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RISK-ORIENTED DESIGN OF BASE-ISOLATED BUILDINGS IN NEW ZEALAND

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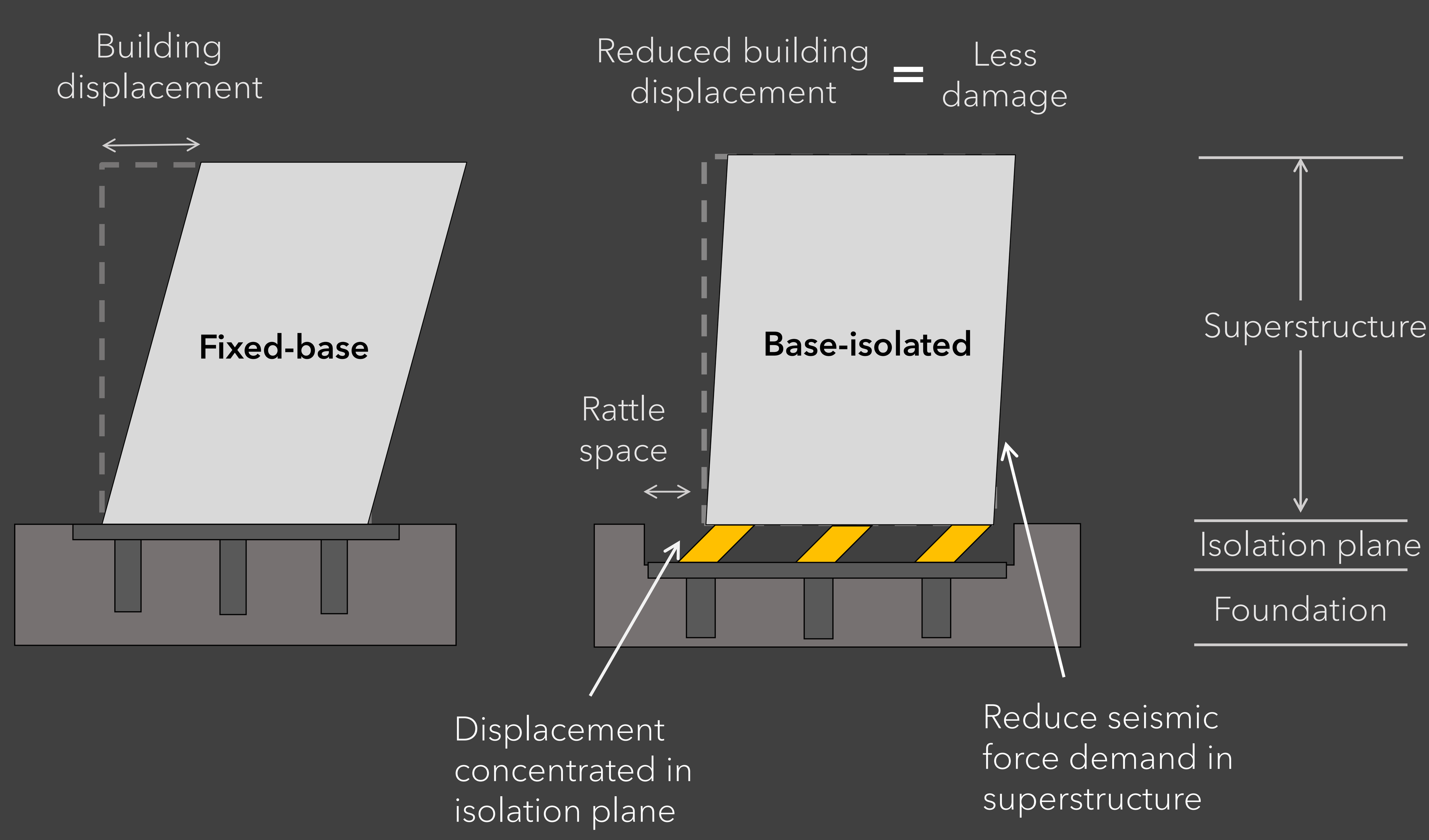
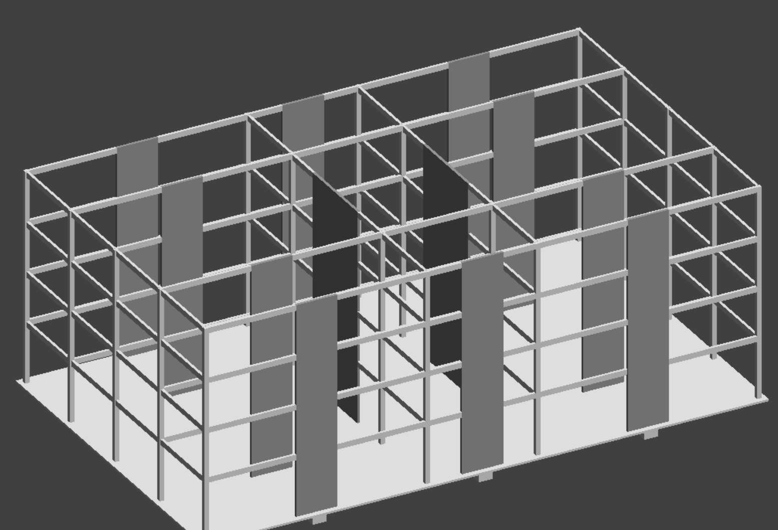
What is base isolation?



