidence of a substantial bond between a number of precast and in situ concrete interfaces.

Figure 20: Smooth end of precast beam where it connected to circular columns (source: Dr Robert Heywood)

The method of roughening stated in the specifications would have been difficult, if not impossible, to achieve at the beam ends. The boxing at the beam ends could not be removed while the concrete was still plastic. The structural drawings did mention the possible use of a retardant on the inside of the boxing. Mr Brooks did not know whether a retardant was used on the precast beams.

Mr Brooks accepted that a kango hammer, or similar, could have been used to roughen up the hardened surface. However he said it would be the kind of job nobody would want to do, particularly bearing in mind that there were a number of beams. Mr Brooks said it is a general trade standard to ensure that the surface of existing concrete is suitably roughened or cobbled where it is to join new concrete, as this aids adhesion. He went on to state that he could not understand why the beam ends would all have been missed. It was his view that the foreman was probably under the impression that he did not have to do it. He added that "those joints get inspected by an engineer or the building inspector" and they should have said something.

We believe an experienced foreman and/or construction manager should have raised this issue with the designer. Mr Brooks acknowledged that standard practice is to roughen construction joints, however Mr Jones did not question this. Mr Shirtcliff appears to have been unaware of the issue. For such a critical construction joint, Mr Harding should have explicitly shown this on the structural drawings or given direct instructions to roughen the joints when he carried out his site inspections. The CCC building inspector should also have been alert to this issue as it frequently arises in construction.

2.3.2.2 Bent-back beam bars

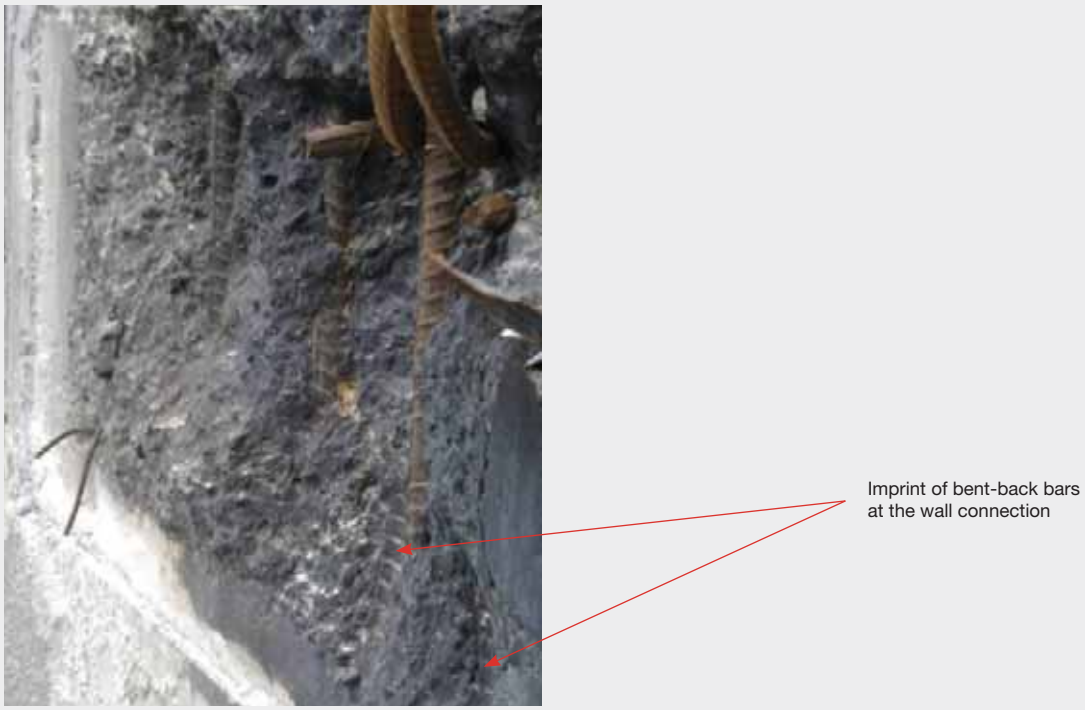
The Hyland/Smith[8] report identified a construction defect where the precast beam bottom bars were "bent-back" instead of being embedded into the wall, as shown in Figure 21(a) and (b). This was in the region where the beams on line 4 (at the northern edge of the floor plate) connected to the western side of the north wall complex. The report stated that:

> …the bottom reinforcing steel in the shell beams had not been developed fully into the Grid C core wall on Line 4 as specified, except at Level 2. The bars had been bent back into the concrete infill in the shell beam

An imprint from the bent-back bars can be seen where the beam would have been hard up against the wall in Figure 21(c). This was evidence that the bars were not embedded in the wall (as required by the drawings) when the concrete for the wall was cast.

(a) Two H24 bars bent back into shell beam

(b) End of beam with slab attached



(c) Imprint of beam end where it connected to the wall

Figure 21: Bent-back bars from Hyland/Smith report

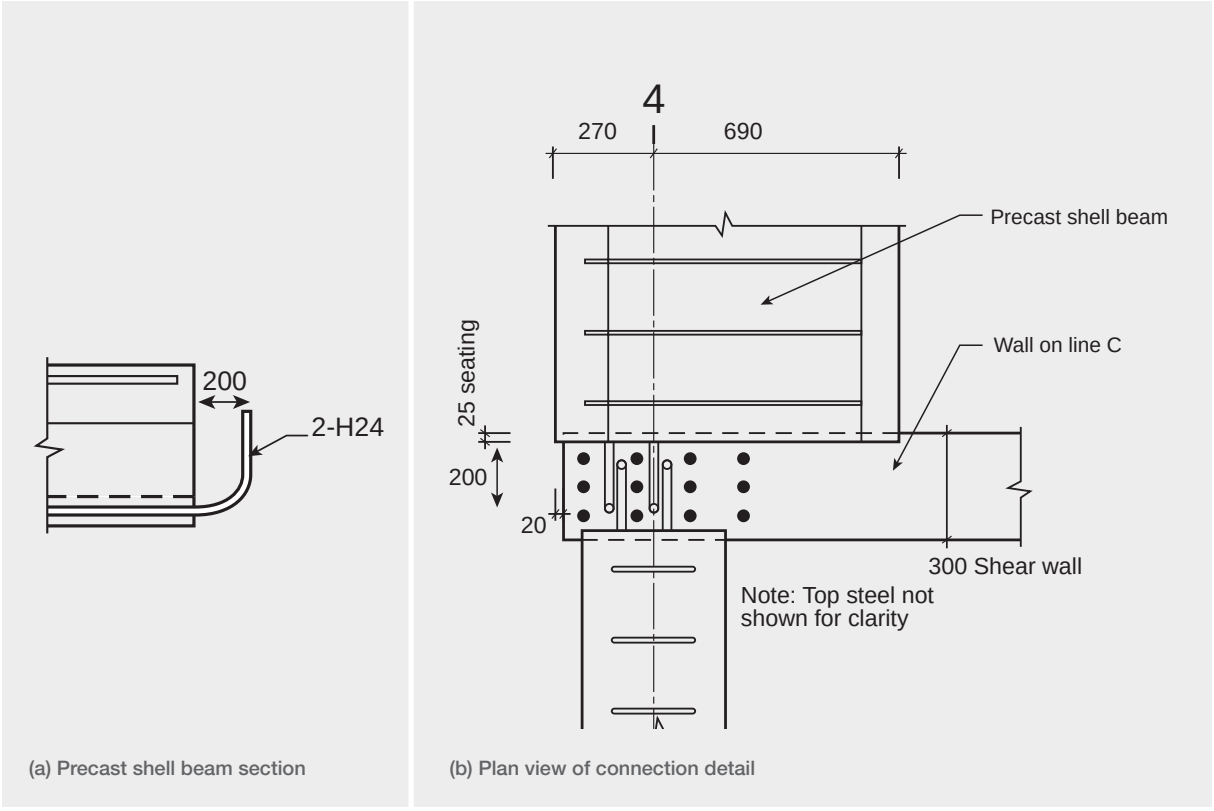


Figure 22: Structural drawing details of the beam-to-wall connection

The structural drawings show the bottom two H24 bars embedded 200mm into the wall on line C, as shown in Figure 22(a) and (b).

Mr Brooks said that steel of this size requires great strength or mechanical assistance to be bent manually and that the resulting bend would be a kink rather than a smooth even curve. Therefore it could not have been bent back on site and was more likely to have been the result of an error by the precast supplier. He commented that this was a serious problem and believed it was a fundamental cause of the collapse.

The evidence suggests that the problem originated at the steel fabricators. When questioned whether gas heating was a method used to bend the bars on site, Mr Brooks said that this was not allowed and suggested they would have been cut off completely if they were in the way. Mr Shirtcliff's evidence was that if there was a problem then there would have been an instruction to stop work from the CCC, or the design engineer, because he designed it and would know exactly what he was looking at. Mr Scott also placed some blame on the suppliers and the design engineer.

Mr Jones was "puzzled" at the connection being correct on level 2 but wrong for all other levels, because the other connections should have been the same. The fact that the bottom (bent-back) bars were not providing a connection to the north wall complex should have been evident to those working on the site, particularly as the level 2 connection was different.

We consider that this error may have made a minor contribution to the way the building collapsed. The connection was poorly detailed by the designer and was further weakened by the bent-back bars. Despite the defect, a degree of connectivity was still provided by the top reinforcing, which passed all the way through the wall. The bent-back bars were a construction defect and the precast units containing this should have been rejected by Mr Shirtcliff and/or Mr Jones. Mr Harding and the CCC inspector would also have had the opportunity to discover this error before the concrete was poured. However, primary responsibility was with the contractors who did not meet the requirements shown in the structural drawings.

Even if these bars were embedded into the wall as shown in the drawings, the connection as detailed was not best-practice. The specified 200mm was unlikely to be enough to develop the full tension strength of those bars, as the concrete could pull out before the bars yielded. The construction defect exacerbated the poorly detailed connection.

2.3.2.3 Spiral column reinforcement

The transverse reinforcement specified in the beam-column joints is not immediately obvious in the structural drawings. In structural drawing S19, which is titled "Beam/Column Joints", there is no transverse reinforcement shown. The structural drawing for the columns (drawing S14) shows the transverse reinforcement of the columns continuing through the beam-column joint. Therefore the designer specified a 6mm diameter spiral at a 250mm pitch for all beam-column joints except those on the western side of the building (line A). This edge of the building had rectangular columns with 10mm ties at 250mm centres. The transverse reinforcement specified in these beam-column joints was inadequate and did not meet code requirements (see section 8.1.7).

The spiral reinforcement in the beam-column joint zones would have been difficult to place due to the congestion of reinforcement and the limited space when the precast beams were in place. The beams would have had to have been in position before the spiral was added due to the location of the hooked beam bars. Mr Jones explained the difficulty of installing the steel in the beam-column joints. He said one wrapping of the spiral steel would have been the maximum. Mr Frost and Dr Heywood examined the building after it collapsed and found no evidence of the spiral confinement being carried through the beam-column joints. Despite the difficulties in constructing this detail, it does not excuse the omission of spiral confinement through the beam-column joints. If it could not be installed, the foreman and/or construction manager should have consulted with the design engineer to find an alternative solution. In the end, the joint reinforcement specified by the designer was deficient and, even if installed correctly, would have made little improvement to the performance of the beam-column joints.

