Wellington Children's Hospital - a different approach to a seismic restraint project

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ABSTRACT

Due to the construction of the new Wellington Children's Hospital being approached as an ECI project, the design approach for the seismic restraints for non-structural elements was different to what occurs on many other projects. From the start of the design stage, the seismic restraint design was for the Non-Structural Elements (NSEs) that were actually going to be installed, not for the services that were envisaged at the design stage but might change after the contract got awarded. Because of the confidence this gave to the overall project, the seismic restraints and services were fully modelled during design. This model was used as the basis for shop drawings. For economical and ease of construction reasons, there was a strong desire to optimise and simplify the seismic restraint design and this involved the use of cradle frames in congested areas that restrained multiple services. As a result of the additional time and detailed modelling, the seismic restraint design could be highly engineered, optimised and fully modelled. This resulted in a design that was efficient both in terms of the engineering and construction. Construction ran smoothly with minimal modifications being required. The intention of this paper is to provide details of the approach used on this project with the hope that other engineers can use some aspects of this approach to achieve success in their seismic restraint projects.

1 INTRODUCTION

The new Wellington Children's Hospital is designated to Importance Level 4 for structural components and the seismic restraint of non-structural elements. The seismic restraint design was to the relevant New Zealand Building Codes. The seismic restraints were fully modelled. The construction/installation of seismic restraints on this project has been very successful with no significant clash or compatibility issues, that commonly occur on some other seismic restraint projects. During the course of installation, only a minimal number of modifications were required to the modelled design.

Some of the key aspects that we consider led to this project being so successful, that we will cover in this paper are:

1. ECI (early Contractor Involvement),
2. The prioritisation of seismic restraint design from the very start of the project,
3. Ownership of the modelling of all services, partition walls and ceilings by the main contractor,
4. The use of cradle frames throughout to optimise the amount of restraint in congested areas,
5. The use of prefabrication.

2 BACKGROUND

Sir Mark Dunajtschik was approached to donate to the construction of a new Children's Hospital in Wellington. Instead of donating towards the cost of construction, Sir Mark Dunajtschik offered to pay for, build and donate the Children's Hospital to the Wellington region. Sir Mark Dunajtschik entered into a Development Agreement with Capital and Coast District Health Board (CCDHB), later known as Te Whatu Ora Capital and Coast

Sir Mark Dunajtschik selected McKee Fehl to be the main contractor for the project. The team for this project were the following:

Architect- Studio Design + Architecture

Structural Engineer- New Zealand Consulting Engineers

Services engineer- Aurecon

Fire Engineer- Fire HQ

Seismic Restraint Engineer- Silvester Clark

BIM - McKee Fehl and sub-consultant

The Wellington Children's Hospital is considered an Importance Level 3 Building for services, as it does not have post disaster functions. However, to provide greater life safety and resilience, the primary building and the seismic restraint of non-structural components were designed for Importance Level 4 demands.

The building is base isolated with triple pendulum isolators. The lateral load resisting structure above the isolation plane consists of steel moments frames in both directions. The gravity structure consists of Comflor (composite metal tray deck) floors supported off the steel beams and columns.

3 ADVANTAGES OF ECI

When a project is designed by consultants, tendered and then constructed by the successful contractor, a lot of decisions that have been made by the design team get altered. One of the main reasons for this is that the successful contractor and sub-contractors, will have allowed for their preferred products and material pricing. For example, a consultant may propose a steel mechanical duct and the contractor may elect to use a composite duct. There is also a tendency with the traditional approach for the seismic restraint design to be a performance specification. What this will mean is that the seismic restraint design can end up being a just-in-time design that occurs after the contract has been awarded. Also, with a traditional approach, there is a tendency to not fully coordinate the seismic restraint design because it is recognised that modifications are likely once the contract has been awarded. Often the seismic restraint design is left to the subcontractors for the individual trades to design and document. This often means the design is not coordinated with other subcontractors.

With the Wellington Children's Hospital being managed with ECI (Early Contractor Involvement) meant that the contractor had control of the services from the start of the design stage. From a seismic restraint design perspective, this meant that the design could start earlier and be documented in detail because this work would not need to be amended later. This simple difference meant there was far more time to consider and optimise the seismic restraint design. It was not the case of a just-in-time approach to the restraint design. This also meant there was more time to explore options to optimise the design by working collaboratively with the services consultants to locate services to suit seismic restraint.

