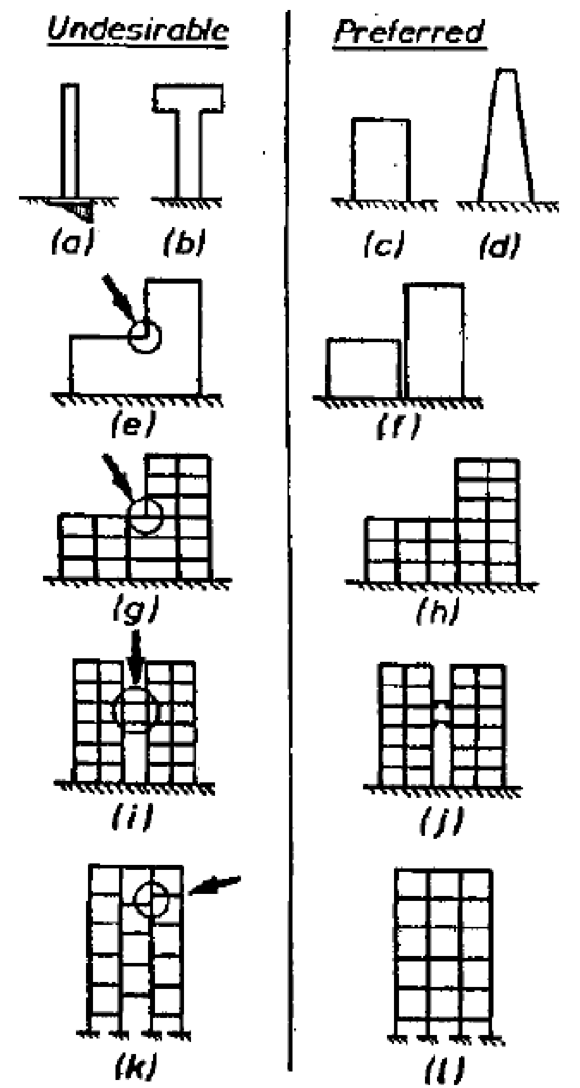
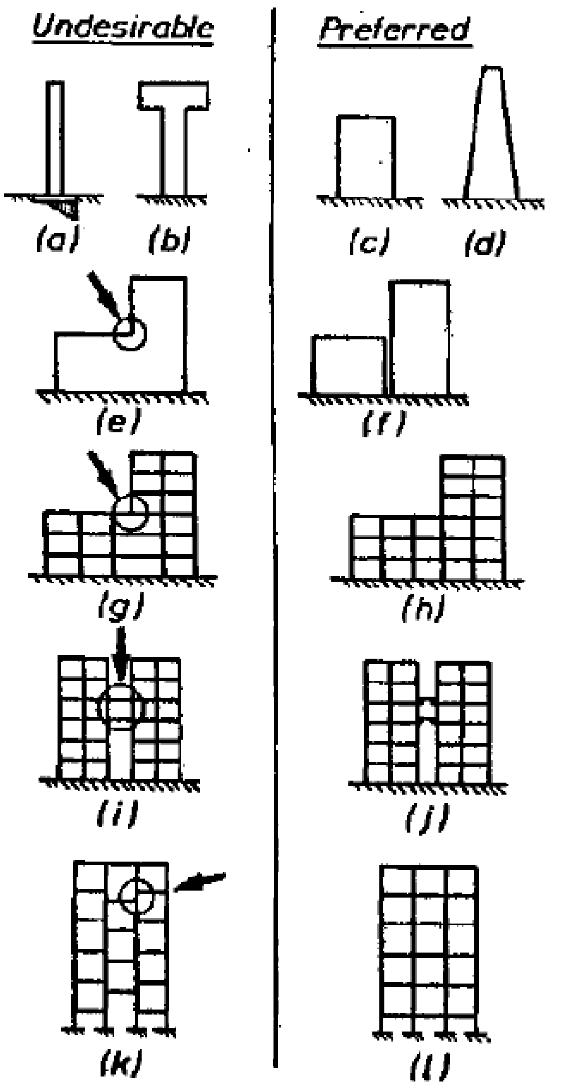
INFLUENCE OF BUILDING CONFIGURATGION ON SEISMIC RESPONSE- RESPONSE IN ELEVATION

- A selection of undesirable and preferred configurations is illustrated in Fig. on right.
- Tall and slender buildings [Fig. (a)] may require large foundations to enable large overturning moments to be transmitted in a stable manner.
- When subjected to seismic accelerations, concentration of masses at the top of a building [Fig. (b)] will similarly impose heavy demands on both the lower stories and the foundations of the structure.
- In comparison, the advantages of building elevations as shown in Fig. (c) and (d) are obvious.



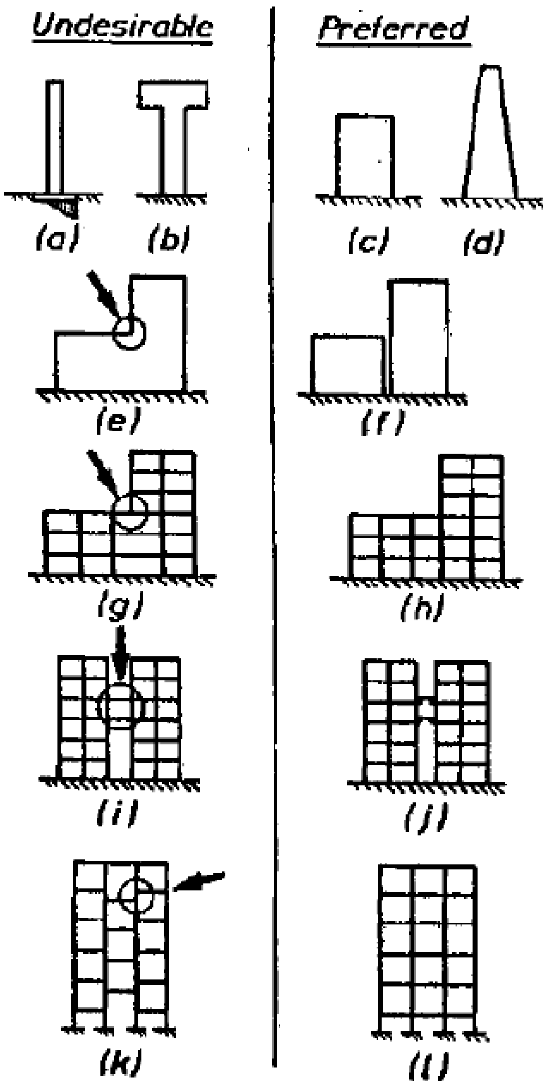
INFLUENCE OF BUILDING CONFIGURATGION ON SEISMIC RESPONSE- RESPONSE IN ELEVATION

- An abrupt change in elevation, such as shown in Fig. (e), also called a set back, may result in the concentration of structural actions at and near the level of discontinuity.
- The magnitudes of such actions, developed during the dynamic response of the building, are difficult to predict without sophisticated analytical methods.
- The separation into two simple, regular structural systems, with adequate separation [Fig. (f)] between them, is a preferable alternative.



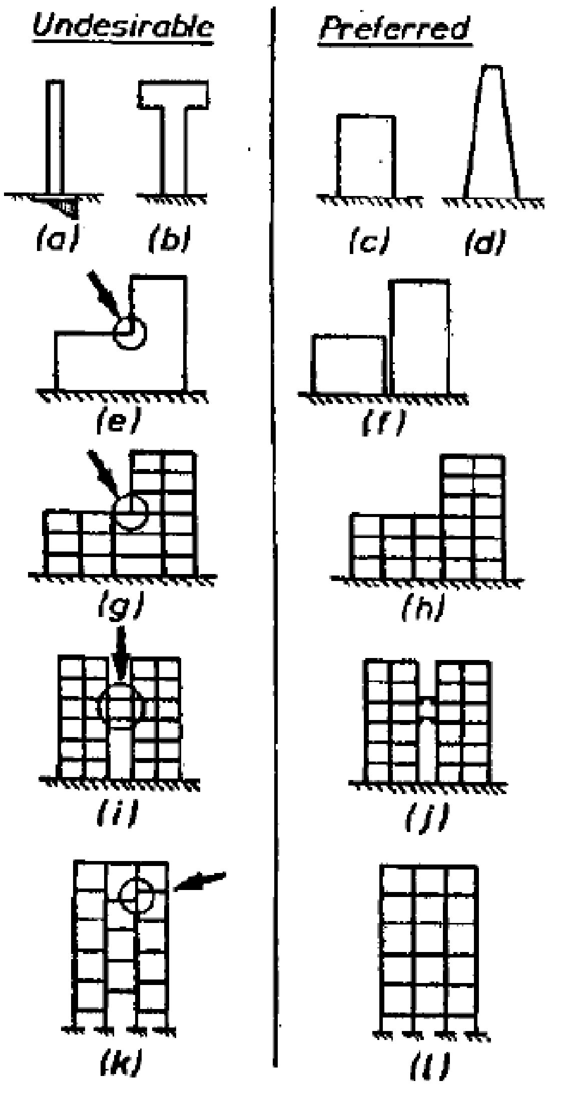
INFLUENCE OF BUILDING CONFIGURATGION ON SEISMIC RESPONSE- RESPONSE IN ELEVATION

- Irregularities within the framing system, such as a drastic interference with the natural flow of gravity loads and that of lateral-force induced column loads at the center of the frame in Fig. (g), must be avoided.
- Although two adjacent buildings may appear to be identical, there is no assurance that their response to ground shaking will be in phase.
- Hence any connections (bridging) between the two that may be desired [Fig. (i)] should be such as to prevent horizontal force transfer between the two structures [Fig.(j)].