The specifications stated that the contractor should comply with all requirements of NZS 3109:1980[9] except where specified otherwise. This Standard provided the minimum requirements for the construction of reinforced concrete and required spiral bars to be welded or terminated with a 135° bend. Mr Jones said in his 45 years' experience in the trade he had never had a copy of this Standard on site. He did not want to comment on how he ensured that the construction complied with the requirements of NZS 3109:1980, apart from saying he did what was required on the drawings and read the specifications. Dr Reay saw some evidence of this return in the column remains at Burwood Landfill and said that this showed that the correct spiral anchorages were provided.

There was also an example of very poorly aligned vertical steel reinforcing in a column with a slightly oval shape. Mr Jones could not offer an explanation for the vertical reinforcement steel being so close to the outside of the columns in a photograph taken by Dr Heywood, as shown in Figure 23. The 6mm diameter spiral, specified by the designer, was described as being "quite light" by Mr Jones. It was stretched out on site to the 250mm pitch. This spiral alone would not adequately restrain the movement of column vertical bars within the formwork. This led to poor cover control with the bars skewed to one side of the column. This illustrates poor quality control; however, this construction defect is unlikely to have altered the behaviour of the columns.

Figure 23: Slightly oval cross-section with poor control of reinforcement cover (source: Dr Robert Heywood)

Despite Mr Jones' concerns about some aspects of the design, there is no evidence that he raised them with anyone during construction in 1986/1987. Mr Jones said that he had learned to keep quiet as he did not have an engineering degree. It is unfortunate that a foreman with such experience did not say anything. We consider that contractors need to be encouraged to raise their concerns with the designer. This may at least have caused reconsideration of some of the design details and resulted in improved construction quality.

2.3.2.4 Seismic separation of western wall

Reinforced concrete block walls were constructed between the beams and columns on the first three levels on the western side of the building. This was for fire resistance purposes and was detailed to be seismically separated from the adjacent columns. The structural drawings show a 25mm gap between the block wall and column, which was filled with a flexible sealant. The Hyland/Smith report stated that some of the reinforced masonry infill walls appeared to have been constructed so that the intended structural separation was not fully achieved. It went on to state that this could have accentuated lateral displacements due to the influence of masonry walls on the west face. Mr Jones recalled a gap down the side of the block work between the rectangular columns on the western wall and there was evidence of a sealant found by Dr Heywood in collapse debris. Mr David Coatsworth, when conducting a post-September inspection of the building, noted a flexible sealant and a gap at the north-west corner on level 2 through which daylight could be seen. It appears that attempts were made to separate the block wall at construction. The negligible damage to the western block wall following the September earthquake supports this. It is unclear if there was adequate clearance for the drifts imposed by the February earthquake; however, if interaction did occur we do not consider the consequences were a significant contributing cause of the collapse.

2.3.2.5 Seismic separation of spandrels

In addition, the Hyland/Smith report explained that the spandrel panels (which were located on the north, south and east faces of the building) were required to be separated from the columns to allow for seismic movement and construction variations with allowable tolerances. The drawings showed a nominal 420mm clearance between adjacent spandrel panels, with a 400mm diameter column in between, giving a nominal 10mm gap. Mr Jones stated that the spandrel panels were precast and lifted with the tower crane and placed between columns fixed to brackets. He did not recollect any specific problems with fitting the spandrels apart from having to chip the edge off one of the panels to ensure there was a gap between the panel and the column. Although it was listed as a potential factor in the collapse in the Hyland/Smith report, the evidence we have heard suggests this is not the case. The strength of the panel and connection are unlikely to have been sufficient to significantly influence the columns.

2.3.2.6 Insufficient attachment of the column C18 to line D-E

Another construction defect was the omission of a bar that connected the top of column C18 to the top of wall D-E. Column C18 is located at the south-east corner of the north wall complex (see section 5.1.3.1, Figure 62(a)). The Hyland/Smith report stated that only three 20–24mm diameter holes were found in the location where column bars pulled out, whereas the drawings specified four H20 bars bent into the wall. The detachment of this connection in the February earthquake is unlikely to have had an effect on the building's performance as a whole.

2.3.3 Supervision

2.3.3.1 Construction management

As the CTV building was a design-build contract lead by Williams Construction, the architect and engineer reported to the builder and not the client. Mr Brooks contrasted this with the former Ministry of Works' contracts, in which the client engaged the engineer and architect and also employed a clerk of works. He explained that a clerk of works had a supervisory position and carried out frequent detailed inspections. Mr Brooks stated that the design-build arrangement had a great deal of influence on the responsibilities imposed on the foreman. He also considered that management expected more from the foremen than they were initially trained or paid for.

Mr Jones was the foreman on the CTV site and described his responsibilities as managing tradesmen, constructing the building to the plans and specifications and keeping the construction on schedule. Mr Brooks described Mr Jones as like many foremen of that era who were fundamentally carpenters by trade, trained to build light timber structures up to three storeys in height, but who over many years of experience picked up other skills and knowledge about construction. Mr Jones does not appear to have completed a formal apprenticeship, but rather worked his way up to leading hand and then foreman over some years. Mr Brooks believed that the CTV building may have been Mr Jones' first experience with a design-build contract. This was confirmed by Mr Jones who also said that there had been less supervision of construction than he had been used to in the past. He was used to having a clerk of works on site, who was "invaluable to the foreman" to help with technical matters.

According to Mr Brooks, the expansion of Williams Construction meant that it was necessary to strengthen the management by employing an engineer who could alleviate some of the responsibility placed on the company's foremen at its various construction sites. Mr Shirtcliff was appointed to this position. Although Mr Shirtcliff was not intended to act specifically as a clerk of works he was, with his assumed engineering background, intended to provide guidance and mentoring to the foremen on several different Williams Construction jobs in Christchurch. When Mr Brooks appointed Mr Shirtcliff it was on the understanding that he was a qualified engineer. In circumstances that we will address shortly, doubts have arisen since the hearing about whether this understanding was correct. If it was incorrect, that would cast further doubt over any supervision he did perform. Mr Brooks stated that he never had cause, or was given cause, to doubt Mr Shirtcliff's technical knowledge. Under questioning, Mr Brooks' assessment in hindsight was that "he just wasn't up to the job". However there is nothing to suggest this was a view he had during the construction of the CTV building. Both Mr Brooks and Mr Scott said they expected Mr Shirtcliff would have visited the CTV site daily. Mr Shirtcliff's evidence was that he only visited the site about once a month because he believed it was a reasonably simple and straightforward job and other projects required more of his attention. Mr Jones' evidence confirmed Mr Shirtcliff's limited involvement. He said Mr Shirtcliff did not spend much time on site and never gave him any instruction on anything to do with construction issues. Mr Jones said he had "very little contact with him".

Although Mr Shirtcliff agreed that it was apparent once he started his job that there was a need for more management and oversight of the project, he said he was unaware that he was supposed to be providing mentoring and guidance and left it to Mr Jones because he considered that he was a highly competent and capable foreman and it was a relatively straightforward job, which was being monitored by the design engineer and the CCC. Mr Shirtcliff accepted that he essentially relied on others.

Mr Shirtcliff was cross-examined about his initial replies to information requests from counsel assisting in which he denied having any involvement with the CTV building. Mr Shirtcliff also accepted that he had lived in Australia under the name "Fisher" and had been extradited to New Zealand to face fraud charges on which he was subsequently convicted and imprisoned.

We consider there were serious issues with Mr Shirtcliff's credibility. However in terms of his involvement with the CTV building his evidence is confirmed by Mr Jones whose evidence we have no reason to doubt. We conclude that Mr Shirtcliff simply did not spend sufficient time on site in order to adequately perform the role of a construction manager. In addition, we accept Mr Brooks' assessment that he was not "up to the job".

Subsequent to the hearing there was media coverage of allegations that Mr Shirtcliff had obtained the Bachelor of Engineering degree he claimed to hold by fraud or deceit. We understand that those allegations are currently being investigated by the New Zealand Police. Engineers Australia has cancelled Mr Shirtcliff's membership. The University of New South Wales may also be conducting inquiries into the issue.

We did not consider it necessary to reopen the hearing to consider this matter. Any such inquiries are properly the role of the police. In addition, we have sufficient material on the role Mr Shirtcliff played in the construction of the building to determine the relevant issues. If it transpires from the Police (or other) inquiries that Mr Shirtcliff did not legitimately hold the engineering degree(s) he claimed, this would only add to the already poor assessment of him.

Mr Jones may have been a competent and experienced foreman. However he was working in circumstances he appears to have been unused to (that is, on a design-build project, as noted earlier, with no clerk of works) and without the guidance, mentoring and technical advice he might have received from a competent construction manager supervising him. There is also a note in the CCC inspection record in August 1987 that a new foreman had been appointed. Mr Jones was unclear on this, but accepted that there may have been a period when he was not on the site. We have not been able to find any further information about this. However, most of the structural elements of the building had been completed by August 1987.

2.3.3.2 Design engineer and CCC inspectors

Supervision of construction was an obligation assumed by ARCE under its contract with Williams Construction. Mr Harding said he visited the site regularly and completed site inspection reports, but there are also indications that the supervision was not as thorough as it should have been. Mr Jones said that he would ring Mr Harding for every concrete pour except the columns, since the steel was sticking out of the columns for the engineer to see when the floor slab was cast. However he said that sometimes Mr Harding did not arrive at the site, but would telephone and tell them to go ahead anyway. Mr Jones said this did not concern him. Mr Harding denied this had occurred. Unfortunately Mr Harding's site inspection records have not been located.

Mr Brooks said precast beams were delivered to the building site where they sat stacked at the site for some time. The problem with the lack of roughening to the beam faces (discussed in section 2.3.2.1) should have been visible to an engineer carrying out regular inspections, as well as to the foreman and construction manager. Mr Harding should certainly have been well aware of the critical significance of beam roughening. The problem with the "bent-back" bars in the precast beams should also have been visible.

The CCC inspection records show a five-month gap in inspections between April and August 1987, with no apparent explanation. Mr Scott thought that the gap showed a problem with the CCC inspection staff and their reliance on the design engineer carrying out supervision. Mr Jones also formed the impression that the CCC inspectors relied on the design engineer to carry out supervision. Mr O'Loughlin, a building inspector with the CCC during this period, commented that the number of inspections for CTV was a "bit light" for a building of that size in relation to both the number of inspections and their extent. However he observed that at that time inspections were occasionally carried out that were not recorded on the microfiche cards. We are not able to make any finding explaining the gap in inspections.

2.3.4 Concrete strength

The structural specification for the building required the concrete in the floors, walls and columns to be special or high grade, supplied from an approved ready-mix plant. The columns at levels 1 and 2 required a concrete strength (after 28 days) of 35MPa and 30MPa, respectively. The floors, walls and columns at levels 3 and above all required a concrete strength of 25MPa.

