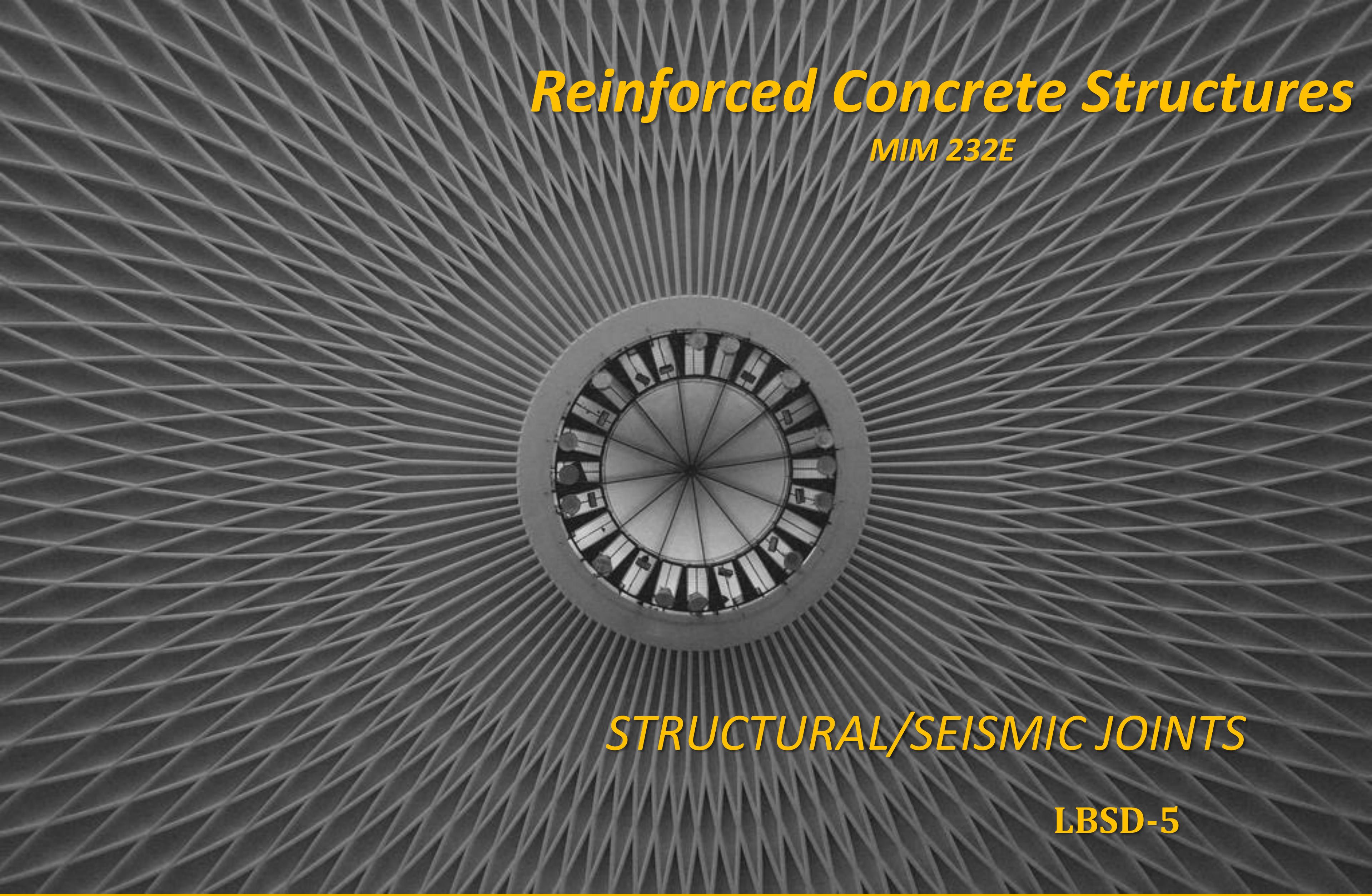

Reinforced Concrete Structures

MIM 232E

STRUCTURAL/SEISMIC JOINTS

LBSD-5

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Structural and Earthquake Engineering WG

Structural/Seismic Joints *Intro*

- In a LBS, continuity is important,
  it has positive effect on the structural behavior

- Secondary effects (temperature, creep, differential settlement etc.) are negligible for bldgs with limited size

- However, secondary effects are important when the size increases

- In some cases, secondary effects may be included in calculations

- However, taking measures to limit secondary effects in design is more convenient (economic reasons)

- To supply it,

  A large structure is seperated into blocks with joints by interrupting continuity

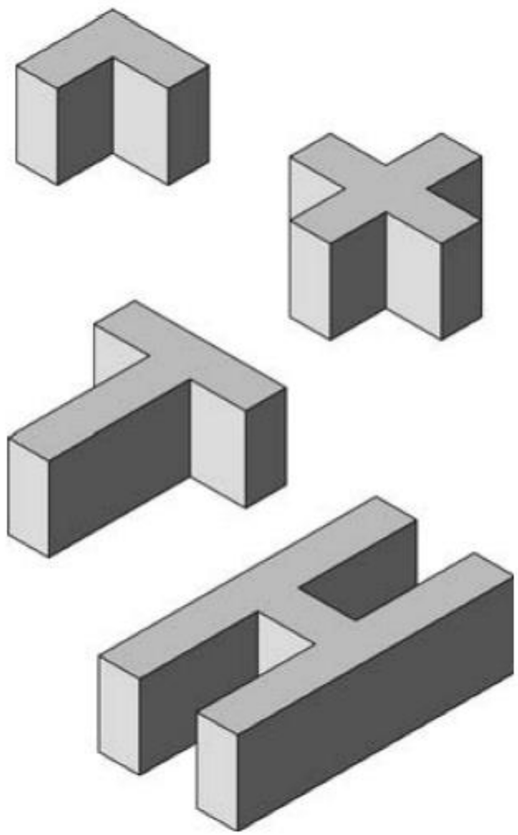
- Therefore, several parts of a structure can independently behave/response by this operation

- Block/part dimensions depend on structural properties for each case.

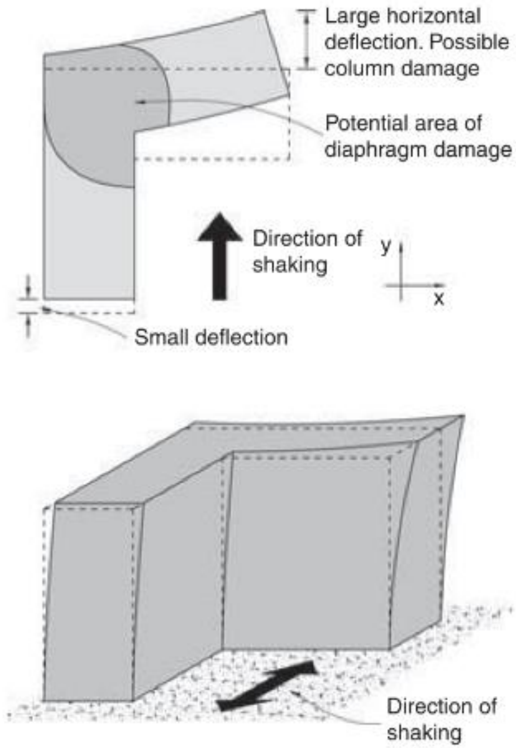
Structural/Seismic Joints *Intro*

- Reasons to make structural joint:

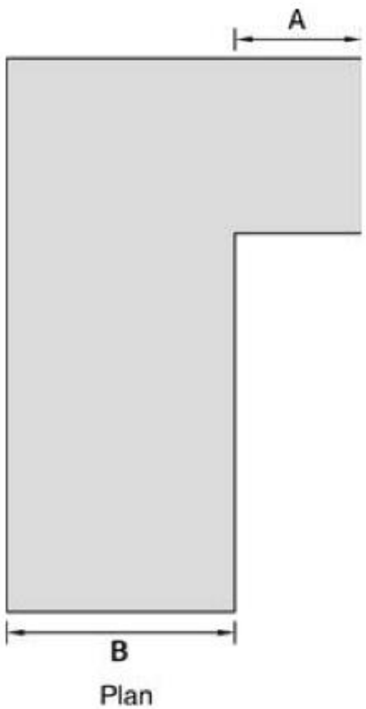
  - Temperature/creep etc. effects
  - Fire
  - Differential settlement in foundations
  - Settlements in mining areas
  - Limit to vibrations (due to machine etc.) in a local area
  - Dividing a structure into blocks that produces less harmful vibration under EQ effects



▲ **8.10** Typical re-entrant corner forms.

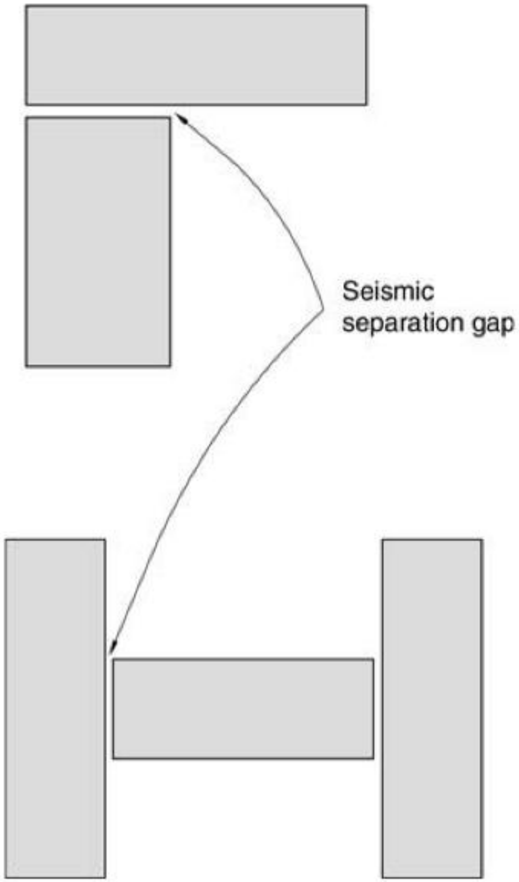


▲ **8.11** The dynamic response of a re-entrant configuration and potential floor diaphragm damage area.



▲ **8.12** A typical definition of an irregular re-entrant configuration is where A > 0.15B.

Structural/Seismic Joints Intro



▲ **8.13** Irregular plan configurations improved by seismic separation gaps.