4 PRIORITISATION OF THE SEISMIC RESTRAINT DESIGN

From the start of the project McKee Fehl recognised the need to ensure a fully compliance seismic restraint design and made this a priority. They engaged Silvester Clark as the seismic restraint engineers in 2018 and embedded us in the design team. They gave us free range to propose methods to optimise the design such as the use of frames in congested areas. This was a luxury compared to some other seismic restraint projects where we are required to make the seismic restraint design work around what the services engineers have already designed and documented.

McKee Fehl also recognised that if seismic restraint solutions were developed early, this would de-risk the construction phase and reduce the potential for construction delays. Early consideration of seismic restraint design also meant that cost efficiencies could be explored, tested and incorporated if appropriate.

Often on projects, the seismic restraint design can be treated as something that needs to be done but not something that is a priority. As a result, it is often put onto individual subtrades to design the restraints for their services. This includes subcontractors having their own individual engineers provide designs, coordination, solutions, and Producer Statements that only apply to the one trade. Issues to do with the compatibility with other services get overlooked. When it comes to the installation of services and restraint it is often a case of first in, first served. This often means that there are significant clash issues between services and restraints that could be avoided if they had all been modelled in the same model.

Another advantage of the design approach adopted for this project was that the restraint solution could be considered holistically and shared to provide restraint to many Non-Structural Elements (NSE). The main areas where this was beneficial was in the corridors where services were particularly congested. With services sharing a cradle system, without the need for individual braced services, there was far less congestion and issues associated due to lack of clearances. This meant a significant reduction in gravity supports as the cradle systems could both restrain and support all the services on it. In many corridors the cradles were also used to restrain suspended ceilings and partition walls.

5 CONTRACTOR OWNERSHIP OF MODELLING

The main contractor, McKee Fehl, used their own internal BIM resources, as well as using an external consultant for some areas, to model the non-structural elements and the seismic restraints. McKee Fehl had full control of the BIM and collaborated with subcontractors to optimise the design. This had the advantage of simplifying coordination. Services could be relocated to suit seismic restraints and vice versa without needing complicated collaboration and the delays associated, where consultant modellers liaise with each other with often several parties involved (seismic restraint engineer, mechanical engineering, hydraulic engineer, and other services engineers).

In congested areas the total weights of services were calculated based on consultant design layout drawings. Rules for the layout and spacing of cradles were determined based on the density of services in various areas. With McKee Fehl input, cradle layouts were optimised to minimise the need for bridging angles and aligning droppers with comflor ribs where possible.

Away from congested areas, when the services became individual runs, we supplied restraint rules (type of restraint system and spacing) and restraints were modelled accordingly. We reviewed the models and drawings to ensure what we had designed, and the rule we had provided, had been correctly implemented.

As with all seismic restraint projects there were still situations where standard solutions would not work, and bespoke solutions were required. In these cases, it was still easier to achieve a bespoke solution than we have found for traditional projects as there was only one lead modeller who needed to be liaised with. The McKee Fehl BIM modelling team could liaise with the other relevant consultants and subcontractors to ensure any modifications to a service did not compromise the design intent.

The overall results of the design approach were very satisfactory. Having the BIM owned and supervised by the Main Contractor meant design and coordination times were efficient.

