

## Progressive Collapse in Precast Structures: What Do Design Guidelines Miss?

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### 1. Background

#### What is progressive collapse?

The loss of a support, such as a column, leads to disproportionately larger damage.

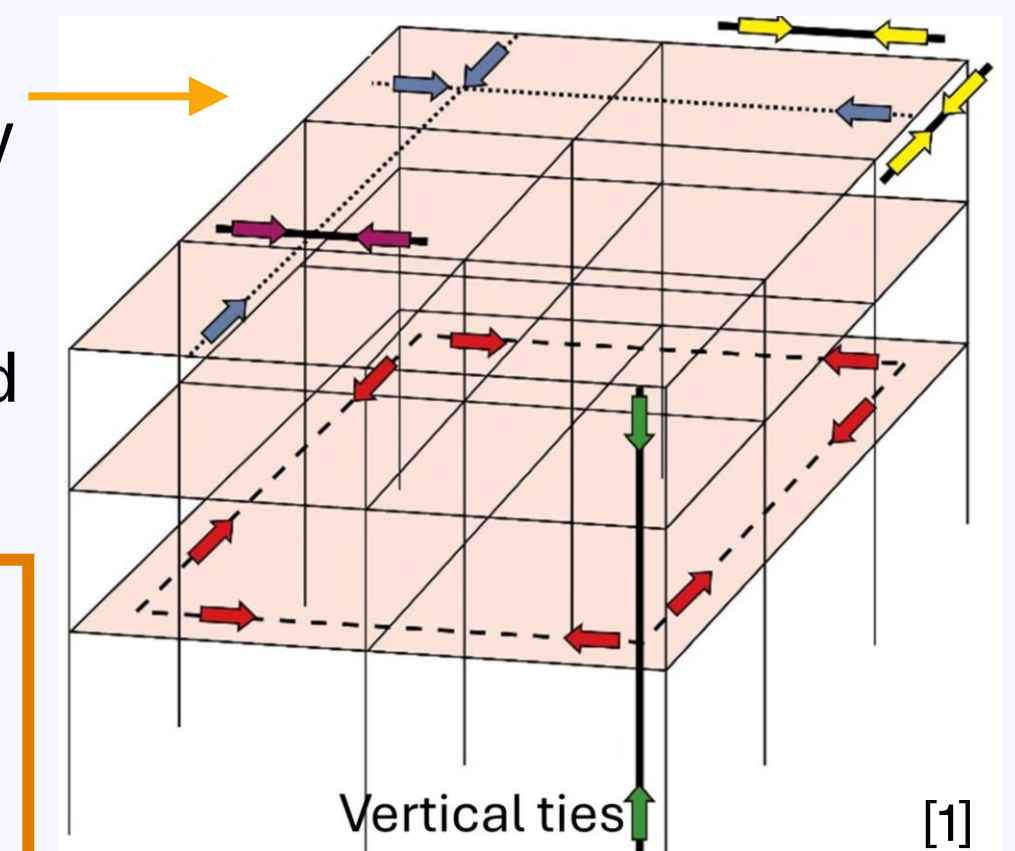


#### What is the design guidelines solution?

- M1: Prescriptive tying of structural elements, typically using reinforcement.
- M2: Analysing structure under removal of columns and ensuring damage will be limited.

#### What is missing in the guidelines?

- Proper treatment of **damage location** in M1.
- Realistic **deformation assumptions** in M1.
- Both M1 and M2 ignore or oversimplify **dynamic effects** of sudden support loss.
- Detailed guidance on **precast connections**.

