CE 331A GEOINFORMATICS

Maj Gen (Dr) B Nagarajan
Dept. of Civil Engg.

Email:nagaraj@iitk.ac.in
Room No : FB 329, Ph: 7435
Office Hrs : 3 pm to 5 pm Wednesday

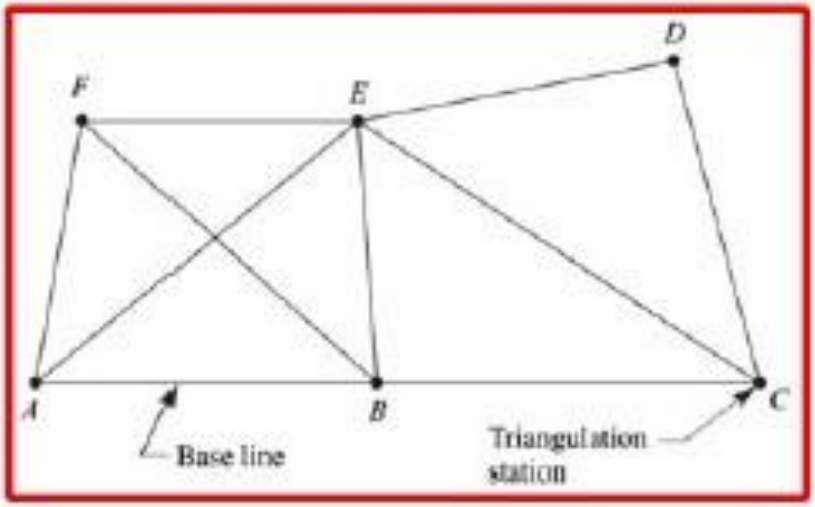
Triangulation and Trilateration

Triangulation

- Consists of a system of number of interconnected triangles in which the length of only one of the line called the baseline and all the angles of the triangles are measured. Knowing the length of one side and three angles, the lengths of the other two sides can be calculated.

Trilateration

- Consists of a series of joined or overlapping triangles. However, for trilateration lengths of all sides of the triangle are measured and few directions or angles are measured to establish azimuth.
- Development of electronic distance measuring (EDM) equipment has enabled measurement of all lengths with high order of accuracy under almost all field conditions.



Objective

- To provide most accurate system of horizontal control points on which less precise triangle may be based which in turn may form a framework to which all other types of surveys may be referred.
- Since a triangulation or trilateration system covers very large area, the curvature of the earth has to be taken into account and hence, the purpose is establishment of horizontal geodetic control to assist in determination of size and shape of earth.
- A combined triangulation and trilateration system consists of a network of triangles in which all the angles and all the lengths are measured.
- Field procedures for establishment of trilateration station are similar to the procedures used for triangulation.

Principle

Known

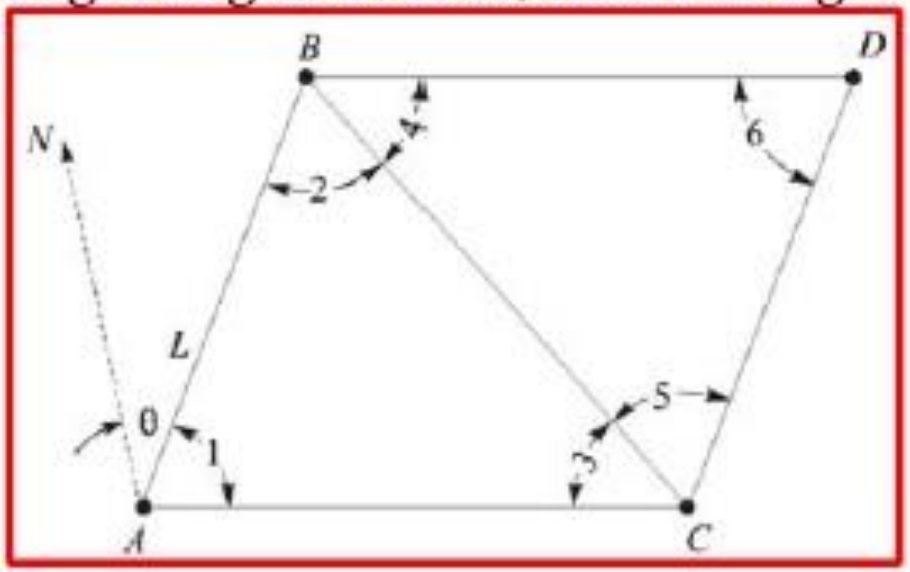
- All angles in both triangles and length L of the side AB, have been measured.
- Azimuth θ of AB has been measured at the triangulation station A, whose coordinates (X_A, Y_A) are known.