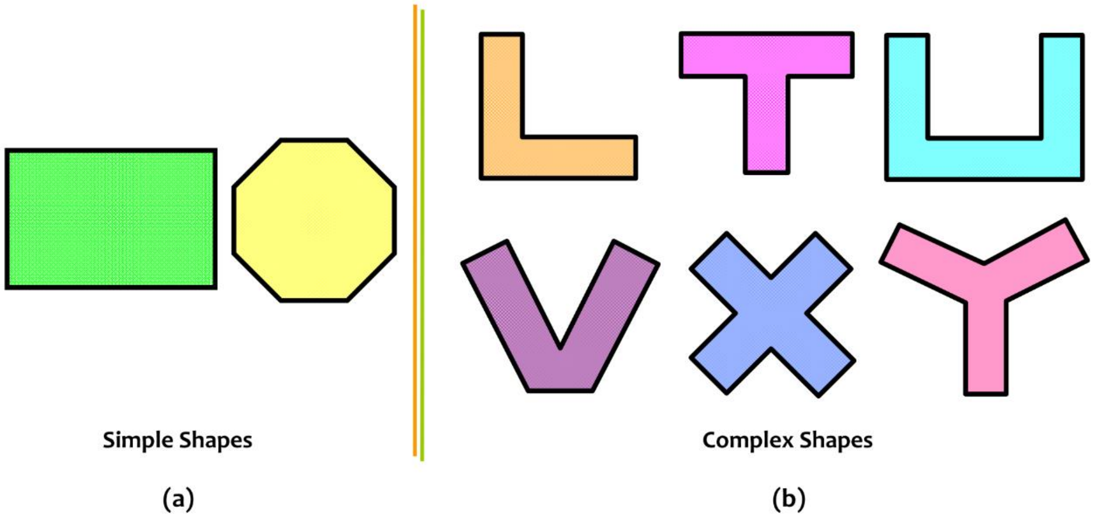


Figure 3.1: *Plan shapes of buildings*: Buildings with (a) simple shapes undergo simple acceptable structural seismic behaviour, while (b) those with complex shapes undergo complex unacceptable structural seismic behaviour

Six buildings, without any irregularity in mass or stiffness, but with complex shapes are chosen to compare the effect of plan shape on elastic behaviour of buildings (Figure 3.4). These buildings have approximately the same plan area of about 2496m². The first six modes of oscillation of each of these buildings are compared in Table 3.1, and shown in Figures 3.5 to 3.10.

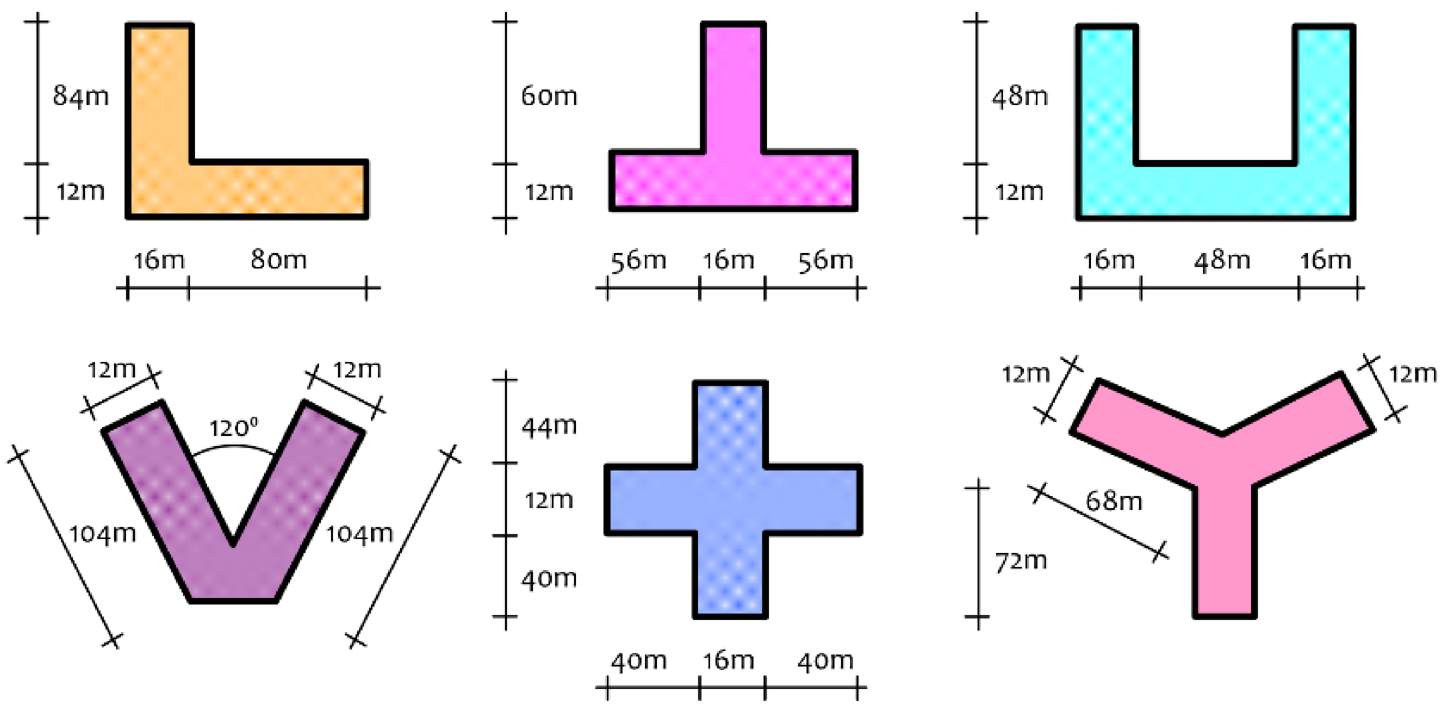


Figure 3.4: *Buildings of different plan shapes*: These buildings have approximately the same plan area

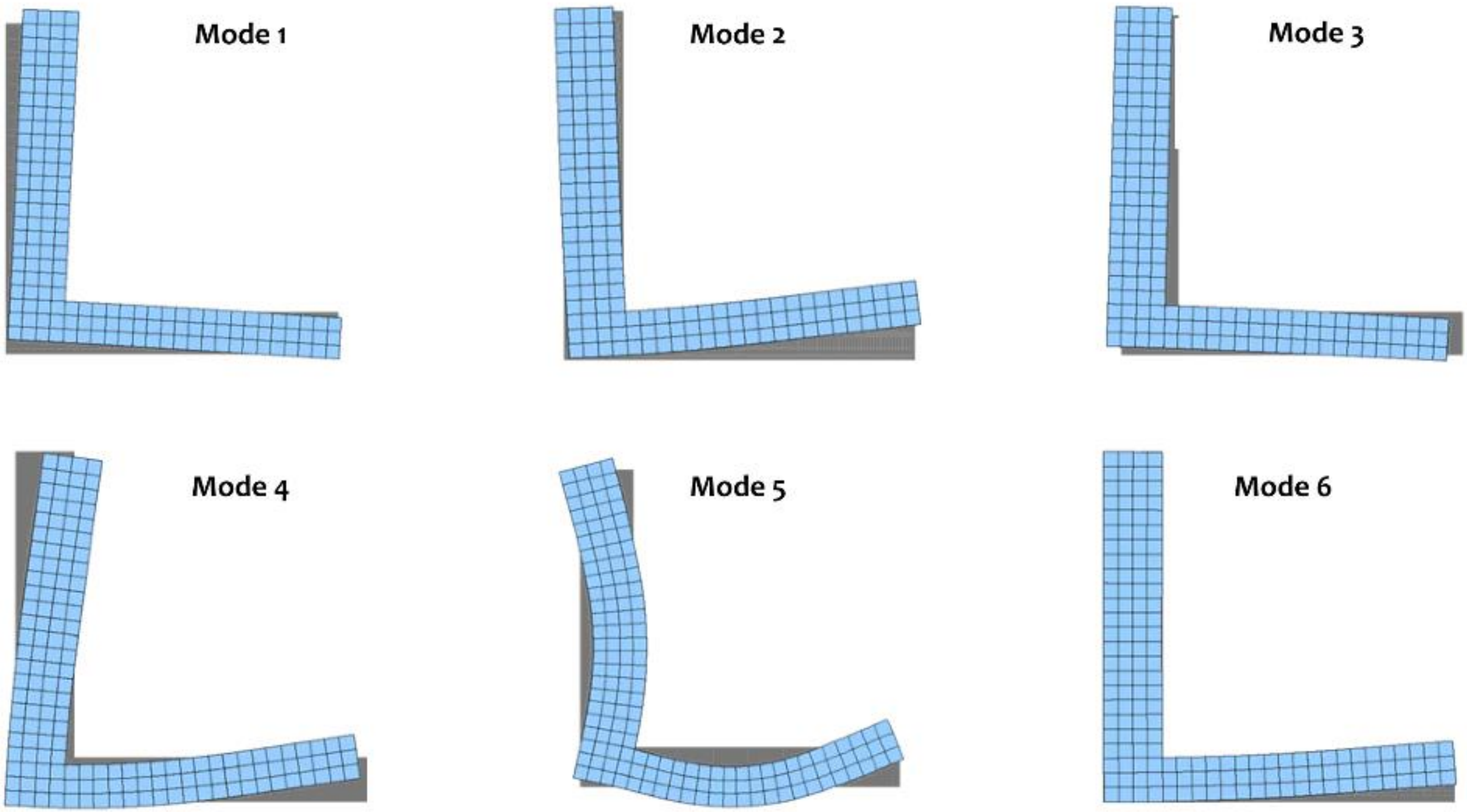


Figure 3.5: *Modes of oscillation*: First six modes of oscillation in building with L-plan shape