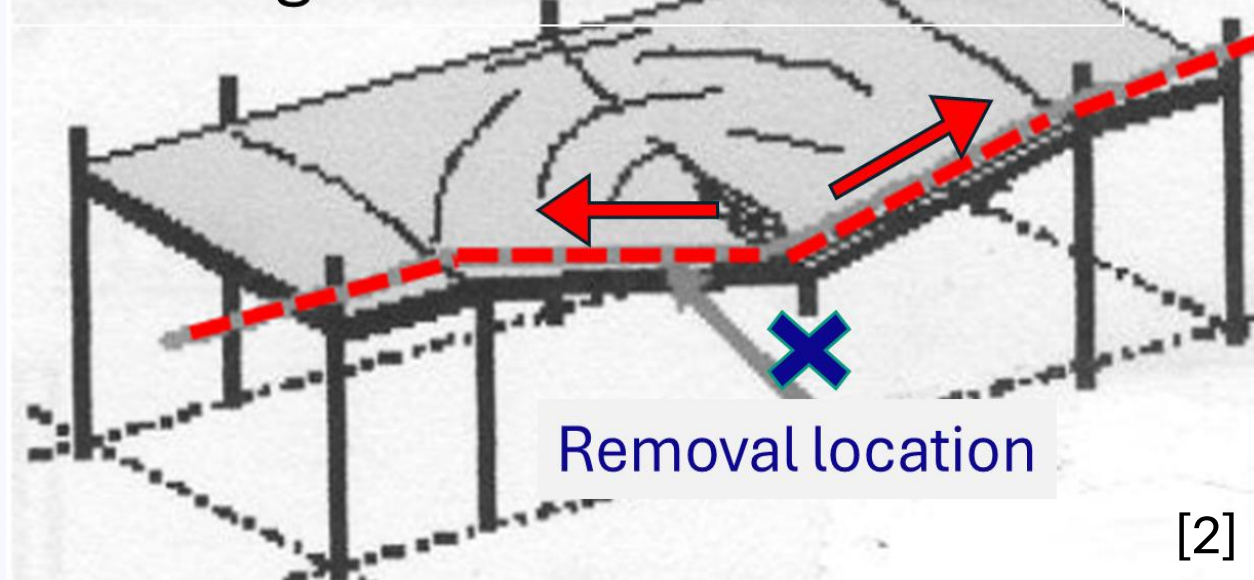


Are the provisions of the guidelines sufficient?

