# 7. Block theory for underground chambers

1) Introduction

- Economical underground chamber design
  - Arrangement for the chambers requiring only minimal artificial support
  - Optimum choices for the orientation, shapes and arrangement of openings to minimize the danger of block movement

- Underground chambers consist of
  - Large, essentially prismatic rooms, branches, pillars, entries & intersections
  - Elements of the openings are planes, edges, corners and cylinders.

- This chapter shows
  - How to determine the key blocks formed by intersections or union of plana excavation surfaces

2) Key blocks in the roof, floor, and walls
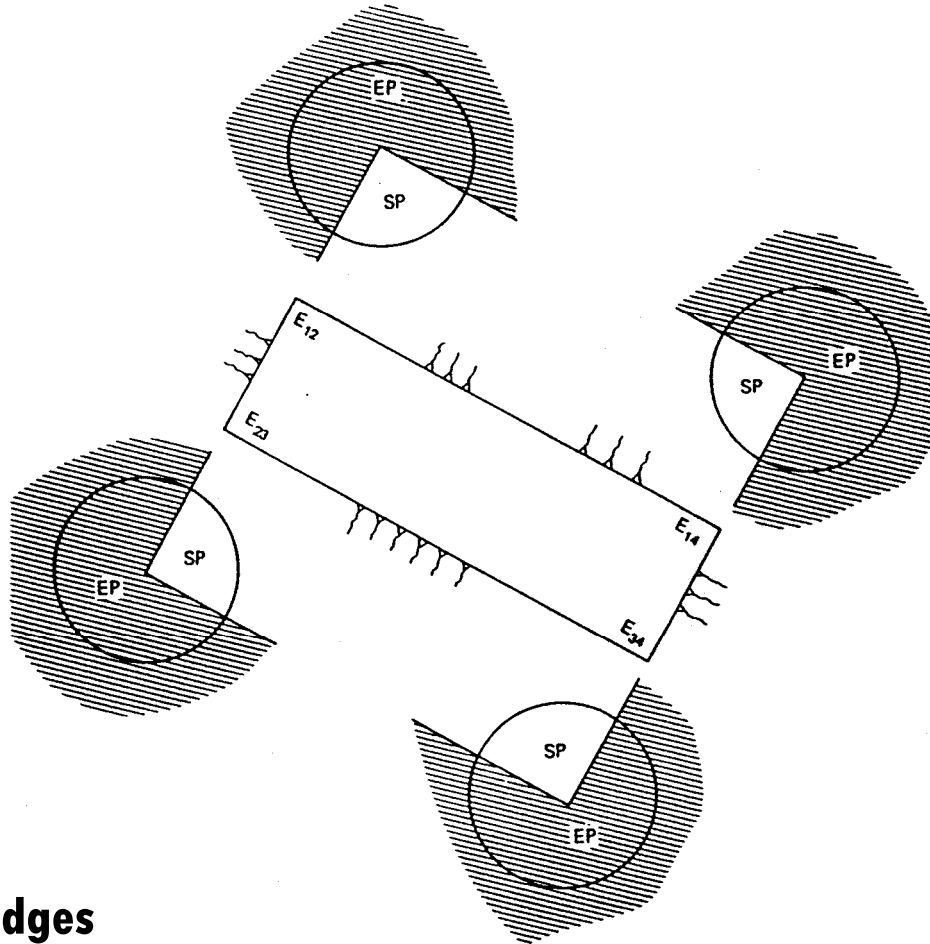

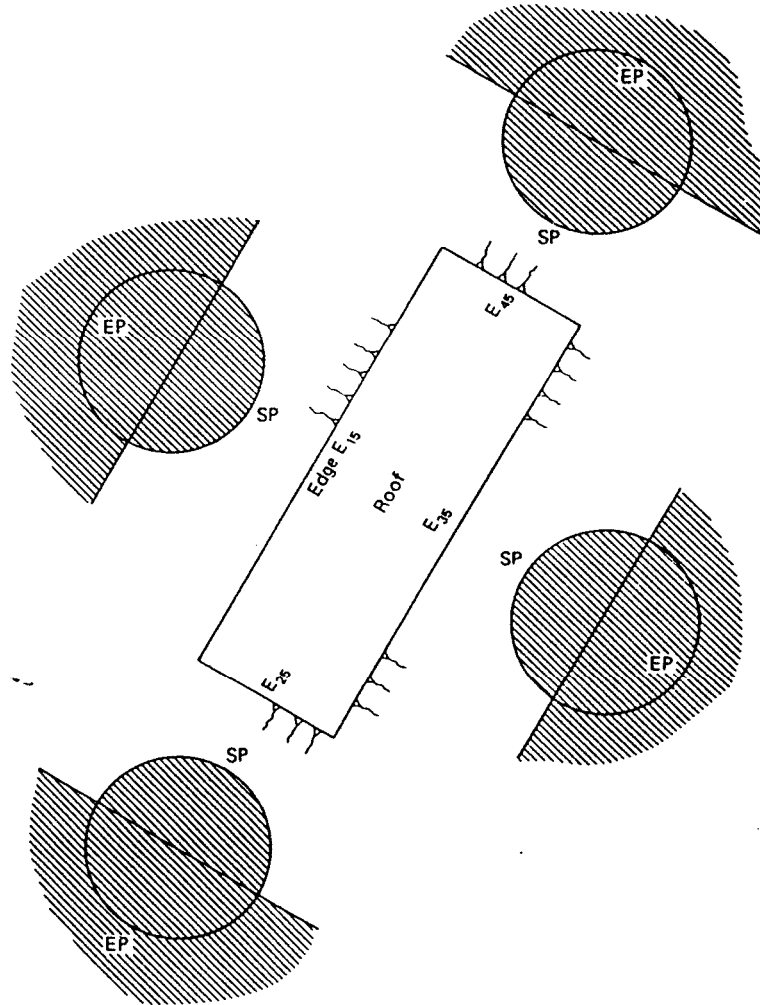(a)

(b)
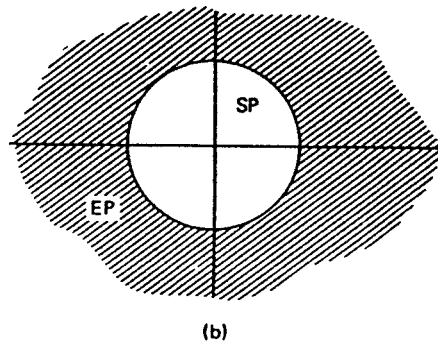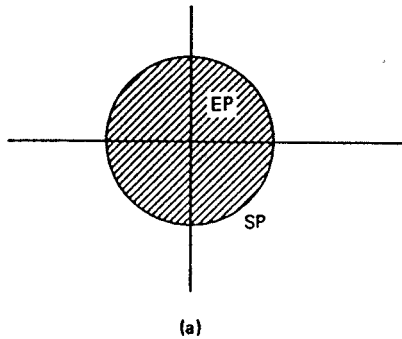
Roof and floor
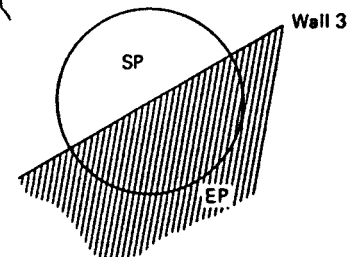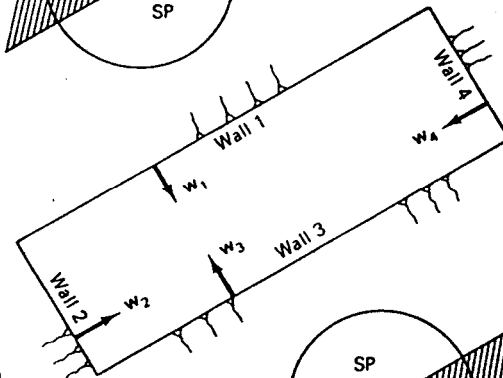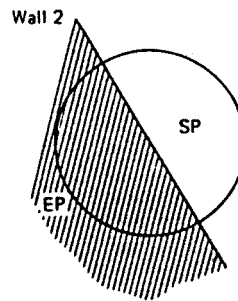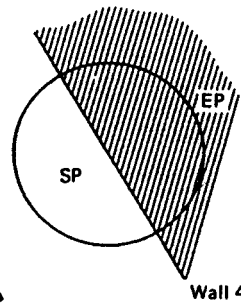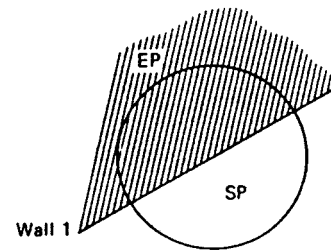
Walls

