Former Magistrates’ Court Building – Strengthening and Performance

Andrew Brown, Jonathan Hill, Carole-Lynne Kerrigan, Murray Mitchell, John Newall

Opus International Consultants Ltd.

2013 NZSEE Conference

ABSTRACT: The original Magistrates’ Court, designed by renowned architect Benjamin Mountfort, was built in 1880-1881 and, as such, is the oldest purpose-built court building in Christchurch. In the 1990’s the Magistrates Court was converted for use as the new family court. As part of the refurbishment of the building, Opus International Consultants (Opus) designed a substantial strengthening scheme that aimed to significantly improve the seismic capacity of this heritage building.

This paper is a case study, discussing the performance of the building and the effectiveness of the strengthening works in preventing damage to the heritage fabric, including identifying areas for improvement. The paper will also present the options and solutions considered for repair of earthquake damage, the selected repair methods and solutions for addressing historic maintenance issues, including the heritage considerations that were integral to these solutions.

1 INTRODUCTION

1.1 Magistrates’ Court, Christchurch

The former Magistrates’ Court is sited in Armagh Street, Christchurch and forms part of the Christchurch justice precinct. The building consists of a two-storey central block surrounded by a single storey structure providing a footprint of approximately 650m^2. The building was constructed in three periods and comprises the two-storey judge’s chambers and single-storey rear court room built in 1880-1881, the front court room building built in 1908-1909, and the public lobby, which was added in 1997. The relative location of each section of the building from the different building eras is shown in Figure 1.1.

The original section of the Magistrates’ Court was designed by Benjamin Woolfield Mountfort who is described by the Historic Places Trust as “one of the foremost architects in Victorian New Zealand” (NZHPT, 2012). Between 1908-1909 a second building was added to the south end of Mountfort's design. This includes a high single storey building on the Armagh Street frontage (refer Figure 1.2), along with a two storey section to the eastern end. This section of the building was designed by A F Macrae, working for the Department of Public Works, who used similar construction methods and design features to the Mountfort building (NZHPT, 2012).

The building is constructed of a base course of green Heathcote trachyte, walls of Port Hills trachyte, and facings of Oamaru limestone.(NZHPT, 2012) Offices and courtrooms are either plastered or lined with brick and stone. Roofing materials include corrugated iron (1880-1881 portions) and slate (1908-1909 portion).

In the 1980’s the building became disused before being converted for use as the new Family Court complex in the late 1990’s. As part of this refurbishment a new lobby was added and the building underwent a substantial seismic upgrade.

The building is now owned by Ngai Tahu Properties Ltd with the Ministry of Justice being a long-term tenant. Its age makes it the oldest purpose built court building in Christchurch.

Figure 1.1: Aerial image showing the staged construction of the building (image courtesy Google Earth)

Figure 1.2: Magistrates' Court, Armagh St elevation prior to September 2010

1.2 **Heritage Significance**

The Magistrates' Court building was added to the Historic Places Trust register in 1991 as a Category I Historic Place. Category I status is given to places of 'special or outstanding historical or cultural heritage significance or value'. In accordance with the Historic Places Act 1993 the former Magistrates' Court building and precinct is also recognised as an archaeological site as it is associated with pre-1900 human activity.

At this time the significance of Mountfort's contribution to the development of Christchurch city was widely acknowledged. This was further emphasised by the contribution the court had made to the development of Christchurch. The Building Classification Committee report presented to the NZHPT stated that "Having served Canterbury for 109 years the Magistrates' Court has historical associations with the community of this region and with the development of New Zealand's judicial system." And of Mountfort "…New Zealand's pre-eminent Gothic Revival architect. It is a simple but refined example of his prodigious design talents."(NZHPT, 2012)

2 BUILDING STRENGTHENING

2.1 Building Upgrade and Structural Upgrade

The building was in a neglected state by the late 1980s. It was leaking, being used as a derelict storage area and had been considered for demolition. Opus investigated the feasibility of converting the building into a facility for the new Family Court, which included transformation of the building to accommodate secure judge's access, spaces for tribunals and court proceedings, public spaces and administration area. The project was shown to be feasible and strengthening for the existing unreinforced masonry building was designed to meet the Ministry of Justice requirements for court facilities to be seismically strengthened.