### 2. Methodology

#### Resisting Mechanisms

- Catenary action: Beams behaving like cables



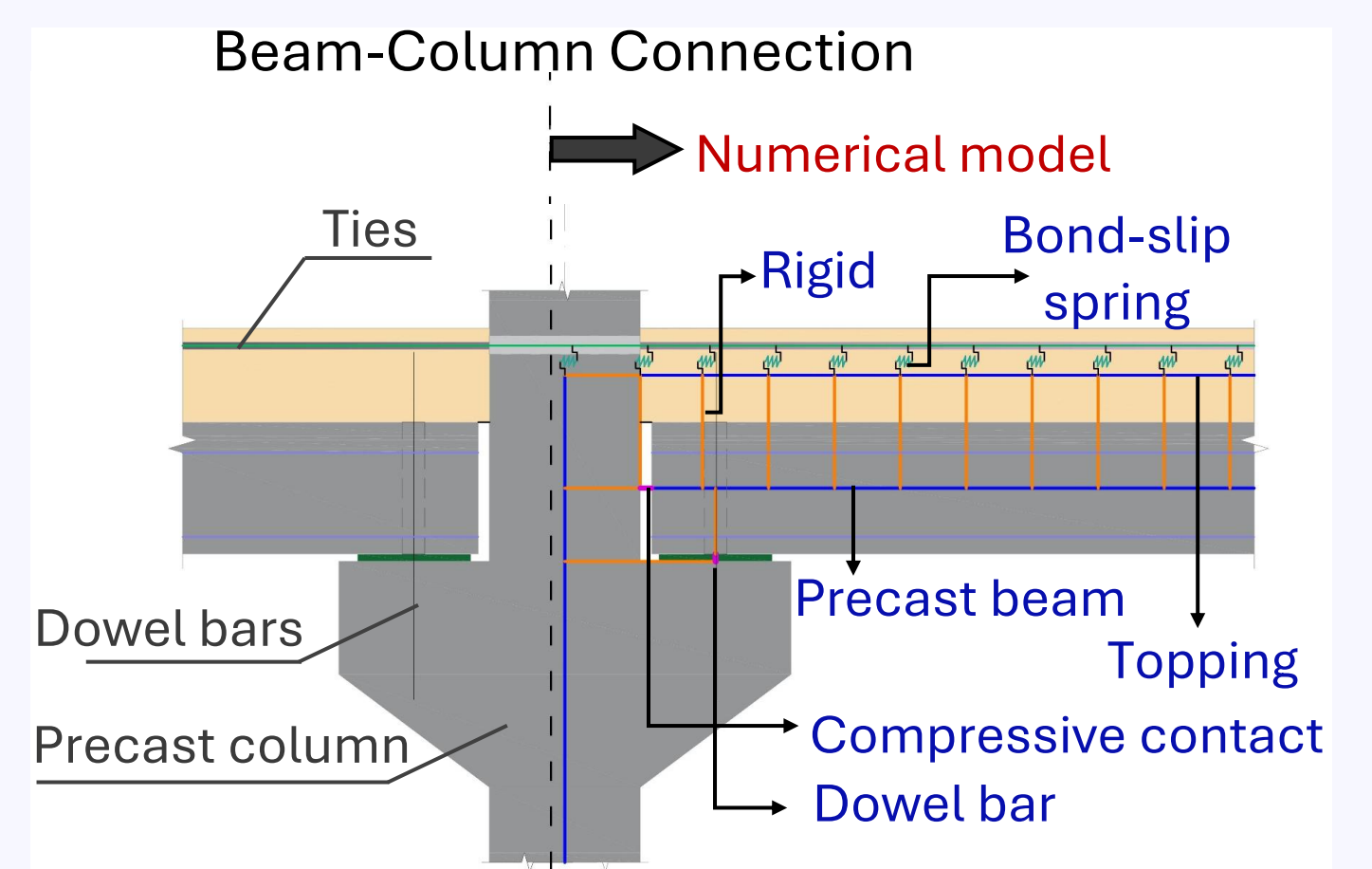
- Flexural action

#### Full-scale test data



- Three column-removal scenarios

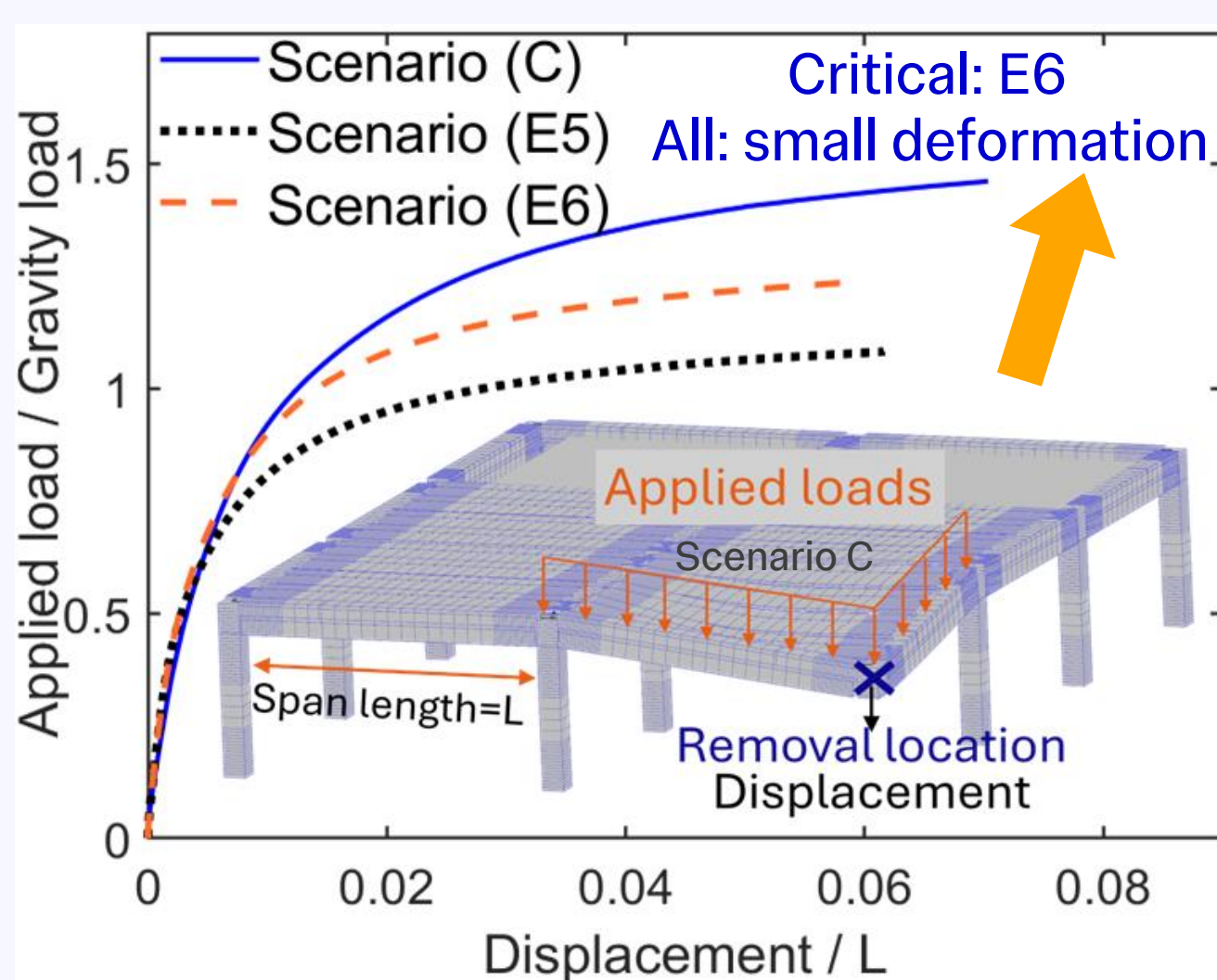
#### Numerical model



- Component-based FEM model

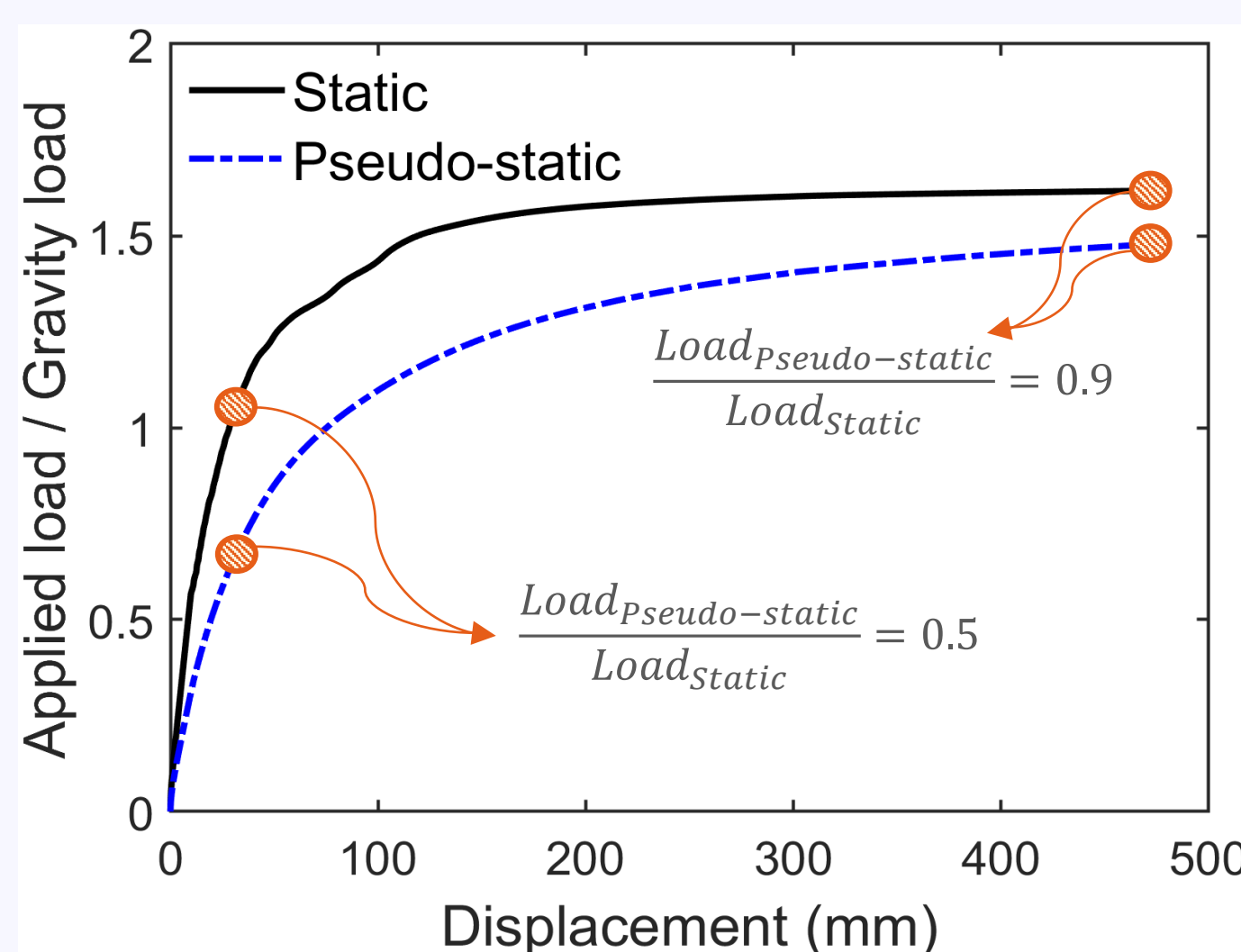
### 3. Results

#### What is the effect of damage location?



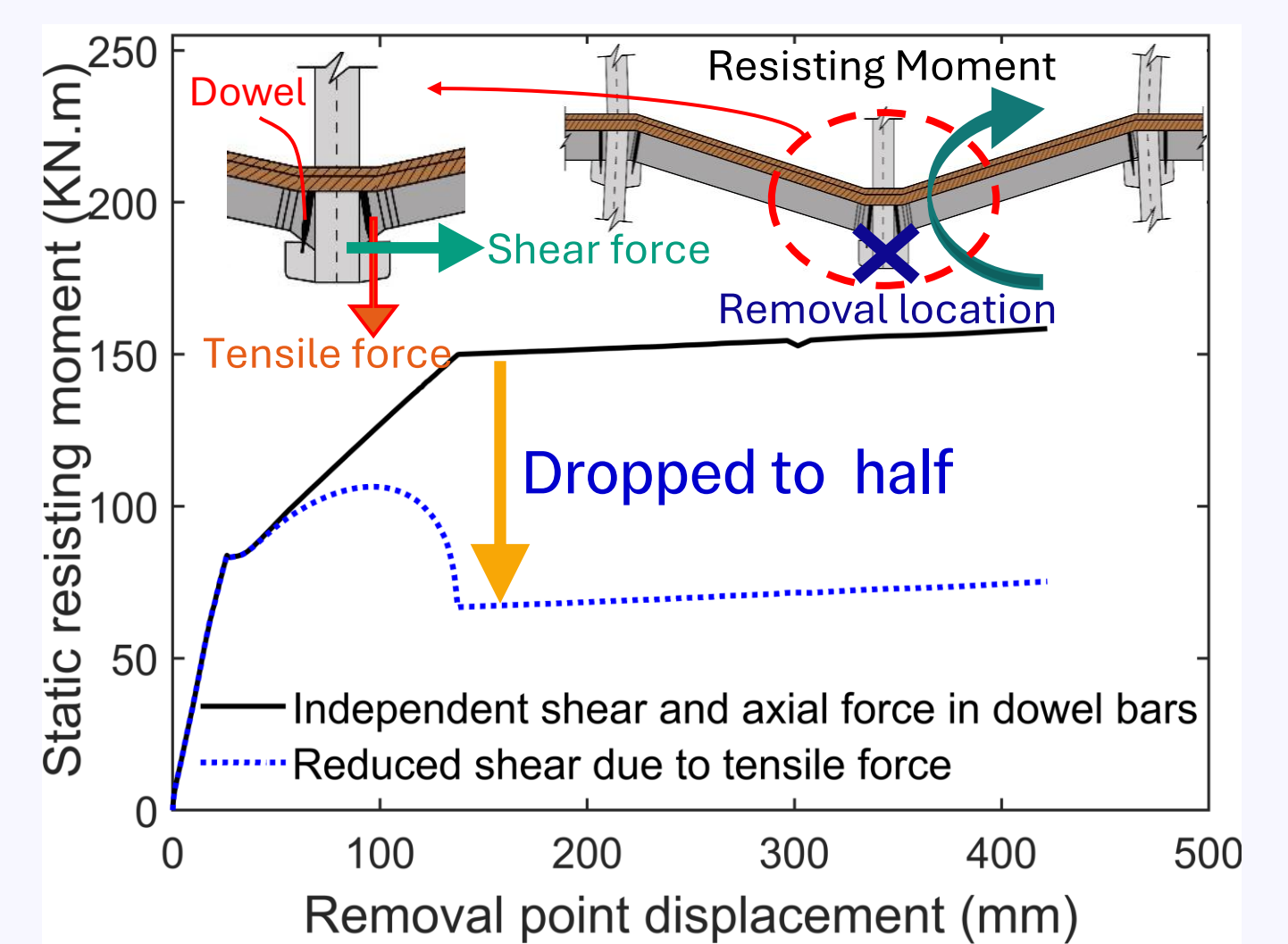
#### How to include dynamic effects? [4]

- Work done by the suddenly applied load (Pseudo-static) = Strain energy (static)



