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Reply to "Discussion 2 on 'Introspection on improper seismic retrofit of Basilica Santa Maria di Collemaggio after 2009 Italian earthquake' by G.P. Cimellaro, A.M. Reinhorn and A.De Stefano" by Enzo Cartapati

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The authors thank the discusser for the additional information, which is provided related to the historical interventions of the church through the centuries. This information was known to the authors, however they decided not to include it in the paper because of lack of space. Additional details regarding the retrofit interventions of the church can also be found in the MCEER report regarding the L'Aquila earthquake (Cimellaro *et al*., 2010).

The authors of the original paper presented and showed the importance of the global effects of stiffening, strengthening and damping produced by the retrofit interventions and there is no justification and/or reason for considering only the local effects.

Regarding the structural joint separating the right side wall of the Basilica from the transversal walls of the cloister, this intervention has never been mentioned before in any paper and it has never been modeled in any FEM from the L'Aquila research team. If this is the case, then *the simply supported beam model* used by Antonacci *et al*. (2010) may not be correct at all in defining the boundary conditions. It will then seem more reasonable to use the *cantilever beam model* described in Cimellaro *et al*. 2010 and in the authors' reply to "Discussion 1" of the same paper.

The vertical acceleration component of ground motion during the L'Aquila earthquake was high, but it was not enough to justify the crush of the pillars which had a cross section of 2.6 m diameter. In the worst scenario, the maximum compressive stress in the pillar is on the order of 2.4 MPa (according to Antonacci *et al*., 2011), while the compressive strength of the external part of the pillar is on the order of 21 MPa, so the axial stress alone cannot be the reason for the collapse. However, it is true that the retrofit intervention of 2000 increased both the vertical and horizontal seismic forces as shown in Cimellaro *et al.* (2010) and in Fig. 1 of the authors' reply to "Discussion 1".

The authors visited the church right after the earthquake as shown by the pictures in the MCEER report (Cimellaro *et al*., 2010), but they did not find any evidence of the crush of the pillars due to the axial loads. If this would have been the case, some evidence of such a movement should appear on the lateral walls and in other parts of the church, which instead show evidence of a lateral movement that the central pillars were not able to support. As shown in Fig. 1 and in Cimellaro *et al.* (2010), the retrofit intervention generated an increment of the tributary mass which increased the seismic forces tributary to the central pillar of the nave.

Figure 10 in the paper represents only a sketch of the collapse mechanism. For the scheme of the correct position of the reticular truss, the authors invite the discusser to read the MCEER report. The discusser emphasizes the fact that "*there was a significant continuity on the two horizontal structures*" and this might be the main reason for the collapse according to the authors, as explained above and shown in Fig. 1.

Different parts of the church have different stiffness properties, but it is still possible to define a center of stiffness for the entire building. The 60 m long walls were indeed restrained at their top from the horizontal reticular truss, which guarantees "*a significant continuity of the two horizontal structures,*" as declared by the same discusser. The observed damage inside the church (Cimellaro *et al*., 2010) occurred for several reasons.

For the discussion about the optimal position of the device, the authors invite to read the other authors' reply to "Discussion 1."

The authors agree that probably, if the designer did not include the horizontal reticular truss, the entire nave might have collapsed, but there is also no doubt that by adding the truss, the designer of the retrofit intervention

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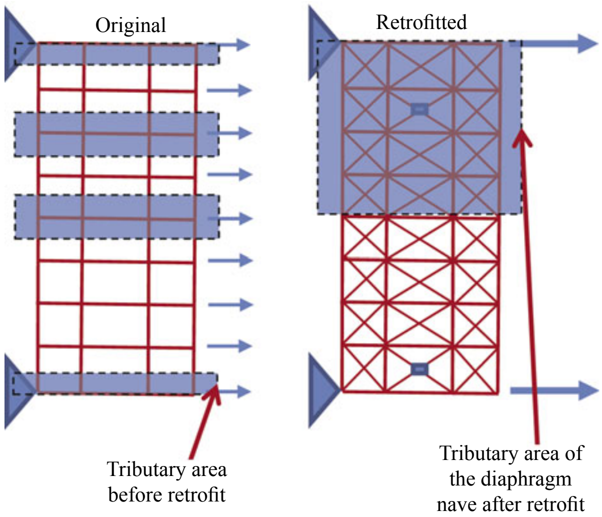

Fig. 1 Increase of the tributary mass due to the retrofit

concentrated the seismic load at the end supports, without proper transfer of the additional forces to the ground. There was no evidence that a suitable check was performed to verify if the end parts of the church, the transept and the façade, respectively, would have the capacity to resist the increased seismic demand. From the field investigation, the facade supported the additional load while the transept did not.

References

Cimellaro GP, Christovasilis IP, Reinhorn AM, De_ Stefano A and Kirova T (2010), "L`Aquila Earthquake of April 6, 2009 in Italy: Rebuilding a Resilient City to Withstand Multiple Hazards," *MCEER Technical Report –MCEER-10-0010*, MCEER, State University of New York at Buffalo (SUNY), Buffalo, New York.