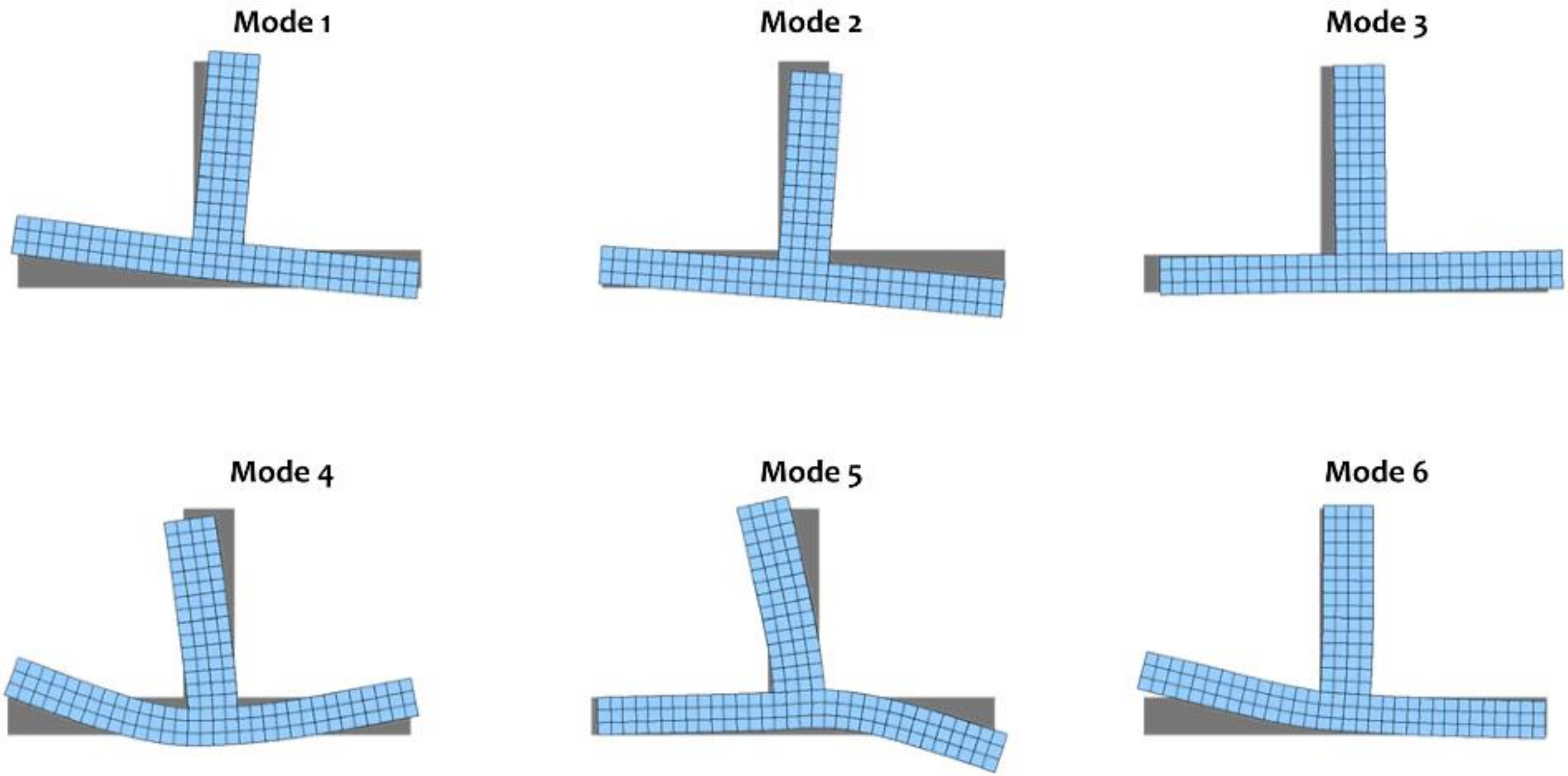


Figure 3.6: *Modes of oscillation*: First six modes of oscillation in building with T-plan shape

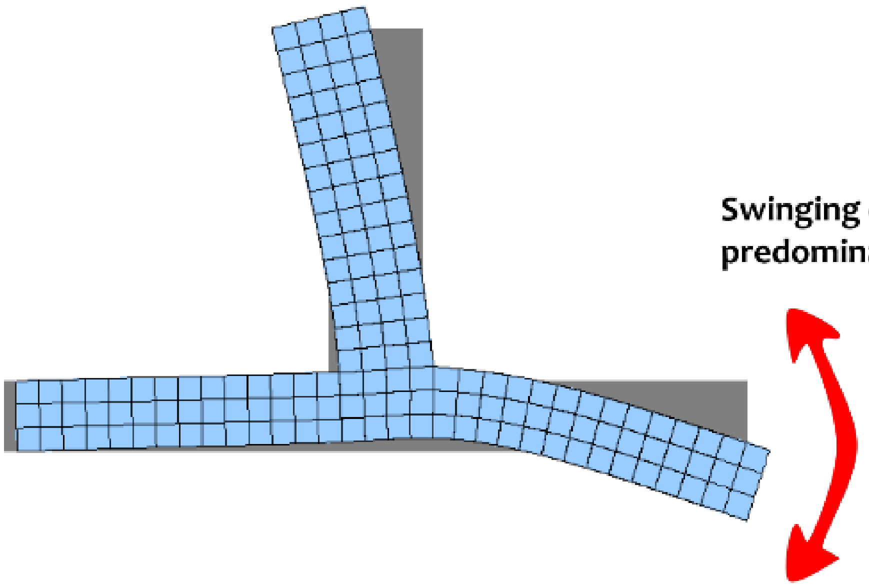
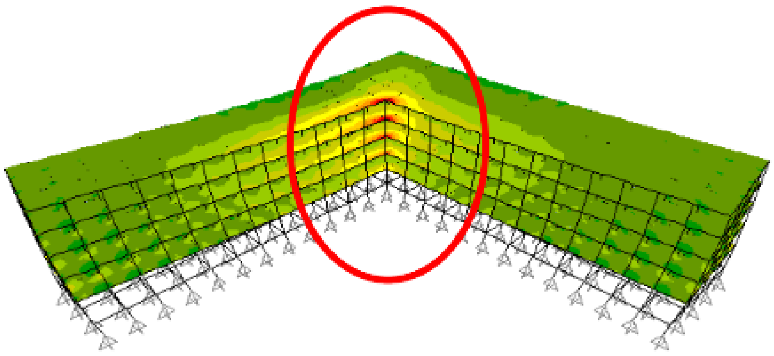


Figure 3.11: *Dog-tail-wagging mode of oscillation*: Only a projection oscillates significantly, while the rest of the building remains almost still



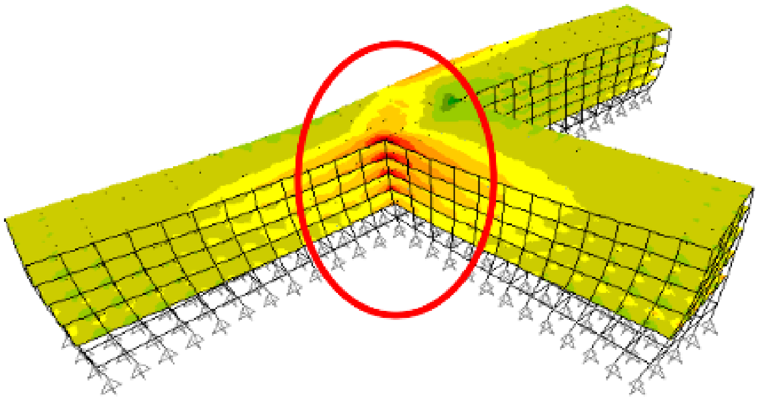
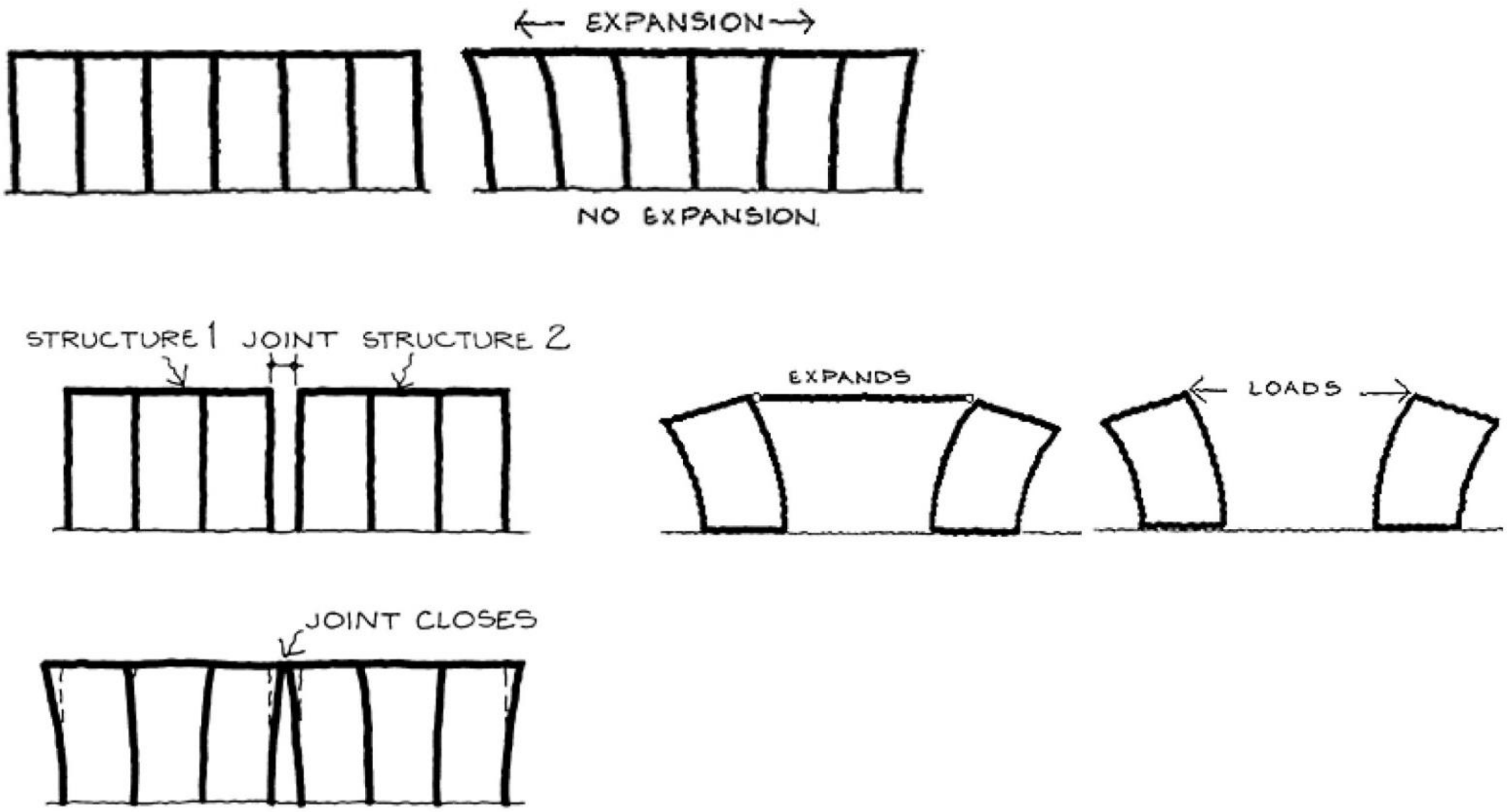