Objective

- To determine coordinates of triangulation stations B, C, and D by the method of triangulation.

Steps

- Use sine rule to get lengths of sides; then bearing and finally coordinates



Purpose of triangulation

(i) To establish accurate control for plane and geodetic surveys of large areas, by terrestrial methods

(ii) To establish accurate control for photogrammetric surveys of large areas

(iii) To assist in the determination of the size and shape of the earth by making observations for latitude, longitude and gravity, and

(iv) To determine accurate locations of points in engineering works such as:

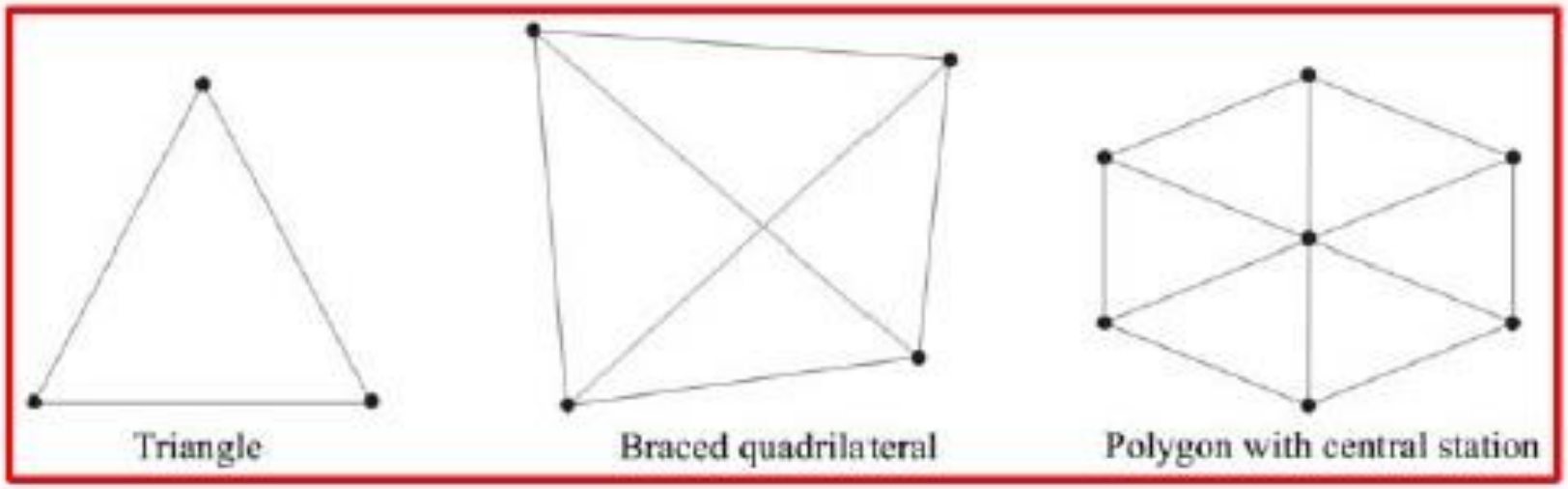
- (a) Fixing centre line and abutments of long bridges over large rivers.
- (b) Fixing centre line, terminal points, and shafts for long tunnels.
- (c) Transferring the control points across wide sea channels, large water bodies, etc.
- (d) Detection of crustal movements, etc.
- (e) Finding the direction of the movement of clouds.