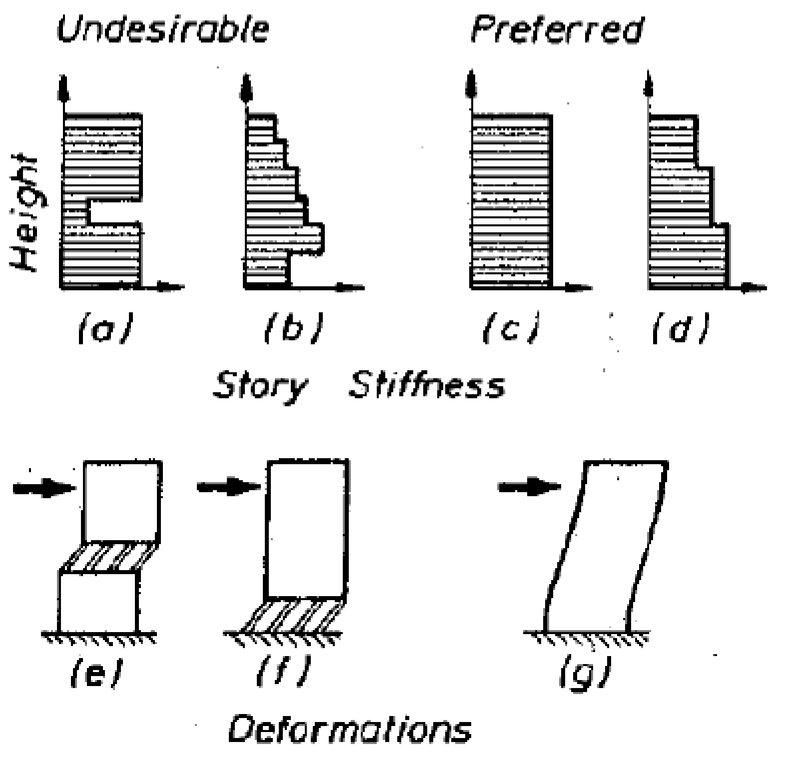
INFLUENCE OF BUILDING CONFIGURATGION ON SEISMIC RESPONSE- RESPONSE IN ELEVATION

- Staggered floor arrangements, as seen in Fig. (k), may invalidate the rigid interconnection of all vertical lateral-force-resisting units.
- Horizontal inertia forces, developed during dynamic response, may impose severe demands, particularly on the short interior columns.
- While such frames [Fig. (k)] may be readily analyzed for horizontal static forces, results of analyses of their inelastic dynamic response to realistic ground shaking should be treated with suspicion.



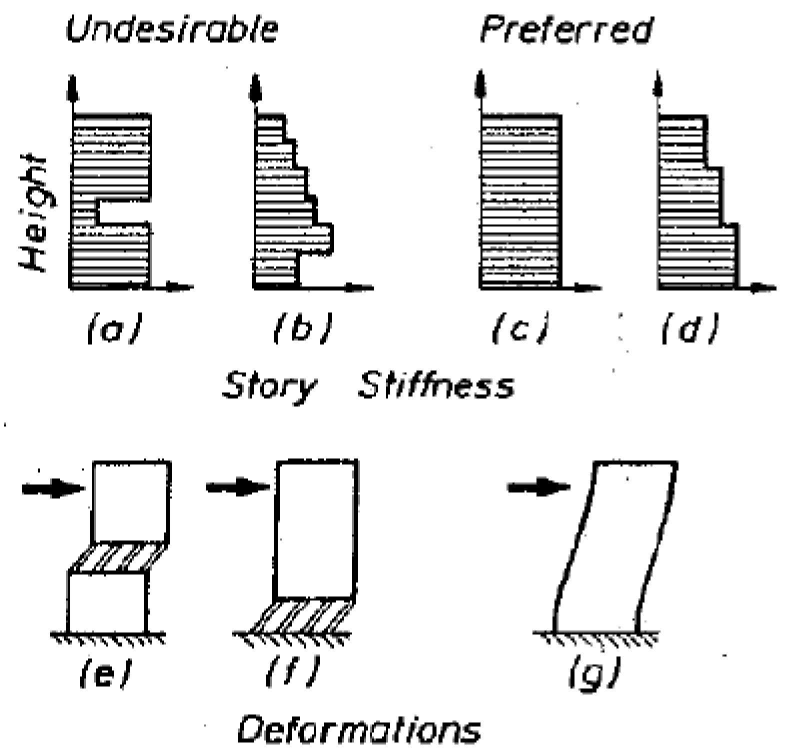
INFLUENCE OF BUILDING CONFIGURATGION ON SEISMIC RESPONSE- RESPONSE IN ELEVATION

- Major deviations from a continuous variation with height of both stiffness and strength are likely to invite poor and often dangerous structural response.
- Because of the abrupt changes of story stiffness's, suggested in Fig. (a) and (b), the dynamic response of the corresponding structures [Fig. (e) and (f)] may be dominated by the flexible stories.



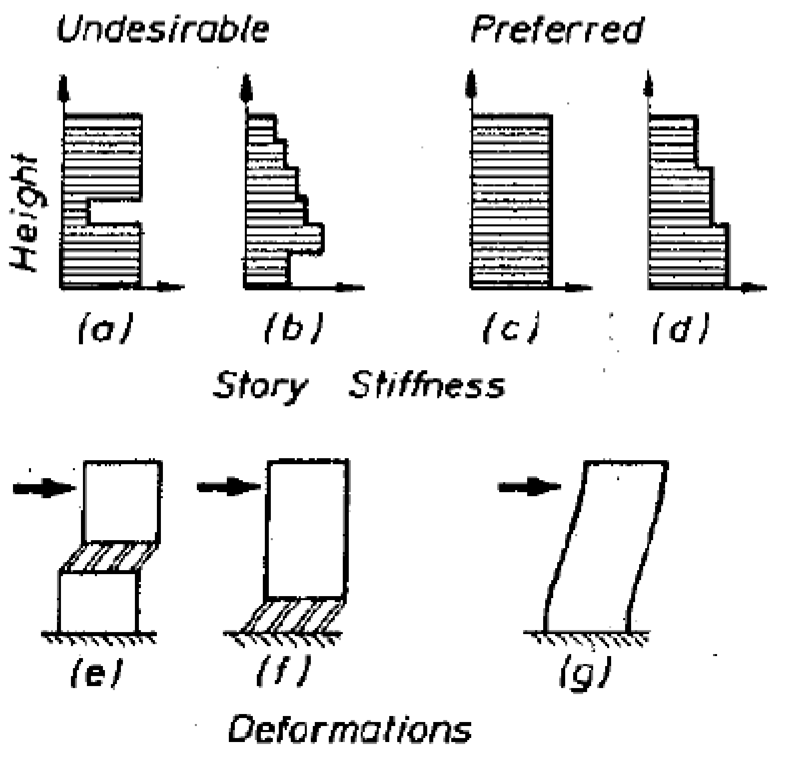
INFLUENCE OF BUILDING CONFIGURATGION ON SEISMIC RESPONSE- RESPONSE IN ELEVATION

- Reduced story stiffness is likely to be accompanied by reduced strength, and this may result in the concentration of extremely large inelastic deformations [Fig. (e) and (f)] in such a story.



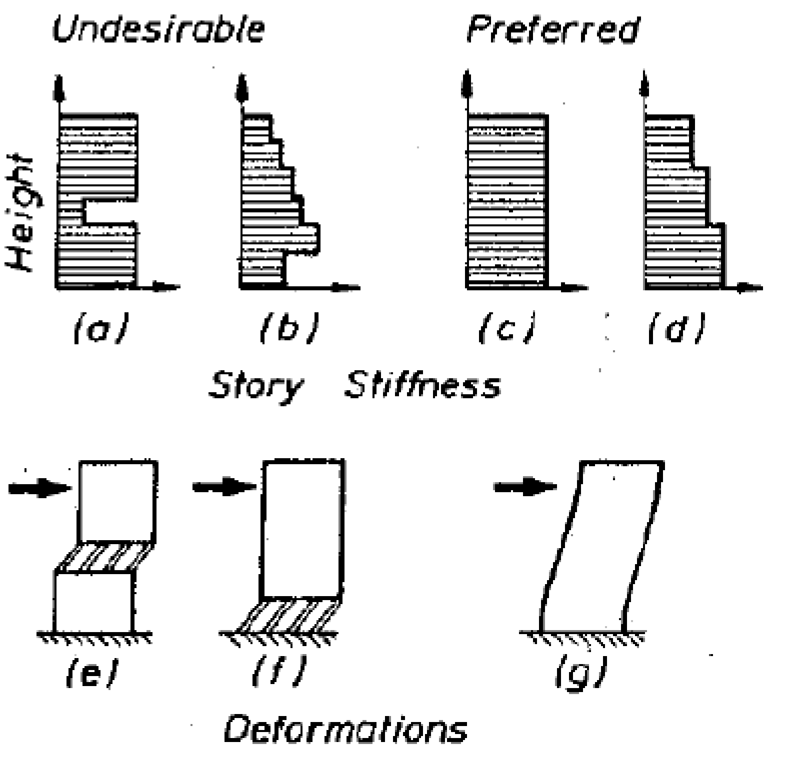
INFLUENCE OF BUILDING CONFIGURATGION ON SEISMIC RESPONSE- RESPONSE IN ELEVATION

- This feature accounts for the majority of collapsed buildings during recent earthquakes. Constant or gradually reducing story stiffness and strength with height [Fig. (c), (d), and (g)] reduce the likelihood of concentrations of plastic deformations ‘during severe seismic events beyond the capacities of affected members.



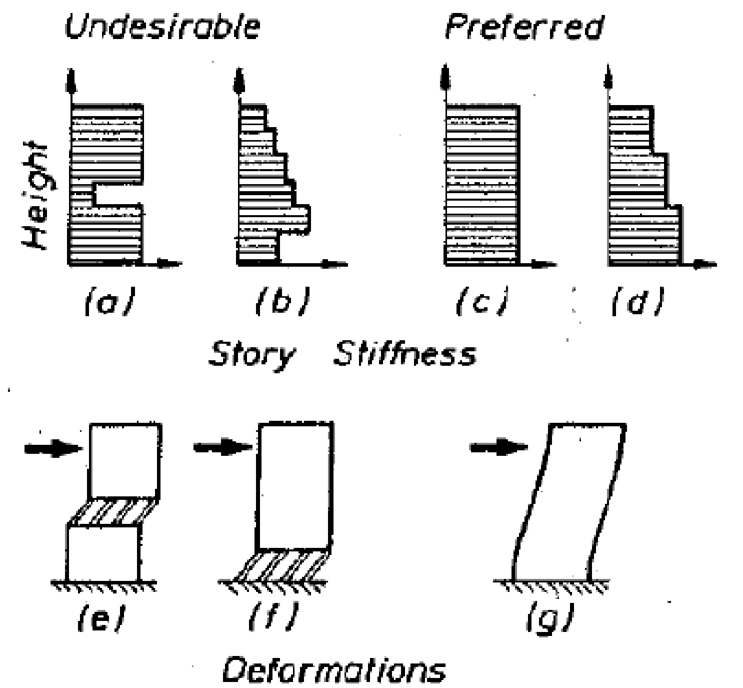
INFLUENCE OF BUILDING CONFIGURATGION ON SEISMIC RESPONSE- RESPONSE IN ELEVATION

- Examples of vertical irregularities in buildings using structural walls as primary lateral-force-resisting elements are shown in bottom Fig., together with' suggested improvements.