Figure 3.12: *Stress concentration at re-entrant corners*: Stress concentration at re-entrant corners in buildings with complex shapes can cause significant damage during earthquake shaking

Table 4.1 Thermal movement of building materials

Material	*Coefficient of thermal expansion per °C × 10^{-6}*	*Approximate increase in a length of 30 m for a 20 °C rise in temperature (mm)*
Concretes	10–14	11.76
Mild steel	12	10.00
Aluminium alloys	24	20.00
Brickwork	8	6.70

TEMPERATURE LOAD EFFECT



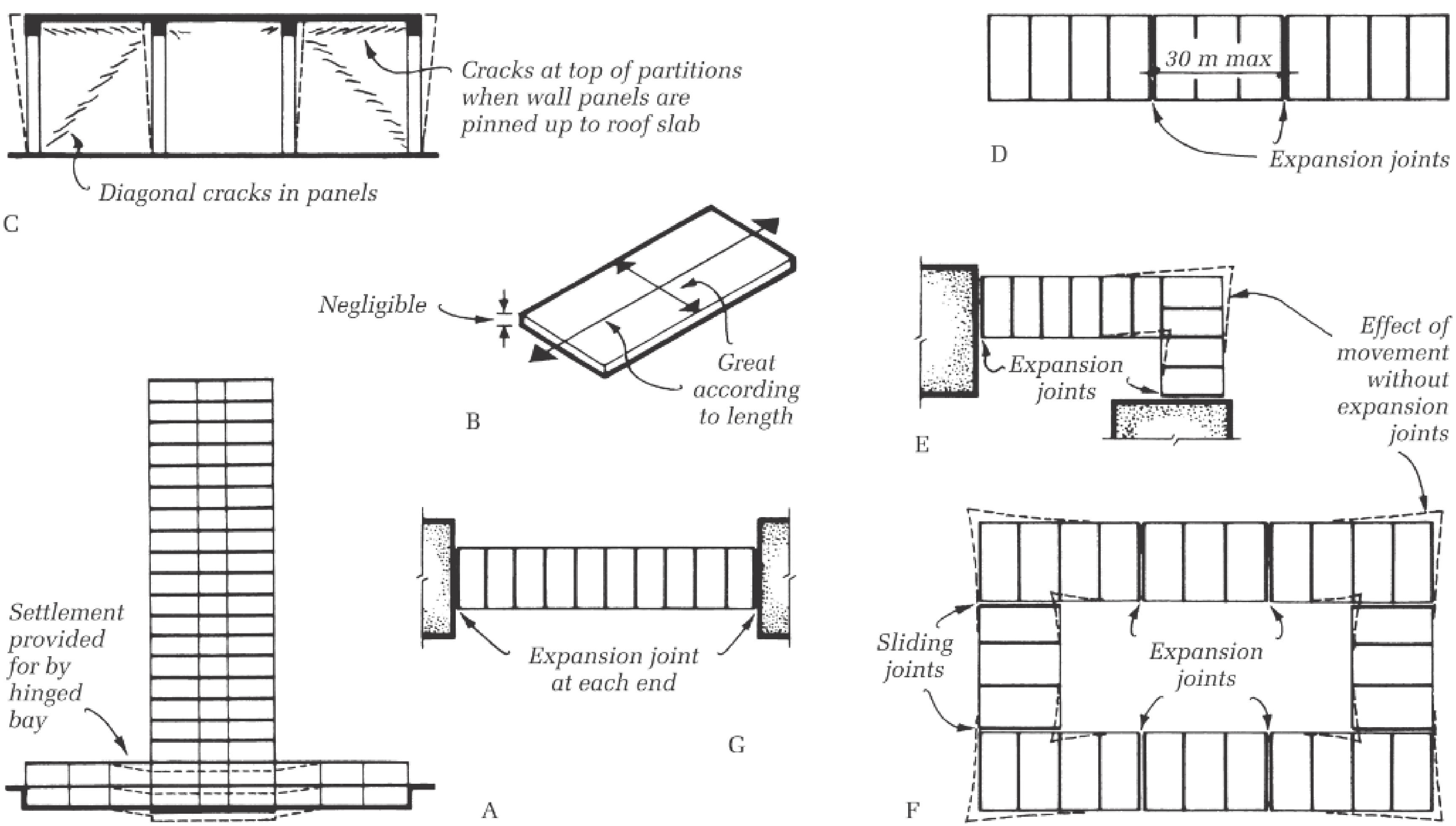
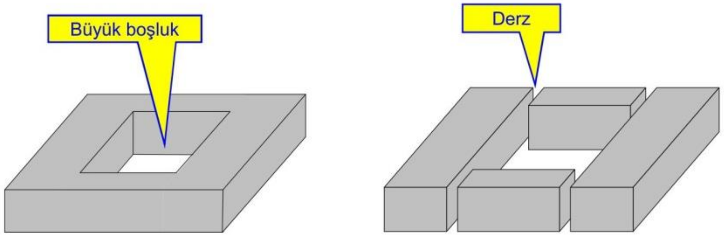
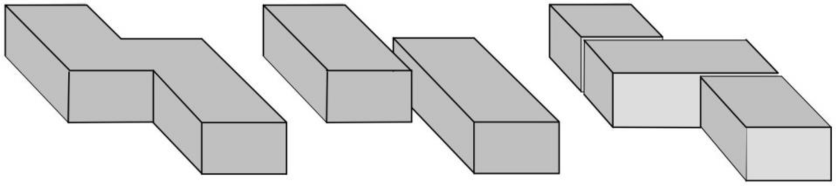


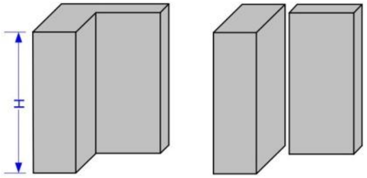
Figure 4.36 Movement control



Kötü İyi



Kötü İyi İyi



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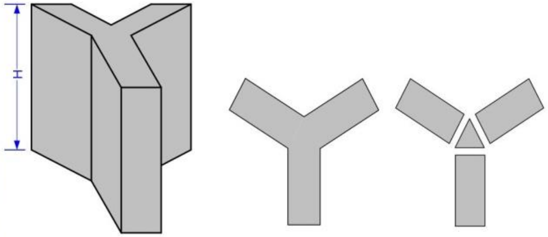
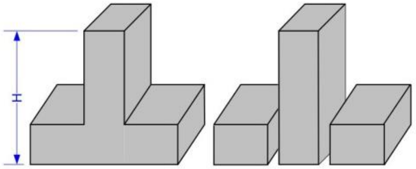


yapı Plan (kötü) Plan (iyi)



Kötü İyi

Expansion joints When the length of the building exceeds much more than 30 m expansion joints are usually provided, placed at intervals not greater than 30 m or at other suitable positions not exceeding this distance apart. These subdivide the length of the building so that the amount of movement within each section is limited, and

they provide space for expansion so that damage to the structure is avoided (D). The actual spacing and widths of the joints can be calculated from the coefficients of expansion and a selected rise of temperature.

Structural/Seismic Joints *Intro*

When the form of the building is such that expansion at some points is restrained, movement will be greater at the unrestrained areas. This can be limited by the provision of expansion joints at the points of restraint as shown in E and F. The design of the end joints in F must permit a sliding action. Expansion joints should similarly be placed where sudden changes occur in plan (G), and where floors and roofs are weakened by large openings in the structure.

Expansion joints should not be limited to the roof slab. They should also be formed in the external walls extending some distance down and inwards to enable the stresses set up by expansion to be distributed. It is common practice to carry expansion joints through the whole of the structure from top to bottom, particularly in monolithic reinforced concrete buildings. In a framed building the simplest method is probably to use double columns and beams as shown in figure 4.37 L, but when double members are undesirable the joint may be formed in the centre of a bay with cantilevered floor slabs or beams, or on the line of a column with sliding bearings to the floor structure as shown in L.