3) Blocks that are removable in two planes simultaneously: concave edges
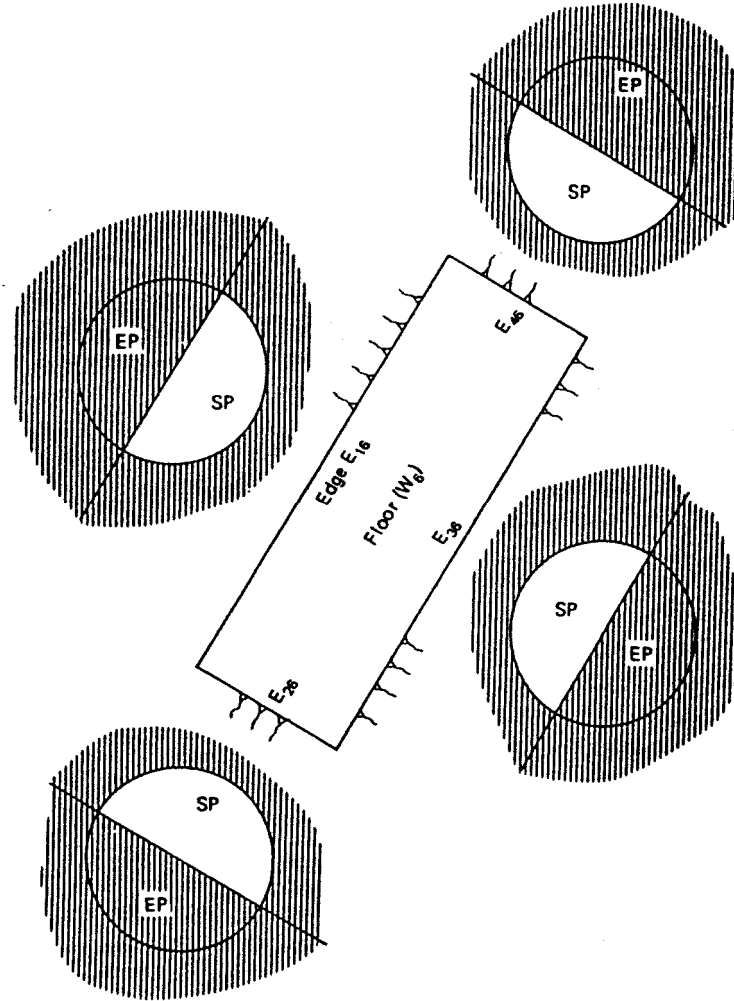

Wall/wall edges

3) Blocks that are removable in two planes simultaneously: concave edges
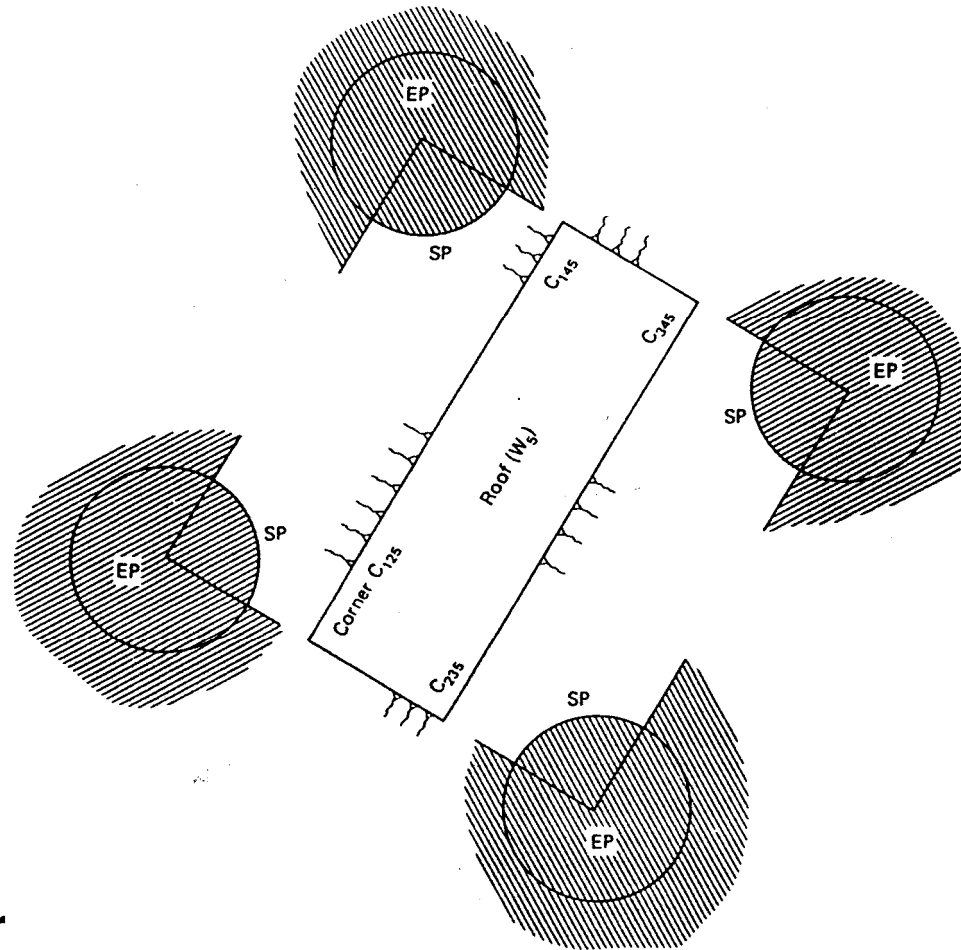

Wall/roof edges

3) Blocks that are removable in two planes simultaneously: concave edges

Wall/floor edges

4) Blocks that are removable in three planes simultaneously: concave corners

Wall/wall/roof corner

4) Blocks that are removable in three planes simultaneously: concave corners
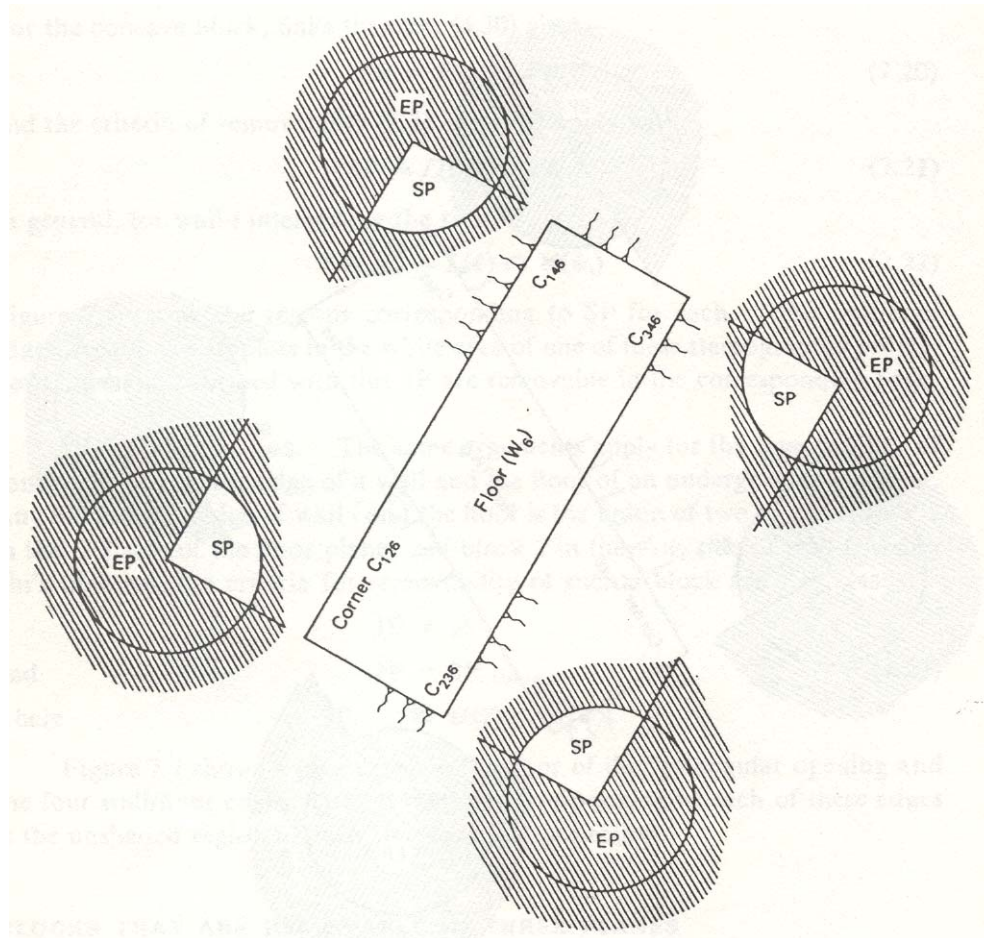
Wall/wall/floor corners