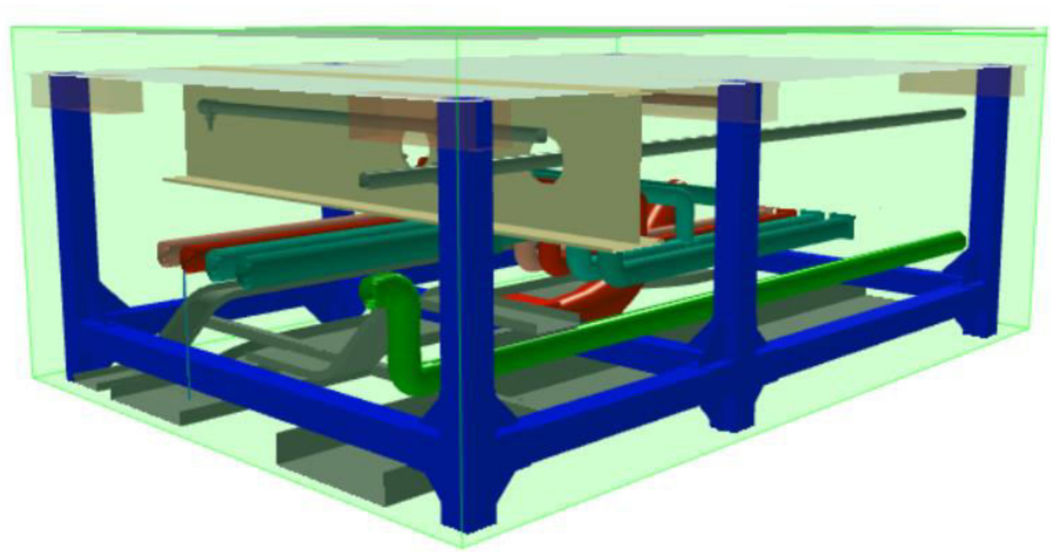


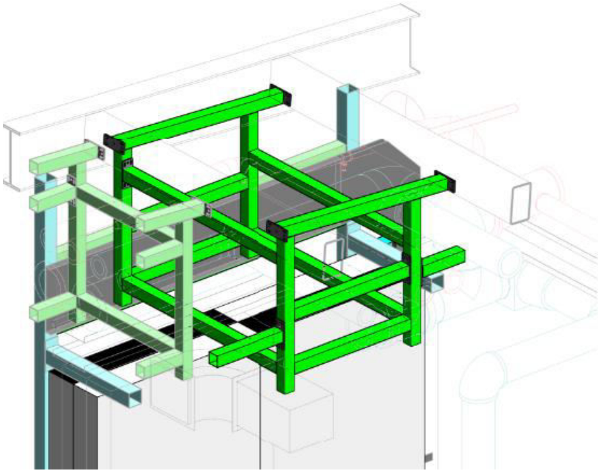
Figure 1- 3D view of modelled services and cradle frame

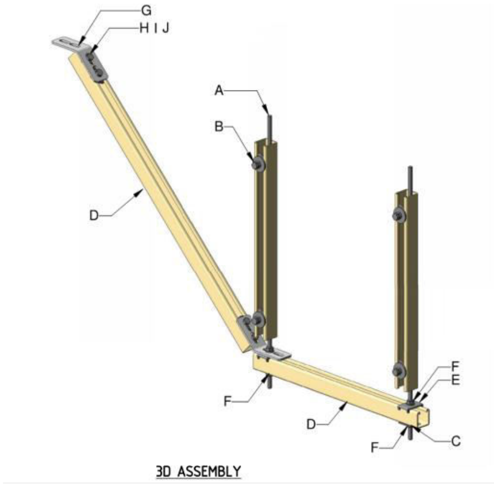
6 DESIGN OPTIMISATION

One driver from McKee Fehl for this project was to optimise the design for economic and speed of installation reasons. This was achieved through simplifying and standardising the restraint systems as much as possible. Throughout the majority of the corridor areas, cradle frames constructed out of SiFramo by Sikla were used. The cradle systems used proprietary connections. We liaised with Sikla to obtain properties for frame sections and connection so we could accurately model the frames. Weights per metre length for the services in corridor areas and the set of services were used to determine the appropriate geometry of the cradle frames. We were able to import and review the BIM and use this information to design appropriate cradle frames.

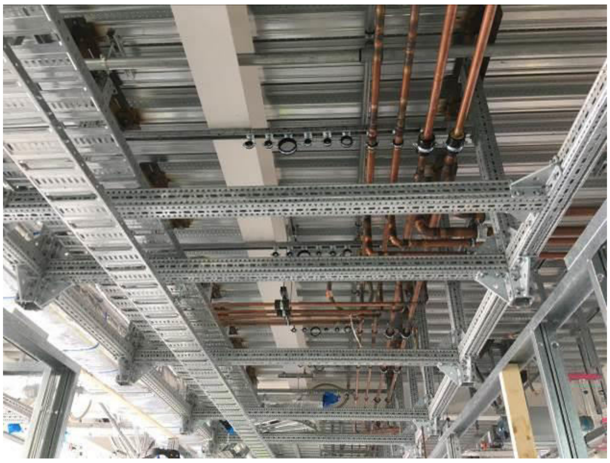
The cradle frames were also used to brace partition walls and some ceilings.

