Homework No. 2.1

The “static” eccentricity between the centre of mass and that of stiffness is calculated on the basis of the nominal member rigidity, $(EI)_n$ calculated as a fixed fraction, e.g. 50% of the uncracked gross section stiffness. The longitudinal reinforcement of members is then dimensioned for the bending moments that account for the so-calculated static eccentricity. Assuming that the effective member rigidity is proportional to the longitudinal reinforcement ratio, ρ, please answer the following:

1. Does the difference between the “nominal” and the “effective” member rigidity cause, in general, the “actual” static eccentricity to be larger, or smaller than the “nominal” one calculated on the basis of the “nominal” member rigidities?
2. On which side of the plan (the one which is closer to the centre of mass than to the centre of stiffness, or the other) is dimensioning against the static eccentricity safe-sided and on which is it not, in view of the difference between the “nominal” and the “actual” value of the static eccentricity?

To answer questions 1 and 2, consider the simple case of a one storey building, in which the seismic action component in horizontal direction X is resisted by just two vertical elements, indexed by 1 and 2, having the same cross sections producing the same moment of inertia of the uncracked gross-section, $I_1 = I_2 = I_c$. The centre of mass is asymmetrically placed in plan and closer to element 1. You may assume that dimensioning for the bending moment gives longitudinal reinforcement ratio, ρ, proportional to M, and that for given cross section, the “effective” rigidity is proportional to the longitudinal reinforcement ratio and to $(EI)_c$. $(EI)_{eff} \approx a\rho(EI)_c$. You may also assume that the “static” eccentricity is determined just on the basis of the rigidity, EI, of elements 1 and 2, nominal, $(EI)_n$, or effective, $(EI)_{eff}$ (cf. Eqs. (2.2).

Denoting by ρ_1 and ρ_2 the reinforcement ratios which result from the dimensioning for the effects of the design seismic action of elements 1 and 2, respectively, please answer questions 1 and 2 for three cases:

a. The reinforcement ratios ρ_1 and ρ_2 both exceed the minimum steel ratio, ρ_{min}: $\rho_1 > \rho_{min}$, $\rho_2 > \rho_{min}$.

b. Both ρ_1 and ρ_2 are less that ρ_{min}, so both elements 1 and 2 are provided with the minimum vertical reinforcement.

c. Element 1 (which is closer to the Centre of Mass) is reinforced with the reinforcement ratio resulting from dimensioning for the design seismic action, $\rho_1 > \rho_{min}$, while element 2 with the minimum reinforcement ratio, as $\rho_2 < \rho_{min}$.

Homework No. 2.2

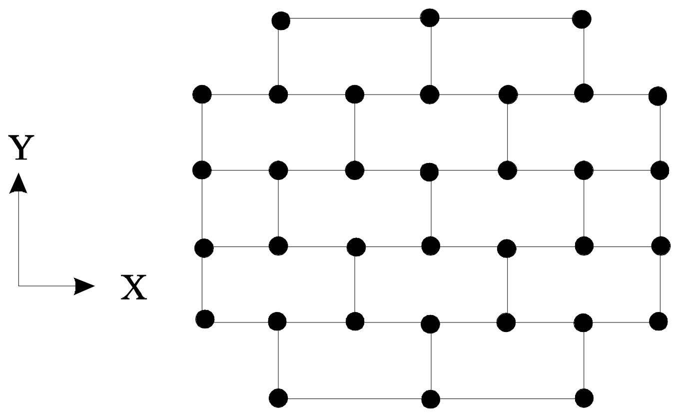
Please show that, in a 3-DOF system, having one translational DOF in each of the two orthogonal directions, X and Y, and one torsional DOF about the vertical axis, Z, the conditions of Eurocode 8, Eqs. (2.4), ensure that the period of the 1st torsional vibration mode is shorter than those of the translational ones in the two directions, X and Y.

Homework 2.3.

Consider a building having storey mass uniformly distributed ever its floor area, *B* x *L*, and a structural system consisting in each of the two directions, X and Y, of several regularly spaced and similar plane frames, except for the two exterior ones, which have 50% of the lateral stiffness of each individual plane frame of the corresponding direction. Please show that such a building cannot fulfill the torsional rigidity condition, Eqs. (2.4), and that, in the special case in which the total lateral stiffness is the same in the two directions X and Y, Eqs. (2.4) are satisfied as equalities.