5) Example: Key blocks analysis for an underground chamber
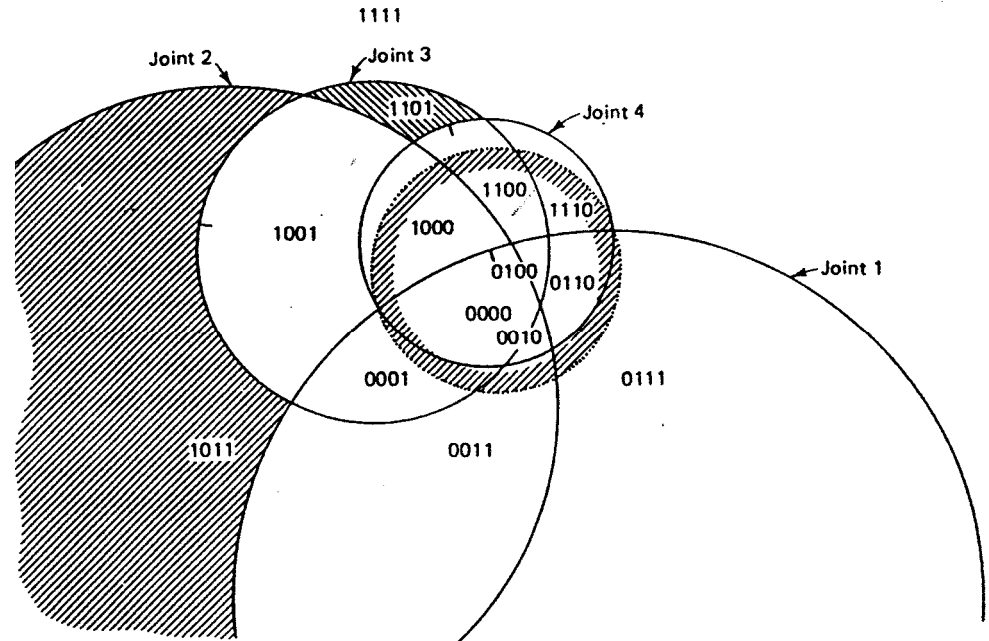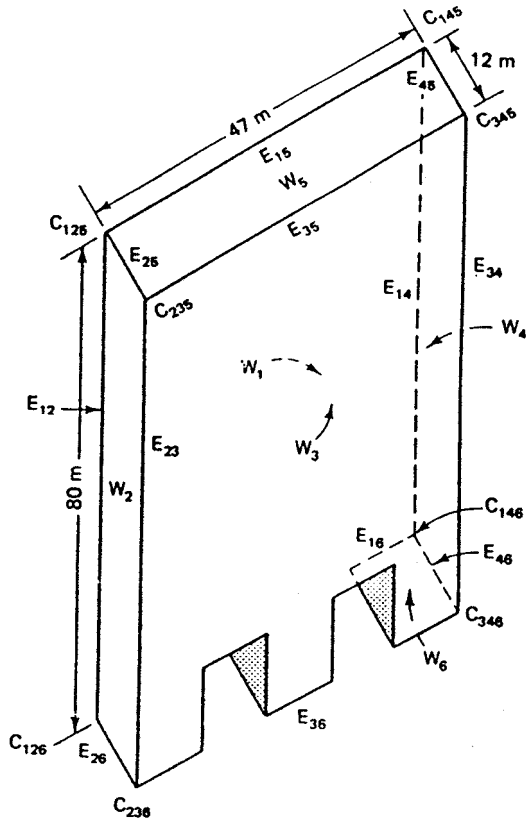
Key blocks of the roof

(Orientations of planes and joints : refer to Table 7.1

5) Example: Key blocks analysis for an underground chamber
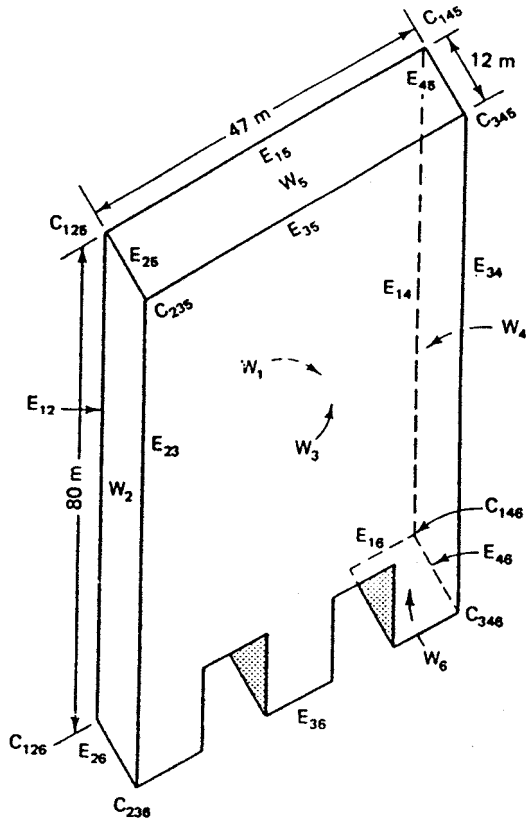
Key blocks of wall 3

5) Example: Key blocks analysis for an underground chamber
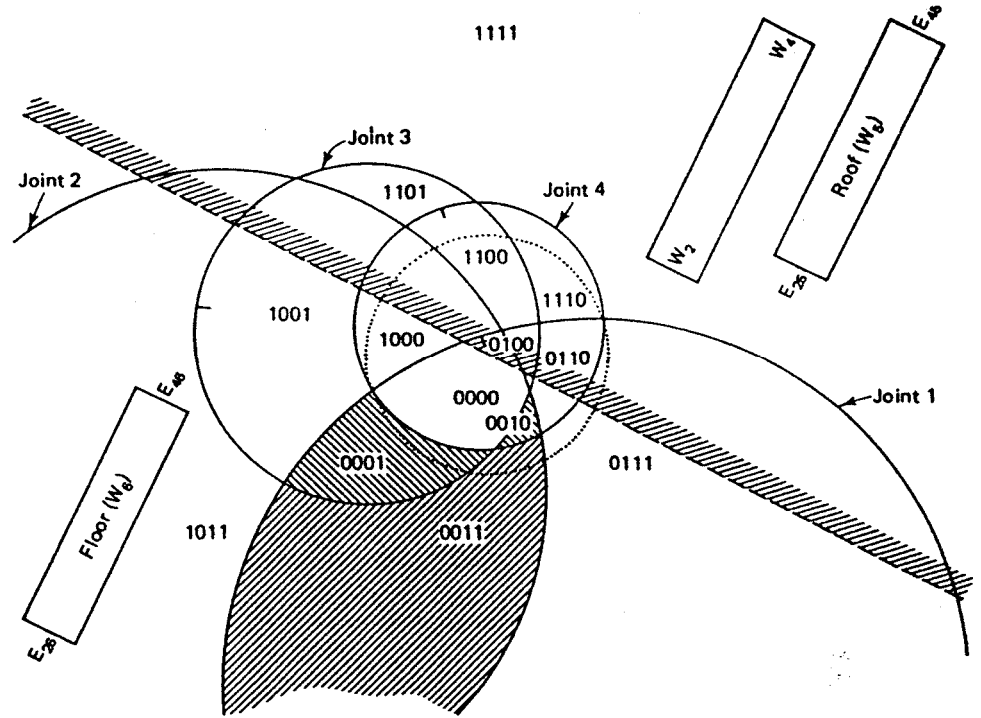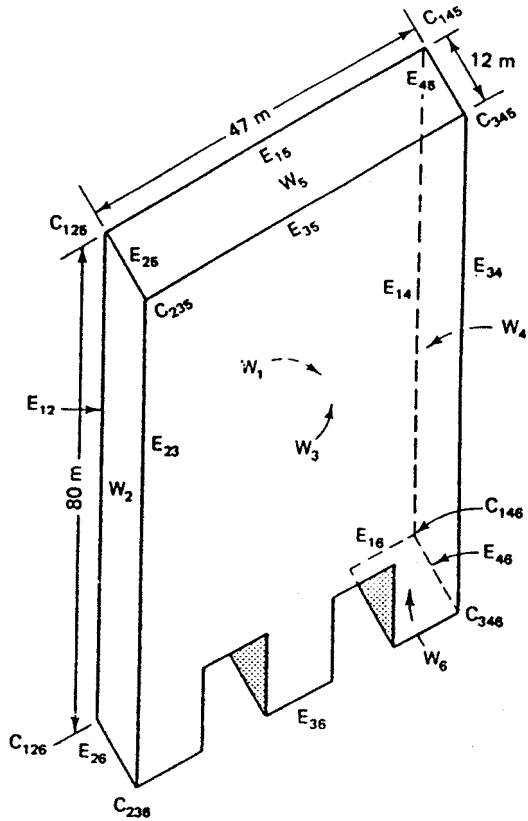
Key blocks of wall 4

