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Numerical Analysis on Evaluation of Collapse Margin of High-Rise Steel Buildings under Extremely Strong Earthquakes

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The safety of high-rises under extremely strong earthquakes is a significant concern for large cities. In this study, the collapse margin of high-rise steel buildings under extremely strong earthquakes is evaluated. A 99-meter high building is designed according to the Japanese design code. Braced frame system is adopted, using H-section beams, square CFT columns and buckling restrained braces (BRB). Fig. 1 shows the global and local views of the proposed numerical model. The model is developed to challenge two requirements. First, the model should be able to take account of various failure states of structural components up to collapse, such as cracking, yielding, local buckling and rupture. Second, although the building has large quantities of members, the model should be simple enough to conduct incremental dynamic analysis (IDA). The fiber beam element, which is simple and effective to simulate the member behavior under combined compression and bending, is adopted extensively for the beams and columns. The section of fiber model for CFT columns is shown in Fig. 2. The uniaxial cyclic material model shown in Fig. 3 is proposed for the steel fiber, and the yielding, stress hardening, Baushinger effect and local buckling are considered. The origin-oriented cyclic model shown in Fig. 4 is applied to the concrete fiber, taking the confined effect into account. The square CFT model is calibrated by a couple of tests and integrated into MSC.MARC using user subroutines. As the preliminary stage of analysis, the collapse mechanism and the safety margin from Level 2 are examined using a single ground motion. The building presents a large safety margin beyond Level 2, and collapses under 500% Kobe Takatori ground motion due to severe damage of the columns in the first story.

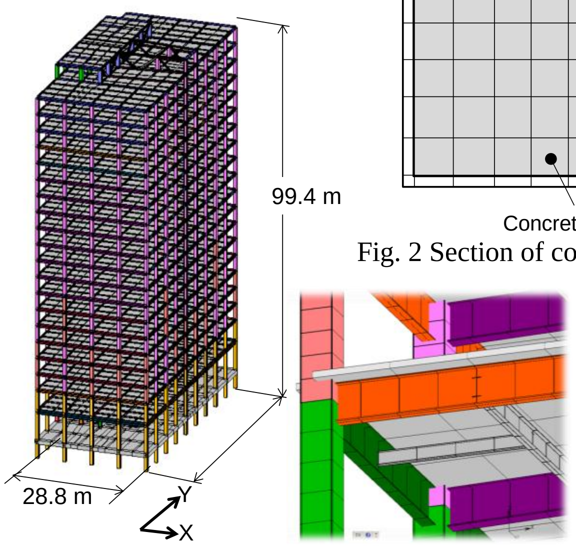

Fig. 1 Structural model

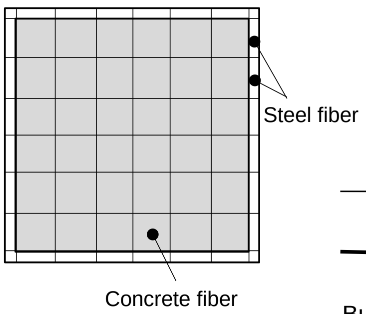

Fig. 2 Section of column model

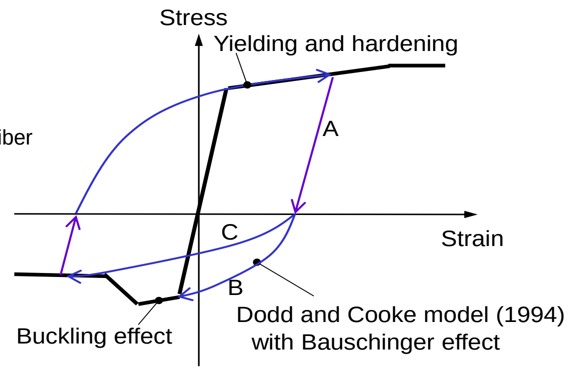

Fig. 3 Cyclic model for steel fiber

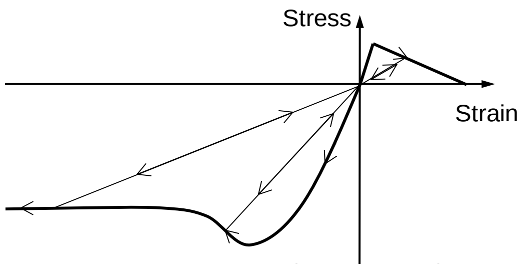

Fig. 4 Cyclic model for concrete fiber