Homework No. 2.4

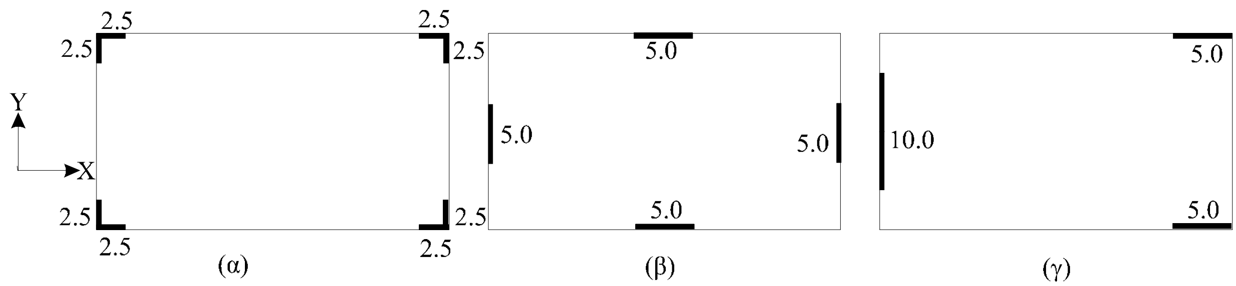
Please comment on the appropriateness of the layout of the framing plan below for earthquake resistance in the two horizontal directions X or Y (dots denote columns and lines depict the beams)



Homework No. 2.5

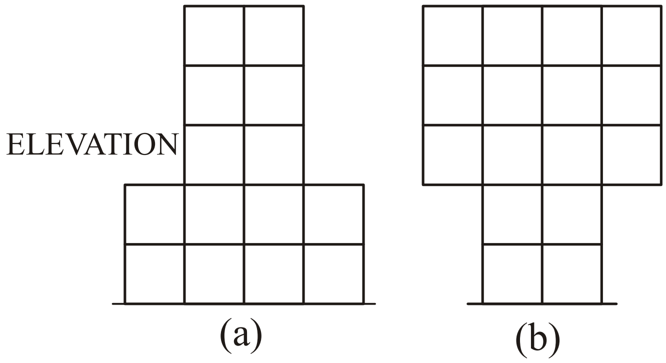
Please compare the alternative arrangements (a), (b) and (c) of shear walls, in a 25m x 25m building plan, all having a wall-hickness of 0.25m, from the point of view of:

- restraint of floor shrinkage,
- lateral stiffness,
- torsional stiffness with respect to a vertical axis,
- vertical reinforcement required for the same total flexural capacity at the base,
- static eccentricity,
- redundancy.