Classification of triangulation

- First order or primary triangulation
  - To determine earth's figure
  - To furnish most precise control points to which secondary triangulation may be based
- Second order or secondary triangulation
  - To cover areas of the order of a region, small country, province
- Third order or tertiary triangulation
  - Connected to secondary control and for providing control for detailed engineering, location and other surveys and to form the immediate control
- Zero order
  - Highest order, mainly for continental level network, established with the help of GPS, satellite photogrammetry

Figures for triangulation

- Basic figures used in triangulation networks are the triangle, braced or geodetic quadrilateral, and the polygon with a central station



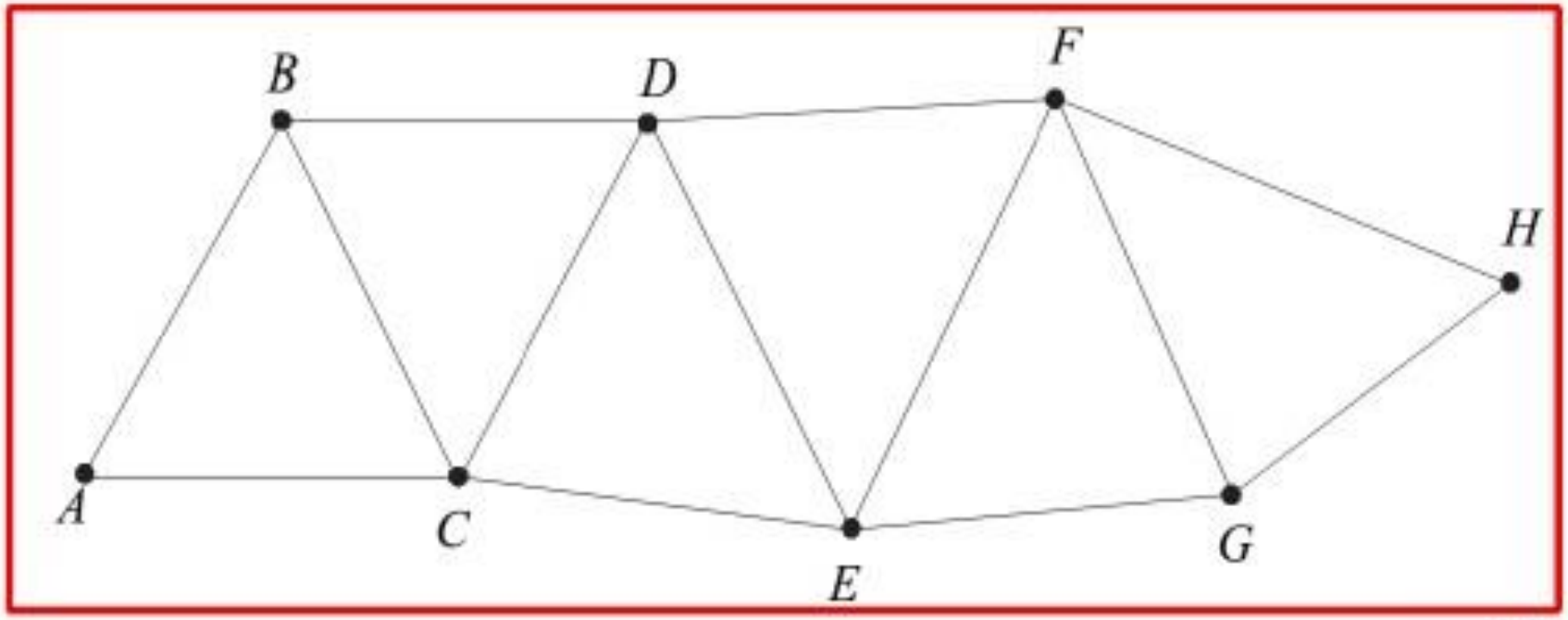
Other figural forms

- Triangulation figure is a group or a system of triangles such that any figure has one side and only one, common to each of the preceding and following figures.
- Common figures:
  - Single chain of triangles
  - Double chain of triangles
  - Braced quadrilateral
  - Centered quadrilateral
  - Combination of above

Q: Which figure is better?