The Hyland/Smith report identified the concrete strength as a construction issue. Material testing of salvaged column samples carried out for the purposes of that report found that the concrete was "significantly weaker than expected". Tests on 26 column samples from levels 1–6 had a mean concrete strength of 29.6MPa. The Hyland/Smith report illustrated this information as shown in Figure 24.

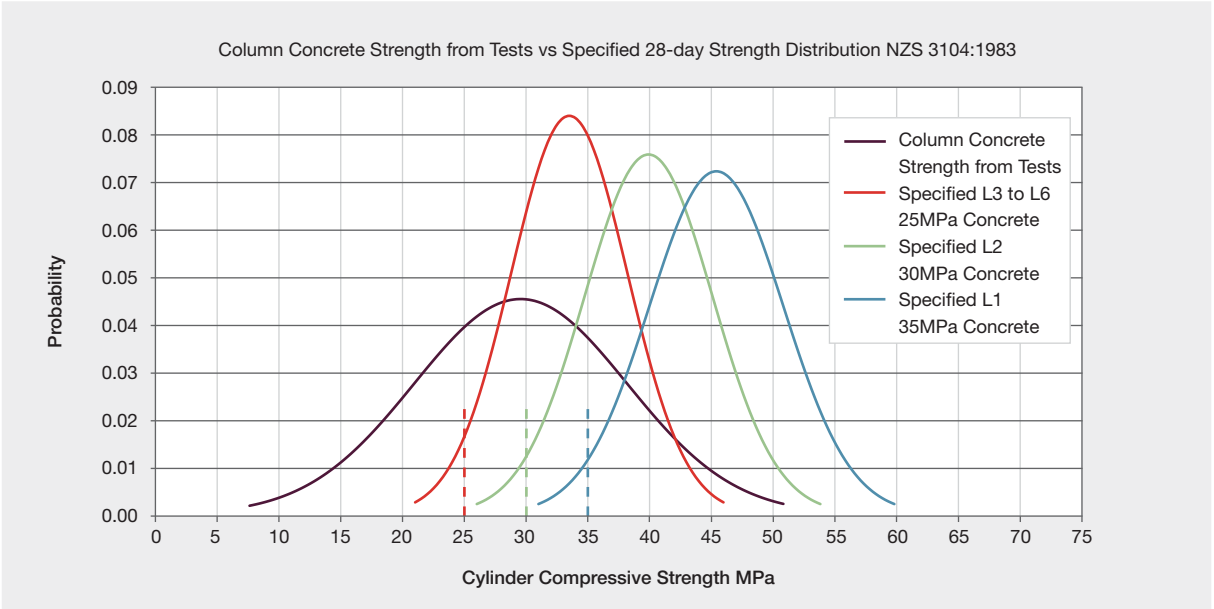


Figure 24: Hyland/Smith report column concrete test strengths compared to specified strength distributions

The Hyland/Smith report also stated an expectation that the actual strengths would be 25 per cent higher than the specified strengths shown in Figure 24. This expected increase was due to "the conservative approach to achieving specified strengths, and the expected strength gain with age". Consequently, "low concrete strength in critical columns" was listed as a factor that contributed (or may have contributed) to the collapse.

A number of experts have expressed disagreement with the Hyland/Smith report's conclusions about concrete strength outlined above. Expert opinion evidence was received from Mr Robert Gaimster, Dr James MacKechnie, Dr Brendon Bradley, Mr Douglas Haavik and Professor Mander. Their principal criticisms included:

- core strengths being taken from areas of distressed concrete;
- the limited number of cores taken to draw firm conclusions;
- erroneous correlation of the Schmidt hammer testing against core strengths;
- the low aspect ratio of some cores;
- testing perpendicular instead of parallel to the column length; and
- an inappropriate interpretation of results.

Mr Gaimster is the Chief Executive of the Cement and Concrete Association of New Zealand (CCANZ), which represents over 300 corporate and individual members. The roles of CCANZ include fostering industry solutions as well as training and research initiatives in concrete-related areas. A submission received from CCANZ was critical of the Hyland/Smith report. CCANZ stated that the testing methodology was inappropriate and there were errors in its interpretation. They considered that the conclusions in the Hyland/Smith report could not be adequately supported.

The Royal Commission requested a peer review of the Hyland/Smith report by Dr MacKechnie, a Plant Engineer at Allied Concrete and an Adjunct Senior Fellow of the Civil and Natural Resources Engineering Department at the University of Canterbury. He criticised the testing processes and referred to incomplete or inconsistent reporting which limited the reliability of information. He went on to state that the conclusions drawn in the Hyland/Smith report were not fully supported by the evidence and ignored accepted guidelines used to interpret core strengths. He said a more rigorous investigation would be required to provide convincing proof of the opinions expressed in the Hyland/Smith report.

Dr Bradley principally looked at the interpretation of the Hyland/Smith report data and its reconciliation with the specifications for the concrete. He said that, irrespective of testing and results, the comparison with specifications was inappropriate and as a result yielded an incorrect assertion that the concrete was below strength.

Mr Haavik, a registered civil engineer in California who specialises in concrete materials, was engaged by Buddle Findlay on behalf of ARCL and Dr Reay to provide independent expert advice. A programme of further forensic investigation included compression testing of concrete cores, ultrasonic pulse velocity and density testing as well as petrographic examinations to determine the condition of the concrete. Mr Haavik noted that his core strengths were 2–55 per cent higher than those of the Hyland/Smith report. His report concluded that there is no reason to believe there was a systemic reduction in the strength of concrete supplied to the building and that, if there was any such strength reduction it would likely be attributable only to gross error for a specific load of concrete. This would itself be extremely unlikely.

The Hyland/Smith report indicated that 26 column samples (21 per cent of all CTV building columns) were tested. This was through a combination of compressive testing of cores and rebound Schmidt hammer testing. Schmidt hammer hardness testing is a useful tool used to measure the surface properties of the concrete which, in turn, can be used to estimate the concrete compressive strength. It was described by Mr Gaimster and Dr MacKechnie as a blunt tool where the correlation between Schmidt hammer results and core strengths is not very reliable. Given the limited number of points used in deriving the correlation, the use of several concrete mix designs in the building and the potential damage to the column surface, we accept that the Schmidt hammer results can give highly variable results and that core compressive test results carry greater significance. The Hyland/Smith report took 19 cores from seven columns (only seven per cent of all CTV columns according to the CCANZ submission). Six of these were from column C18 as shown in Figure 25. This was identified as a length of the column from level 1, which had a specified strength of 35MPa.

This column is visibly damaged with cracking and discoloration due to fire. This type of distress will reduce the compressive strength of the concrete. The six cores taken from this specimen had a "test core average" of 16MPa, which was regarded as an outlier by Mr Gaimster and Dr MacKechnie.

Figure 25: Concrete cores taken from column C18 on line 4, adjacent to wall D-E (source: Hyland/Smith report)

In addition, 16 of the 19 cores were 70mm in diameter. Mr Haavik stated that depending on the core diameter there may be differences in strength of up to 30 per cent. It is desirable to have larger core diameters; Mr Haavik's testing used 99mm core diameters. Mr Haavik's cores were drilled down the middle of the column to provide a cylinder that was parallel to the direction of concrete placement. This was thought to be important by Mr Haavik as the orientation of concrete aggregate may have given different compressive results depending on the direction of the core sample. We accept his evidence.

Taking into account all of the evidence we heard on the issue we are of the view that the concrete was likely to have been at or above the strength specified by the designer and that there is no reliable evidence to suggest the concrete was understrength in any columns.

2.4 Drag bar retrofit

2.4.1 Holmes Consulting Group review

On 24 January 1990 HCG was engaged to prepare a pre-purchase review of the building as part of the due diligence being carried out by a prospective purchaser, the Canterbury Regional Council (CRC).

Mr John Hare, at that time a senior engineer with HCG, gave evidence that, as the time frame given by the CRC was limited, the report was never intended to be a full peer review of the design of the building. Mr Hare obtained architectural drawings and some of the structural drawings from Alun Wilkie Associates and from those drawings was able to carry out an approximate seismic analysis.

Having reviewed the structural drawings and the primary load paths, Mr Hare identified that there appeared to be "an area of non-compliance with the code of the day with respect to the tying of the floors to the shear walls, specifically to the north core walls". Mr Hare said that he "picked this up fairly quickly as there appeared to be no connection detailed for the walls on either side of the lift shaft". This issue was described by Mr Hare in his draft report as a "vital area of non-compliance with current design codes".

On 26 January 1990 Mr Hare visited the offices of ARCL. He said he recalled that at some stage during his visit he saw both Dr Reay and Mr Geoffrey Banks. Mr Banks was a structural engineer and at that time a shareholder and director of ARCL. Mr Hare was able to view ARCL's file, which included a complete set of drawings and a soils investigation report. He said he discussed his concern in relation to the floor diaphragms with either Dr Reay or Mr Banks during that visit. He also recalled being told that the issue may have been addressed during construction and that inquiries would be made to confirm that. He said that he was told by either Dr Reay or Mr Banks that the original design engineer, Mr Harding, was not available as he had left the firm but that Mr Banks would be available to comment on aspects of the design.

Dr Reay said in evidence that he did not recall this meeting and did not think he had attended it. Mr Banks recalled meeting with Mr Hare but could not recall whether Dr Reay was present. We consider that it is more likely that Mr Hare's recollection is correct, particularly as it was indicated to him that the issue may have been addressed during construction. As Mr Banks was not employed by Dr Reay's firm at the time of the CTV construction, that information could only have come from Dr Reay.

Mr Hare referred to Mr Harding's design calculations (pages S56 and S57), which addressed the connection of the floors to the north wall complex. He said that those calculations failed to address the tie force to the walls on lines D and D–E (although he said they did consider the shear calculations for the orthogonal walls, including the south wall and the north wall through the shear and the slab). In other words, they addressed an earthquake in the east-west direction but not in the north-south direction. Mr Hare observed that the floor diaphragm of the building adjacent to the north wall complex was "punctured by the lift, stair and service risers" and as a result there were relatively few direct connections from the floor diaphragm to the north wall complex and there appeared to be insufficient reinforcement tying the floors and north wall complex together.

With the exception of Mr Harding, there was no issue taken by any witness with these observations, nor with the assertion that the connections did not comply with the codes of the day (NZS 4203:1984 and NZS 3101:1982). Mr Harding said that the connections could have been improved, but did not accept that they were non-compliant. Mr Grant Wilkinson, Mr Hare's supervisor at HCG at the time, said it was "absolutely fundamental" that there was a load path between the floors and the supporting walls and described the issue identified with the building as a "critical structural weakness". Both Dr Reay and Mr Banks accepted that, in today's terms, the issue identified with the building was a critical structural weakness. Dr Reay also described it as "fundamental engineering" and as a "straight blunder".

As part of his review, on 29 January 1990, Mr Hare spoke to Mr Bluck at the CCC. Mr Hare's purpose was to ascertain whether the CCC had identified any issues during the building permit and construction process. Mr Bluck raised three issues unrelated to the structure of the building. Mr Hare said he did not see the CCC file.