5) Example: Key blocks analysis for an underground chamber

JPs with one repeated joint set

5) Example: Key blocks analysis for an underground chamber
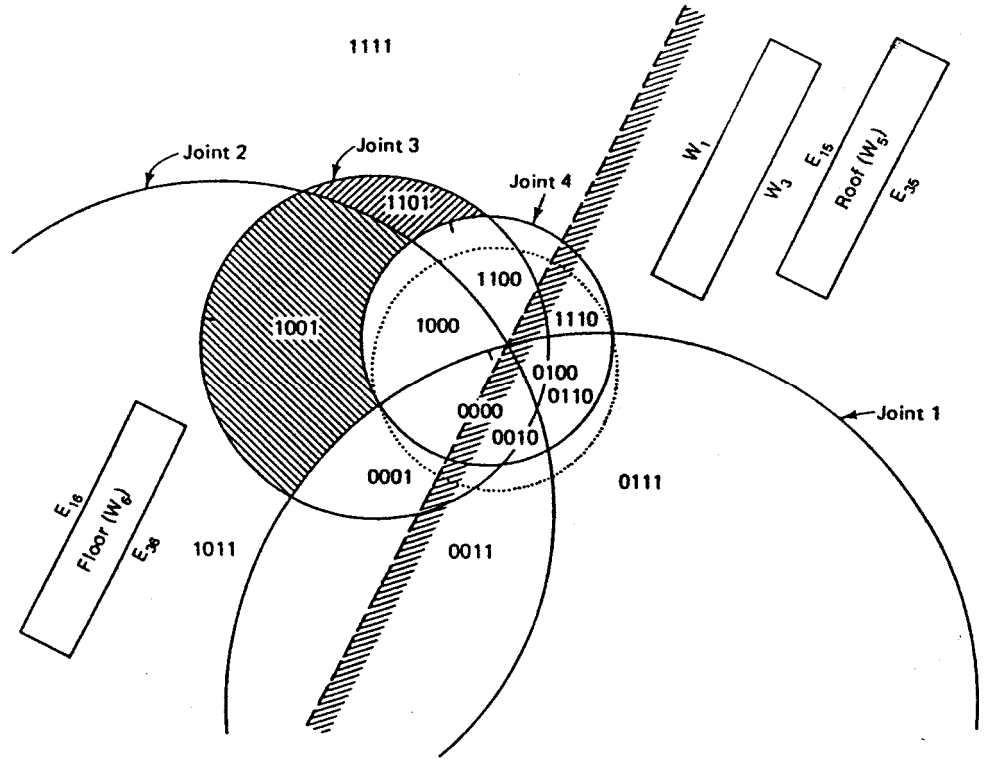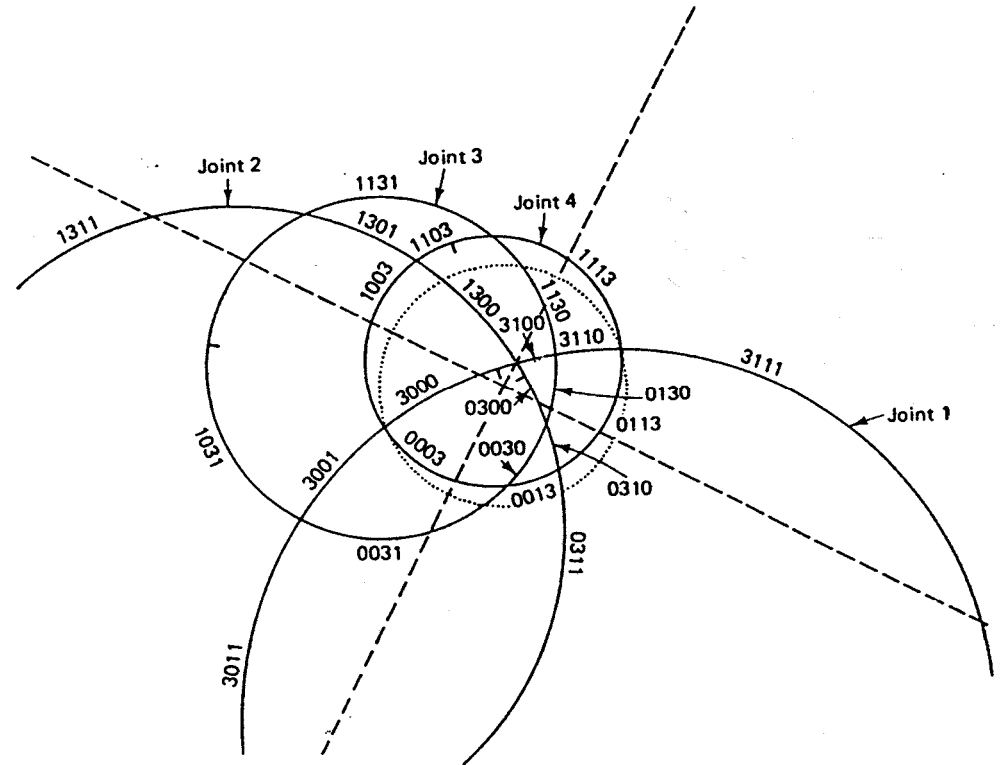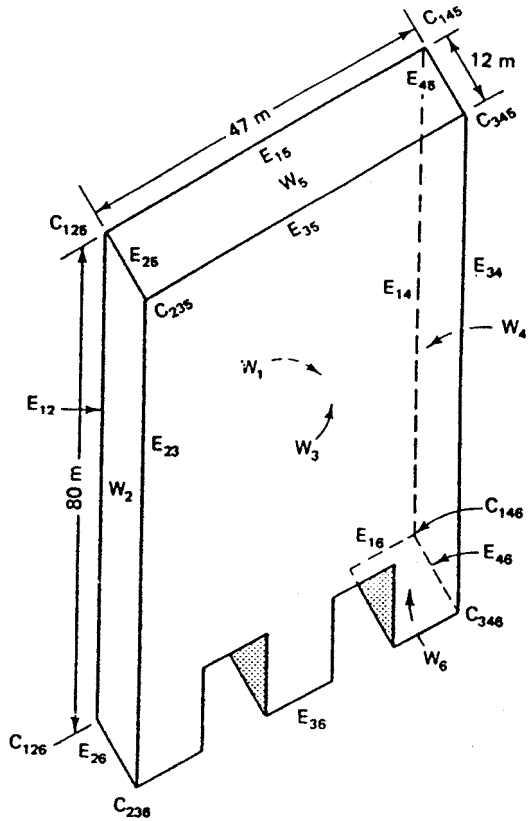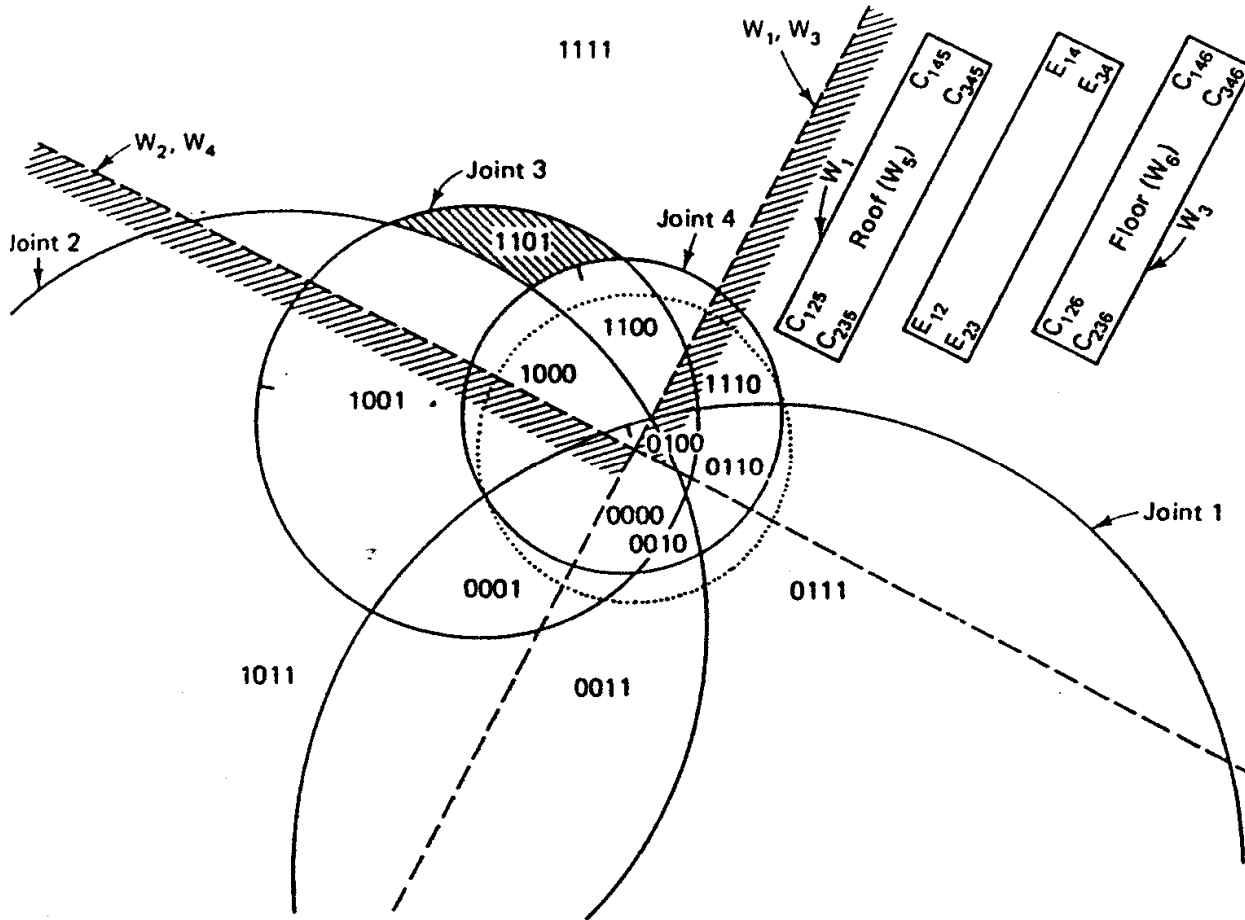