Structural/Seismic Joints Intro

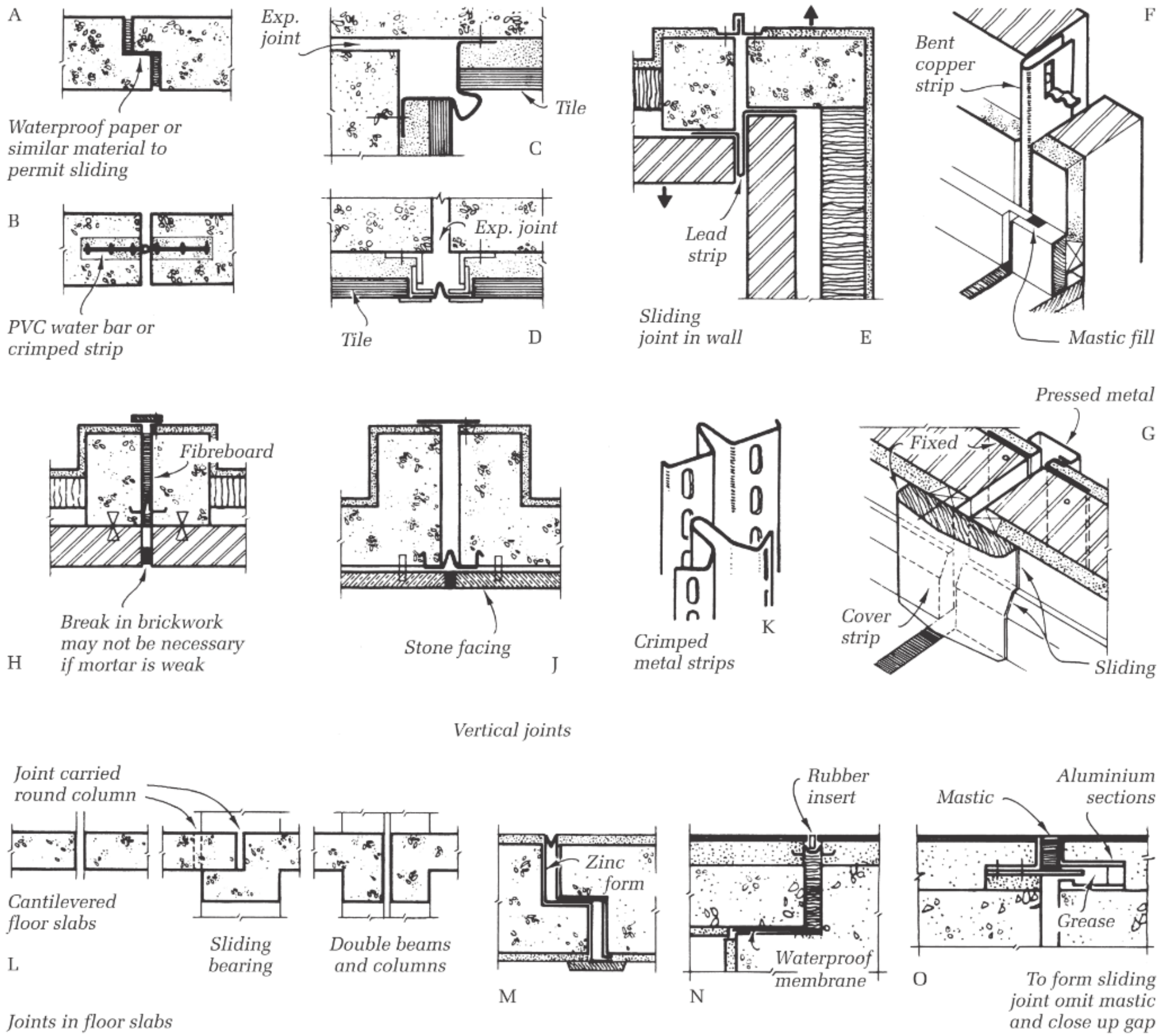
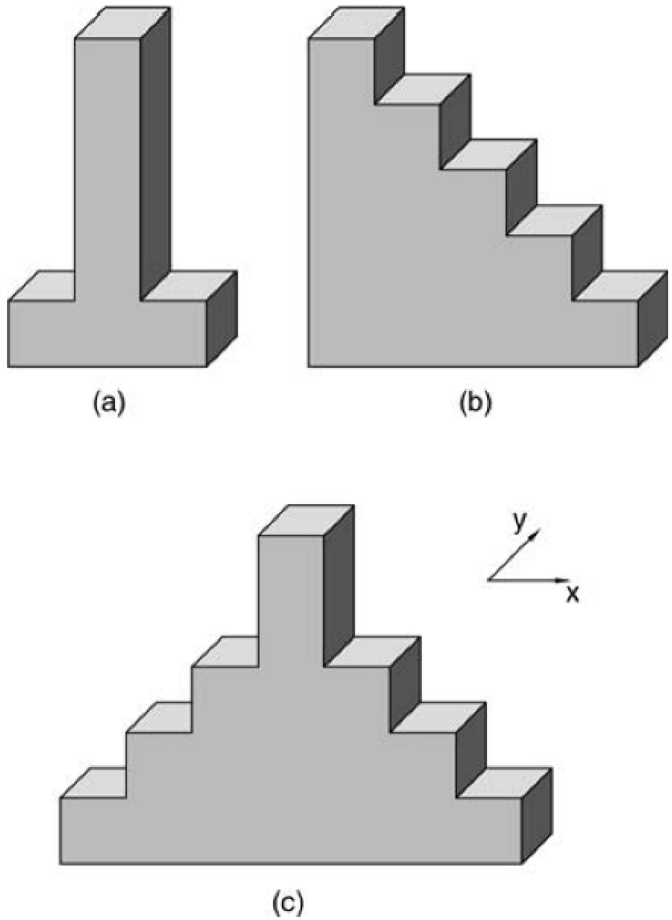
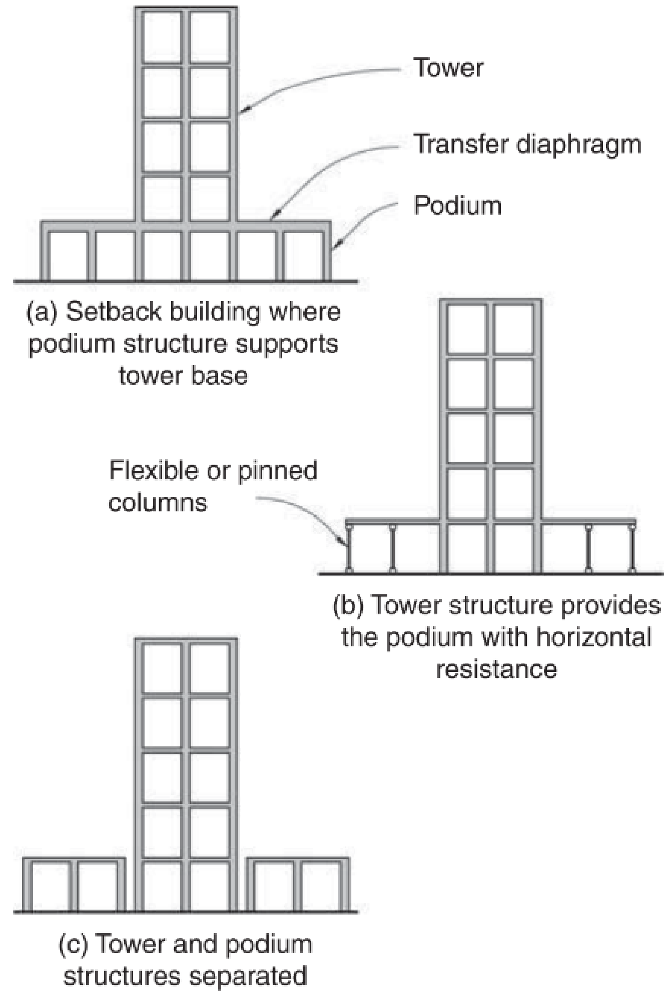


Figure 4.37 Expansion joints

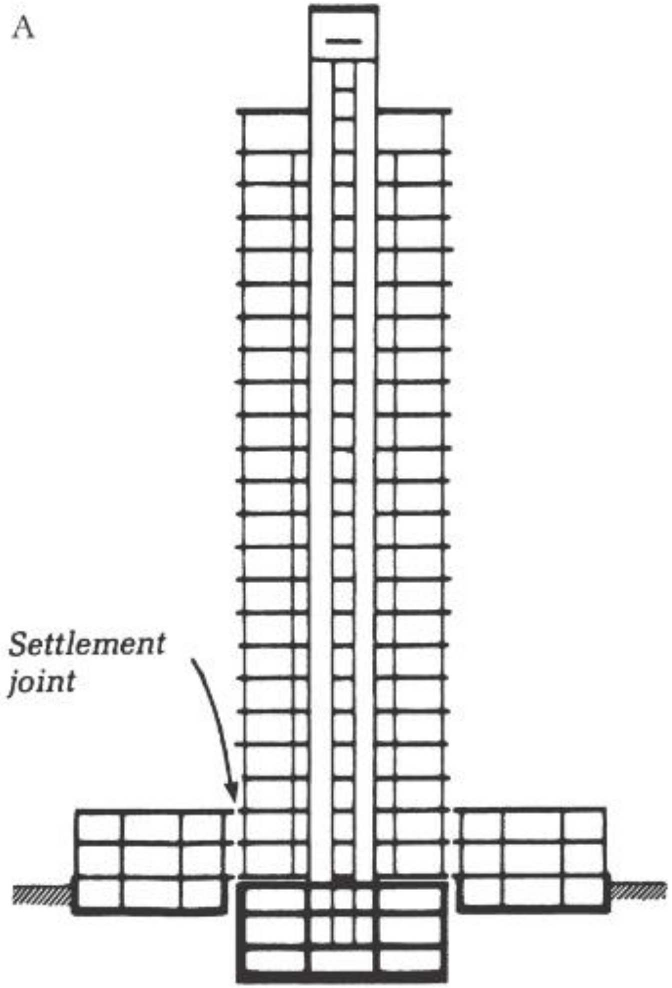
Intro



▲ **9.21** Typical setback configurations.



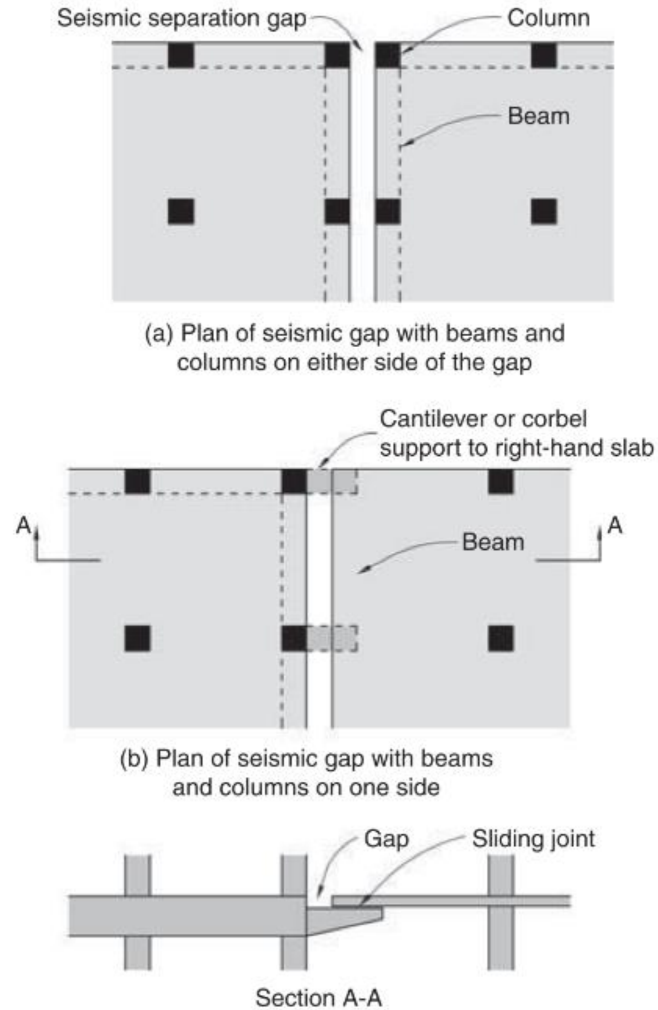
▲ **9.22** Different approaches to the configuration of a tower and podium building.