Mr Hare did not recall discussing the floor connections with Mr Bluck. This was also evident from the file note Mr Hare made of his discussions with Mr Bluck. Mr Hare said he suspected the reason he did not raise this issue with Mr Bluck was because ARCL had suggested that provision may have been made for it during construction and that this was to be verified by the use of a bar-finder. He was also unsure whether he had been provided with the most recent drawings at that time.

The next day Mr Hare inspected the building with Mr Banks. Mr Banks used a bar-finder to try and determine whether any reinforcement had been added during the construction process. He was unable to locate any significant reinforcement. Levels 1 and 4 were unavailable for inspection on that day.

On or about 31 January 1990 HCG was asked to supply a copy of their report as it stood at that time to the CRC's representative. The facsimile attached to that report referred to it as a draft. However the report itself did not contain any such reference.

The "Conclusions" section of the report stated:

> **3.0 Conclusions**
>
> Due to the limited time available for the report, our review has been limited to a brief inspection of the building and documents, and approximate calculations. No materials testing has been undertaken, and inspection has been limited to such areas as were readily accessible. Given these qualifications, our conclusions are as follows:-
>
> 1. The building is in a condition appropriate to its age and the contractor-as-developer form of construction.
> 2. The layout and design of the building is quite simple and straight forward and generally complies with current design loading and materials codes.
> 3. A vital area of non-compliance with current design codes, seen in the documents, is in the tying of the floors to some of the shear walls. This item is under review with the original consultants, but if confirmed will require potentially expensive remedial work. However, this cost is a matter for discussion between the current owner and their consultants.
> 4. Apart from ongoing maintenance costs, which should be minor, no major costs are anticipated in association with the structure, subject to 3, above.

The issue in relation to the diaphragm (floor) wall connections was also referred to in paragraph 6.3 under the heading "Lateral Load Resistance", as follows:

> An area of concern however has been discovered in the connections of the structural floor diaphragm to the shear walls. While this is not a concern on the coupled shear wall to the south of the building, connections to the walls at the North face of the building are tenuous, due to penetrations for services, lift shafts and the stairs, as detailed on the drawings.
>
> The result of this would be that in the event of an earthquake, the building would effectively separate from the shear walls well before the shear walls themselves reach their full design strength.
>
> Discussion has continued on this matter with Mr Geoff Banks of Alan Reay Consulting Engineer, and it currently appears that there may have been some provision made for this during construction. However, no documentation apparently exists, so it would only be safe to assume that this aspect fails to comply with current design codes.

HCG had been asked, as part of its review, to give advice on the likely costs of fixing the defects identified in the floor connections. Mr Hare prepared a draft remedial detail which involved the insertion of steel drag bars on levels 1–5 of the building (this was a reference to all levels above the ground floor). That detail was prepared solely for the purpose of determining the approximate cost of any remedial work. It was not developed to a final design stage nor was it passed on to ARCL.

On or about 31 January 1990 HCG was instructed by the CRC's agent to stop any further work and its engagement ceased.

On 1 February 1990, Mr Wilkinson of HCG sent a memorandum to Warren and Mahoney, Architects (who were engaged by the CRC), advising that a quotation had been received for remedial structural works, as per HCG's detail, of approximately $14,000 plus GST. HCG was subsequently advised that the CRC had decided not to proceed with the purchase of the building. Mr Hare was not certain when HCG was told this or whether they were told why the CRC had decided not to proceed.

In a letter Mr Banks sent to ARCL's insurers dated 1 February 1990, Mr Banks noted that the potential purchaser had an option until 28 February 1990 and had requested a two-month delay in settlement to give time to complete the remedial work. Mr Hare said in evidence that he was not aware in January or February 1990 of any option to purchase or any request for a delay in settlement.

Mr Banks had been asked by Dr Reay to liaise with HCG over this issue. Mr Banks said his role was focused on the detail while Dr Reay provided an oversight role. Mr Banks said that, as he was relatively new to ARCL and had not had any previous involvement with the building, he liaised with Dr Reay throughout. Dr Reay said he saw it more as a "joint situation" as opposed to him overseeing Mr Banks' actions.

2.4.2 ARCL's reliance on the HCG report

Both Mr Banks and Dr Reay said that they relied on the HCG report, in particular the statement to the effect that HCG considered that, apart from the issue Mr Hare had identified, the building generally complied with current design loading and material codes. They therefore did not consider that it was necessary to carry out any wider inquiry into the structural integrity of the building.

Mr Banks said he was not asked to carry out a general review and nor would he have carried one out of his own accord. Asked if such an obvious oversight should have alerted him to the need to look at the rest of the building, Mr Banks said the calculations for these connections appeared to be absent but not for anything else. Mr Banks was unaware of Mr Harding's lack of experience in the design of multi-level buildings at the time he designed the CTV building and said this would have been relevant to his enquiries. Dr Reay said that he had not told Mr Banks of this because he did not think Mr Harding was inexperienced and, in any event, the defect identified was a fundamental one relating to load paths rather than the design of multi-level buildings.

In cross-examination Mr Hare accepted that the report made "clear positive statements in respect of compliance" except in respect of the single issue identified. However he did not agree that there was nothing further to be done in respect of the report as it had not been checked and reviewed. Mr Hare said a full detailed analysis would have been necessary to assess the potential non-compliance of the columns.

Mr Wilkinson noted that the report was incomplete. It did not contain the name of the author and was unsigned. He explained that the objective of a pre-purchase review was to try and identify any "gross" errors or "obvious" problems. He estimated that this review would have taken some 30 hours compared to the 300–600 hours required for a full review.

Counsel assisting submitted that the contention by Dr Reay and Mr Banks that they could rely on the HCG report, in particular the statement that the building otherwise generally complied with the building codes at that time, could be rejected on a number of grounds. In particular it was clearly not a full peer review and was qualified by the limitations stated in the report.

Counsel for ARCL and Dr Reay submitted that Dr Reay was entitled to rely on the HCG report as it was not stated to be a draft and did not contain any disclaimer. Counsel for Mr Banks submitted additional reasons: Mr Hare had reviewed architectural and some structural drawings at Alun Wilkie Associates; viewed the structural drawings, calculations and a soils report at ARCL's offices; made enquiries with the CCC and undertaken an inspection of the building (excluding levels 1 and 4). In addition, it was submitted, it was clear that this was the only issue identified in Mr Banks' subsequent discussions with Mr Hare and Mr Wilkinson.

Notwithstanding the matters raised by counsel for Dr Reay and Mr Banks, we consider that it should have been apparent to them that the report was not a full review of the structural integrity of the building. Further, no enquiry was evidently made of HCG to ascertain the extent and implications of the qualifications stated in the report. Dr Reay knew of Mr Harding's inexperience at the time he designed the building. The identification of such a "fundamental" design error should have signalled the need for a more detailed review of the design, especially given that this was the first time he had looked at the structural drawings.

Reliance on the HCG report meant that an opportunity was lost to conduct a full review of the building's design.

2.4.3 ARCL's investigations

Mr Banks said that he discussed the concerns identified by Mr Hare with Dr Reay, and that they agreed they had to be investigated. Mr Banks said it was immediately apparent to him that the connections were tenuous.

He said that it appeared from the structural drawings that there were only a limited number of light 12mm diameter reinforcing bars in the connections between the floors and the north wall complex. The ability of the north wall complex to carry north-south seismic loads was therefore reduced. Mr Banks said that there did not appear to be any calculation dealing with the seismic load in the north-south direction. He could not say whether that calculation had been done but was missing from the file, or whether it had not been carried out at all.

He said he discussed the matter with Dr Reay who thought that the potential point of weakness identified may have been addressed during construction. Mr Banks said that he had not found any record of such remedial work in the archived files at ARCL but still thought it might have been addressed because Dr Reay had thought so and because the building had been granted a permit by the CCC. However when Dr Reay gave evidence about this issue, it was apparent that this suggestion was not based on any knowledge. It was just a possibility.

Dr Reay gave evidence that he contacted Mr Harding who said he was unable to recall any site instructions dealing with the issue. Therefore, as Dr Reay said, by this point it was "increasingly unlikely" that the problem had been addressed. Mr Banks said that he and Dr Reay agreed they should proceed on the basis that the issue had not been addressed during construction and develop a remedial solution. Dr Reay referred to this decision as a "pragmatic" one. Mr Banks did not think it was a pragmatic decision, but rather a sound decision based on the likelihood that the work was needed.

In any event, it was clear from the evidence of both Dr Reay and Mr Banks that they had accepted (albeit for different reasons) that remedial works would be required and that ARCL was responsible for this as successor to ARCE.

On 1 February 1990 Dr Reay and Mr Banks met Mr P W Young of KPMG Peat Marwick, the receivers for Prime West. A letter from Mr Young to Dr Reay the following day referred to that meeting:

> Further to our meeting on 1 February 1990 with yourself and Mr Geoff Banks, we record our understanding of the steps to be taken with regard to the alleged non-compliance with current design codes as recorded in the structural report prepared by Holmes Consulting Group Limited, dated January 1990.
>
> You have advised that investigations are continuing as to whether or not steel ties were placed between the structural floor and some shear walls as a metal detector has indicated the presence of some steel.
>
> You have also advised that the cost of the remedial work would be approximately $5,000 and should take only one week's work to complete.
>
> In view of the relatively modest cost for the remedial work, you have advised it is more cost effective to assume that the steel is not in place, as the cost of further investigating the matter would in all probability exceed this amount. You have also advised that there is reasonable agreement with Holmes Consulting Group as to the level of remedial work required, and that once carried out, there is no suggestion that the building is not at proper standard.
>
> On an entirely without prejudice basis, you have offered to complete engineering drawings for the remedial works and presumably oversee their completion at your own cost. Both parties have reserved their positions with regard to who should bear the contractors' cost of carrying out the repairs.
>
> To ensure that Holmes Consulting Group can promptly report to the Canterbury Regional Council that current design codes have been fully complied with, no doubt you will ensure that full agreement is obtained with them as to the level of the work required.
>
> We have advised Mr Stock, Solicitor for the Canterbury Regional Council, that the remedial work is to be carried out forthwith and did not appear to be potentially expensive as intimated by Holmes Consulting Group. Further, we have advised that the work should take approximately a week to complete, and accordingly will not disrupt the Council's fit-out and move into the building.
>
> We impressed upon you the extreme difficulty we have had locating a purchaser for this property and I am sure you appreciate that we must ensure that the sale is not put in jeopardy by restricting the Council's ability to take possession without delay, since it has been expressed to us that time is of the essence. Accordingly, we appreciate the prompt attention you have given to this matter and we would hope that a costing for these works could be arranged to enable commencement early next week.
>
> Please advise if your understanding of the situation is not as set out above.

At the meeting with Mr Young, Dr Reay and Mr Banks were given a copy of the HCG report. In a letter of 1 February 1990 from Mr Banks to ARCL's insurer Mr Banks advised on behalf of ARCL that:

- their own review of the drawings had confirmed the apparent lack of ties to two walls;
- they had contacted the engineer directly involved with the design and observation of the project but he was unable to recall any site instructions given on this issue and they had found no reference to it in the written instructions on file; and
- they had used an electronic reinforcing bar locator at one level, which indicated that some reinforcement was present, but not the quantity, and the readings may have been affected by metal work in the walls or the metal tray flooring system, and could not be totally relied on.