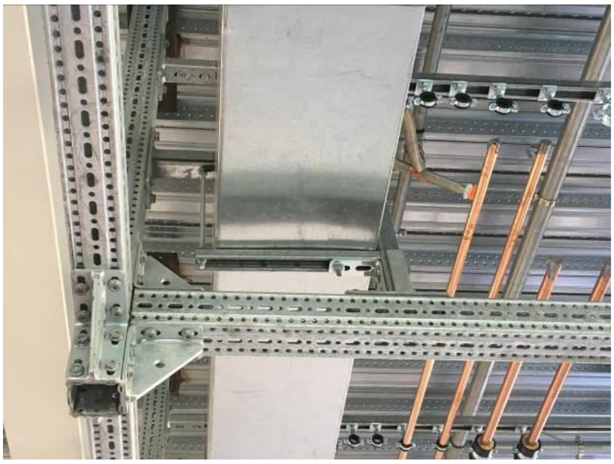
The part coefficients/accelerations for the design of services were provided by the structural engineer for the building, New Zealand Consulting Engineers Limited. These came from the model they had used to analyse the building.





Figures 2 and 3- 3D of cradle for shared service and 3D of trapeze for individual restrained services





Photographs 1 and 2- Cradle frames with installation of services occurring

All parts of the restraint system were modular with off-the-shelf systems used. These systems include Sikla Framo for individual services runs for items such as duct, cable tray of pipework. For suspended ceilings, the proprietary Tracklok system was used. Anchor connections to the structure were achieved using seismic qualified anchors.

Photographs 3 and 4- Individually restrained services

7 PREFABRICATION

To further optimise the installation, the cradle frames were prefabricated. This involved point cloud surveying the soffit of the Comflor so that connection brackets arrived on site suitably detailed for the situation where they would be installed.

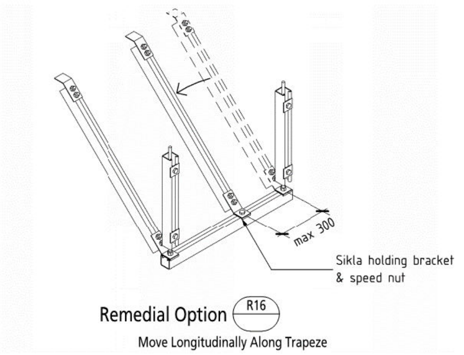
The prefabricated cradle frames were installed on site prior to services being installed. This meant that services were installed onto the restraint system rather that the restraining structure being installed around the services. If there were any issues with the location of services, they could be adjusted to suit the frames. As those involved in seismic restraint installation will understand, this is far easier than trying to fit seismic restraints around congested services.

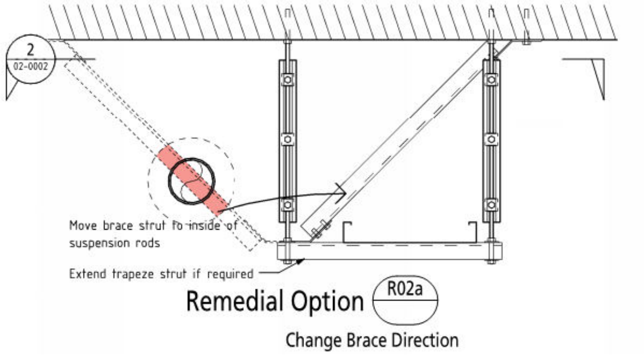
Photograph 5- Cradle frames installed prior to services installation.

8 MONITORING GENERAL

Monitoring was carried out using the software program PlanGrid. PlanGrid uses a pdf platform. “Stamps” are applied to each seismic restraint on the plan pdf. The stamps can be opened, photos taken and marked up to show any remedial work required. Alternatively, as was mostly the case, the restraint can be signed off in PlanGrid as correctly installed.

In the case of this project, we found that the overall monitoring went smoothly due to modulisation of the cradles. As with all projects, there were a few challenges that arose but once solutions were developed, these could be applied when this issue arose again.





Figures 2 and 3- examples of remedial options.