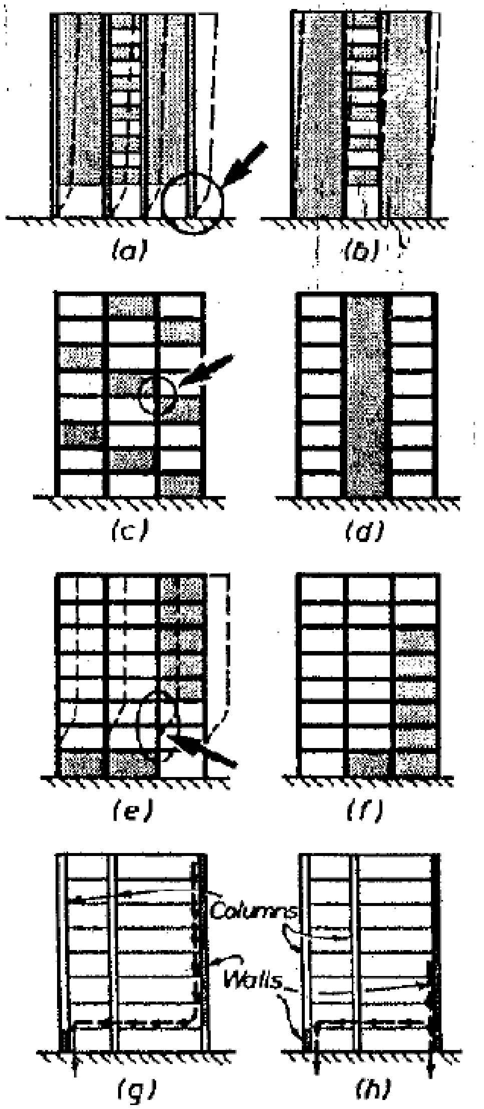
INFLUENCE OF BUILDING CONFIGURATGION ON SEISMIC RESPONSE- RESPONSE IN ELEVATION

- When a large open space is to be provided in the' first story, designers are often tempted to terminate structural walls, which may extend over the full height of the building, at level 2 [Fig. (a)].
- Unless other parallel walls, perhaps at the boundaries of the floor plan, are provided, a so-called soft story will develop.
- This is likely to impose ductility demands on columns which may well be beyond their ductility capacity.



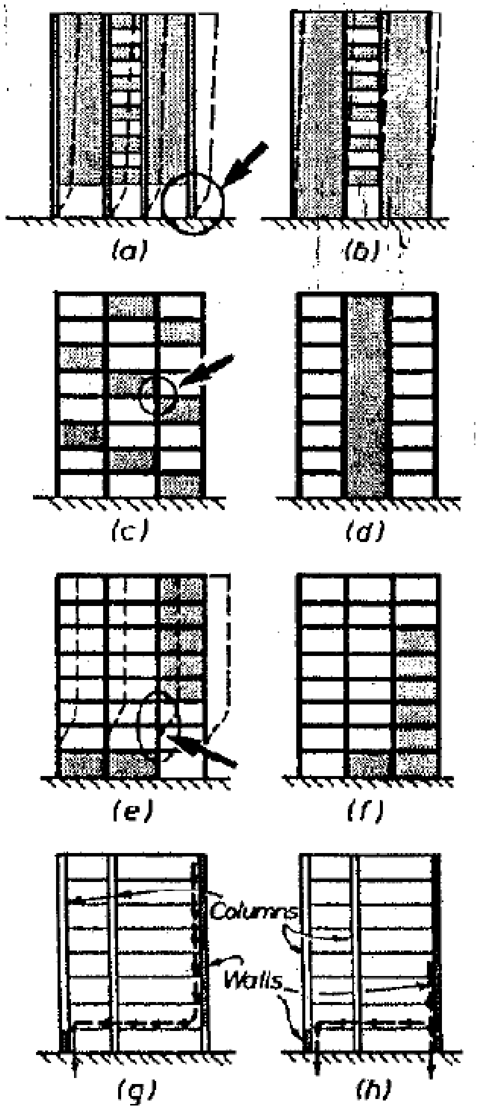
INFLUENCE OF BUILDING CONFIGURATGION ON SEISMIC RESPONSE- RESPONSE IN ELEVATION

- A continuation of the walls, interconnected by coupling beams at each floor, down to the foundations, shown in Fig. (b), will, on the other hand, result in one of the most desirable structural configurations.
- Staggered wall panels, shown in Fig. (c), may provide a stiff load path for lateral earthquake forces.
- However, the transmission of these forces at corners will make detailing of reinforcement, required for adequate ductility, extremely difficult.



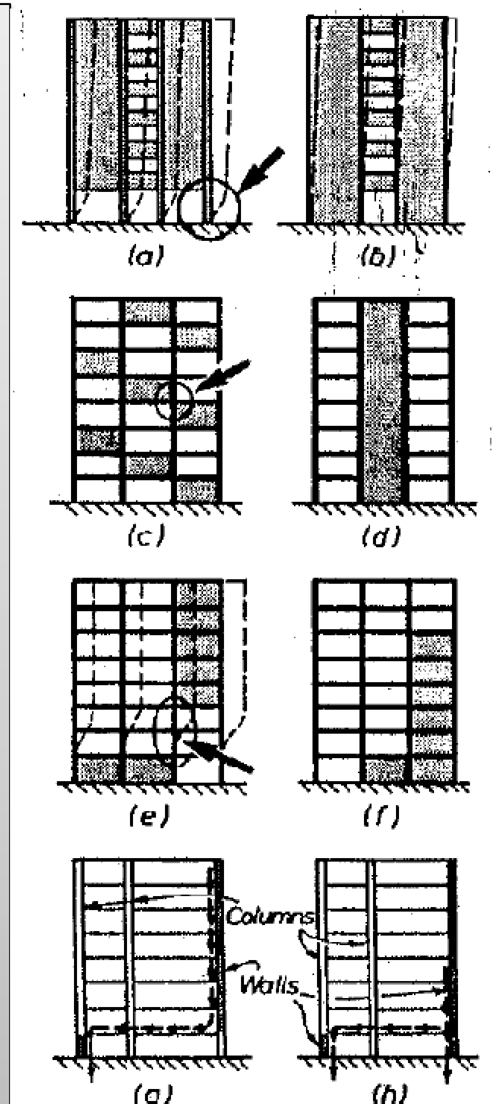
INFLUENCE OF BUILDING CONFIGURATGION ON SEISMIC RESPONSE- RESPONSE IN ELEVATION

- The assembly of all panels into one single cantilever [Fig. (d)] with or without interacting frames will, however, result in an excellent lateral force resisting system.
- An interruption of walls over one or more intermediate stories [Fig. (e)] will invite concentrations of drift in those stories, as suggested previously.
- Discontinuities of the type shown in Fig. (f), are, on the other hand, acceptable, as strength and stiffness distribution with height is compatible with the expected forces and displacements.



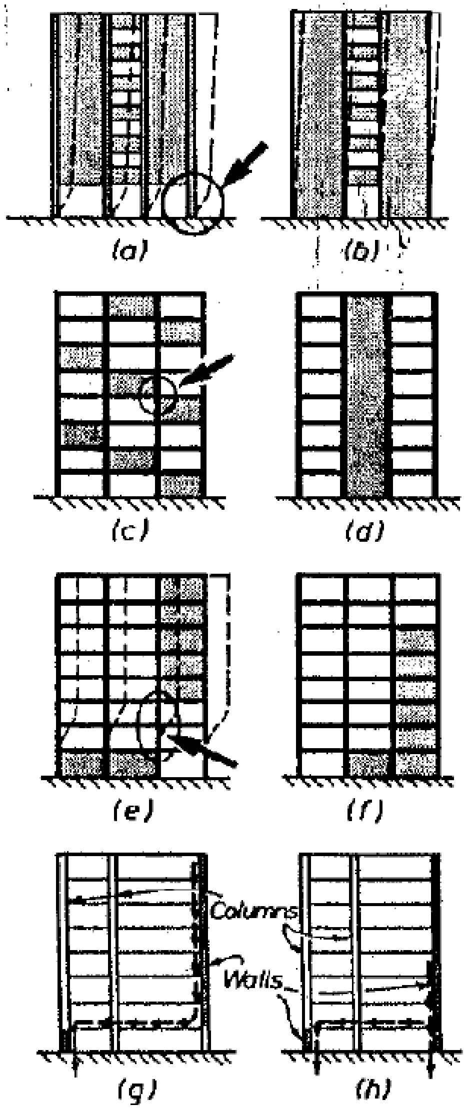
INFLUENCE OF BUILDING CONFIGURATGION ON SEISMIC RESPONSE- RESPONSE IN ELEVATION

- The side view of the structure shown in Fig. (a) may be as shown in Fig. (g).
- It shows that a major portion of the accumulated earthquake forces from upper levels, resulting in large shear at level 2 of the wall extending above that level will need to be transferred to a very stiff short wall at the opposite side of the building.
- The arrows in Fig. (g) indicate the gross deviation of the path of internal forces leading to the foundation, which may impose excessive demands in both torsion in the first story and actions within the floor diaphragm.