Mr Banks proposed the following course of action:

- to agree with HCG on the precise scope of the work they considered might be inadequate;
- to confirm with HCG the level of load for which the floor to wall tie should be designed; and
- to design the remedial work that would be required if the ties were not present.

Mr Banks said he telephoned Mr Wilkinson on 2 February 1990 to obtain HCG's agreement as to the level of work required. The same day Mr Banks wrote to Mr Wilkinson in the following terms:

> Further to our discussion by telephone this morning, we confirm that the scope of the possible non-compliance referred to in your report on the building is the connections between the walls on gridlines D and D/E, as shown on the attached sketch SK1 from levels 2 to 6 inclusive (level 1 being the ground floor carpark).
>
> The proposed remedial work, if required, would consist of a total of two ties per floor, tying the walls to the floor diaphragm.
>
> The agreed maximum tie load is 300 kN per tie. We understand that this load would be reduced on lower floors in accordance with the "Parts and Portions" section of NZS 4203:1984.
>
> Please contact this office today if your understanding of this situation is not as outlined above.

Mr Banks said the HCG report was not specific as to walls that were of concern or which levels required ties. He had therefore discussed these issues with Mr Wilkinson on the basis that reduced loads on the lower floors might mean that additional restraint may not be needed on those floors. Mr Wilkinson said that, although he could not recall specific details of the conversation, the issues were set out in Mr Banks' letter. In relation to the penultimate paragraph of that letter, Mr Wilkinson said he would have expected Mr Banks to have derived the loads for each floor from the relevant standard. Mr Banks could not recall why there was a need to request a reply that day, other than that he was aware of the potential sale of the building. He said he and Dr Reay did not have significant safety concerns since the building was vacant. Mr Wilkinson said that he did not have any issue with the contents of the letter and therefore did not reply.

On 14 February 1990 Mr Banks telephoned Mr Hare. Mr Banks made a file note of the telephone conversation. Mr Hare's recollection of the conversation differed from that of Mr Banks and to some extent from Mr Banks' file note. Mr Banks' recollection (and his file note record) was that they had "agreed loads" on each floor. Mr Hare said that he had indicated to Mr Banks that the loads Mr Banks had calculated appeared to be "around the right figures" but that it was up to Mr Banks to check and finalise these. The file note also recorded:

> Confirmed reduced connection [at level 1] may be ok (could compensate at L2 if necessary).

Mr Hare said that he had indicated to Mr Banks that Mr Banks would have to check whether this was possible by investigating other mechanisms that would be required to make up any shortfall. He had expressed the view that caution should be exercised if it were ARCL's intention to reduce the load at level 1. He said that he certainly did not agree to it. Mr Banks said that he did not recall Mr Hare saying this and that if Mr Hare had expressed a reservation about the approach Mr Banks would have recorded it in his file note and discussed it further with him. In cross-examination, Mr Hare said that he would have told Mr Banks that the absence of a tie meant that a tie should be put in. He would have been reluctant to agree to any transfer of load vertically when it would have been just as easy to put a tie in. Mr Hare accepted that he had not carried out detailed calculations such as those later done by Mr Banks to ascertain whether or not there could be a redistribution of the load.

As we have noted above ARCL had notified its insurer of the issue. The insurer had given approval to ARCL to agree with HCG on the precise scope of the original design HCG considered to be inadequate, the level of load for which the floor connection should be designed and the design of the remedial work.

Mr Banks completed an "annual report on status of claim" for the Consulting Engineers Advancement Society Incorporated (CEAS) on 9 April 1990 in which he stated, "[w]e are still investigating whether there is a deficiency, and if so, details of remedial work". However, apart from the investigations at the site on 30 January 1990 and inquiries made of Mr Harding (and possibly of Mr Jones, the site foreman during construction), we did not hear any evidence of further investigations at or around that time.

After a flurry of activity in late January and early February 1990, there followed a period of approximately one year until February 1991 when it appears that nothing was done by Dr Reay or Mr Banks to address the issue. Mr Banks said that he did not know what had happened during that period. He assumed that, having raised the issue with the owner of the building, the process would continue to a conclusion.

Dr Reay said HCG had not advised ARCL that they were no longer involved and he did not believe that the receiver had communicated anything to him. In Dr Reay's view ARCL had made sure that the people who needed to know there was a problem knew of it. He assumed the potential purchaser was still working out whether or not they were going to buy the building. He said that whenever he drove along Madras Street he would look to see if there was any activity in the building as he was concerned that if there were signs of occupation there could be a risk. He did not believe the status of the building changed during 1990. He did not recall contacting the receiver but said that he and Mr Banks would have discussed it at some point and would not have let it run on indefinitely, as they had not forgotten that they had an obligation.

An article appeared in the Christchurch newspaper *The Press* on 4 February 1991 reporting the sale of the building by the receivers. This article was seen by one or both of Dr Reay and Mr Banks who then discussed it. Dr Reay said they concluded that the new owner must not have been aware of the issue with the floor connections otherwise ARCL would have been approached before the purchase. Therefore both he and Mr Banks decided they should get in contact with the new owner.

Mr Banks said they considered it was their ethical obligation to advise the new owners but as their insurer was involved they needed to obtain its approval before doing so. Mr Banks' file note of his conversation with Mr Peter Smith of CEAS records that Mr Banks asked: "what are our obligations (if any) to notify anyone re status of review to date?" Mr Banks said his own file note appeared inconsistent with his recollection of matters and that it was always his intention to notify the new owner. Dr Reay's interpretation of the file note was that Mr Banks was seeking advice on the degree to which they should notify, but not whether they should in fact notify. However he could not explain the sentence further down in the same file note: "Preliminary advice from insurance [point] of view is no further action". Dr Reay said they were agreed that no matter what, they needed to notify the new owner.

ARCL sought legal advice before taking this step. That advice was received in March 1991 and provided by ARCL to its insurer who then, in a letter dated 9 April 1991, confirmed their agreement that ARCL inform the new owner.

However a period of five months followed during which nothing was done to notify the new owner. Dr Reay could not explain this delay other than to suggest that they had to ascertain the identity of the new owner from the receiver. It is difficult to reconcile this delay with Dr Reay's acceptance that once there was a new owner there was some urgency to notify.

Criticism was made by counsel assisting of the 21 month delay from January 1990 to October 1991 before remedial work was carried out. Mr Wilkinson said he thought that time frame was acceptable in the circumstances and drew an analogy to the times the CCC allowed for the strengthening of earthquake-prone buildings. Mr Trevor Robertson, a Senior Principal of Sinclair Knight Merz, working in the role of Principal Structural Engineer, was called by Mr Hannan, counsel for HCG and Mr Hare to give expert evidence on issues relevant to the ethical and reporting obligations owed by an engineer undertaking a review of a building for a prospective purchaser. Mr Robertson has over 40 years' experience as a structural engineer, and has twice been appointed by IPENZ as a member of ethical complaints investigating committees. We accept that Mr Robertson is an expert in the field of ethical standards for engineers. He disagreed with Mr Wilkinson and considered the matter should have been addressed within three to six months.

We agree with Mr Robertson. This was a significant issue that had the potential to affect the safety of users of the building. While the building was not occupied during this period, this was no guarantee that people would not have been in the building from time to time.

We accept that Mr Banks was effectively taking his direction from Dr Reay. However, as owner of the firm that designed the building, Dr Reay should have acted more expeditiously and proactively to resolve this fundamental defect.

We do not consider there is a sufficient basis on which to determine the reason for this delay. As we have said, the dilatoriness was unacceptable; however, Dr Reay and Mr Banks did take some action after they became aware of the sale.

In a letter dated 11 September 1991, or a telephone call shortly before that letter, Mr Banks advised Mr Russell Ibbotson of Madras Equities Limited (Madras Equities), which had purchased the building on 21 December 1990, of the issue. Unfortunately that letter cannot now be found. In a letter dated 30 September 1991, replying to Mr Banks' letter, Mr Ibbotson described his understanding of the problem as "an engineering design fault omission in the structure which could impact on insufficient loadings to meet the normal earthquake requirements".

The letter went on to record Mr Banks' comments that:

> …the remedial work, if required, will be relatively simple to carry out whilst the building is predominantly unoccupied and should not involve a major expense outlay. It is also noted that it is a possibility that the apparent problem may not, in fact, be a problem and that this can only be determined by further work involving some drilling to determine the extent of the reinforcing steel work in position.

Counsel assisting submitted that the suggestion in September 1991 that the problem may not in fact exist was a "charade" because Dr Reay had made inquiries in early 1990 which tended to confirm that nothing had been done during construction that differed from what was shown on the structural drawings. In addition, there was nothing in any of the records to show anything had been done.

Counsel for Mr Banks submitted that Mr Banks had been told by Dr Reay that the issue might have been addressed during construction and Mr Banks reasonably thought that may have been the case as the building had been given a building permit. It is unclear if Mr Banks viewed the permitted plans at the CCC. Had he done so he would have seen that the connections between the north wall complex and the floors were the same as depicted on the drawings at ARCL's office. The claim that there may have been some uncertainty over the issue in October 1991 is difficult to reconcile with what Mr Banks described as the "sound" decision in February 1990 to proceed with the remedial work.

We are not prepared to conclude that this was a charade. However we do consider that it was somewhat disingenuous to continue to maintain this stance rather than accept that remedial work was clearly required and take prompt action to ensure it was carried out.

A submission was also made by counsel assisting that Dr Reay and Mr Banks attempted to minimise the extent of the problem in their dealings with the receiver and Mr Ibbotson, although it was accepted that this may in part have been motivated by the need to avoid acceptance of liability for insurance purposes. As noted earlier Mr Young of KPMG Peat Marwick already had a copy of the HCG report when he met Dr Reay and Mr Banks on 1 February 1990 to discuss the issue. However he was not an engineer. Mr Banks did not accept the proposition put to him in cross-examination that KPMG was not given an "entirely candid statement" of the position at that time. We consider that the letter of 2 February 1990 from Mr Young to ARCL conveys that Mr Young's impression was that the issue was relatively minor.

Mr Ibbotson said that he was advised that the problem was of a minor nature and remedial work if required would be relatively simple. He said he did not consider he had to advise the ANZ Bank, the incoming tenant, because the issue had been described as only minor. Counsel for Mr Banks submitted that Mr Ibbotson's letter of 30 September 1991 appeared to show an appreciation of the significance of the issue and that the reference to "minor" was in relation to the cost of the remedial work, as confirmed by Mr Ibbotson when giving evidence. However, Mr Ibbotson was not an engineer either. Mr Banks accepted in cross-examination that, "from a technical point of view", it would have been more accurate to say that, as far as they were aware, there was an engineering design fault omission in the structure which was highly likely to impact on the loadings to meet earthquake requirements.

We consider that while there appears to have been an element of minimisation in the actions of Dr Reay and Mr Banks, this was likely motivated by the perceived need to protect the insurance cover and does not, in our view, imply any ulterior motive.