The strengthening scheme aimed to improve the seismic performance of the building to not less than 67% of the requirements of NZS4203:1992, the loading code in force at that time. Additionally, the strengthening scheme aimed to improve the toughness and resilience of the building by introducing more reliable structural elements into the building. The key heritage objective was to maintain the general external appearance of the original structure. It was accepted that the internal heritage fabric could be altered to achieve the strengthening objectives, as alterations to the layout were required to facilitate the change in use of the building to a family court facility.

The strengthening scheme included the following major works:

- Stripping out all the internal non-structural elements;
- Installation of reinforced sprayed concrete lining to inside of all exterior walls. This included the removal of the inner wythe of the perimeter triple brick walls to accommodate the sprayed concrete without increasing the wall thickness;
- Restraint of the remaining brick wall elements and the Oamaru stone cladding to the new concrete walls by the use of regularly spaced dowel bars tied into the wall reinforcing cage;
- Installation of a new internal concrete foundation below the original floor level to support the sprayed concrete lining and additional earthquake loads associated with the strengthened walls;
- Installation of a new concrete slab throughout the ground floor level as shown in Figure 2.1. This photo is taken at first floor level;
- Installation of new plywood ceiling diaphragm installed under the existing timber roof trusses and throughout the first floor part of the building; and,
- Installation of a new steel frame roof system to create a new entrance area from the western side.

Other secondary elements of the building were also upgraded during these works, including the chimneys and the wall capping stone, which were restrained using steel rod dowels. The chimneys were all specified to be strengthened using reinforced concrete filling of the flue.

The stonework was repointed in areas where it was particularly degraded, including the northern and western walls.

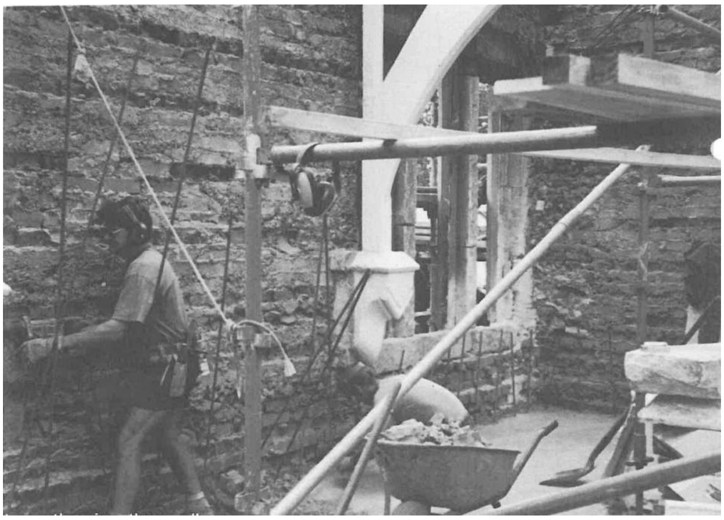

Figure 2.1: Interior stripped out and new ground floor installed prior to installation of reinforcement and sprayed concrete to the walls.

The project was considered a good example of adaptive reuse, and the project team aimed to meet the principles of the 2010 ICOMOS New Zealand Charter for the Conservation of Places of Cultural Heritage Value. The works were completed without any notable alteration to the visual impact on the original facades on the south, east and north sides.

Although the project received a Civic Trust award for the heritage aspects of the project, some heritage advocates at the time considered that too much of the internal heritage fabric had been removed as part of the project: the majority of the internal fit out needed to be replaced to accommodate the functional requirements of the Family Court and the relatively intrusive strengthening scheme. In reviewing the strengthening scheme the authors note that it did not achieve the concepts of transparency and reversibility promoted by New Zealand Historic Places Trust (McClean 2010), as other strengthening objectives of toughness and resilience were considered a higher priority at the time by the designers.

3 BUILDING PERFORMANCE DURING CHRISTHCHURCH EARTHQUAKE SEQUENCE

3.1 Initial Assessment and Securing Works

The former Magistrates' Court building suffered no significant damage during the September 2010 earthquake and continued to function as usual.

As with most buildings in central Christchurch, the building was subjected to intense shaking during the February 2011 earthquake. Nearby acceleration records indicate that the building experienced spectral accelerations in excess (Megget, 2011) of the designed performance level of 67% of the NZS4203:1992 requirements (Andrews; Butcher; Hutchinson; Kolston, 1992). In this context the building is considered to have performed very well, with only relatively minor damage noted to secondary elements following the initial inspections.