#### What is the effect of connection detailing?

- Tensile force in the dowel bars reduces their shear capacity.



### 4. Conclusions

- Although M1 distinguishes only between peripheral and internal ties, **damage location** within peripheral frames was decisive.
- **Dynamic effects** reduced load capacity by up to 50% compared to static resistance, with smaller effects at larger deformations.

- The large **ductility** presumed in M1 ( $Displacement/L \approx 0.2$ ) was not reached here.
- The **precast connection detailing** had a significant impact, indicating a substantial reduction in resistance.
- Using these parameters, this research develops a modified design procedure that represents **actual structural behaviour**.

References:  
[1] Mann, A. P., S. J. Alexander, J. N. Carpenter, J. P. Cartz, M. Chryssanthopoulos, G. T. Harding, A. E. K. Jones et al. "Practical guide to structural robustness and disproportionate collapse in buildings." , 2010. [2] Fédération internationale du béton., Design of precast concrete structures against accidental actions: guide to good practice fib Bulletin 63 (2012), International Federation for Structural Concrete (fib) [3] Buitrago M, Makoond N, Moragues JJ, Sagaseta J, Adam JM. Robustness of a full-scale precast building structure subjected to corner-column failure. InStructures 2023 Jun 1 (Vol. 52, pp. 824-841). Elsevier. [4] Izzuddin BA, Sio J. Rational horizontal tying force method for practical robustness design of building structures. Engineering Structures. 2022