We have discussed the delay in taking action at some length because, although it does not relate directly to the reason that the building collapsed in

the February earthquake, the issue is relevant to the Royal Commission's overall Inquiry. The Terms of Reference require us, among other things, to consider the roles and responsibilities of those involved in the construction sector. We have seen that as requiring us to consider the responsibilities of engineers (and indeed others) who become aware of defects in buildings. This is an issue that has arisen in different settings in the course of our Inquiry, and on which we make recommendations in Volume 7. We consider it important to state our view, which we repeat, that the period that elapsed between discovery of the problem and taking remedial action was unacceptable.

2.4.4 Installation of drag bars

As we have already mentioned, some of the correspondence about this issue indicated that ARCL would confirm the design loads of the floor connections with HCG. However it is clear that, as Mr Robertson put it, there had been a "passing of the baton". The responsibility for ensuring completion of the appropriate calculations and design lay with Dr Reay and Mr Banks.

Mr Hare gave evidence comparing the preliminary design he had done with the remedial work carried out by Mr Banks, in particular the decision by Mr Banks not to install drag bars on levels 2 and 3. Mr Hare accepted the exercise was not necessarily one of comparing "like with like". He did however express the view that it would have been easier to simply install drag bars on all floors apart from level 1, although he accepted his view could be affected by an element of hindsight.

Drag bars were never going to be as effective as an original code compliant connection. Further, the highlighted defect was a potential life safety issue and the additional cost of installing drag bars on the other two levels would have been minimal. We agree with Mr Hare that it would have been better to have done this.

However we consider that Mr Banks was correct in his view that by applying the Parts and Portions provisions of the Code the loads could be redistributed so that drag bars were not required on levels 2 and 3. Mr Banks referred to a criticism in the Hyland/Smith report that the Parts and Portions provisions in NZS 4203:1984 as applied to the connection of diaphragms to seismic lateral load-resisting walls seem inadequate. Mr Banks said he agreed with the criticism now, but he applied the provisions in accordance with the relevant standard in force at the time.

Figure 26 shows the location of the drag bars and their state after the collapse of the building.

(a) The north wall complex after the collapse

(b) Part of the north wall complex after the collapse

(c) A fractured drag bar on the wall on line D-E

(d) A bent drag bar on the wall on line D

Figure 26: The locations of the drag bars and their state after the collapse of the building

2.4.5 Building permit

No building permit was obtained from the CCC before the drag bars were installed on levels 4, 5 and 6 in October 1991. Mr McCarthy, the Resource Consents and Buildings Policy Manager of the CCC, said that a permit would have been required for that work under CCC Building Bylaw 1990[10], which came into force on 4 July 1990. Clause 2.2.1 stated "No person shall erect or commence to erect any building without first obtaining a building permit from the Engineer". The term "erect" was defined as including "any alteration, repair or addition to any building theretofore or hereafter erected". "Building" was defined in Clause 1.1.1 of the Bylaw as follows:

> "Building" in addition to its ordinary and usual meaning, means any thing or part of a thing constructed or erected whether temporary or permanent, movable or immovable…[11]

Counsel for Dr Reay submitted that this clause was so widely framed that it could have required a permit for the erection of a shelf. Although the Bylaw may have been widely framed, we think it clear that this structural work required a permit.

Mr Banks said that in the early 1990s, before the Building Act 1991 was enacted and in force, the building permit process was much "less structured" than it is now in terms of the detail with which the process was defined. Even if this was the case, we do not accept that it meant a permit would not have been required.

Dr Reay said that, based on his experience in dealing with Mr Bluck over many years, he believed Mr Bluck's view would have been that the retrofit works were part of the original job and that no permit was required, although Mr Bluck might have asked to receive details about what was undertaken. However this is contrary to Clause 2.16.1 of the Bylaw, which required written approval from the City Engineer authorising a departure from the original permit drawings. Given what we heard about the standards applied by Mr Bluck we find it difficult to accept that he would have ignored this requirement. In addition, approximately a week before the installation of the drag bars in October 1991, ARCL was involved in fit-out work for the ANZ Bank tenancy of the building. That work involved the erection of non-structural block walls for which a building permit was obtained.

We are of the view that the failure to apply for a permit was a clear omission, which meant that the inadequacy of the floor connections to the north wall complex in the original design was not drawn to the CCC's attention in 1991.

2.4.6 Ethical obligations

Mr Robertson expressed the view that, as Dr Reay and Mr Banks had indicated an acceptance of responsibility to attend to the design issue raised with them, HCG did not have an ongoing ethical obligation in relation to the issue. If ARCL had not accepted that responsibility HCG would have had to consider reporting the matter to the engineers' professional body, IPENZ. Dr Reay questioned whether there had been a "passing of the baton", as Mr Robertson put it, but he and Mr Banks did not dispute that they were ethically obliged to attend to the issue. Mr Rennie QC also took issue with Mr Robertson's view that Mr Hare and Mr Wilkinson did not have any obligation to do anything despite being aware of the issue.

Although the current IPENZ Code of Ethics is more comprehensive than the code that existed in 1990, Mr Robertson said the disclosure obligation clauses are not substantially different. In his view something more definite is required. He thought engineers would welcome a "tightening up of the rules", particularly in relation to disclosure obligations if the advice of a reviewing engineer is rejected or neglected.

We agree with the submissions of counsel assisting that the drag bar issue highlights the need for an appraisal of the obligations of disclosure of knowledge about a structural weakness that has the potential to affect the safety of the users of a building or the public. Disclosure to an owner or even the original design engineer may not result in the matter being dealt with in a timely manner or at all. This raises the issue of whether there is a need for disclosure to an independent statutory body such as a territorial authority so the matter will be dealt with expeditiously. We are of the view that such an obligation is necessary and that it should not only apply to engineers but also to people such as owners, contractors, and others who become aware of such information. The fact that so many people were aware of the issue with the connection of the floors to the north wall complex over some years, without the CCC ever being made aware of it, highlights this need.

We return to the subject of disclosure obligations in Volume 7, section 3.

2.5 From 1991 to 4 September 2010

The CCC issued a number of permits and consents (including resource consents) for work on the CTV building between the time of original construction and 4 September 2010. In most cases, the approved work would have had no impact on the structural performance of the building in an earthquake. Some of the notable alterations are described below.

2.5.1 Fit-out for ANZ in 1991

On 20 September 1991, Wilkie and Bruce Architects (the firm in which Mr Wilkie practised) applied to the CCC for a building permit for alterations to level 1 that were excluded or removed from an earlier application. The part of level 1 that was converted from car parking to office space included all of the area to the east of grid line D as seen on Figure 27.

The application included the installation of concrete block walls along parts of grid lines D, F, and 1, as shown on Figure 27. These were detailed by ARCL in drawings stamped as approved by the CCC on 1 October 1991. The concrete block walls that were installed at this time were removed in 2000 as part of the fit-out for Christchurch Television (CHTV), a predecessor of CTV.

The preparation of the drawings by ARCL took place at around the same time as correspondence between Mr Banks and Mr Ibbotson on behalf of the owner in relation to the installation of drag bars. The implications of this are noted in section 2.4 of this Volume.

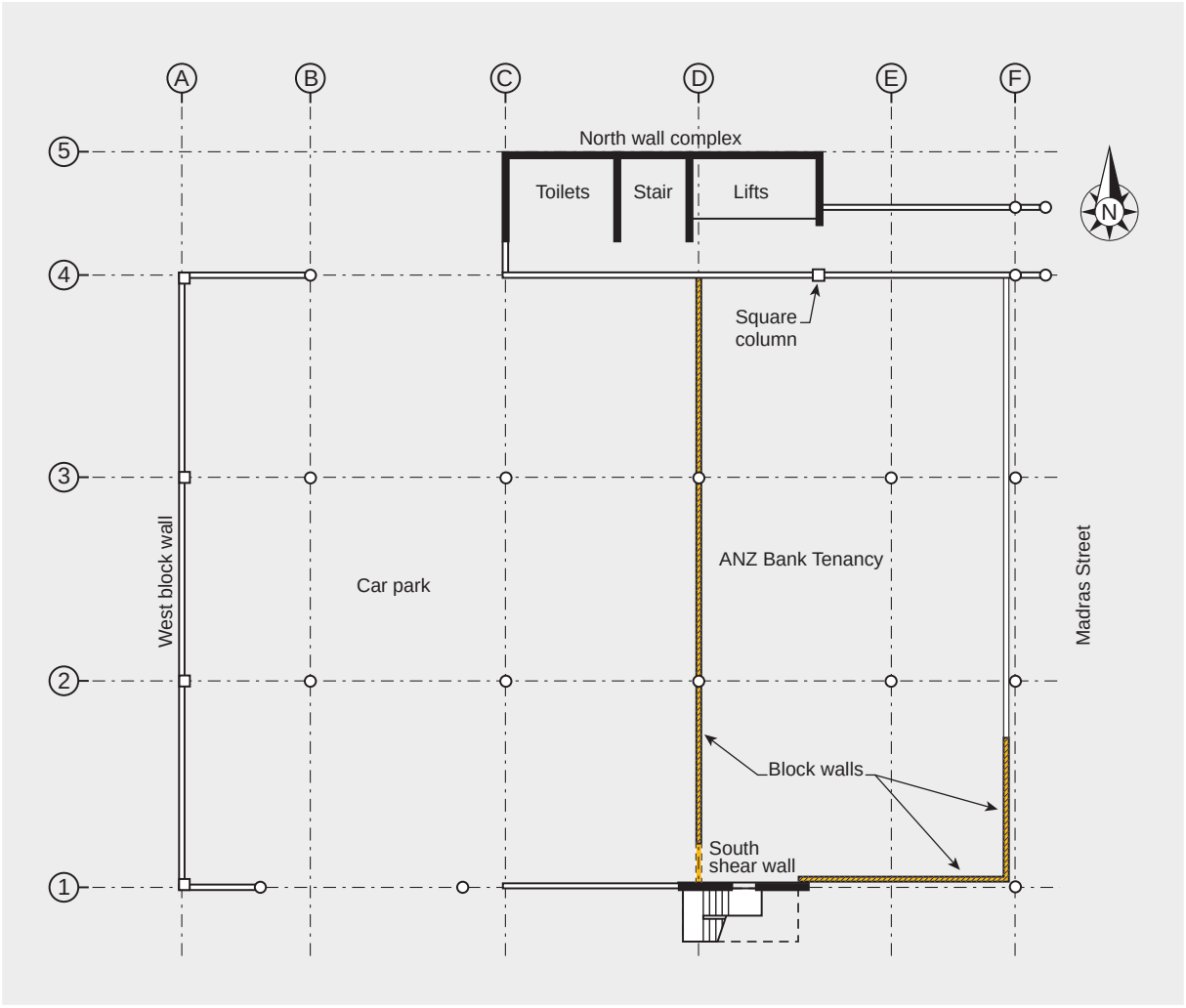


Figure 27: Level 1 showing the extent of area converted to office space for ANZ in 1991

2.5.2 CHTV tenancy fit-out in 2000

2.5.2.1 Building consent

On 28 April 2000, Warburton Team Architecture Limited applied for a building consent for "Interior fit-out, levels ground and first floor, new internal stair, new exterior canopy" for CHTV. The stated intended use was "office" and it was noted that this was not a change of use. The work included a further extension of office space into the car park on level 1 and other than lightweight internal partitions became the final form of the building up until the February earthquake.