Rapid assessments carried out in the days after the February 22nd 2011 earthquake identified the heavy masonry chimneys as a potential fall hazard. Consequently, the building had a red placard placed on it until the chimneys were "made safe" and a detailed inspection of all the masonry completed.

Following a detailed inspection the following items were identified as having sustained structural damage that would require repair:

- Two of the four chimneys sustained damage and had partially fallen, see Figure 3.1.
- Movement of some stonework at the top of some gables, Figure 3.2 and 3.3.
- Minor cracking to some remaining brickwork.
- Potential minor opening of shrinkage cracks in the sprayed concrete.

- Damage to internal linings throughout the building.

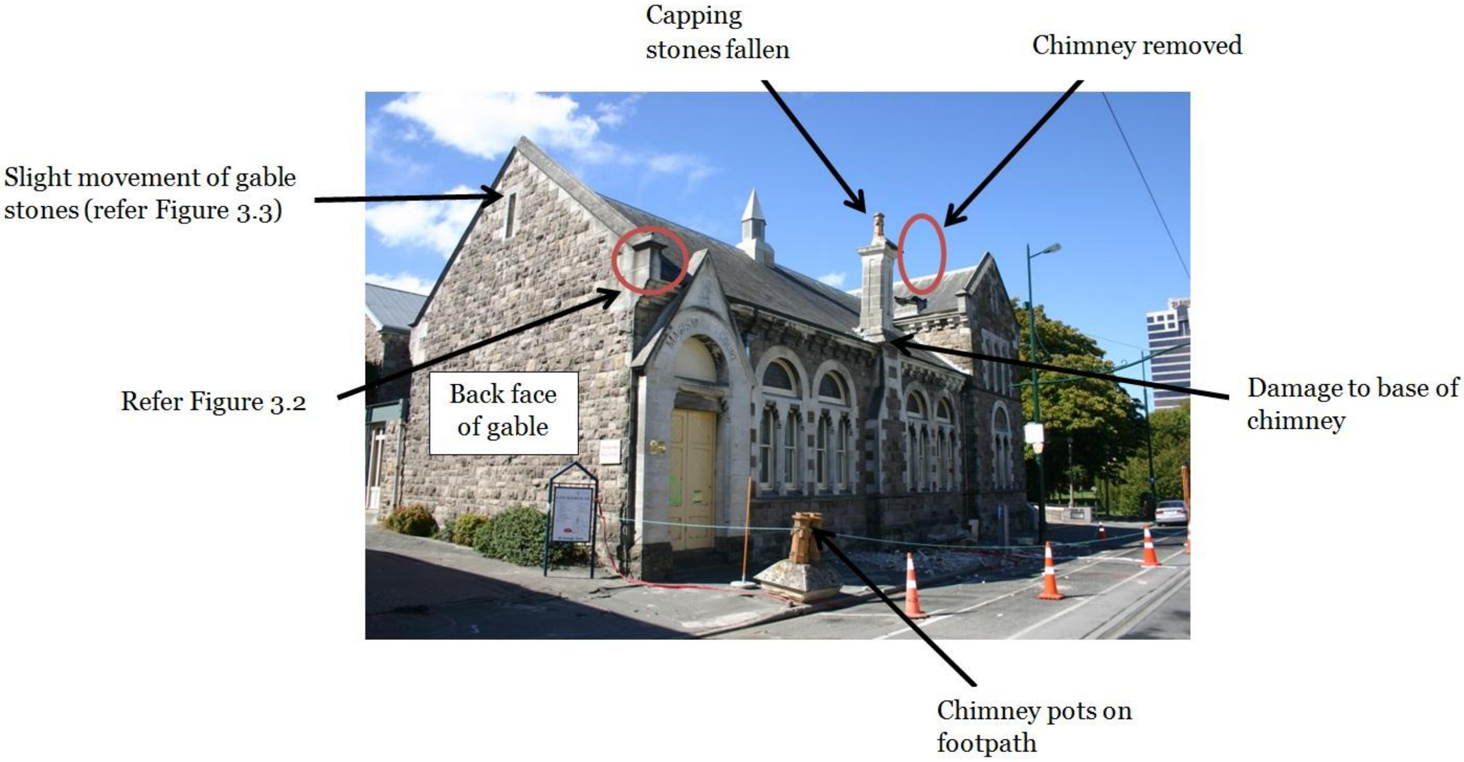

Figure 3.1: West and South elevation taken after February 22nd 2011 earthquake

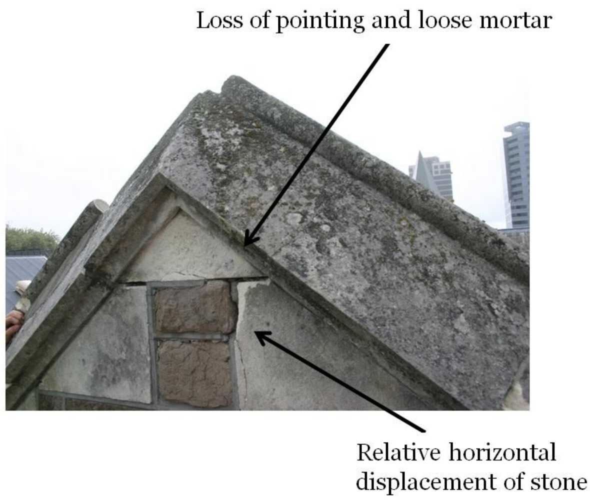

Figure 3.2: Rocking damage to stonework at bottom of gables Figure 3.3: Movement of stonework at top of gables

In addition to structural damage, the land to the east of the building, including the ramp to the basement of the adjacent Law Courts building, had moved approximately 120mm towards the nearby Avon River. Although there was some evidence of settlement presented by minor floor sloping at the southern end of the building, there was no suggestion of large settlements or verticality issues.

The key securing works involved the deconstruction and careful removal of the damaged chimneys to secure storage.

3.2 Detailed Engineering Evaluation

Once securing works were completed, Opus was engaged to complete a Detailed Engineering Evaluation of the old Magistrates' Court. This evaluation focused on the in plane and out of plane capacity of the strengthened walls, the performance of the ceiling diaphragm, the effects of the ground conditions and the performance of the peripheral elements including the chimneys and stone cladding elements.

The analysis showed that the building was at a current level seismic code compliance of approximately 55% NBS at Importance Level 3. This is governed by one area of connection between the ceiling diaphragm and the concrete walls. This would suggest that the strengthening comfortably exceeded the target performance of 67% of the code of the day (NZS 4203:1982) and is consistent with the level of damage noted during the inspections. The other elements of the building were found to be over 67% NBS.