Key block of edge E_{23}

TABLE 7.3 Summary of Removable Blocks for the Example Considering Roof, Floor, Walls, Concave Edges, and Concave/Concave Corners

Position	Removable Blocks with:		Reference Figure
	No Repeated Joints	1 Repeated Joint	
Roof (W_5)	1101, 1011	1131, 1301, 1103, 1311, 1031, 3011	7.11, 7.14
Floor (W_6)	0010, 0100	3100, 0300, 0310, 0130, 0030, 0013	7.11, 7.14
Wall 1 (W_1)	0110, 0010	3110, 0130, 0310, 0113, 0030, 0013	7.12, 7.14
Wall 2 (W_2)	1101, 1100, 1110	1103, 1300, 3100, 1130, 1301, 1131, 3110, 1113	7.13, 7.14
Wall 3 (W_3)	1001, 1101	1301, 1003, 3001, 1031, 1131, 1103	7.12, 7.14
Wall 4 (W_4)	0001, 0010, 0011	3001, 0031, 0003, 0030, 0310, 0013, 0311, 3011	7.13, 7.14
Edge E_{12}	None	3110	7.14, 7.15
Edge E_{23}	1101	1131, 1301, 1103	7.14, 7.15
Edge E_{34}	None	3001	7.14, 7.15
Edge E_{14}	0010	0013, 0030, 0310	7.14, 7.15
Edge E_{15}	None	None	7.12, 7.14
Edge E_{25}	1101	1131, 1301, 1103	7.13, 7.14
Edge E_{35}	1101	1131, 1301, 1103, 1031	7.13, 7.14
Edge E_{45}	None	3011	7.13, 7.14
Edge E_{16}	0010	0030, 0013, 0310, 0130	7.13, 7.14
Edge E_{26}	None	3100	7.13, 7.14
Edge E_{36}	None	None	7.12, 7.14
Edge E_{46}	0010	0030, 0013, 0310	7.13, 7.14
Corner C_{235}	1101	1131, 1301, 1103	7.14, 7.15
Corner C_{146}	0010	0030, 0310, 0013	7.14, 7.15
All other corners	None	None	

5) Example: Key blocks analysis for an underground chamber
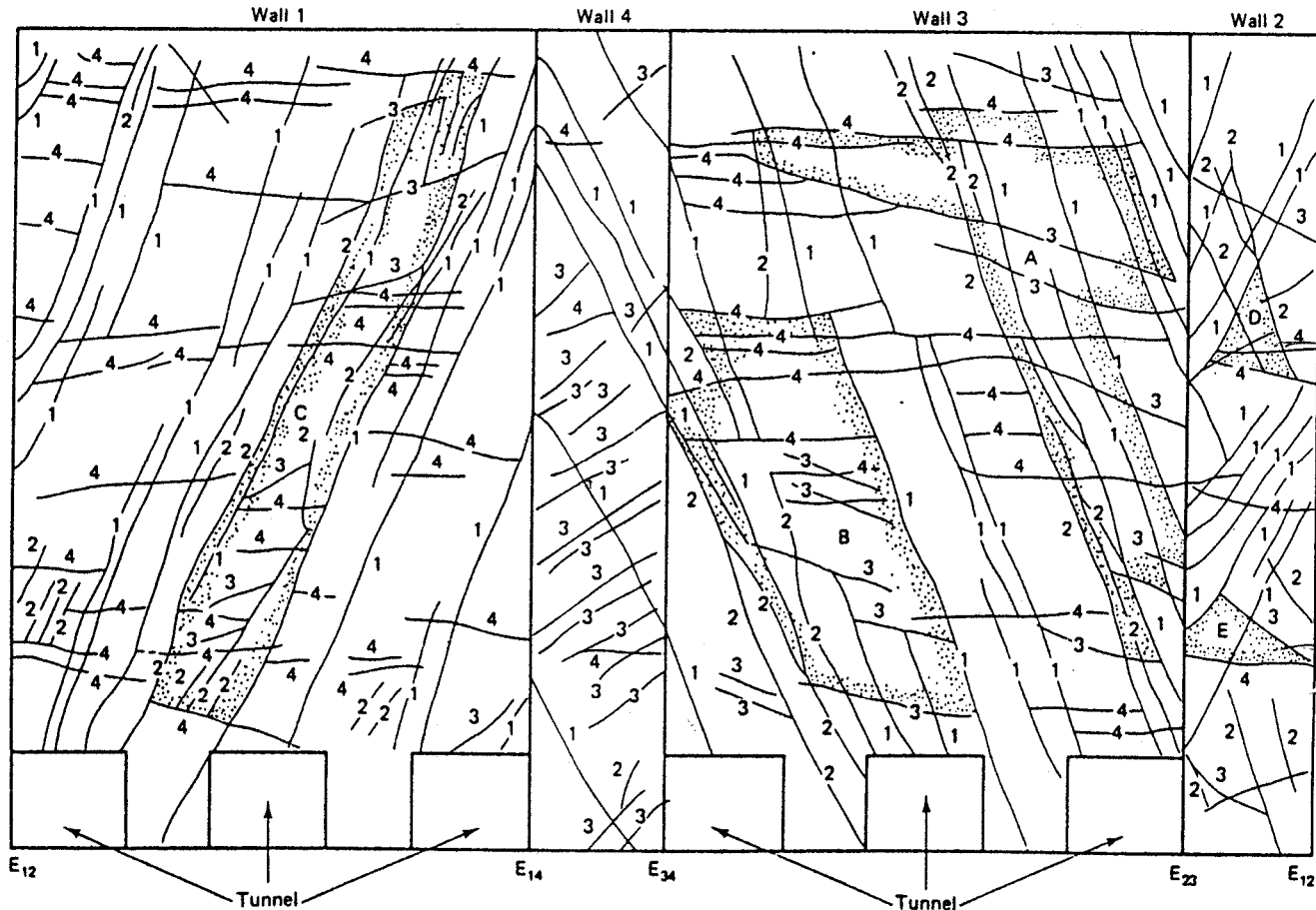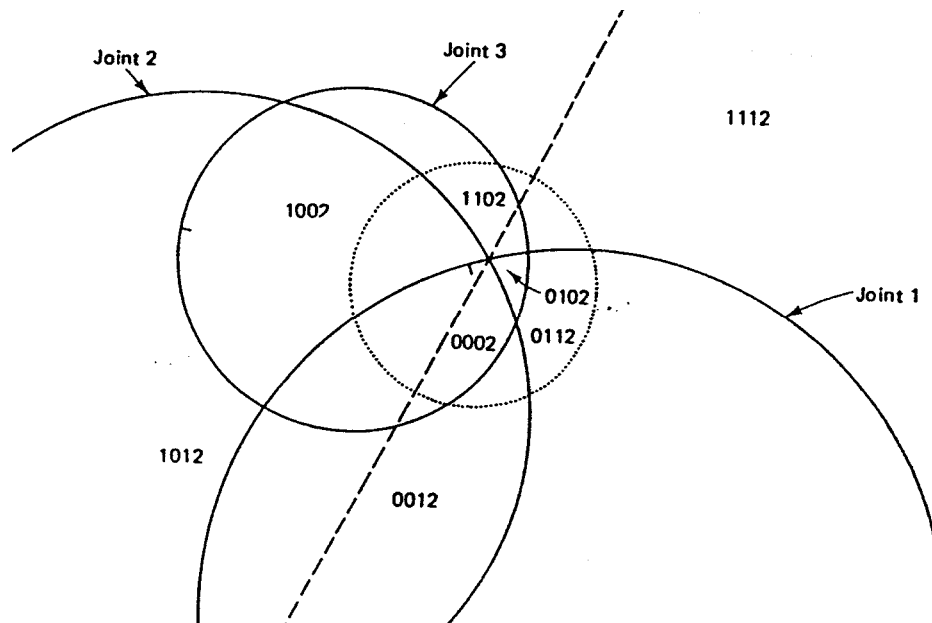