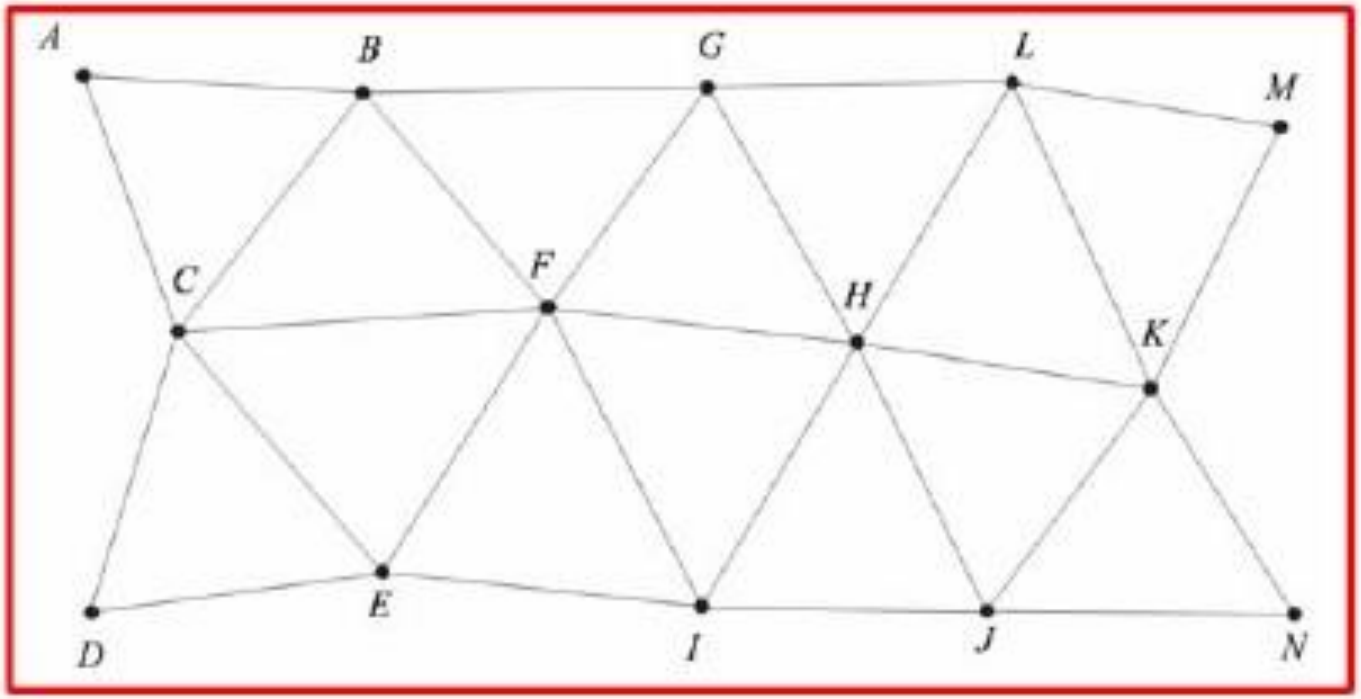
1. Single chain of triangles

- Used when narrow strip is to be surveyed.
- Economical
- Not very accurate but rapid work
- Does not provide checks on computed lengths
- Frequent check bases are provided to control errors