The conclusion of the assessment was that substantial expenditure would be required to further improve the future seismic performance of the core structural elements. In addition, the large masonry chimneys and elements of the stone cladding needed to be repaired and strengthened to improve their future performance.

3.3 Strengthening Performance

It is considered that the extent of damage was minimal when examined in the context of the earthquake loading and ground movement at this site. The key areas of structural damage were at the top of the stone gables and at the chimneys. Intrusive inspection revealed that the previous strengthening works had not been completed as specified. Notably, the chimney that suffered the most significant damage had not had the strengthening flue installed above the roof line. And, whilst the sprayed concrete on the gable had been installed to underside of roof rafter level, it did not extend to the top of the gable walls, thus leaving an unstrengthened area at the top of the gable.

Despite these areas of damage, the previous strengthening can be regarded as a success as it was extremely effective in preventing damage to the majority of heritage fabric of the building. This is in contrast with many of the other heritage buildings of similar construction in the Christchurch central city area.

4 REPAIR AND UPGRADE

The design of the repair and upgrade works was undertaken by a team of engineers experienced in working on heritage buildings, nationally and internationally recognised heritage specialists, stonemasons experienced in heritage buildings, and materials specialists.

4.1 Chimney Reinstatement

Following several discussions between the building owners, NZHPT, Christchurch City Council Heritage Response Team (HRT), stonemasons and Opus engineers and build heritage specialist, it was concluded that the three large chimneys and one small chimney on the southern and central sections of the building were significant enough to warrant reinstatement.

The larger chimneys were approximately 700mm x 700mm square and stood approximately 3 m from the base to the capping piece. The main design consideration was how to secure the stone chimneys in an effective manner that would resist overturning and limit strain in the stonework so as to prevent fragments of the soft Oamaru stone from falling onto public areas.