Deep cellular basement

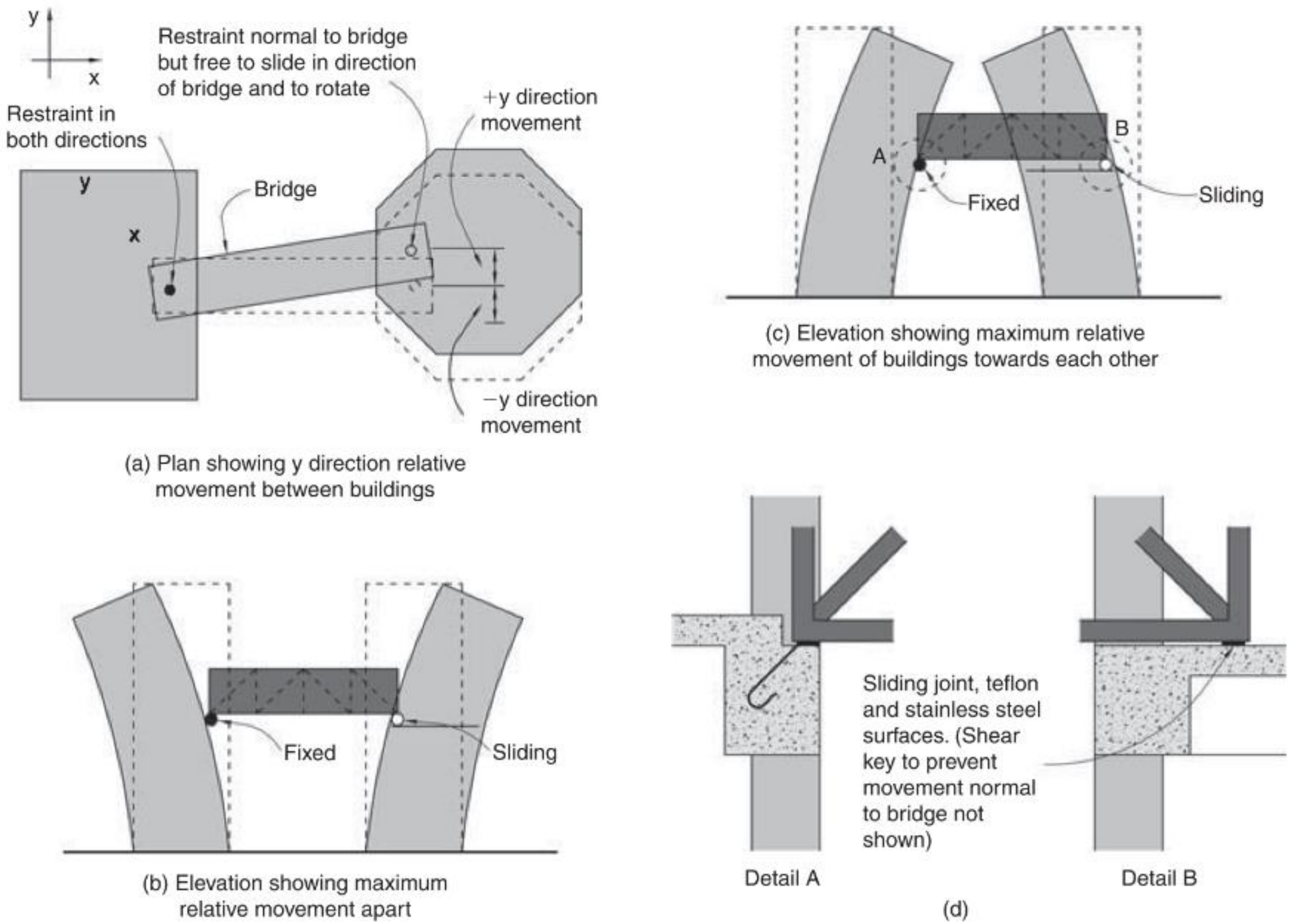
Structural/Seismic Joints *Intro*

▲ **8.28** A seismic joint between floors, walls and ceilings of two separated structures, San Francisco.



▲ **8.29** Two methods of supporting flooring at a seismic separation gap.

Bridging Between Buildings



▲ **8.31** The relative drifts between two separated buildings (a) to (c) and generic bridge seating details (d).

Structural/Seismic Joints

Bridging Between Buildings

▲ **8.30** Collapsed bridge formerly spanning between two buildings. 1995 Kobe, Japan earthquake.

- Main types;

  - Expansion joint
  - (shrinkage, creep, temperature change)

  - Settlement joint
  - (in case of difference of foundation soil, difference of weigth/heigth of structural parts)

  - EQ/Seismic joints

    (to reduce EQ effects)

- Distance between Joints:

  - Unfavourable effects given above can be removed/minimized by dividing a structure into parts by means of joints in two direction

  - There is no unique value for distance/spacing

  - For a very smooth building (no secondary effects such as temperature, diff. settlement etc.),
    L: 40~45m

Structural/Seismic Joints

distance between joints

- In general,

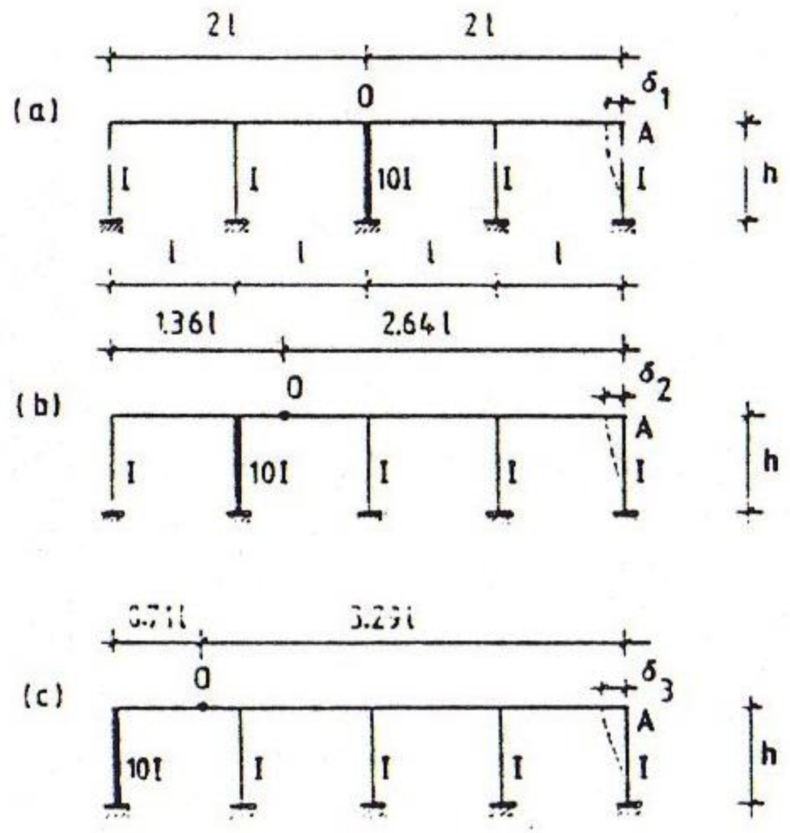
  L ~≤ 30

- It should be less than 30m in structures in that external effects is important

- L ~< 30 in case of fire danger

- L ~≤ 35; in the case of high temperature change

effect of symmetry



The same condition & temperature effect

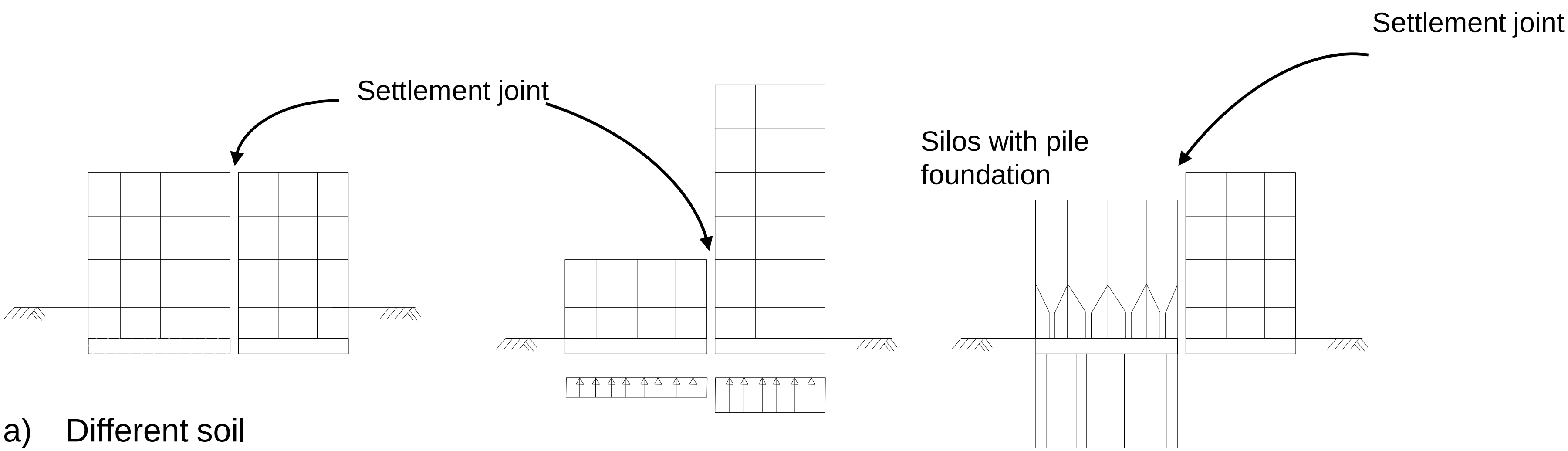
$\delta_1 = \delta$

$\delta_2 = 1.32\,\delta$

$\delta_3 = 1.64\,\delta$

Settlement joints

- Settlement joint is used where needed; independent from dimensions



a) Different soil condition (differential settlement)