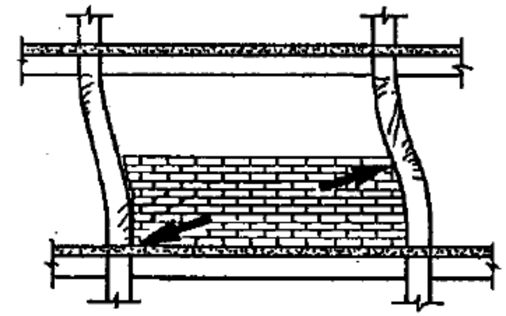
INFLUENCE OF BUILDING CONFIGURATGION ON SEISMIC RESPONSE- RESPONSE IN ELEVATION

- Both of these undesired effects will be alleviated if the tall wall terminates in the foundations [Fig. (b)], while sharing the base shear with a short wall, as shown in Fig. (h).
- Another source of major damage, particularly in columns, repeatedly observed in earthquakes, is the interference with the natural deformations of members by rigid nonstructural elements, such as infill walls.



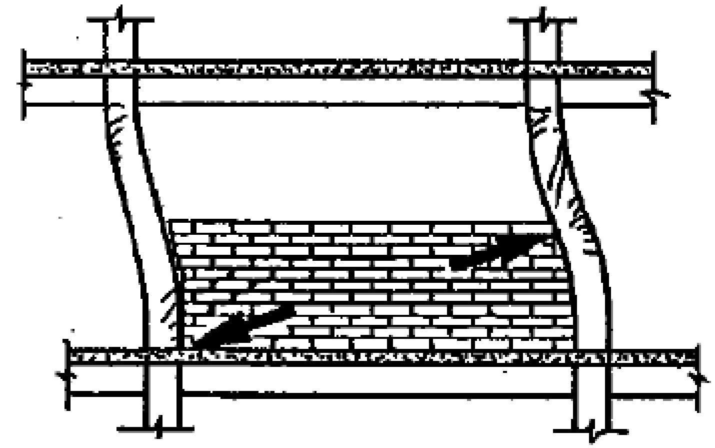
INFLUENCE OF BUILDING CONFIGURATGION ON SEISMIC RESPONSE- RESPONSE IN ELEVATION

- As Fig. on the right shows, the top edge of a brick wall will reduce the effective length of one of the columns, thereby increasing its stiffness in terms of lateral forces.
- Since seismic forces are attracted in proportion to element stiffness, the column may thus attract larger horizontal shear forces than it would be capable of resisting.
- Moreover, a relatively brittle flexural failure may occur at a location (mid height) where no provision for the appropriate detailing of plastic regions would have been made.



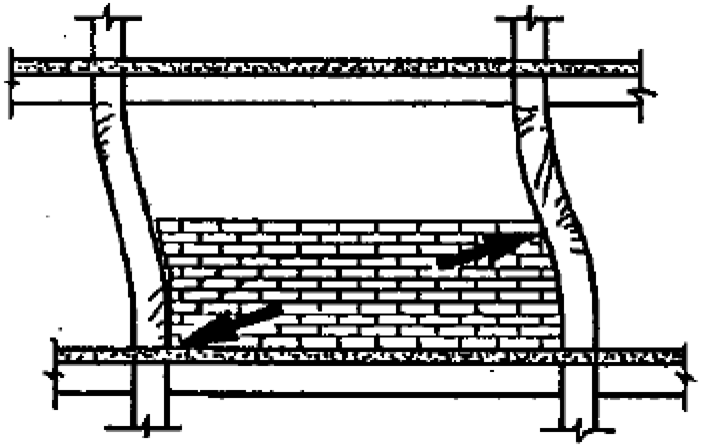
INFLUENCE OF BUILDING CONFIGURATGION ON SEISMIC RESPONSE- RESPONSE IN ELEVATION

- The unexpected failure of such major gravity-load-carrying elements may lead to the collapse of the entire building.
- Therefore, a very important task of the designer is to ensure, both in the design and during construction, that intended deformations, including those of primary lateral-force-resisting components, in the inelastic range of seismic response, can take place without interference.

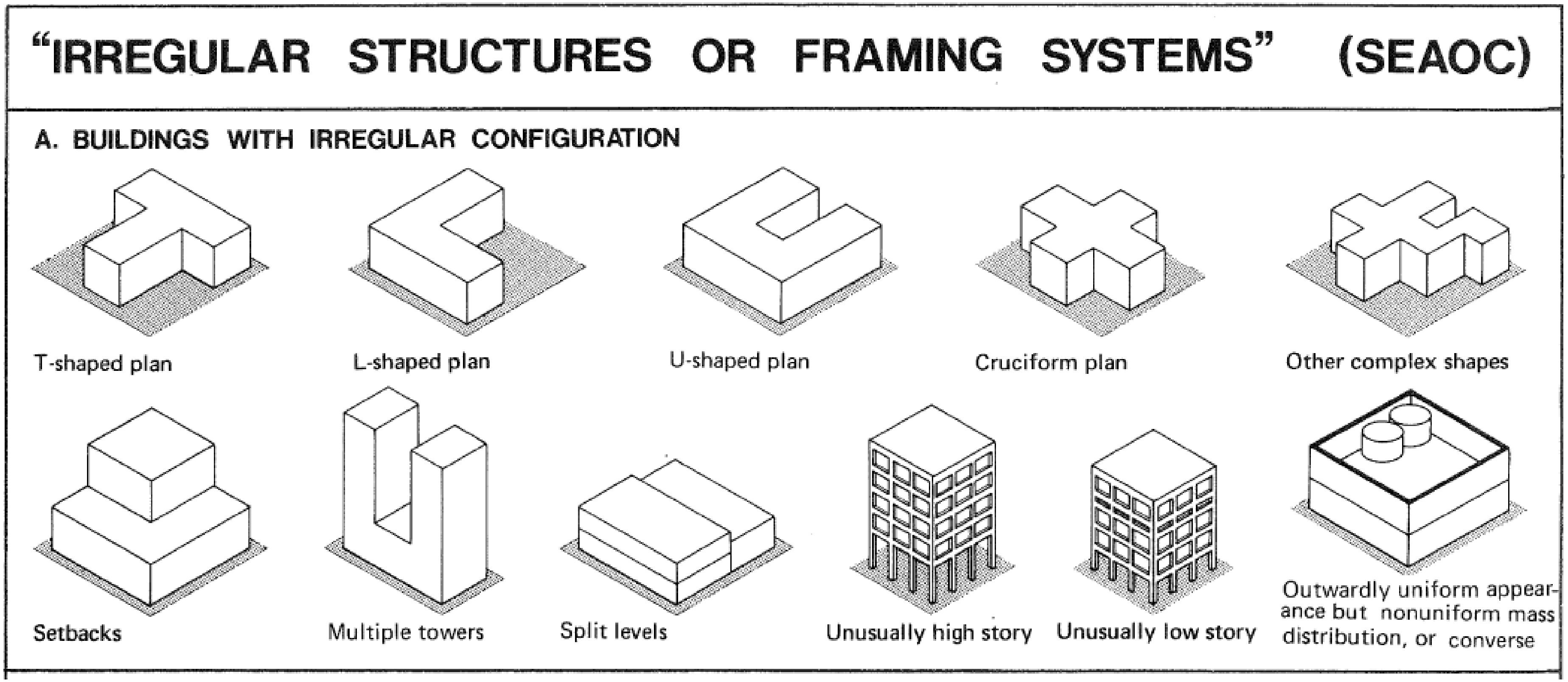


INFLUENCE OF BUILDING CONFIGURATGION ON SEISMIC RESPONSE- RESPONSE IN ELEVATION

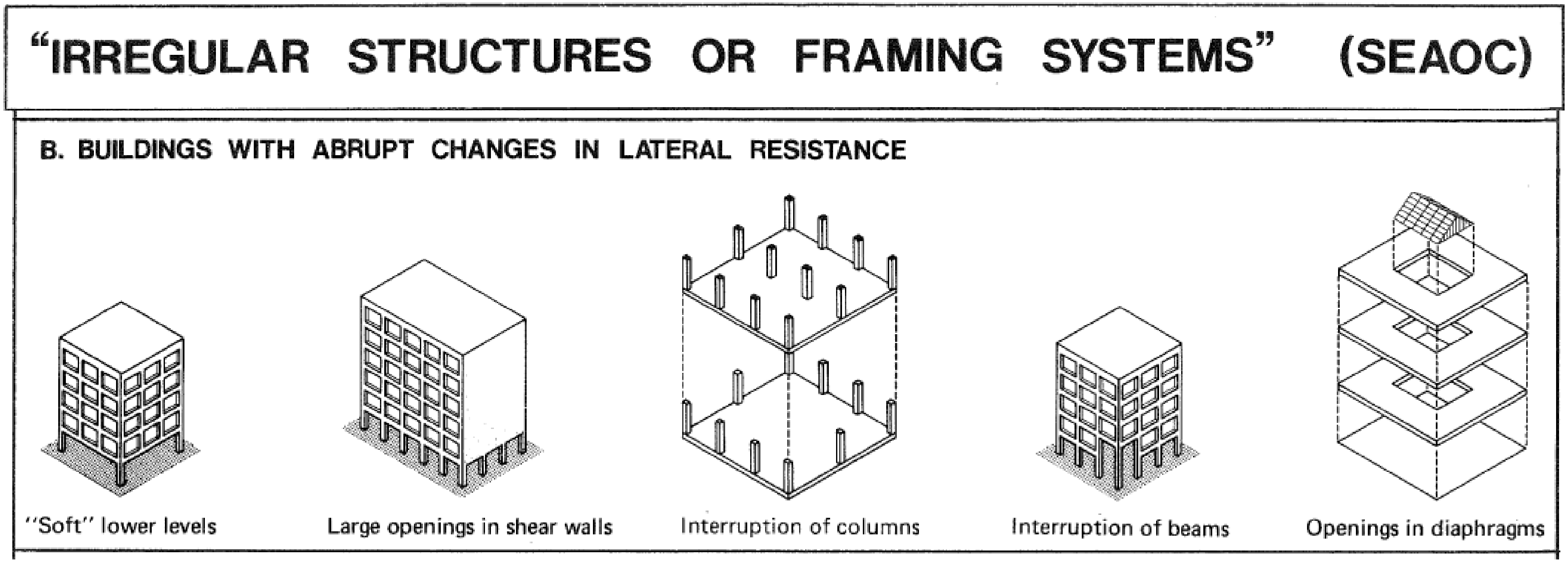
- In the context of seismic design the observance of principles relevant to configurations is at least as important as those of structural analysis, the art in detailing for ductility's of critical regions, and the assurance of high quality in workmanship during construction.