Geological trace map of the chamber

6) Choice of direction for an underground chamber

The most critical key blocks

1) They belong to the largest free planes.
2) They involve joints of large extent.
3) Their space pyramids contain steep vectors

3 joint sets with W₁ and W

Relationships between key blocks of walls, concave edges and corners

1) If JP belongs to a removable blocks of E_{ij}, then JP belongs to a removable blocks of W_i and W_j.
2) If JP belongs to a removable blocks of C_{ijk}, then JP belongs to a removable blocks of W_i, W_j, and W_k.
3) If JP belongs to a removable blocks of C_{ijk}, then JP belongs to a removable blocks of edges E_{ij}, E_{jk}, and E_{ik}.

# 6) Choice of direction for an underground chamber
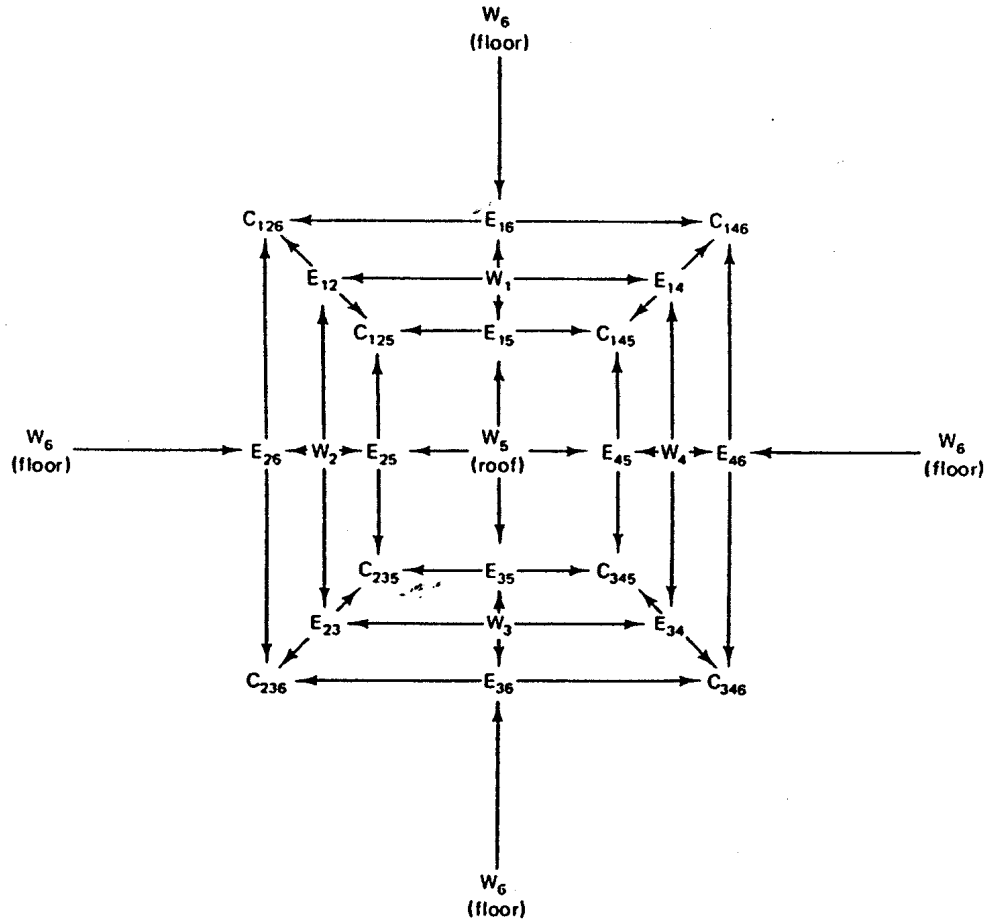
Linkage diagram for walls, edges, and corners