b) Different load condition

c) Different foundation and superstructure condition

Settlement joints

- No joint is used
  if there is no differantial settlement risk

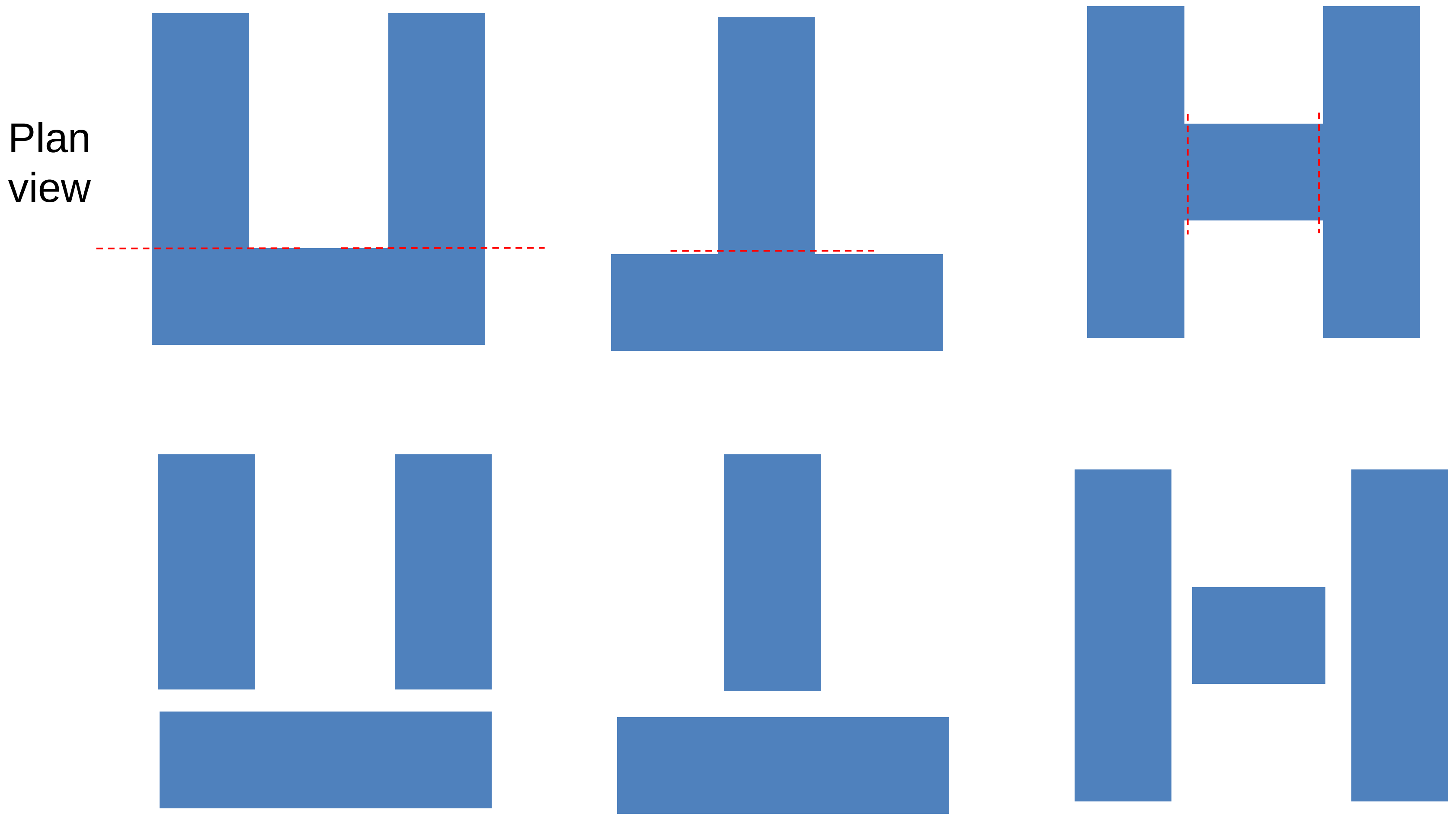
- If differential settlement is expected on soil, the structure is divided into blocks, which is also proceeded in foundation.

Seismic joints

- Under EQ loads; a building with square/almost square plan have good behavior
  (center of gravity and center of rigidity are close, very limited torsional effect)

- Therefore, buildings having U, T, H plan, or long buildings should be properly divided by joints

Seismic joints



Structural/Seismic Joints

designating joint locations

- Joints have several functions to perform

- How to determine joint locations:

  - Divide a structure into blocks/parts considering dimension limits in plan

  - Limits depend on temperature change, slenderness of GF columns, shear wall locations, symmetry etc.

Structural/Seismic Joints *designating joint locations*

- Joint is proceeded to foundation; in the case of discrepancy in soil (because of differantial settlement).

It is independent from dimension and designated where needed;

other effects are also considered

- Joints are located considering EQ effects;

block behavior should be good structurally under EQ

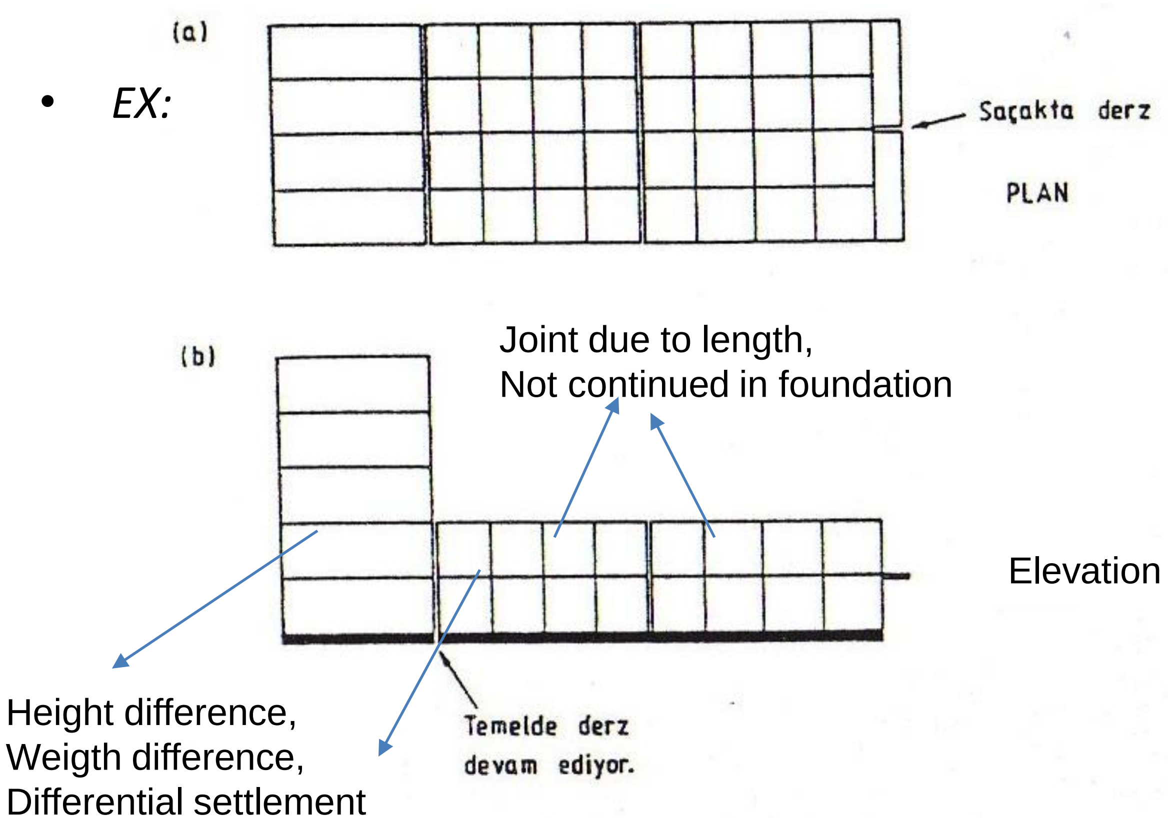
- Around the machines that have vibrations; joints continued in foundation should be arranged

Structural/Seismic Joints *designating joint locations*

- Minimum number of joint is designated,
  but they must be arranged where needed

- In case of improper joint arrangement, unrecoverable/ imprortant damages may be occur

- *EX:*



joint form

- Structural form of joints:

Main two duties of joint details;

1) Supplying independent movement/response of blocks

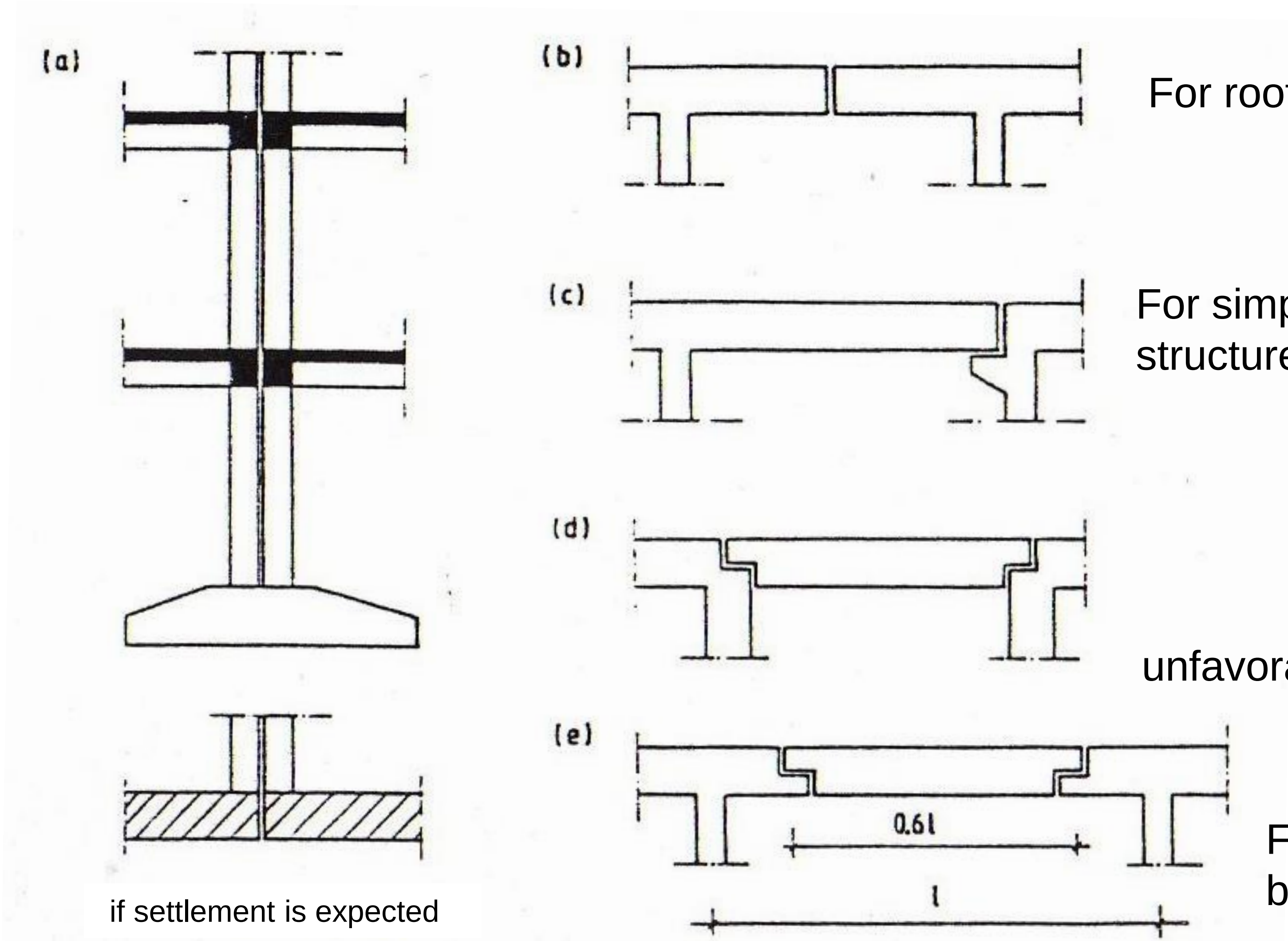
2) Supplying water/temperature isolation

joint form

- Most used form,
  using double structural members along joint.
  the cost increases, but the most convenient way to make joint;
- If soil condition is proper, joint does not continue in foundation