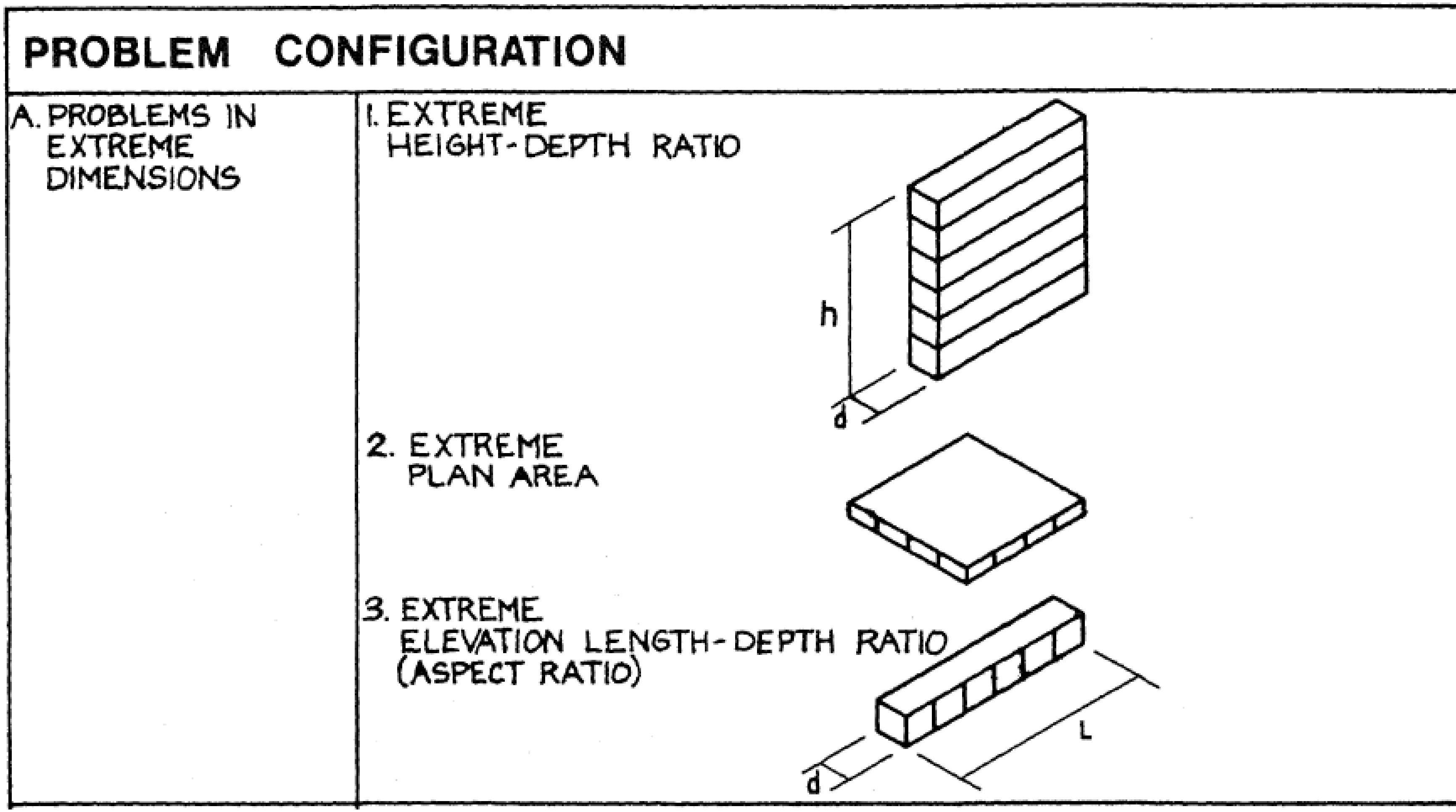
INFLUENCE OF BUILDING CONFIGURATGION ON SEISMIC RESPONSE



INFLUENCE OF BUILDING CONFIGURATGION ON SEISMIC RESPONSE



INFLUENCE OF BUILDING CONFIGURATGION ON SEISMIC RESPONSE

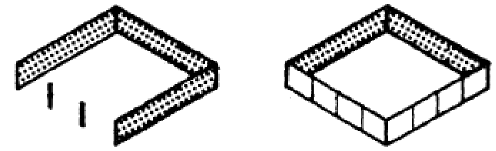


INFLUENCE OF BUILDING CONFIGURATGION ON SEISMIC RESPONSE

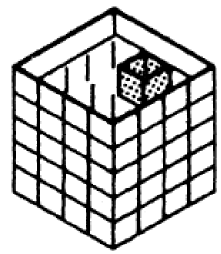
B. PROBLEMS OF HORIZONTAL LAYOUT

1. SIMPLE PLAN CONFIGURATION

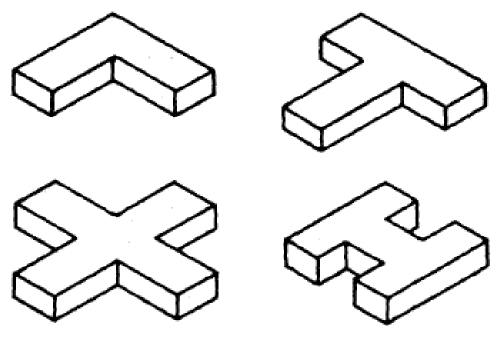
a. variations in perimeter strength-stiffness