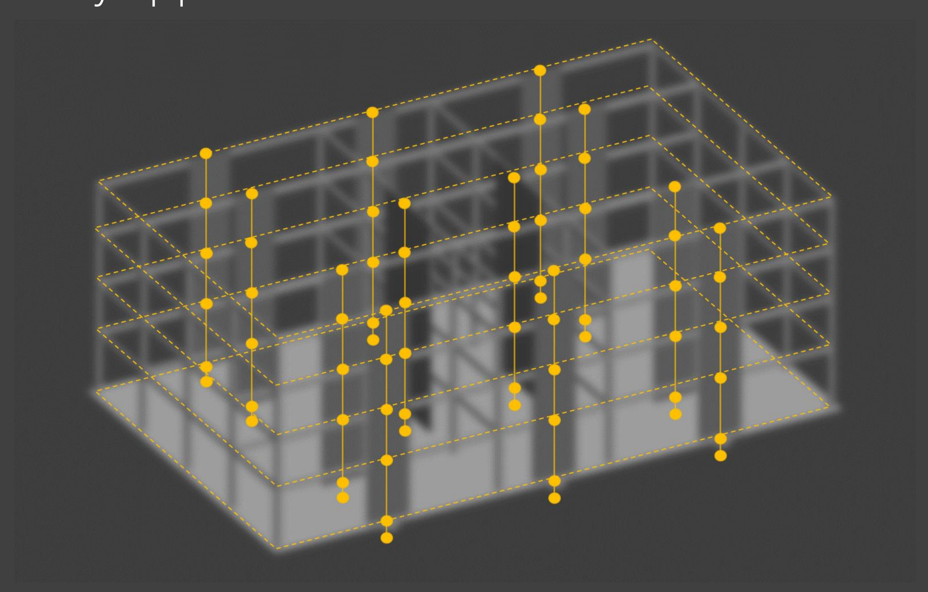
What is the best way to control the seismic risk of base-isolated buildings?

1 NZSEE/MBIE recently developed a base isolation design guideline aiming to provide some consistency for isolation design in New Zealand. Recognising there are some differences with international seismic design procedures for base-isolated buildings, it is deemed necessary to assess and validate the performance of base-isolated buildings designed using the new guidelines. The design will consider three superstructure types including RC wall, steel eccentrically braced frame, and steel moment resisting frame; and three isolation types including lead rubber bearing, double friction pendulum, and triple friction pendulum.

Design base-isolated buildings using the recently published NZSEE/MBIE isolation design guidelines.



Build and **validate** the numerical models of these base-isolated buildings in OpenSees with lumped plasticity approach.



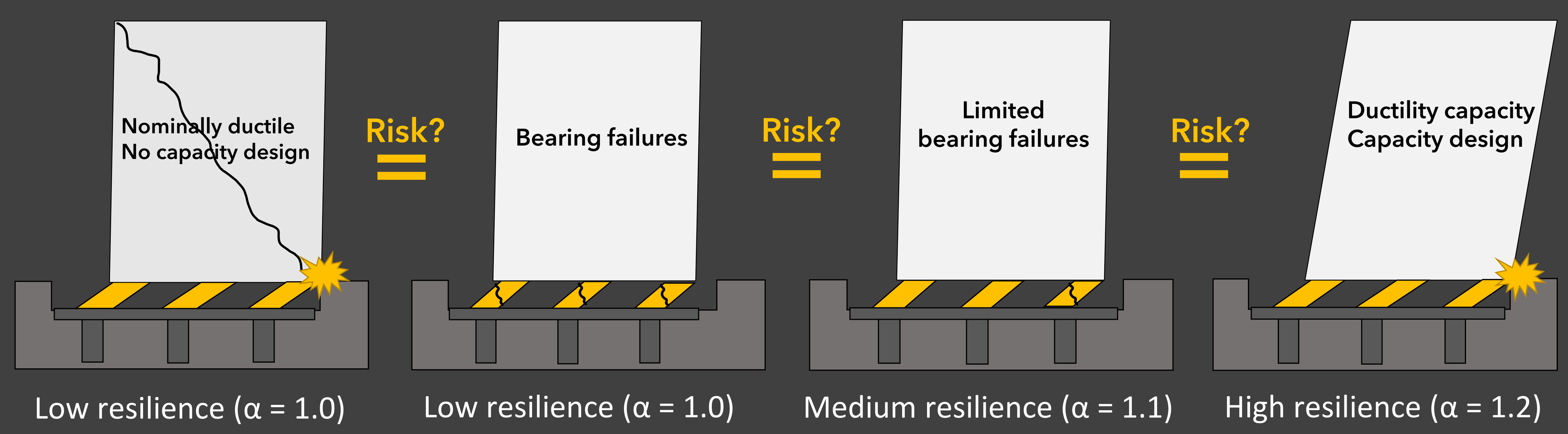
Assess the buildings' performance following the Pacific Earthquake Engineering Research Center's Performance-Based Earthquake Engineering (PEER-PBEE) framework. The performance will be expressed in terms of (i) the annual rate of failure, (ii) the annual rate of exceeding different loss ratios, and (iii) the expected annual loss.