6) Choice of direction for an underground chamber

Procedure for choosing the direction of an underground chamber

1) Draw the great circles of all joint sets in the stereographic projection plane.
2) Draw the line through the intersections of each pair of the great circles.
3) Arbitrarily denote right and left sides of each line standing for right/left walls
4) Determine removable blocks belonging to each line (Table 7.5).
5) Determine removable blocks belonging to the angles bounded by two adjacent lines (Table 7.6).
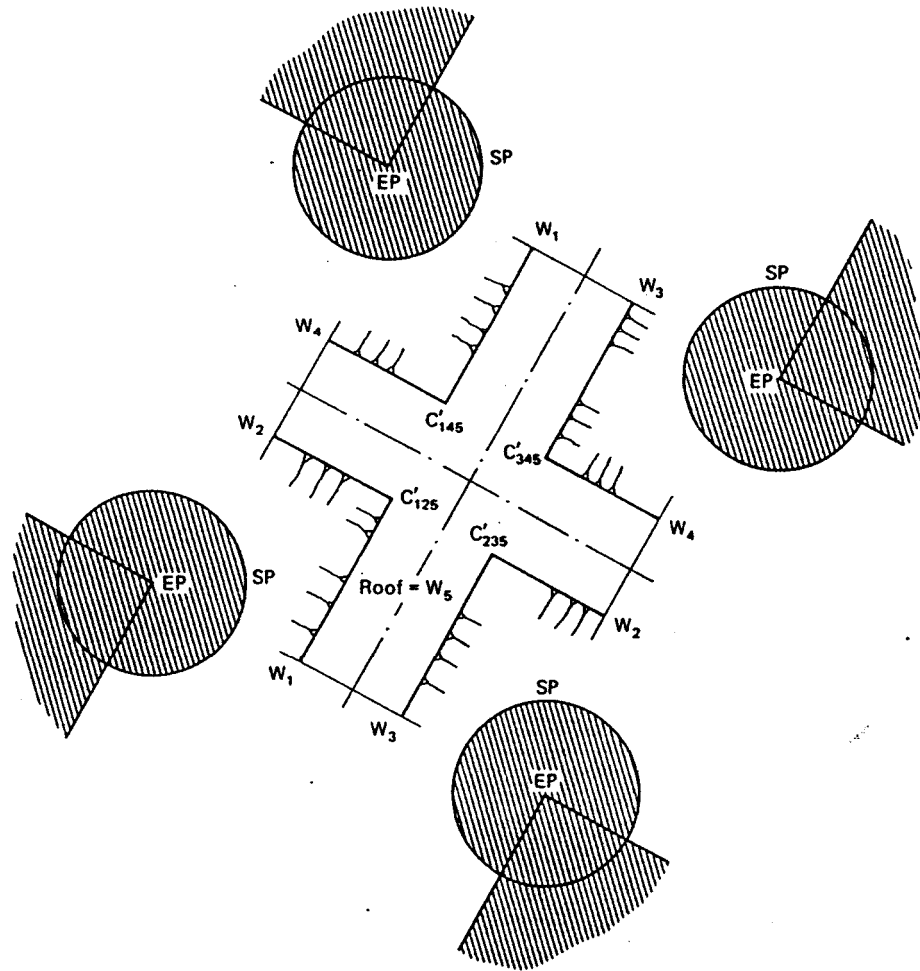
6) Choice of direction for an underground chamber
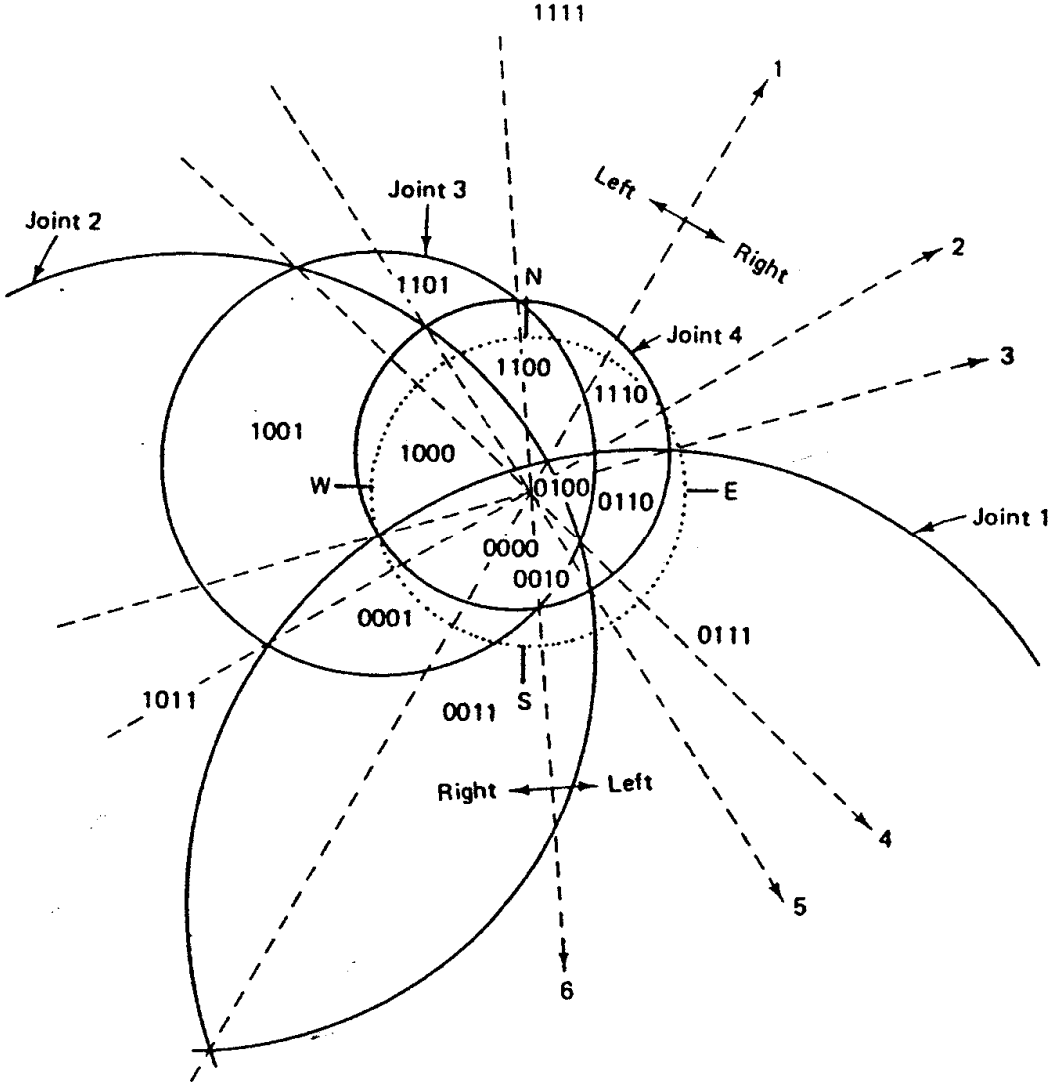
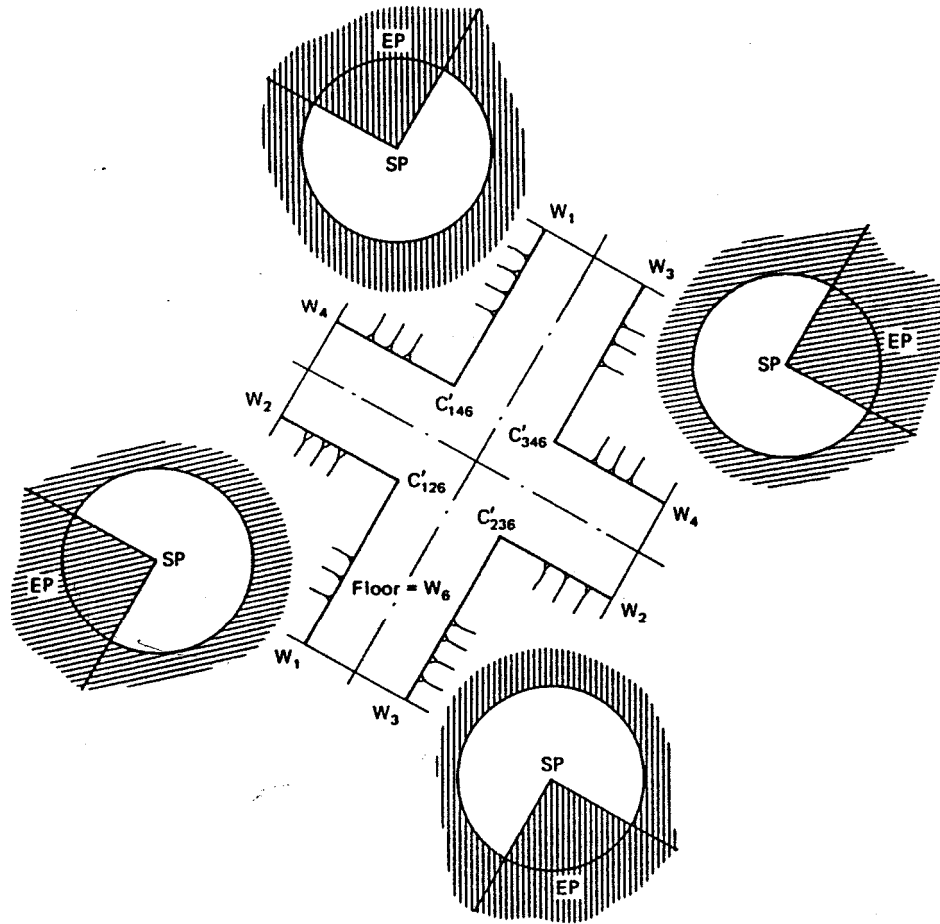# 7) Intersections of underground chambers
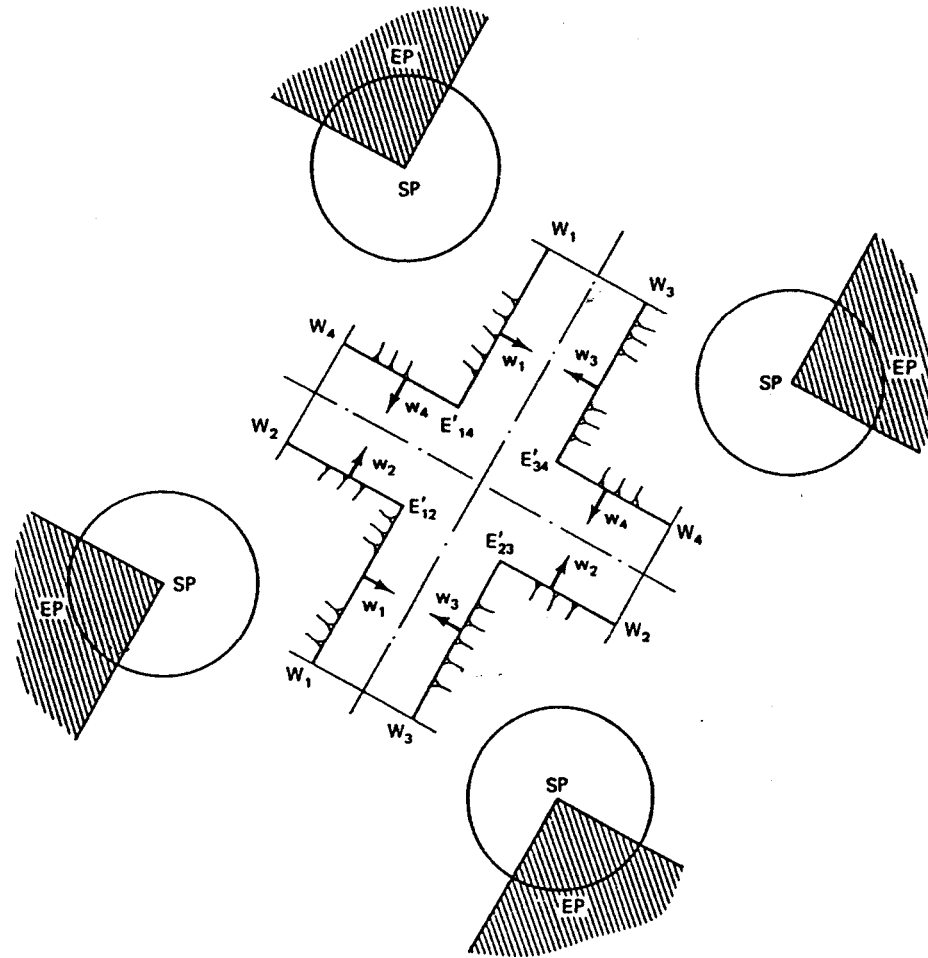
SP for inside edges of intersecting chamber
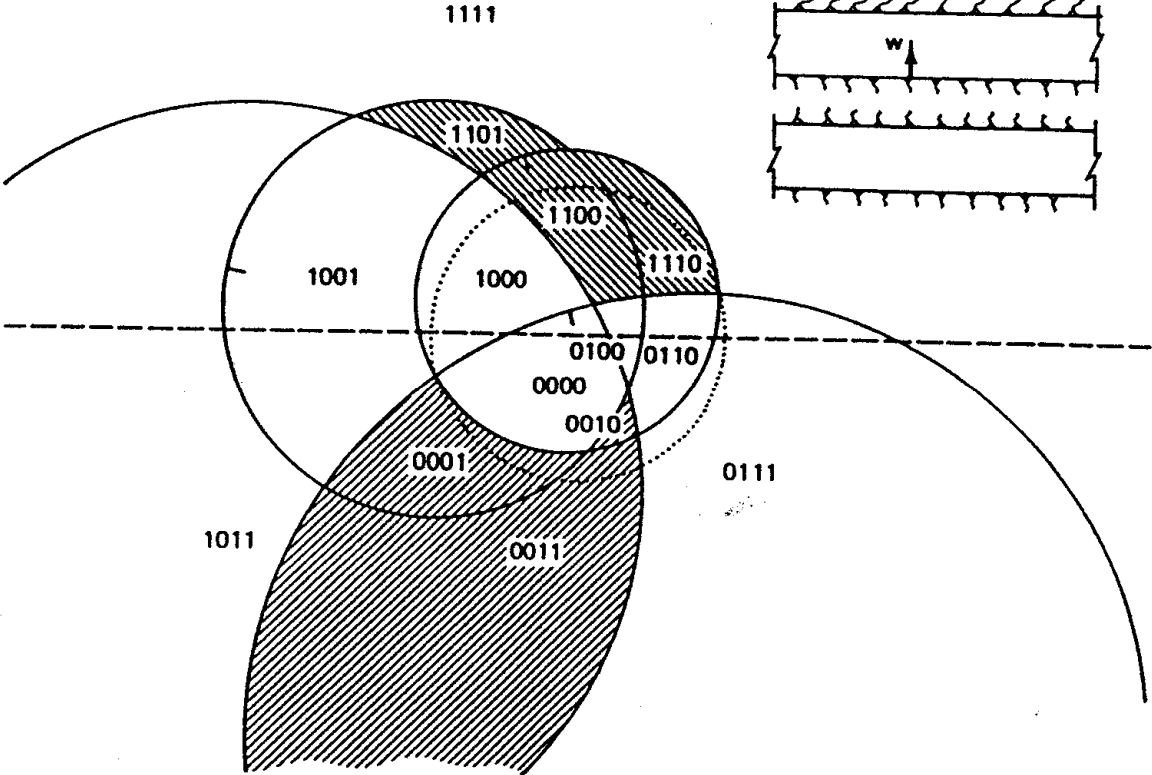
7) Intersections of underground chambers