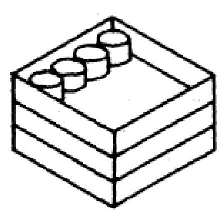
b. false symmetry



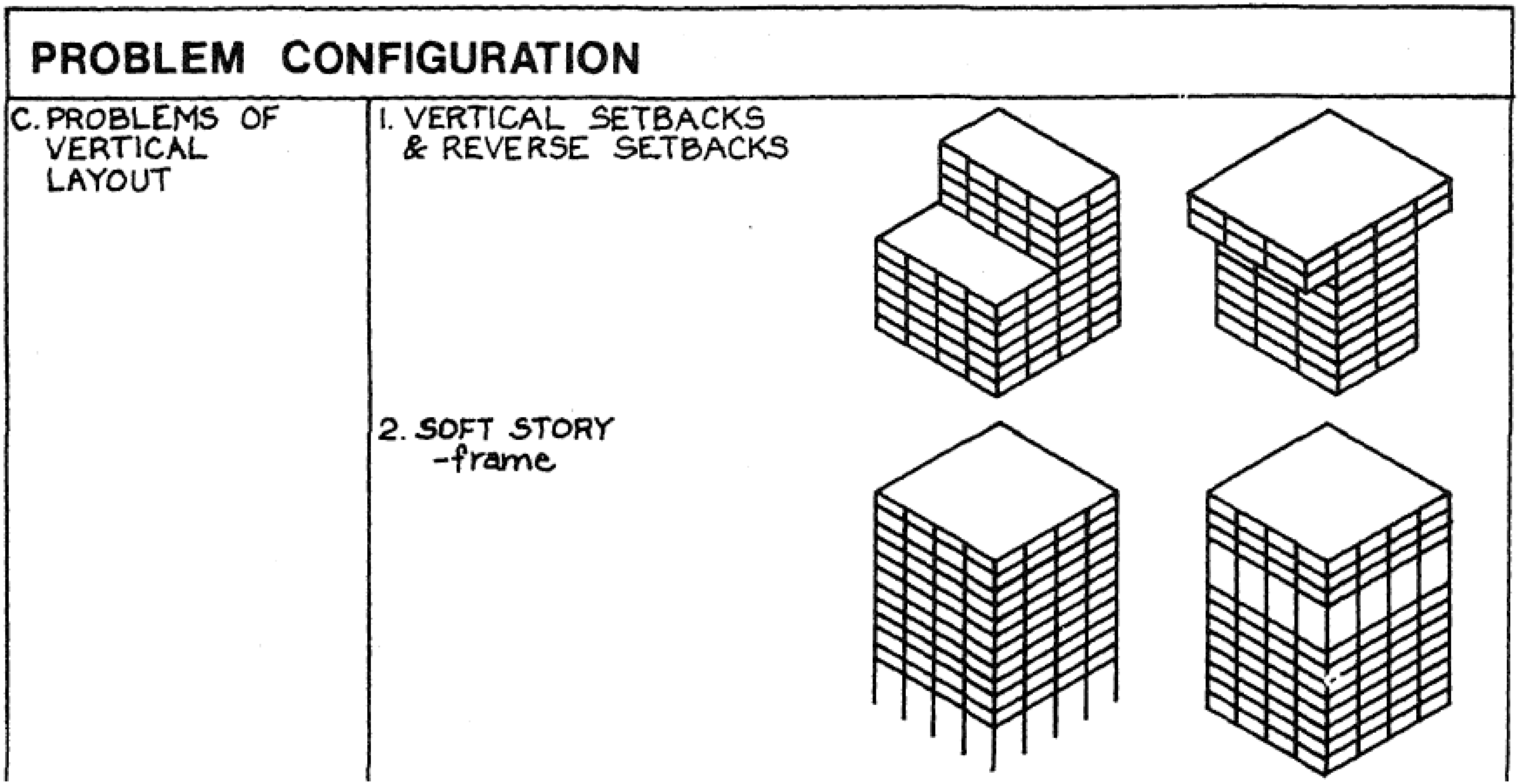
2. RE-ENTRANT CORNERS



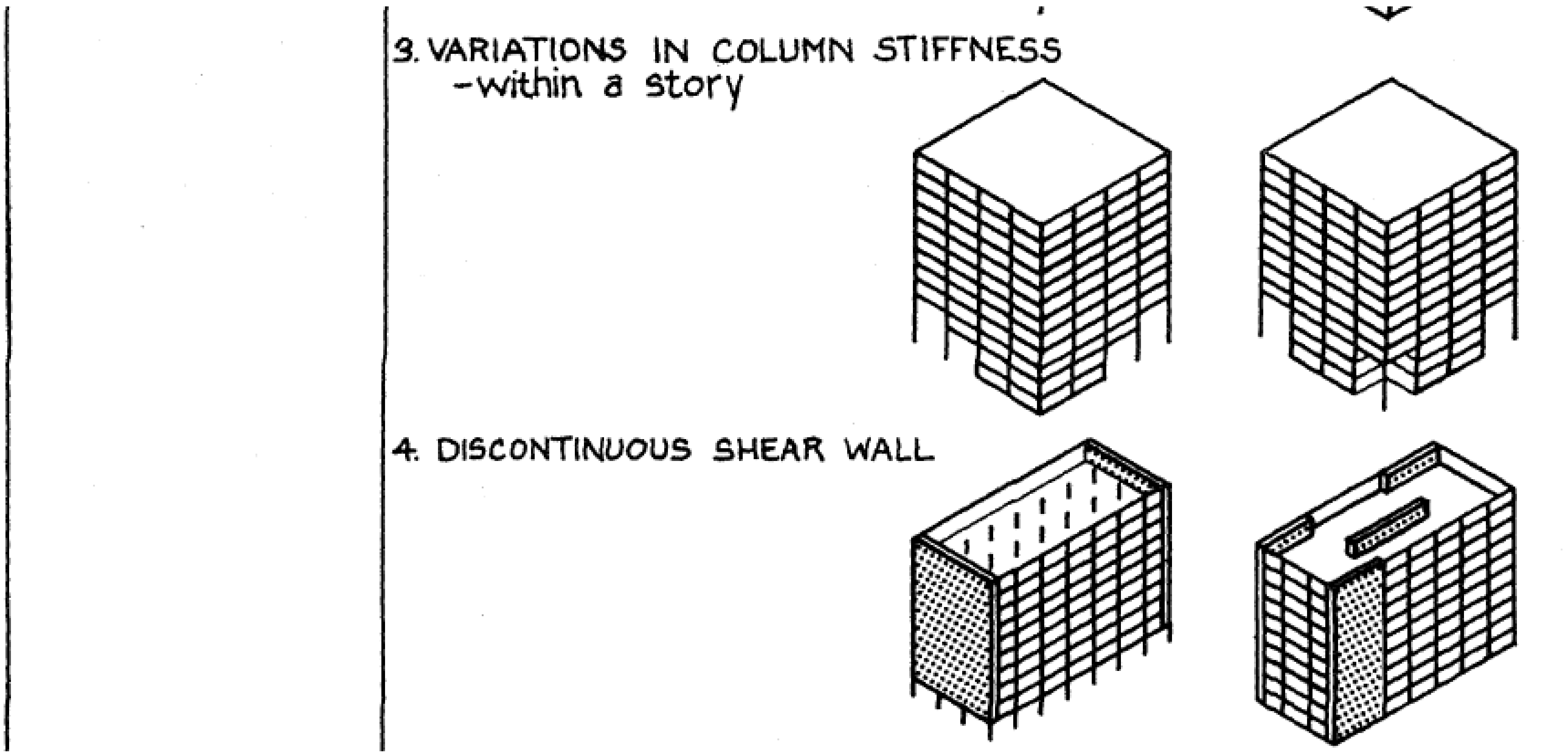
3. MASS ECCENTRICITIES



INFLUENCE OF BUILDING CONFIGURATGION ON SEISMIC RESPONSE

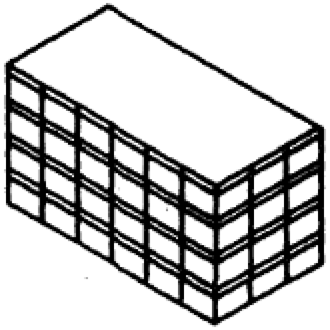


INFLUENCE OF BUILDING CONFIGURATGION ON SEISMIC RESPONSE

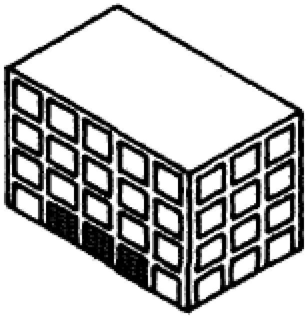


INFLUENCE OF BUILDING CONFIGURATGION ON SEISMIC RESPONSE

5. WEAK COLUMN – STRONG BEAM

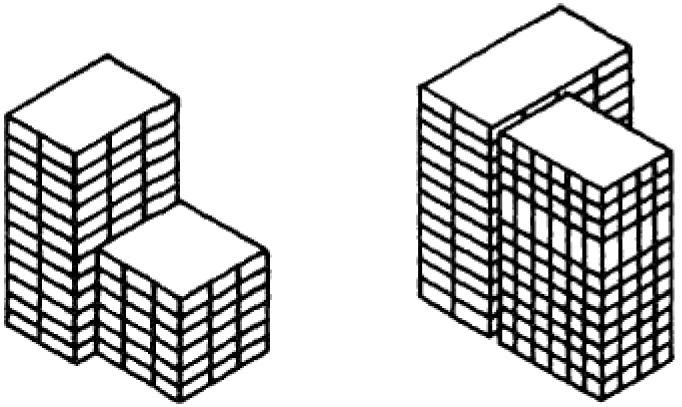


6. MODIFICATIONS OF PRIMARY STRUCTURE

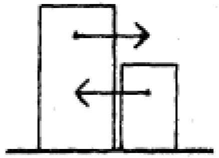


INFLUENCE OF BUILDING CONFIGURATGION ON SEISMIC RESPONSE

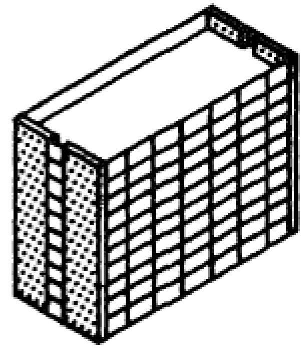
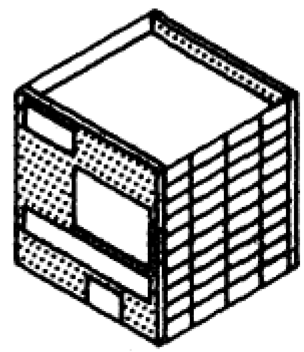
PROBLEM CONFIGURATION	
D. PROBLEMS OF ADJACENCY	1. BUILDING SEPARATION (POUNDING)



INFLUENCE OF BUILDING CONFIGURATGION ON SEISMIC RESPONSE

ARCHITECTURAL STATEMENT	STRUCTURAL PROB-LEM STATEMENT	SOLUTION
may be different parts of same building (set-back) or buildings on adjacent sites	possibility of pounding dependent on building period, height, drift, distance	ensure adequate separation, assuming opposing building vibration 