2.5.2.2 Installation of internal stairwell

The building consent application included cutting a penetration in the floor of level 2 so that an internal stairwell could be installed (see Figure 28). In addition, holes were to be drilled near the east end of the south shear wall. A building consent for the internal stairwell penetration was issued by the CCC on 10 May 2000. We have considered whether this work would have impaired the structural performance of the building in an earthquake.

An engineer from Falloon and Wilson Limited designed the floor penetration. Mr Falloon, who is principal of the company and was a Registered Engineer, checked the design and signed a producer statement. Mr Falloon gave evidence at the hearing that he carried out calculations to check the gravity loads but not the lateral loads. However he considered that the lateral load paths from the floor diaphragm would not be altered because the area cut out for the stair opening was only a small proportion of the total floor area. The rest of the floor diaphragm was available to transfer lateral loads to the shear walls. In his opinion, level 2 would not attract as much lateral action as the upper floors.

The Royal Commission asked Mr William Holmes to assess this design. Mr Holmes expressed the opinion that, "…the connection of a trimmer beam with drilled in dowels at the end of a major shear wall should have included a note to carefully monitor drilling and avoid cutting of bars". Mr Falloon agreed with this in hindsight. He had no specific recollection of the observation of the project, so could not confirm if the drilling of the holes had been monitored.

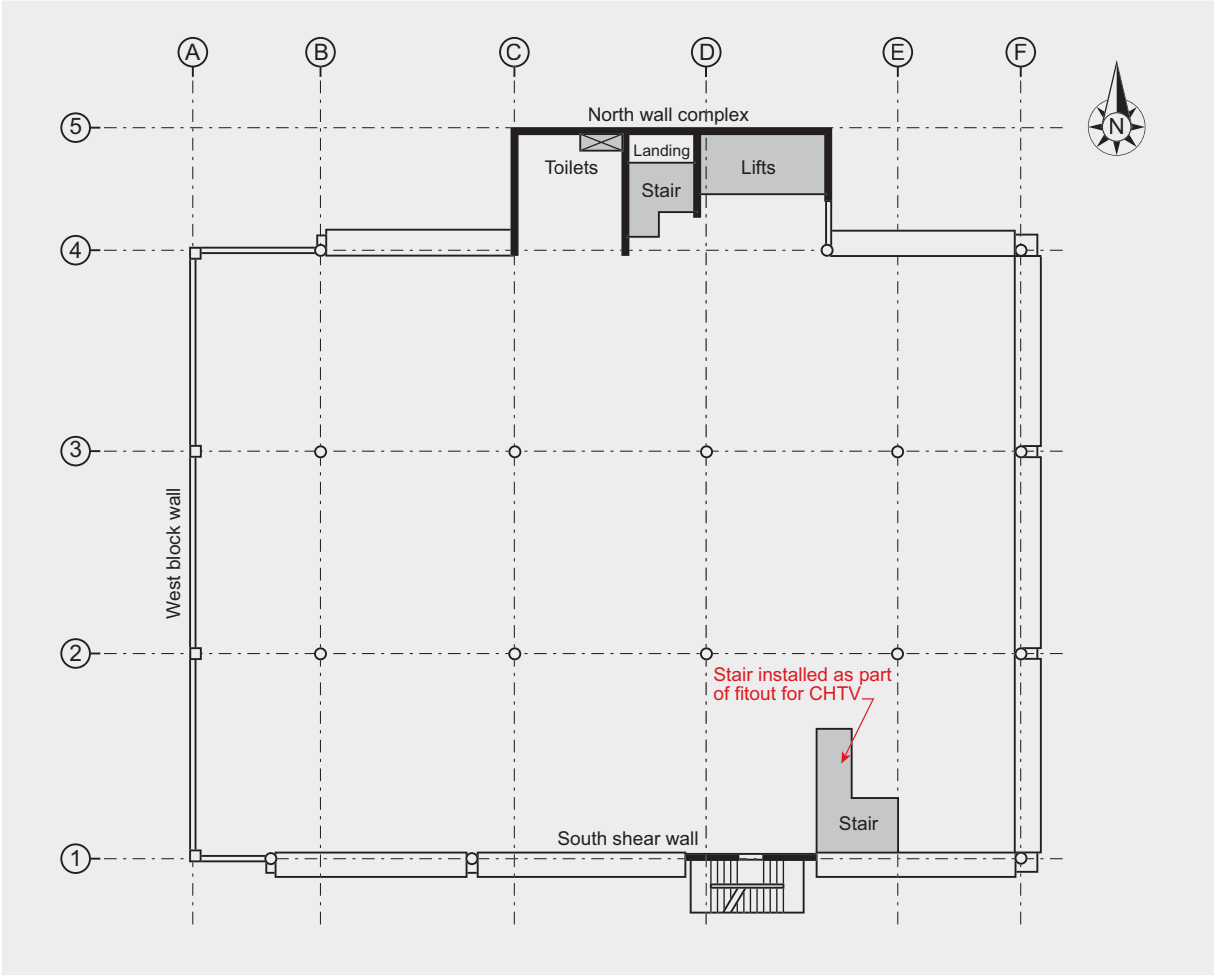


Figure 28: Level 2 showing location of stair installed for CHTV fit-out

After the collapse of the building, Dr Heywood took a photograph of the end of the steel beam that attached to the south shear wall (Figure 29). It can be seen in this photo that an additional hole has been drilled in the beam. We consider that it is likely that the original hole conflicted with the location of reinforcing steel so was relocated; however there is no evidence to confirm this. Relocating the fixing bolt would be consistent with the construction worker hitting steel as it would be difficult for a masonry bit to drill through that steel.

Figure 29: End of trimming beam

The penetration in the floor of level 2 was taken into account in the non-linear time history analysis (which was carried out as part of the DBH investigation). Mr Ashley Smith said in evidence that the penetration did not encroach onto the south shear wall and the remainder of the connections to the wall, along with the connections to the line 1 beams, were considered adequate to transfer seismic forces into it.

The Royal Commission asked Mr Holmes to calculate whether the penetration could have had any effect on the seismic performance of the CTV building. Having considered the matter he concluded that, "the vertical flange reinforcing was not cut by the installation of the western trimmer beam and therefore this installation had no effect on the seismic performance of the building". There was no evidence to the contrary.

In our view, the penetration of the level 2 floor would not have affected the seismic performance of the building.

Recommendation

107. Where holes are required to be drilled in concrete, critical reinforcing should be avoided. If it cannot be avoided, then specific mention should be made on the drawings and specifications of the process to be followed if steel is encountered, and inspection by the engineer at this critical stage should be required.

2.5.3 Going Places tenancy fit-out in 2001

2.5.3.1 Building consent

Going Places was a language school. On 16 May 2001 Design Edge Limited submitted an application for a building consent to the CCC. The work was described as a new fit-out. It was stated to be a change of use and was treated by the CCC on that basis. A building consent was issued on 20 June 2001.

2.5.3.2 Change of use

As the work was considered to be a change of use, Section 46(2) of the Building Act 1991 applied:

> (2) **The use of the building shall not be changed unless the territorial authority is satisfied on reasonable grounds that in its new use the building will—**
>
> (a) **Comply with the provisions of the building code for** means of escape from fire, protection of other property, sanitary facilities, and **structural and fire-rating behaviour**, and for access and facilities for use by people with disabilities (where this is a requirement in terms of section 25 of the Disabled Persons Community Welfare Act 1975) **as nearly as is reasonably practicable to the same extent as if it were a new building**; and
>
> (b) **Continue to comply with the other provisions of the building code to at least the same extent as before the change of use.**
>
> [emphasis added]

Subsection 2(a) is important because a change of use of a building could result in a structural upgrade. In the case of a building like the CTV building, which was designed under previous codes, it provided a statutory mechanism by which the building could be brought to a state closer to current building codes.

The owner was obliged under section 46(1) of the Building Act 1991 to advise the CCC of the change of use. This obligation was met by the declaration on the building consent application form.

A fire report was submitted to address means of escape from fire. Sanitary facilities and access and facilities for people with disabilities were addressed in response to issues raised by the CCC during the assessment process.

The only reference on the CCC file to the structural behaviour of the building is in a "Structural Checklist" completed by Mr Peter Harrow, a Senior Structural Engineer at the CCC. This is reproduced as Figure 30.

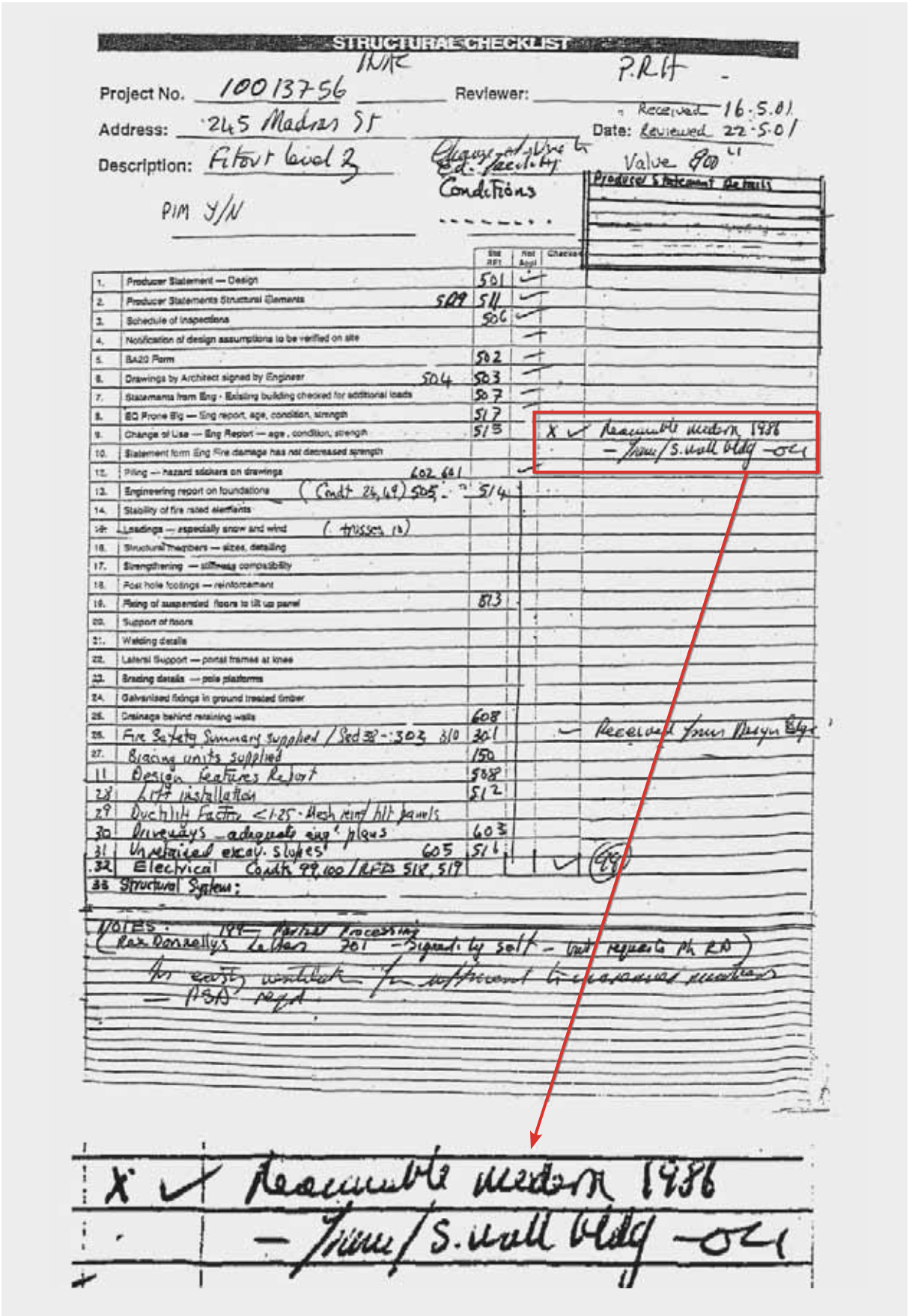


Figure 30: CCC structural checklist for Going Places building permit application

The relevant note shown in the red box on Figure 30 read:

> Reasonable modern 1986
>
> -Frame/ S. wall bldg- OK

Mr McCarthy of the CCC gave evidence after making enquiries of Mr Harrow. Mr McCarthy said that Mr Harrow:

> ...looked at the layout of the particular floor involved and determined that the extra 20 people would not have increased, structurally increased the live load on the floor to an extent where he felt that there was a structural upgrade required. …He advises me that typically buildings built after 1976 were generally considered to be, at this time, around about two-thirds of the design code as at early 2000.

Mr McCarthy was asked if Mr Harrow gave any consideration to the age of the building and the code that it would have been built under:

> Yes he did. That's, I think, apparent from the words in the, alongside of the change of use so I think what he – what that says is something like this was a modern 1986 building with a shear wall, a shear wall frame building… so that was his consideration.

When asked if he knew if any consideration was given to the fact that there had been a change to the code in 1995, in particular as it affected transverse reinforcement in columns Mr McCarthy said:

> I am not aware of that…but certainly what I would say is that Mr Harrow would have been very well aware of that, he's – and broadly I think that would have been in the consideration of the fact that there was two-thirds – the building was assessed at being approximately two-thirds of the code at that stage.

Section 46(2) of the Building Act 1991 required the CCC to be satisfied on reasonable grounds that in its new use, the building would comply with the provisions of the Building Code for structural behaviour as nearly as is reasonably practicable to the same extent as if it were a new building. Mr Laing for the CCC referred to Auckland City Council v New Zealand Fire Service[12] as the only authoritative case law at the time of the application. In that case, Justice Gallen said:

> In the end, what the cases say is that the obligation is not absolute. It must be considered in relation to the purpose of the requirement and the problems involved in complying with it, sometimes referred to as "the sacrifice." A weighing exercise is involved. The weight of the considerations will vary according to the circumstances and it is generally accepted that where considerations of human safety are involved, factors which impinge upon those considerations must be given an appropriate weight.

Counsel assisting submitted that the CCC did not have reasonable grounds to conclude that the building would in its new use comply with structural requirements as nearly as was reasonably practicable to the same extent as if it were a new building. It was submitted that there is no evidence of any consideration of this issue other than what is recorded in the checklist, and this is limited to the age and general type of building.

Mr Laing referred to the evidence given by Mr McCarthy about what Mr Harrow had done and submitted that there is evidence that the CCC was aware of the differences in codes and the implications of this. It was submitted that the CCC could reasonably have concluded that the building complied "as nearly as reasonably practicable" in terms of structural behaviour. It was also submitted that it is not appropriate to single out changes to requirements for transverse reinforcement to columns as something that should have been addressed, because it would set an unreasonably high standard of scrutiny in the exercise of the CCC's powers relating to a change of use: it would have involved a significant review of the structural drawings as a whole and of the relevant codes.

It would have been reasonable for the CCC to request that the owner provide verification of the structural compliance of the building in terms of section 46(2). The CCC may then have been able to make an informed decision without making generalised assumptions. It appears that it was considered that without further analysis, two-thirds strength of the current building code requirements was as near as was reasonably practicable to current code requirements. The CCC assumed that, as they had issued a building permit for the building and inspected it during construction, it complied with the codes of 1986. Although the approach taken by the CCC was not without risk, we doubt that it can be criticised for failing to comply with the Building Act 1991. Given that the CTV building was a relatively new building and the change of occupancy was of only one floor, we doubt that the CCC was required to do more.

2.5.4 The King's Education tenancy

King's Education was primarily a school for English as a second language. It moved into level 4 of the CTV building some time before May 2008. Counsel for the CCC informed the Royal Commission that the CCC's position was that the tenancy amounted to a change of use. However, the CCC held no record of any notification of the tenancy.

Seventy-one students and nine staff died on this floor when the building collapsed. It is likely that the occupancy numbers, and hence the number of fatalities, would have been significantly less than this if the use had remained as office space.

Madras Equities failed to comply with section 46 of Building Act 1991 or section 115 of the Building Act 2004 by allowing the use of level 4 to change without first obtaining CCC approval. Had this approval been sought, the CCC would have been required to be satisfied on reasonable grounds that in its new use the building would comply with the provisions of the Building Code for structural behaviour as nearly as is reasonably practicable to the same extent as if it was a new building. In the absence of clear evidence of the date King's Education moved in, it is not clear which Act applied.

We cannot speculate what action might have been taken had Madras Equities advised the CCC of the change in occupancy. It is nevertheless appropriate to note that the failure to advise the CCC of the change of use meant that the intended statutory protection for users of the building was unable to have any effect.

2.5.5 Holes drilled for the installation of services

Counsel for ARCL and Dr Reay called evidence from Mr Daniel Morris, a former owner of a concrete cutting business Knock Out Concrete Cutters, about the drilling of holes through concrete and reinforcement in the CTV building. He said that between 1995 and 2000 his company was contracted to drill holes in the building in order to install services. He said that as many as 200 holes with diameters ranging from 40–100mm could have been drilled, although when he was cross-examined acknowledged he had not personally been on site and was only guessing at the number and location of holes drilled. Indeed, he accepted that his estimate of numbers could be "wildly inaccurate". We did not hear any other evidence that holes of that size were drilled in structurally significant parts of the building. Mr Frost and Dr Heywood, who were on the site of the CTV building after it collapsed (as discussed in section 5.1), and who examined debris at the Burwood landfill, did not report any holes in beams. Dr Heywood stated that he had looked at approximately 10 internal beams during the USAR operation following the collapse, and a similar number at the Burwood landfill, and did not see any cored holes. Further, no holes in beams were recorded in the Hyland "CTV Site Examination and Materials Tests"[13] report.

The building permit and consent plans for alterations to the building show holes were to be drilled in floor slabs for plumbing services. The location of these holes was, without exception, such that none would have been required through the concrete beams on grid lines 2 and 3. If any holes were required to have been drilled in beams then it is likely that these would have been in the beams on grid line 4 beside the toilet block. If there were holes in these beams it would be expected that they would have been reported as they were visible until the north wall complex was demolished.

In summary, we are unable to find on the evidence that significant holes were drilled in the structural members of the building. We consider it is unlikely that any holes that were drilled would have had any effect on the seismic performance of the building.

2.5.6 Status of the building immediately before the September earthquake

2.5.6.1 Earthquake-prone status

The Building Act 2004 contains a definition of "earthquake-prone building". Buildings that fall into this category in Christchurch must comply with the CCC's earthquake-prone buildings policy under which structural upgrading is required within a specified time. There is extensive discussion of these matters in Volume 4 of this Report.

The CTV building was not identified as earthquake-prone before the 4 September 2010 earthquake. This is consistent with the opinion expressed in the Hyland/Smith[8] report that the building's capacity would have been in the order of 40–55 per cent of new building standard, at a time when the earthquake-prone building threshold was 33 per cent.

2.5.6.2 Building warrant of fitness

The building had a current building warrant of fitness that had been signed by the owners' authorised agent on 27 May 2010, and which was valid until 1 May 2011.

The warrant of fitness does not relate to any structural item, however the form notes that the current, lawfully established use at that time was “WL Offices”, with no reference to the school activity. The WL reference (Working – Low fire load) is likely to refer to the fire purpose group for offices from the compliance documents to Building Code Clause C – Fire Safety. Using the same purpose groups, the school activity would have been CS (Crowd – Small) for this building. The stated maximum number of occupants that could safely use the building on the form was 180. It is likely that the number of occupants was less than this number at the time of the February earthquake.

The warrant of fitness information is not consistent with information held elsewhere on the CCC file for the building in respect of its use, but this was not a factor in the collapse of the CTV building.

References

1. *Duncan v Alan Reay Consultants Limited* HC CHCH, CIV 2006-409-251 [1 December 2008]

2. Noble, Judge G.S. (1995). *Report of the Commission of Inquiry into the Collapse of a Viewing Platform at Cave Creek Near Punakaiki on the West Coast*.

3. The evidence was unclear as to when Mr Harding became an Associate. It was suggested by Mr Rennie QC that he gained this status when his hourly rate was increased from $53 per hour in May 1986 to $60 an hour in June 1986. Mr Harding said that this was possible but he could not recall when he became an Associate.

4. NZS 4203:1984. *Code of Practice for General Structural Design and Design Loadings for Buildings*, Standards New Zealand. Clause 3.7.4.1(c) provided that for irregular structures more than four storeys high, horizontal torsional effects shall be taken into account by the three-dimensional model analysis method of Clause 3.5.2.2.2. Mr Harding used the word "eccentric" in his evidence, describing why he believed an ETABS analysis was mandatory for Landsborough House but that his use of the word "eccentric" in this context means the same as "irregular".

5. Christchurch City Council. (1985). *Christchurch City Council Bylaw Number 105 (Buildings*). Available on request from the Christchurch City Council.

6. NZS 3101:1982. *Code of Practice for Design of Concrete Structures*, Standards New Zealand.

7. It is not clear how many of these were engineers.

8. Hyland C., and Smith, A. (2012). *CTV Collapse Investigation for Department of Building and Housing: 25 January 2012*. Wellington, New Zealand: Department of Building and Housing.

9. NZS 3109:1980. *Specification for Concrete Construction*, Standards New Zealand.

10. Christchurch City Council. (1990). *Christchurch City Council Bylaw 1990*. Available on request from the Christchurch City Council.

11. The definition of "building" in the Bylaw goes on to provide a list of matters specifically excluded from the meaning of the word "building", none of which are relevant to the matter we are considering.

12. *Auckland City Council v New Zealand Fire Service* [1996] NZLR 330. (NZLR are the New Zealand Law Reports).

13. Hyland, C. (2012). *CTV Building Site Examination and Materials Tests for Department of Building and Housing: 16th January 2012*. Wellington, New Zealand: Department of Building and Housing.

Note: Standards New Zealand was previously known as the Standards Association of New Zealand and the Standards Institute of New Zealand.