6.2. REQUIREMENTS FOR ANALYSIS MODELING

6.2.1 – Modeling of frame elements shall be made with *frame finite elements* in linear analysis. Modeling in nonlinear analysis can be made with *plastic sections (plastic hinges)* in the framework of lumped plasticity approach or through *fiber elements* in the framework of distributed plasticity approach. Regarding the plastic hinge length, an appropriate empirical relationship may be selected from the literature, subject to approval of the *Independent Reviewer(s)*. In nonlinear analysis, alternative modeling approaches may be followed upon the approval of *Independent Reviewer(s)*. In linear and nonlinear models of steel frames, shear deformation in the beam-column panel zone shall be considered.

6.2.2 – In linear analysis, modeling of reinforced concrete walls and their parts shall be made with *shell finite elements*. In simple walls, frame elements may be used as an alternative. When shell elements are used, elastic modulus (E) of shell elements can be appropriately reduced in bending in order to be consistent with the *effective bending rigidities* of the frame elements with cracked sections (see **6.2.4**).

6.2.3 – In modeling reinforced concrete walls and their parts for nonlinear analysis, *fiber elements* or alternative modeling options may be used in the framework of distributed plasticity approach, subject to approval of the *Independent Reviewer(s)*. Shear stiffnesses of reinforced concrete walls shall be considered.

6.2.4 – Effective bending rigidities shall be used for reinforced concrete frame elements with cracked sections. In the preliminary design stage described in **6.3.1**, empirical relationships given in the relevant literature may be utilized. In other design and verification stages described in **6.3**, effective bending rigidity shall be obtained from the section's moment-curvature relationship as follows:

$$(EI)_{\mathrm{e}} = \frac{M_{\mathrm{Y}}}{\phi_{\mathrm{y}}'} = \frac{M_{\mathrm{N}}}{\phi_{\mathrm{y}}} \qquad \textbf{(6.1)}$$

where M_{Y}, represents the state of first-yield in the section. The corresponding curvature ϕ_{y}' represents a state where either concrete strain attains a value of 0.002 or steel strain reaches the yield value, whichever occurs first. The nominal plastic moment M_{N} corresponding to effective yield curvature ϕ_{y} is calculated with concrete compressive strain reaching 0.004 or steel strain attaining 0.015, whichever occurs first. In calculating the moment strengths of columns, axial forces due to gravity loads only may be considered.

6.2.5 – In preliminary design stage described in **6.3.1**, design strengths, (f_{d}), of concrete, reinforcing steel and structural steel are defined as the relevant characteristic strengths, (f_{k}), divided by material safety factors. In other design and verification stages in **6.3**, expected strentghs, (f_{e}), shall be used as design strengths without any material safety factors. The following relationships may be considered between the expected and characteristic strengths:

Concrete	$f_{\mathrm{ce}} = 1.3 f_{\mathrm{ck}}$	
Reinforcing steel	$f_{\mathrm{ye}} = 1.17 f_{\mathrm{yk}}$	
Structural steel (S 235)	$f_{\mathrm{ye}} = 1.5 f_{\mathrm{yk}}$	**(6.2)**
Structural steel (S 275)	$f_{\mathrm{ye}} = 1.3 f_{\mathrm{yk}}$	
Structural steel (S 355)	$f_{\mathrm{ye}} = 1.1 f_{\mathrm{yk}}$	