Hazard Analysis ➡ **Structural Analysis** ➡ **Damage Analysis** ➡ **Loss Analysis**

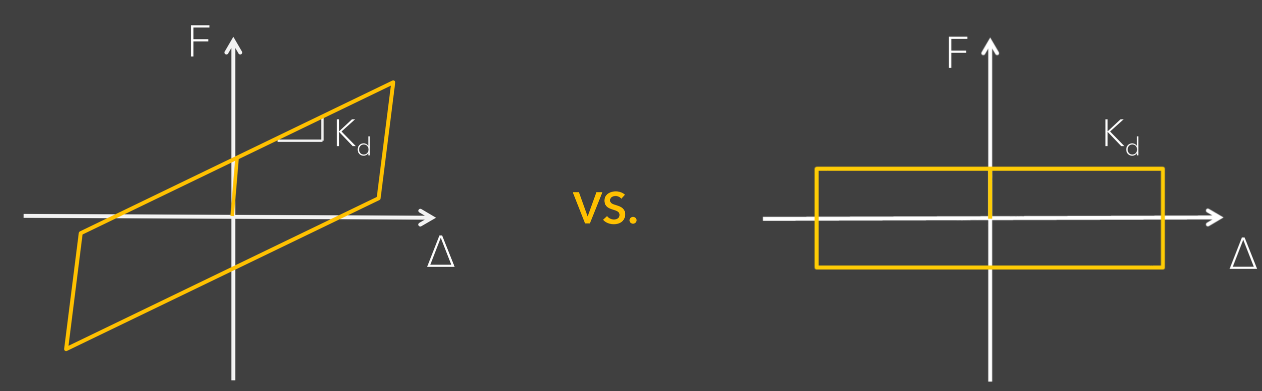
There are uncertainties in every stage of the risk analysis, such as the uncertainties in ground motions, material properties, isolator properties, modelling approaches, soil-foundation-structure interaction, component fragility, and repair cost. A sensitivity study will be carried out to investigate the impacts of these uncertainties. The research will then incorporate the uncertainties within the risk analysis accordingly.

2 After gaining a good understanding of the building performance, it is time to consider how do some of the design criteria affect the building performance. Therefore, The second objective is to investigate the impacts and identify means of improving design criteria for base-isolated buildings. The following two design criteria, which are robustness factor and post-yield stiffness will be investigated.

What happens beyond ULS? The rattle space and isolator displacement capacity are sized to accommodate Collapse Avoidance Limit State (CALS) level of shaking. A **robustness factor, α** is introduced to allow a reduction in rattle space based on the consequence of building failure. The following four scenarios are all permitted. The question is, do they lead to a similar performance in terms of annual rate of failure or loss? Numerical models will be built and analysed to compare their risk, with the possibility to calibrate the robustness factor.



Providing **post-yield stiffness, K_d** in an isolation system can reduce the overall displacement and residual displacement during an earthquake. However, a significant amount of post-yield stiffness can also increase the seismic force within the superstructure. Francis et al. (2022) suggests that the flat-sliding friction bearings can be effective for light-frame housings. The research will explore the feasibility of extending this idea to larger buildings. At the same time, the research investigate the impact of lowering the post-yield stiffness on floor acceleration, storey drift, residual displacement, and losses.



3 The focus of the research is centred around question: **What is the best way to control the seismic risk of base-isolated buildings?** Previous objective aims to improve seismic risk of base-isolated buildings based on the current design approach. Objective three proposes a risk-oriented design approach to allow engineers to better control the seismic risk of base-isolated buildings. This approach could be a **risk-targeted design framework**, which sets risk metrics like monetary loss as the direct design target. The framework will look to build upon the considerations of some of the probabilistic design approaches in literature. Furthermore, the proposed approach could **prescriptive** which is calibrated to a certain type of buildings such as medium density housings, where the building types are assumed to be regular and simplified in layout. In addition, the innovative process used in the Italian Progetto C.A.S.E. will be considered, in which as basic set of design criteria were provided to construction companies to design superstructures atop base-isolated RC platforms that were designed by separate specialist engineers.

Define risk target ➡ **Determine the hazard and gather general building information** ➡ **Link risk target to EDP limits, using tools like storey loss functions** ➡ **Design building**

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