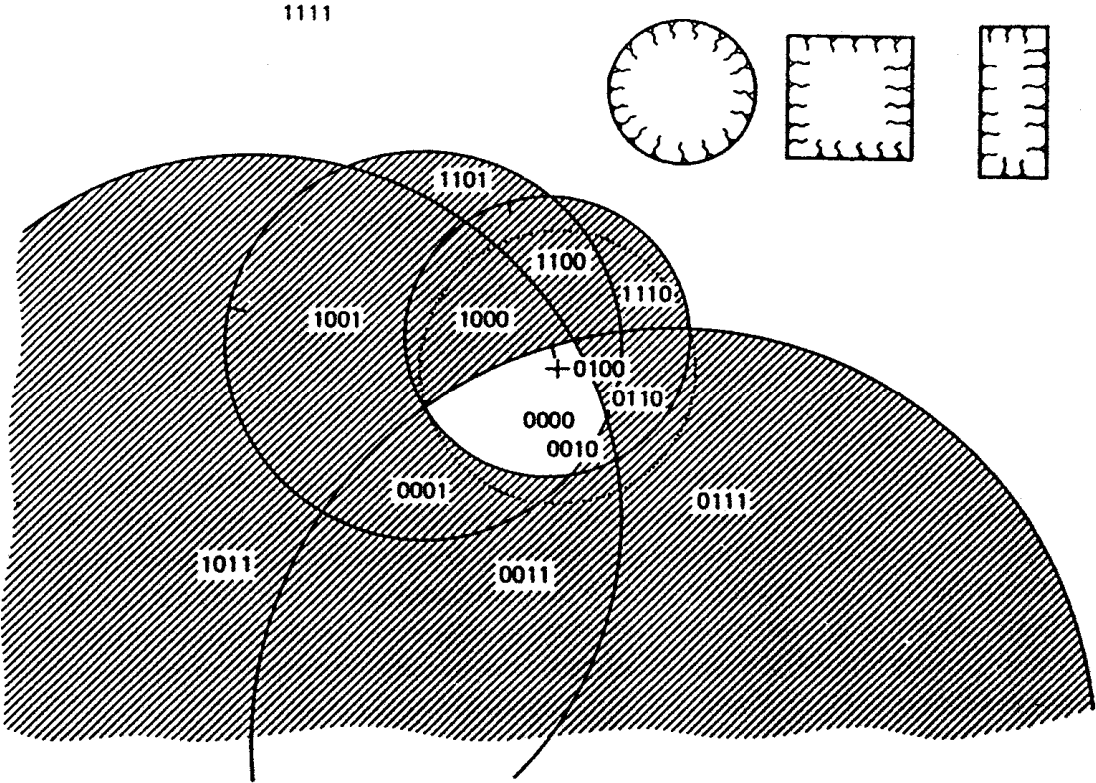**SP for wall/wall/roof corners of intersecting chambers**

SP for wall/wall/floor corners of intersecting chambers

8) Pillars between underground chambers

Key blocks of a wall (rib)

8) Pillars between underground chambers

Key blocks of a pillar