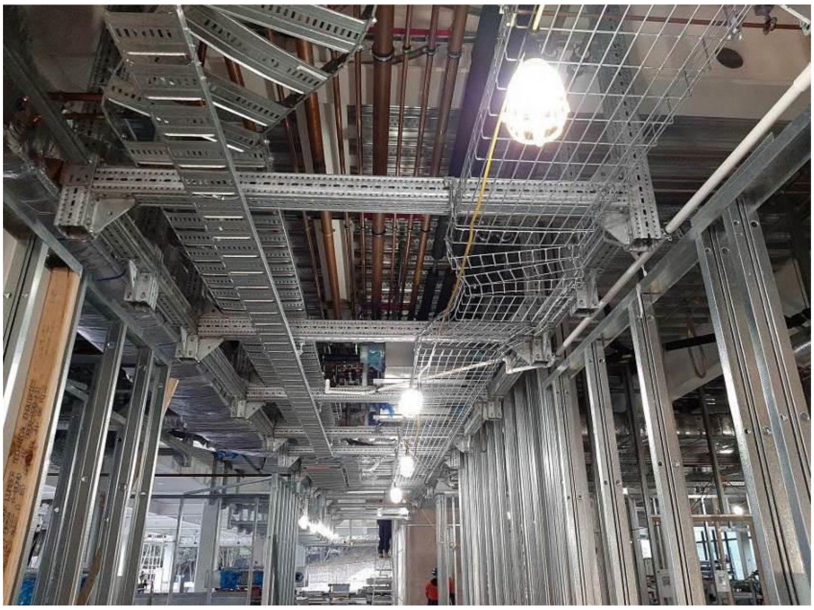
9 DISCUSSION

A challenge with the seismic restraint design for traditionally run projects is engineering a restraint design that will survive through to construction. This is often not possible due to inevitable modifications that occur when the design is inherited by the successful contractor. Achieving a well-engineered design can also be compromised by time constraints once the contractor takes ownership of design. Design and documentation projects tend to occur just-in-time before it is too late to install restraints. This results in the designs being rushed, not fully considered, not well modelled (if at all) and not optimised. This can be particularly challenging when individual subcontractors are designing restraints for their service in isolation from other subcontractors, with responsibility for design and sign-off of the restraint design the responsibility of the individual subcontractor.

Due to the way the Wellington Children's Hospital project was contracted, this meant that the seismic restraint design did not need to change after the contract was awarded. It also meant there was more time to consider and properly engineer the restraint design to avoid having to modify the design or accept a compromising design during construction.

In our opinion, the way the Wellington Children's Hospital project was run is an optimum way to achieve a fully compliant and efficient design. We have not experienced a project that ran as smoothly through the design and construction phases. We appreciate that most projects do not have a high level of ECI involvement and design management. However, there are still many aspects from this project that could be considered to help make other projects better engineered. For example, having a lead BIM modeller to coordination of the seismic restraints for services, ceilings and partitions. Also, the design in congested areas could be optimised by assuming the use of cradle frames at the start. Alternatively, if responsibility for restraint design is put onto the successful contractor, the specification could stipulate frames in designated congested areas and that the subcontractors take responsibility for the restraint design in areas where services are not congested.

One aspect of the design approach that cannot be overstated was the prioritisation of the seismic restraint design. Seismic restraint was not treated as something that had to be done for compliance. It was not something that was considered after the services had been designed. The responsibility for seismic restraint design was not deferred to subcontractors. A well-engineered seismic restraint design was considered an essential part of this project success. It formed a key consideration when locating services.



Photograph 6- View of frame in congested corridor area while services installation is occurring

10 CONCLUSIONS AND RECOMMENDATIONS

This paper has described the reasons the seismic restraint design for the new Wellington Children's Hospital was successful in achieving well-engineered and efficient seismic restraint solutions. Some of the reasons for the success are as follows:

1) The contractor and design team considered a key component to the success of the project was having a well-engineered and modelled seismic restraint design.
2) There was high level of ECI involvement and management in the design stages meaning there were not significant changes that occurred during the construction stages.
3) The seismic restraint design was prioritised and considered from the start of the project as the services were being designed. Just-in-time seismic restraint design was avoided.
4) The Main Contractor (McKee Fehl) lead the BIM modelling. This greatly simplified the modelling and coordination of seismic restraints.
5) The seismic restraint design was optimised with the use of cradle frames in congested areas. These cradles provided seismic restraint and gravity support to multiple services. The use of cradle frames helped alleviate congestion through not requiring sway braces to individual services.
6) Prefabrication was used with cradle frames installed prior to the services being installed. This sped up construction and reduced installation delays.

The combination of all these factors resulted in a well-engineered compliant restraint design that required far less modification during construction. While it will not be possible on every project to achieve all the factors that helped make this restraint project successful, there are many aspects that could be adopted for projects that are not design and build.

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