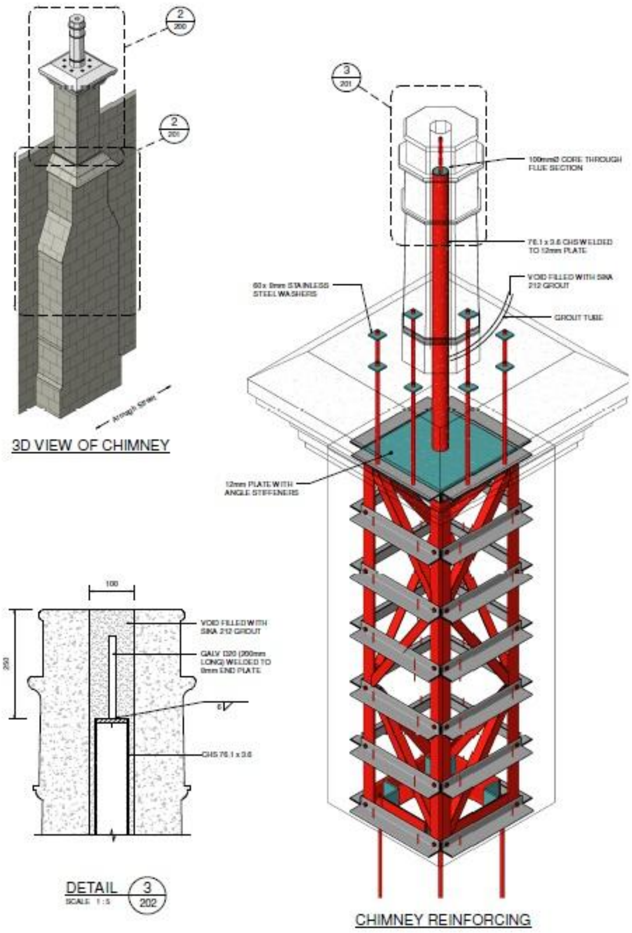

Figure 4.1: Chimney strengthening details

The first step was to reduce the mass of the chimneys. Replicas constructed of alternative materials, such as fibreglass, were not acceptable solutions from a heritage perspective, so the option of cutting the original stone down to a veneer was proposed. It was determined by the stonemasons that the soft Oamaru stone could be cut down to a minimum of 100mm. Steel frames of equal angles were prefabricated and installed to provide the skeleton required to rebuild the chimneys to their original dimensions and appearance.

The challenge was the restraint of the steel frames at the base, with some chimneys having no breast below the roof level, and the outside line of the chimney projecting beyond the face of the wall below. A combination of deep drilling to install rods to the base of the wall and steel struts to resist overturning was adopted, as shown in Figure 4.1.

Through all of these stages, careful consideration was given to the heritage fabric of the building. Roof slates were carefully removed to expose the existing structure and limitations were placed on altering the original building, including removing the original sarking under the roof tiles. The highly weathered nature of the original stone chimney masonry meant that some were damaged during the deconstruction stage. Figure 4.2 shows the chimneys along the Armagh Street frontage following the reinstatement.

Figure 4.2: Rebuilt chimneys along Armagh Street frontage

4.2 Gable Repairs

The shotcrete walls were found to extend only to the underside of the roof rafters that sat against the gable wall. Rocking of the upper portion of the gable about the interface between shotcrete and brick caused damage to the stonework (Figure 3.2), with the potential for partial collapse of stones or stone fragments into public spaces. In addition, the pointing and mortar at the apex of the gables had failed.

To address this hazard, and to prevent further damage to the heritage fabric, it was decided to remove the capping stones along the full length of the gable, deconstruct the apex of the affected gables and extend the concrete backing up to the underside of the capping stones before reinstatement and pinning into the concrete backing. Figures 4.4 and 4.5 indicate the works in progress and the completed west gable.

Figure 4.3: Work in progress on repair of west gable

Figure 4.4: Stonework repairs on west gable complete

4.3 **Stone Restraint and Repointing**

When undertaking the structural and heritage survey of the building, it was evident that previous pointing and mortar joint remedial works were causing failure of the trachyte stone. This failure, as delamination, was the result of mortar mix strength exceeding the strength of the trachyte masonry.