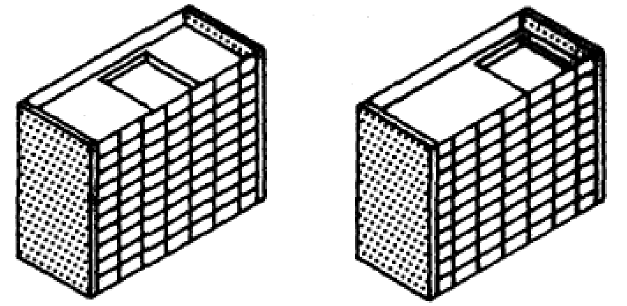
INFLUENCE OF BUILDING CONFIGURATGION ON SEISMIC RESPONSE

E. SHEAR WALLS	1. COUPLED  2. RANDOM OPENINGS 

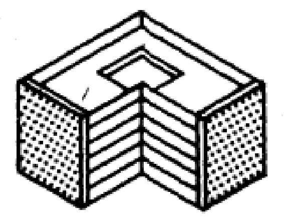
INFLUENCE OF BUILDING CONFIGURATGION ON SEISMIC RESPONSE

F. DIAPHRAGM

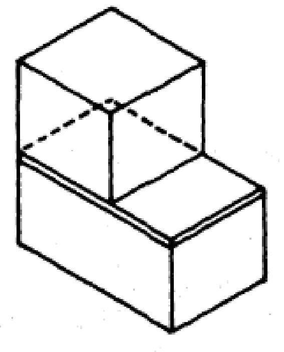
1. OPENINGS



2. SHAPE

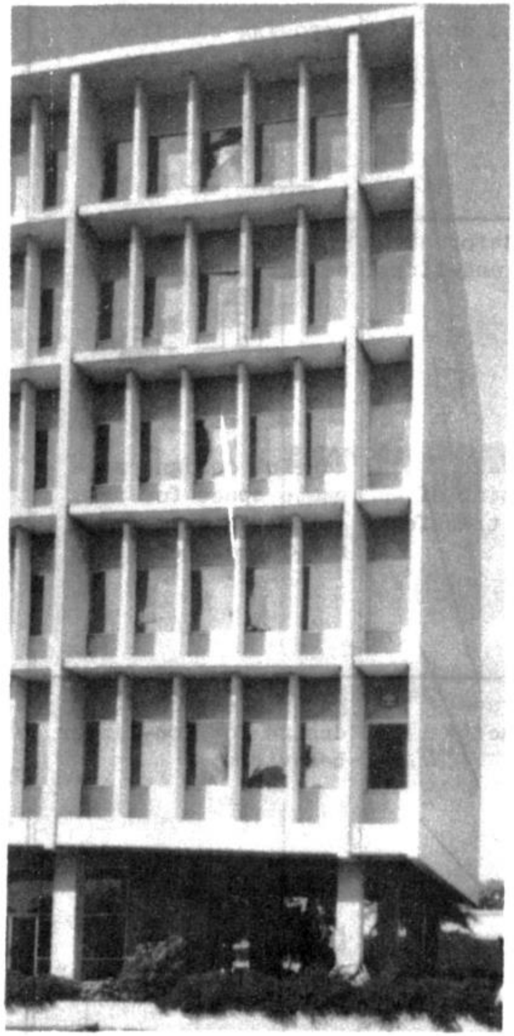


3. TOWER



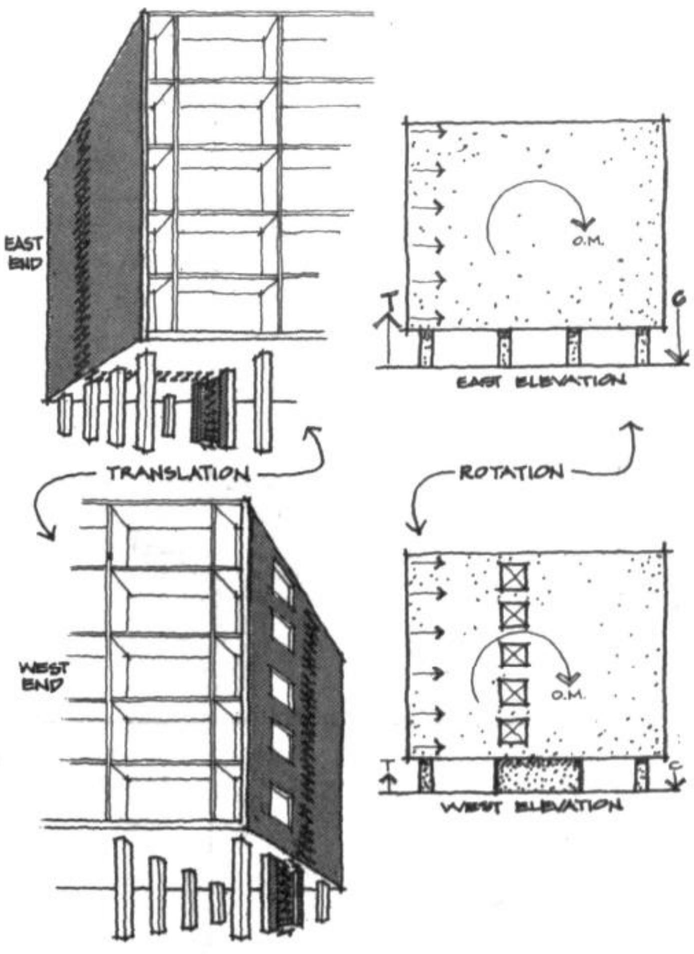
INFLUENCE OF BUILDING CONFIGURATGION ON SEISMIC RESPONSE-CASE HISTORY OF IMPERIAL COUNTY BUILDING

- The Imperial County Services building is a six story reinforced concrete structure, built in 1959, which suffered a major structural failure in the Imperial Valley earthquake of October 1979 (Figure I).
- Detailed study of the building damage shows that the four free standing columns at the East end of the building failed by overturning, since the outer pair of columns show more distress than the inner.



INFLUENCE OF BUILDING CONFIGURATGION ON SEISMIC RESPONSE-**CASE HISTORY OF IMPERIAL COUNTY BUILDING**

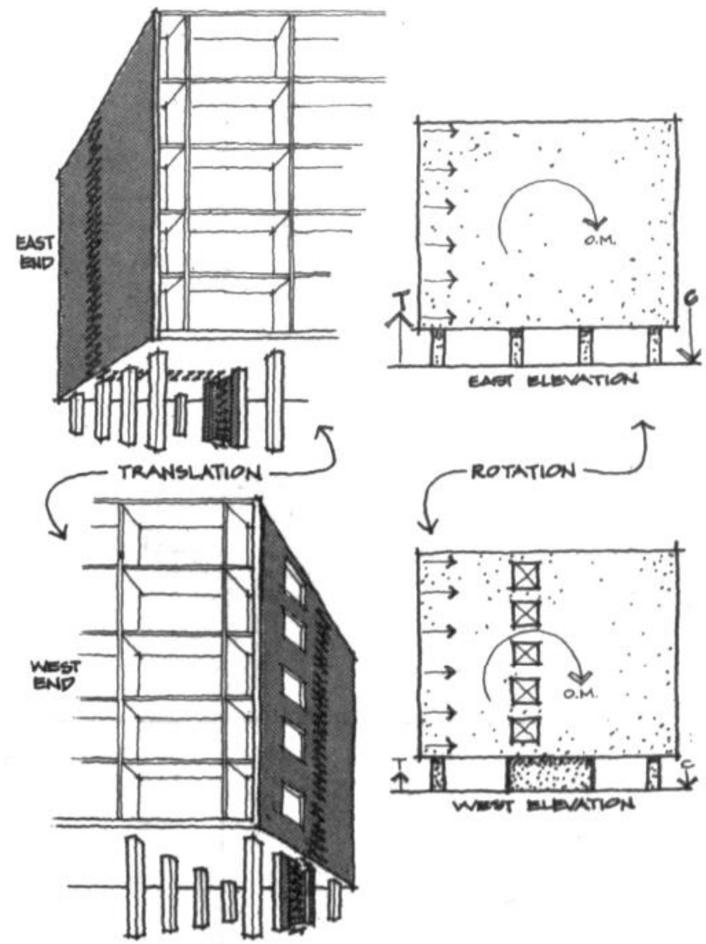
- The condition at the East end represents a classic instance of shear wall discontinuity, in which an abrupt change of strength and stiffness occurs at the point where the shear wall, weighing approximately 300 tons, terminates at the second floor.
- Figure schematically indicates the East end's two horizontal load paths: to resist translation, shear stresses can be carried in the plane of the second level floor structure in to an interior ground level wall.



END WALL CONDITIONS, IMPERIAL COUNTY SERVICES BUILDING

INFLUENCE OF BUILDING CONFIGURATGION ON SEISMIC RESPONSE-**CASE HISTORY OF IMPERIAL COUNTY BUILDING**

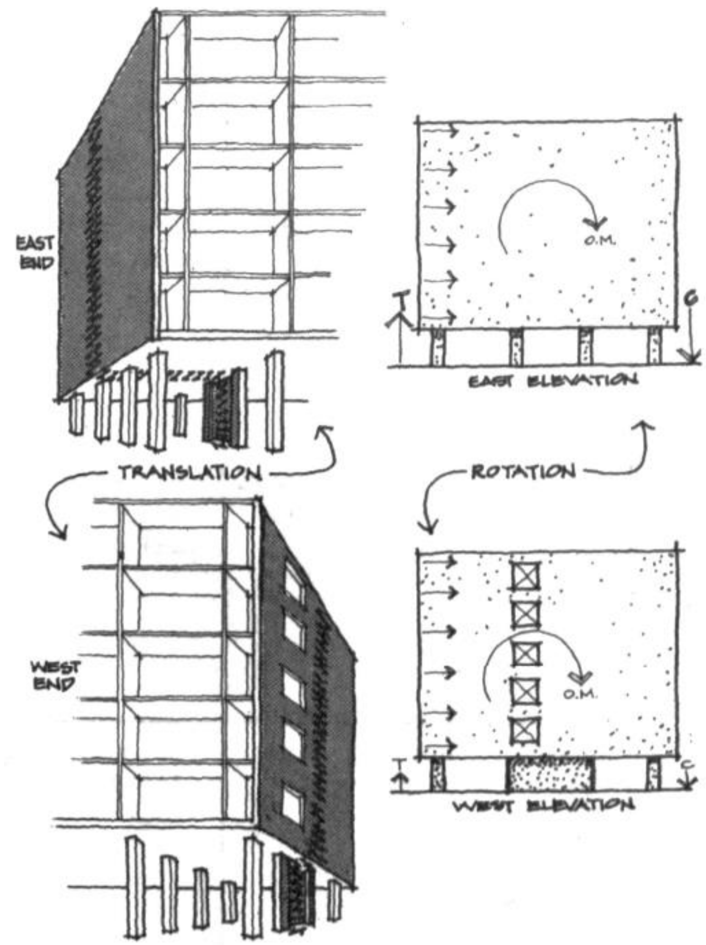
- However, rotational (overturning) forces (which are perpendicular to the second floor) are not transferred across in this manner, and only the columns beneath the end wall can supply the tension-compression couple required to resist the overturning moment. The corner columns take the bulk of these alternating axial forces.



END WALL CONDITIONS, IMPERIAL COUNTY SERVICES BUILDING

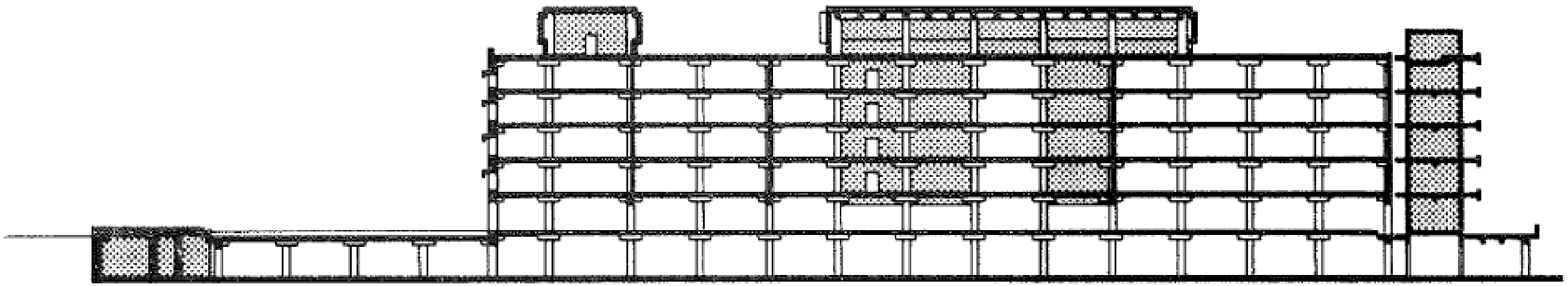
INFLUENCE OF BUILDING CONFIGURATGION ON SEISMIC RESPONSE-**CASE HISTORY OF IMPERIAL COUNTY BUILDING**

- At the West end, the stiff ground level shear wall beneath the upper wall prevents large axial forces from reaching the columns, and this end of the building suffered negligible damage.
- Thus the major differences in damage between the West and East ends of the building are paralleled by a major difference in architectural configuration.