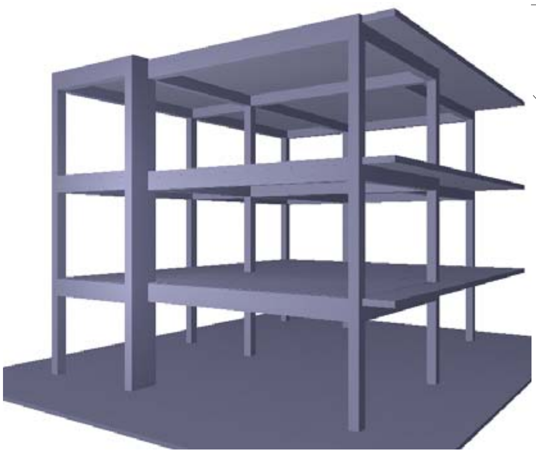
Homework No. 2.6

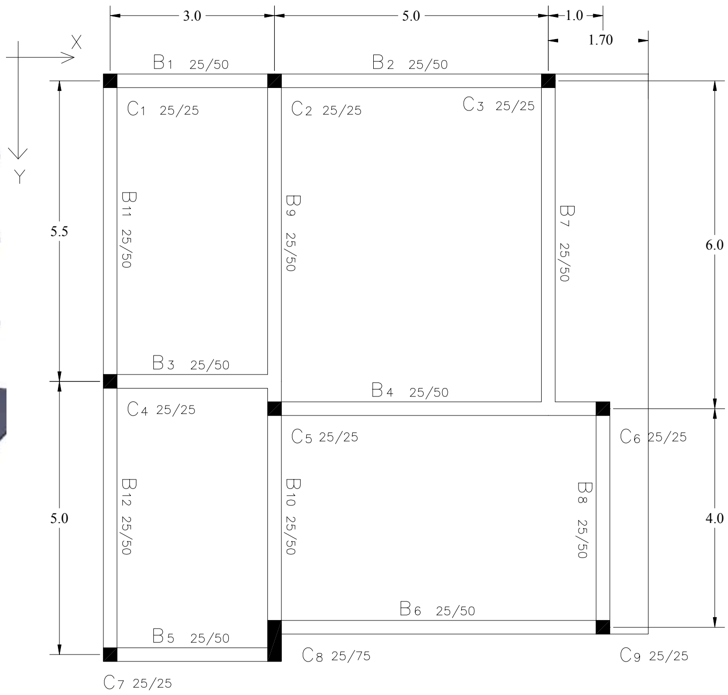
Please comment/compare configurations (a), (b) from the point of view of earthquake resistance.



Homework No. 2.7

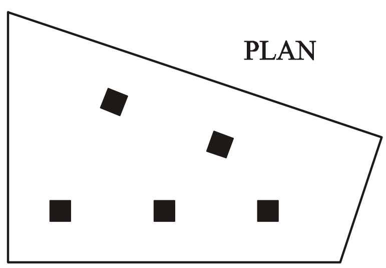
Please determine the approximate location in plan of the Centre of Mass as the centroid of the floor plan and of the Centre of Stiffness on the basis of the moments of inertia of vertical elements, for the 3-storey building shown below. On the basis of the outcome, and of other features of the framing comment on its appropriateness for earthquake resistance, separately for horizontal directions X and Y. Cross-sectional dimensions are in cm.





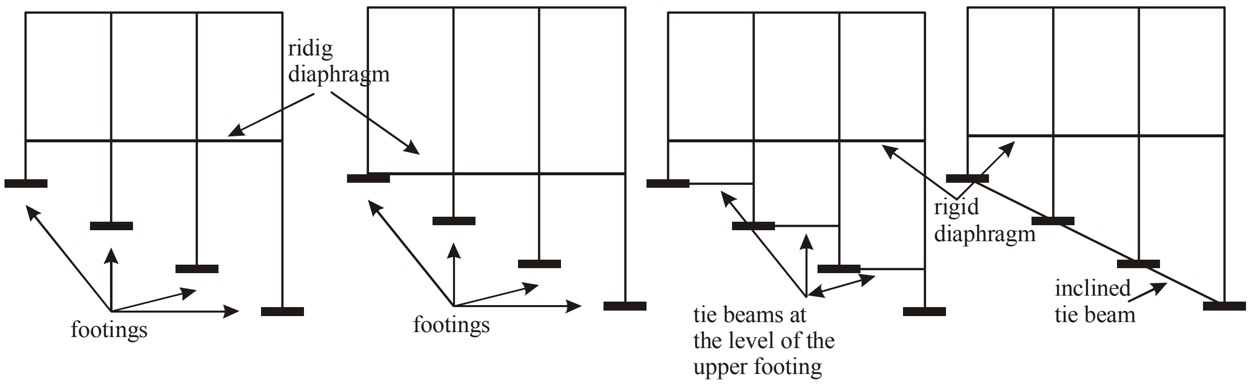
Homework No. 2.8

A multi-storey building has the quadrilateral plan shown in the figure. Interior columns have an irregular layout in plan. The layout of partition walls and of interior beams supporting the slab is different in different storeys. What would be your choice for the lateral-load resisting system of the building and for its foundation, and why?



Homework No. 2.9

Please comment on the pros and cons of the alternative foundation systems (a) to (d) for a building at a steep slope; propose an alternative scheme, better than the four options shown.



(a) (b) (c) (d)

Homework No. 2.10

The 3-storey building of the sketch is built on a slope. Part ABCD has 3 storeys and a frame structural system. Part EFGH has in the middle a concrete core for an elevator shaft and staircase. You are invited to propose a foundation system for the two wings of the building and a structural system for the superstructure (including your reasoning).