INTISARI

Saat ini di Indonesia, metode analisa struktur yang banyak digunakan adalah *Strength Based Design* (SBD). SBD berorientasi pada kekuatan struktur dan secara implisit menyatakan perilaku struktur secara nonlinear dalam proses desain. Meski demikian, penggunaan SBD masih kurang tepat karena pada proses analisanya masih menggunakan cara linear-elastik dan menekankan pada penyelamatan jiwa, tanpa memperhatikan aspek ekonomis bangunan. Berawal dari kejadian gempa bumi Northridge pada 17 Januari 1994 dan Kobe pada 16 Januari 1995 yang menimbulkan perkiraan kerugian sebesar US$80 *billion* dan US$100 *billion* akibat banyaknya kerusakan bagian non-struktur bangunan, *Performance Based Seismic Design* (PBSD) mulai diperkenalkan. PBSD menekankan pada penyelamatan jiwa serta aspek ekonomis bangunan, dan menggunakan cara inelastik sehingga menyatakan perilaku nonlinear struktur secara eksplisit. Pada tesis ini, diuraikan perkembangan dan konsep PBSD, serta disajikan aplikasi PBSD pada evaluasi bangunan tingkat tinggi beton bertulang (Apartemen XYZ 39 lantai). Evaluasi Apartemen XYZ dilakukan untuk 3 level performa struktur yakni, *Immediate Occupancy* (IO), *Life Safety* (LS), dan *Collapse Prevention* (CP).

Pada *preliminary design*, evaluasi struktur dilakukan dengan analisa response spektrum menggunakan perangkat lunak CSI SAP200 dan ETABS. PBSD dengan *nonlinear response history analysis* dilakukan menggunakan perangkat lunak CSI PERFORM-3D. Pemodelan elemen struktur yang boleh mengalami perilaku inelastik diantaranya elemen balok, dan perilaku lentur pada dinding geser. Untuk elemen kolom, pelat, dan perilaku geser pada dinding geser hanya diijinkan berada pada kondisi elastik.

Pada SBD tidak diketahui saat kapan balok, kolom, maupun dinding geser akan mengalami kerusakan saat digoncang gempa. Pada PBSD, dapat dinyatakan kapan dan elemen mana yang akan rusak saat digoncang gempa. Perencanaan struktur Apartemen XYZ dengan PBSD memungkinkan pemilik bangunan memilih level performa struktur yang dikehendaki yaitu IO, LS, ataupun CP untuk memperoleh biaya yang paling ekonomis. Hasil PBSD menunjukan bahwa *usage ratio* struktur

pada level IO adalah 1,24 (dengan keadaan batas elemen balok), 6,41 (dengan keadaan batas elemen kolom), dan 1,46 (dengan keadaan batas elemen dinding geser). Dengan demikian pada level IO saja, struktur apartemen tidak mampu menahan beban yang bekerja, terlebih pada level LS maupun CP.

Kata kunci: *Strength Based Design (SBD), Performance Based Seismic Design (PBSD), nonlinear response history analysis, bangunan tingkat tinggi*.

ABSTRACT

Strength based design (SBD) has become the most popular structural analysis method used by structural engineers in Indonesia. The orientation focused on the strength of structures and implicitly take into consideration non-linear behavior of the structures in its design process. In the design process, SBD uses linear-elastic method and emphasizes human life aspect without taking into account the building economical aspect. That is why SBD is not the best structural design approach. Due to the incidents of Northridge earthquake in 1994 as well as Kobe earthquake in 1995 which were causing huge economical loss worth US$80 billion and US$100 billion respectively resulted from extensive non-structural damage, Performance Based Seismic Design (PBSD) has become urgent. PBSD focuses on both human life and building economical aspects. It uses inelastic method and therefore explicitly show the non-linear behavior of structures. In this thesis, the development and concept of PBSD, as well as the application of PBSD in the evaluation of a reinforced concrete tall building structure (39-story XYZ Apartment) will be performed. The apartment evaluation will consider three structural performance levels as follows: Immediate Occupancy (IO), Life Safety (LS), and Collapse Prevention (CP).

For the purpose of preliminary design with response spectrum analysis, CSI softwares SAP2000 and ETABS were used. The PBSD implements a nonlinear response history analysis model using CSI software PERFORM-3D. The model includes inelastic member properties for elements that are anticipated to be loaded beyond their elastic limits. These include the beams, and core-shear wall flexural behavior. Core-shear wall shear behavior, diapraghm, slabs, and columns are expected to remain elastic and are modeled with elastic properties.

In SBD, a moment when elements (beams, columns, etc.) are damaged by earthquake can not be predicted. Contrary in PBSD, the detail moment can be shown, and the next damage elements can be guessed. The design of the XYZ Apartment using PBSD allows its owner to select performance level of the structure whether IO, LS, or CP to get the most economical building. The result of PBSD

showed usage ratio of the structure in IO performance level as follows: 1,24 with beams limitation; 6,41 with columns limitation, and 1,46 with shear wall flexural-behaviour limitation. It concluded that the structure in the IO performance level can not stand against the load applied, moreover in both LS and CP.

Keywords: *Strength Based Design (SBD), Performance Based Seismic Design (PBSD), nonlinear response history analysis, tall building.*