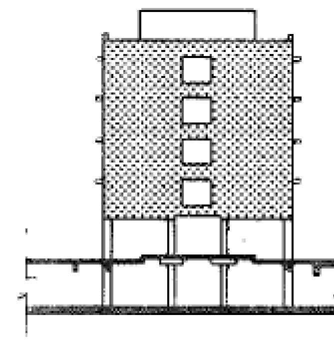
END WALL CONDITIONS, IMPERIAL COUNTY SERVICES BUILDING

INFLUENCE OF BUILDING CONFIGURATGION ON SEISMIC RESPONSE-**CASE HISTORY OF OLIVE VIEW HOSPITAL**



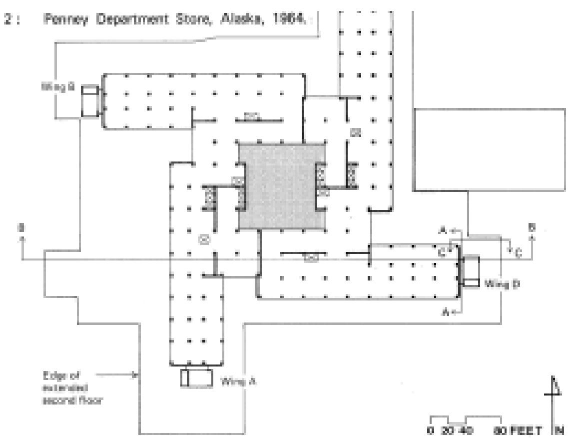
Section B-B

Figure 3: Olive View Hospital, California, 1971.



Section A-A

Figure 2: Penney Department Store, Alaska, 1964.



INFLUENCE OF BUILDING CONFIGURATGION ON SEISMIC RESPONSE-CASE HISTORY OF OLIVE VIEW HOSPITAL

- The general vertical configuration of the main building was a 'soft' two-storey layer of rigid frames on which was supported a four-storey (five, counting penthouse) shear wall-plus-frame structure (Figure 3).
- The second floor extends out to form a large plaza: thus, in photographs, the main building appears to have a single soft storey, rather than two.
- The severe damage occurred in the soft storey portion, which is generally to be expected (Figure A).

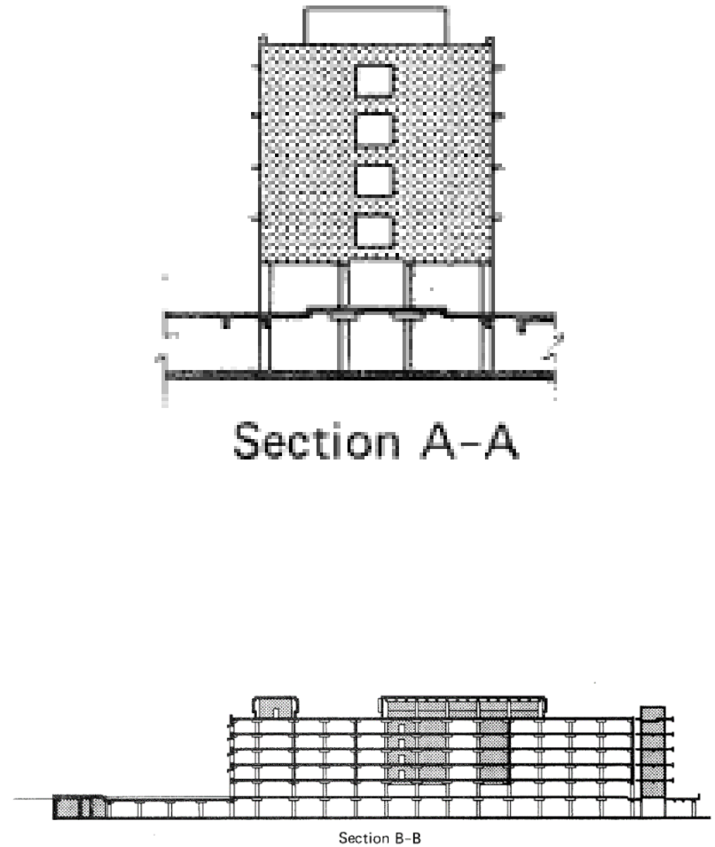
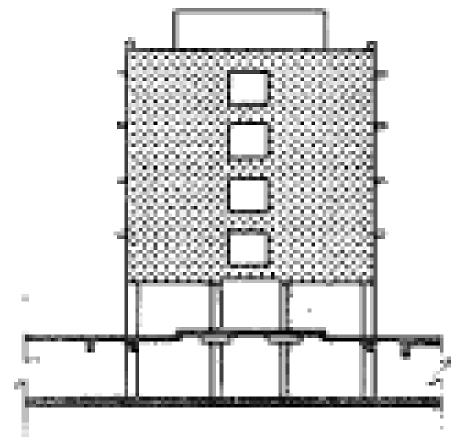


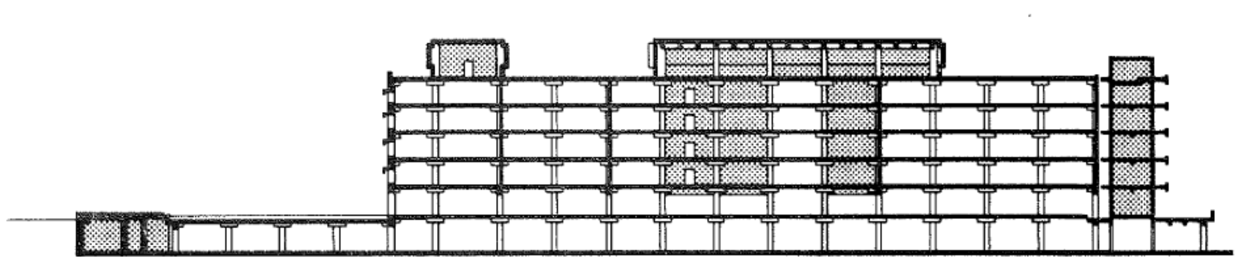
Figure 3 : Olive View Hospital, California, 1971.

INFLUENCE OF BUILDING CONFIGURATGION ON SEISMIC RESPONSE-**CASE HISTORY OF OLIVE VIEW HOSPITAL**

- The upper stories moved as a unit, and moved so much that the columns at ground level could not accommodate such a huge displacement between their bases and tops and hence failed.
- The largest amount by which a column was left permanently out of plumb was 2.5 feet.



Section A-A

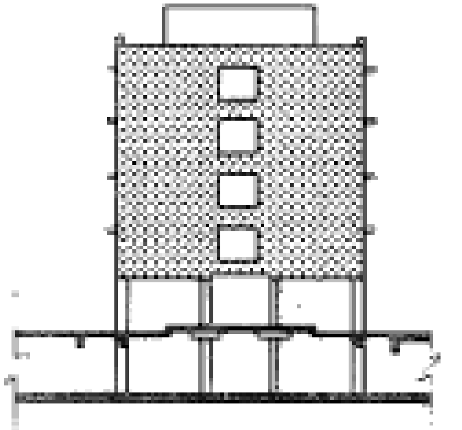


Section B-B

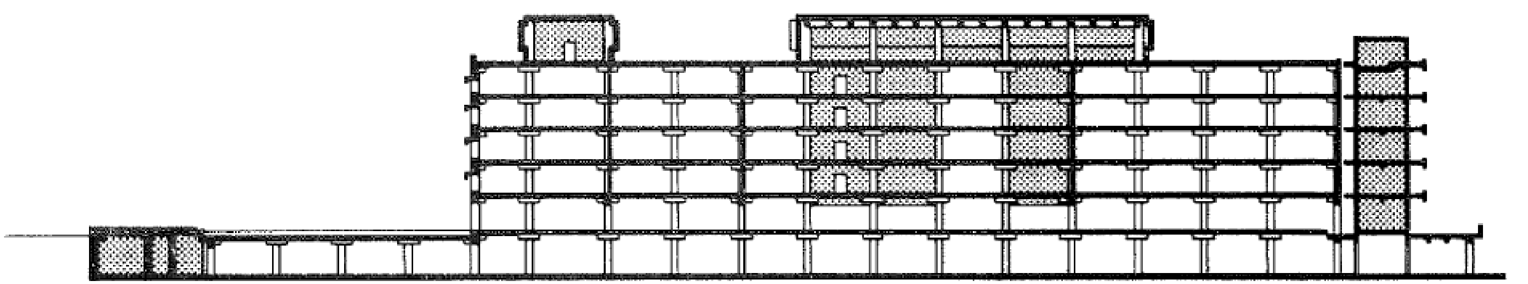
Figure 3: Olive View Hospital, California, 1971.

INFLUENCE OF BUILDING CONFIGURATGION ON SEISMIC RESPONSE-CASE HISTORY OF OLIVE VIEW HOSPITAL

- A discontinuity in vertical stiffness and strength leads to a concentration of stresses and damage, and the storey which must hold up all the rest of the stories in a building should be the last, rather than the first, component to sacrifice.



Section A-A

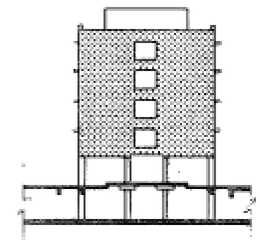


Section B-B

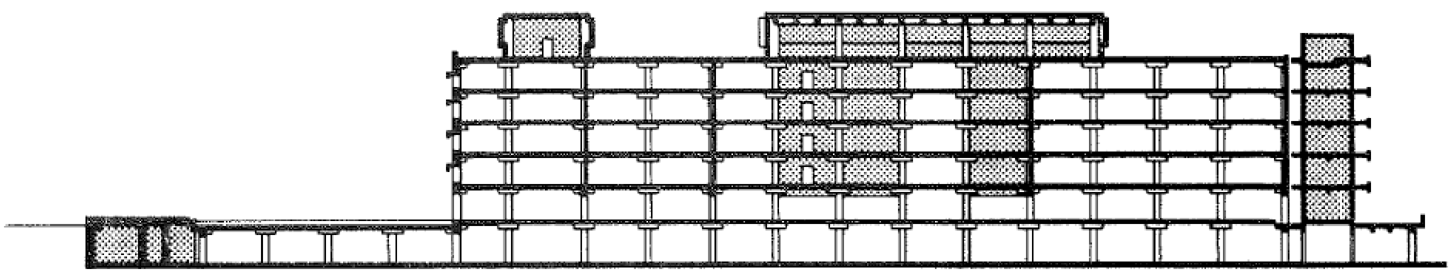
Figure 3 : Olive View Hospital, California, 1971.

INFLUENCE OF BUILDING CONFIGURATGION ON SEISMIC RESPONSE-CASE HISTORY OF OLIVE VIEW HOSPITAL

- Had the columns at Olive View been more strongly reinforced, their failures would have been postponed, but it is unrealistic to think that they would have escaped damage.
- Thus the significant problem lies in the configuration, and not totally in the column reinforcement.



Section A-A



Section B-B

Figure 3 : Olive View Hospital, California, 1971.