Porosity and permeability are important factors that influence the performance of masonry materials. The voids in masonry are usually filled with air that expands and contracts due to changes in temperature and moisture, allowing the material to 'breathe'. As the air moves through the masonry it carries water vapour with it which condenses within the pore spaces, leading to an accumulation of moisture. This moisture content reaches equilibrium in ambient conditions and, in time, case hardening of masonry occurs on the evaporation surface, producing a stronger, less permeable, more durable surface.

In addition to water vapour, the accumulation of salts during the drying phase of a building exerts pressure on the masonry, ultimately resulting in masonry failure. Lime mortars allow buildings to 'breathe' through 'sacrificial' mortar joints. These joints promote evaporation and control of salts within a wall and, in time, they fall out because they are weaker than the masonry. It is worth noting the salt content of lime mortars is negligible, while Portland cements have a high soluble salt content which does not facilitate breathing. Further, the addition of gypsum to cement (to retard rapid setting), adds more salt to a mortar mix.

At the former Magistrates' Court, lime mortar joint repairs had previously been carried out over an extended period, using a variety of strong cement-based mortar mixes. This resulted in the inability of masonry to breathe, the retention of water and salts and, as a consequence, the rapid delamination of the trachyte (evident within a period of 15 years). This failure of the stone was exacerbated by the Canterbury earthquakes and the need to carry out repair work concurrently with the earthquake repairs.

Consultation with David Young, (Heritage Consultant and advisor on building conservation and heritage management, Melbourne) resulted in a team approach that considered the optimum use of mortar mix, current building code requirements, international best practice conservation methods and engineering solutions in a dynamic earthquake environment.

Figure 4.5: Armagh Street frontage following completion of repairs and strengthening

The use of a 1:2:9 (cement:lime:sand) mix , to achieve a 5-6MPa after 24 months, was considered the most appropriate short-term conservation-based solution. This was, however, in conflict with engineering requirements for a minimum 1:1:6 mix to attain a reasonable structural strength. The variety and strengths of mortar mixes were extensively debated - does one lose a building due to a strong mortar mix causing masonry failure over time, or weak mortar resulting in seismic failure? The compromise, as an immediate temporary solution, was the use of a 1:1:6 bedding joint mix with a 1:2:9 pointing mix (20mm deep or 2.5 times the joint width) in areas of the worst failure. As mitigation, the team recommended a future assessment of all mortar joints to determine all causes of failure and water penetration. It was also agreed that tests be carried out on the performance of a number of different mortar mixes in identified areas around the building over a number of years to determine the optimum mix for a permanent solution.

5 CONCLUSIONS

The seismic strengthening scheme implemented in the 1997 as part of the conversion to the Family Court was very effective, limiting the damage to secondary elements such as the chimneys and gables. This demonstrates the benefits that a strengthening scheme which has a high degree of resilience and toughness, can provide in preserving the heritage fabric of buildings in seismic regions. It is the authors' view that greater emphasis should be placed on the toughness and resilience of strengthening schemes, particularly for Category I buildings. This may require a trade-off with the concepts of reversibility and transparency. This balance should be considered against the objective of preserving our built heritage beyond the next big earthquake.

Secondary elements of URM buildings that are subject to high accelerations, such as gable ends and chimneys require detailed consideration, particularly if the objective is to limit damage to heritage fabric as well as the more commonly adopted aim of minimising life safety risks. In this instance highly interventionist strategies were required to provide a suitable heritage and engineering solution, whereas before the Canterbury earthquakes a more minimalist and less intrusive solution, such as that initially adopted for these elements may have been favoured.

Mortar selection is a key aspect in the long-term performance of masonry buildings, and greater awareness of the issues associated with poor mortar selection may help preserve our built heritage. Selecting the correct mortar mix is a complex issue that requires balancing competing demands for strength and permeability, particularly for repair of buildings during a period of on-going aftershocks.

A collaborative team environment between where team members can debate the relative merits of competing heritage and engineering demands and solutions is essential to arriving at a robust and long-term solution of complex heritage projects

6 ACKNOWLEGMENTS

The authors would like to acknowledge the contractor, Hawkins Construction, for their care and attention to detail in completing the repairs to heritage elements and the stonemason, Ben West of Stoneworks, for his contribution to the design process for repair of the chimneys and gables.

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