Structural/Seismic Joints

joint form



if settlement is expected

For roofs

For simple structures

unfavorable

For bridge

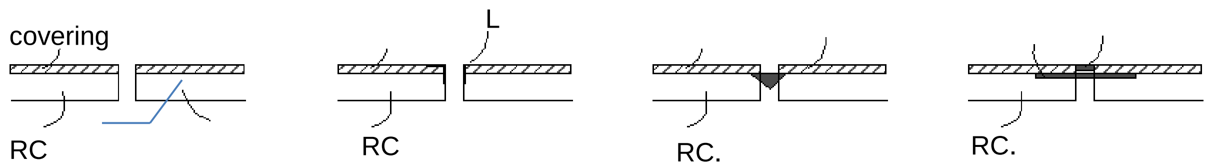
joint form

- Favourable ways of b,d and e cases;
  - Not effected by differential settlements
  - No foundation problems
  - More economic than ‘a’ (no double members)
- However, these types are only used for special conditions

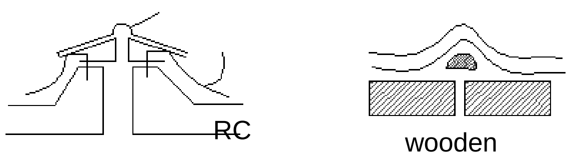
Structural/Seismic Joints

Filling the joint gaps

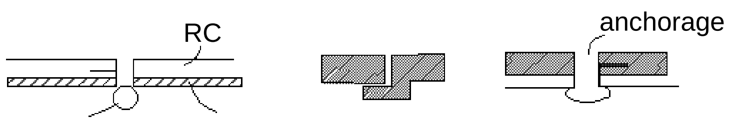
a) Slab



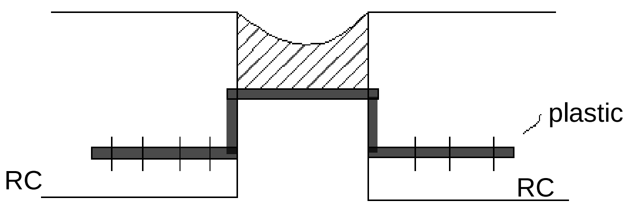
b) Roof

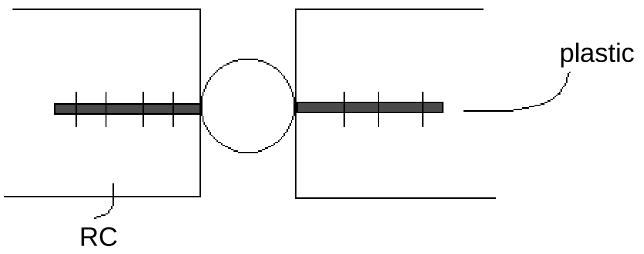


b) Façade



d) Foundation





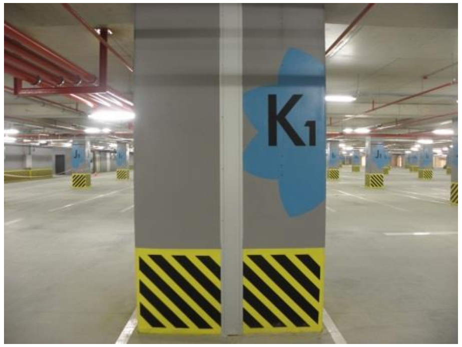
Structural/Seismic Joints

fabrication

- Joint is continued at all secondary members (plaster, paint etc.) as well as structural members
- Joint gap width should allow movement of blocks, but should be minimum in terms of isolation
- ~3cm is ok (if it is sufficient in terms of EQ)
  (consider shrinkage)

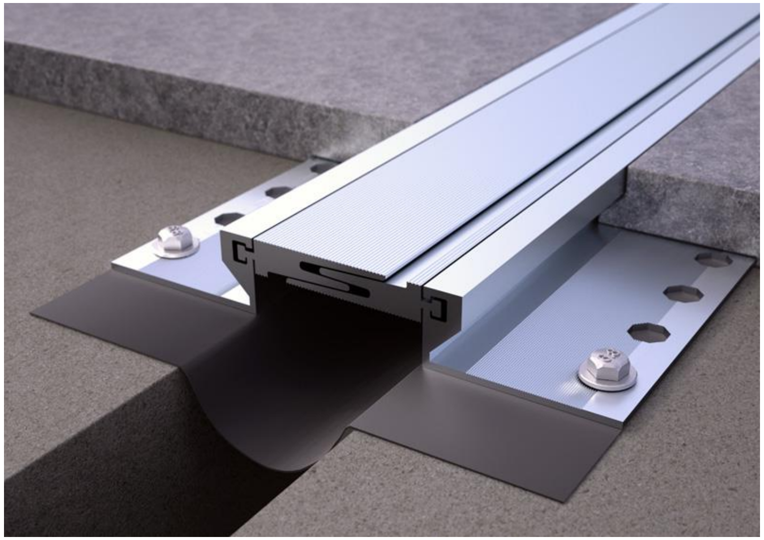
Structural/Seismic Joints

Examples



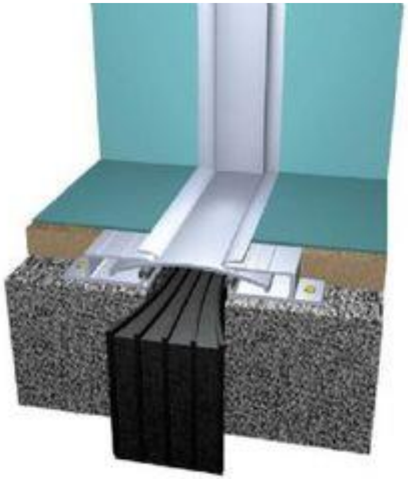
Structural/Seismic Joints

Examples



http://www.emac.es/en/profiles/category/flush-joints-metal.html

http://teknologi-bahanbinaan.blogspot.com.tr/2013/12/sealing-materials-for-joints-in-concrete.html

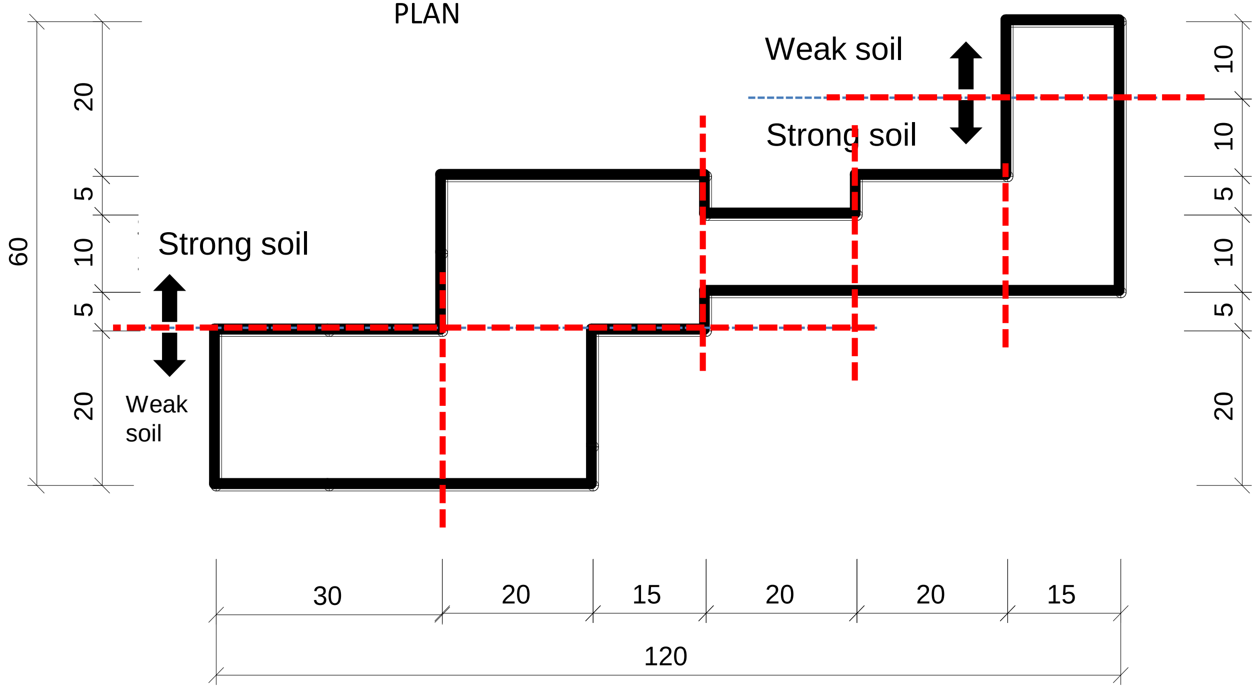


http://www.hellotrade.com/mandas-enterprises/structural-movement-joint-system-fire-barrier.html

Structural/Seismic Joints

Examples

PLAN



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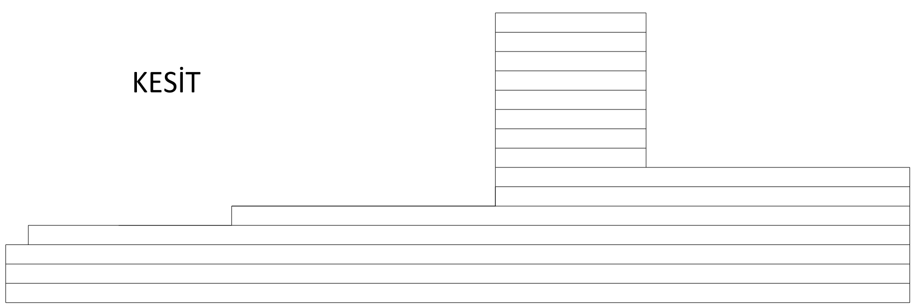

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