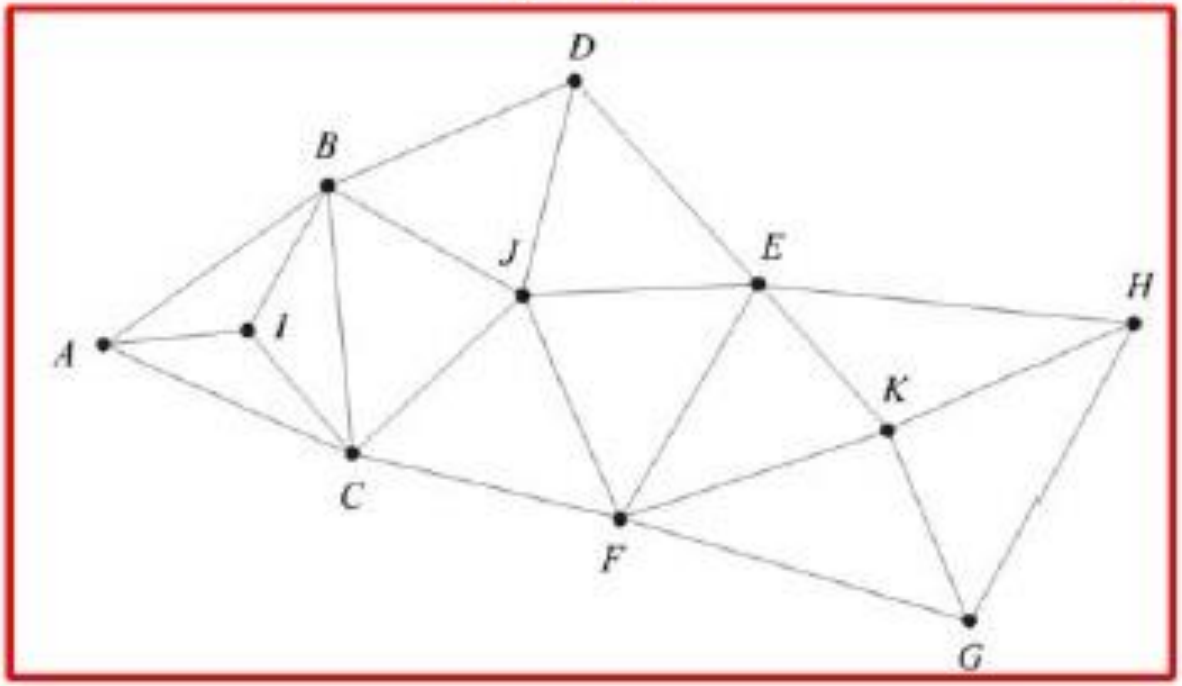
2. Double chain of triangles

- Used to cover large areas
- Provides accurate results since lengths of various sides can be checked from two independent routes



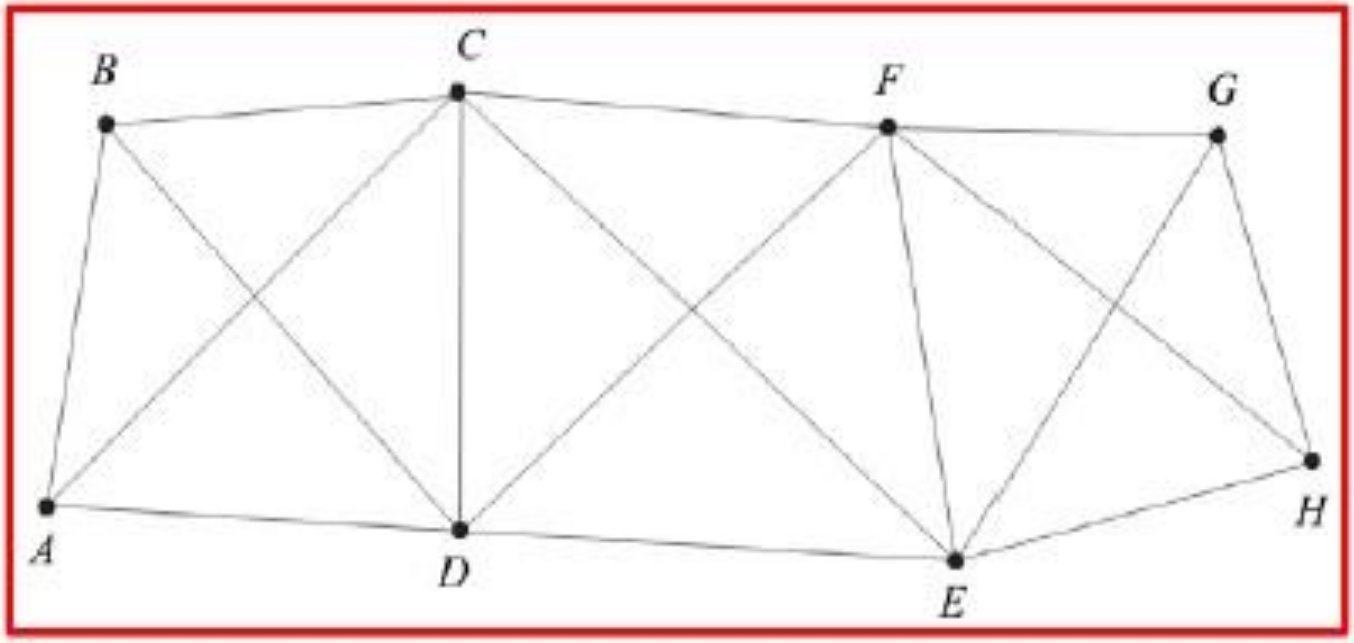
3. Centered Figure

- Used when vast area in all directions is required to be covered, especially in flat country; centered figures are quadrilaterals, pentagons, or hexagons with central stations.
- Though this system provides checks on accuracy of the work, generally it is not as strong as the braced quadrilateral arrangement.
- Better results but progress of work is quite slow due to the fact that more settings of the instrument are required (many angles are to be observed, many stations have to be occupied); will take time in adjustment.

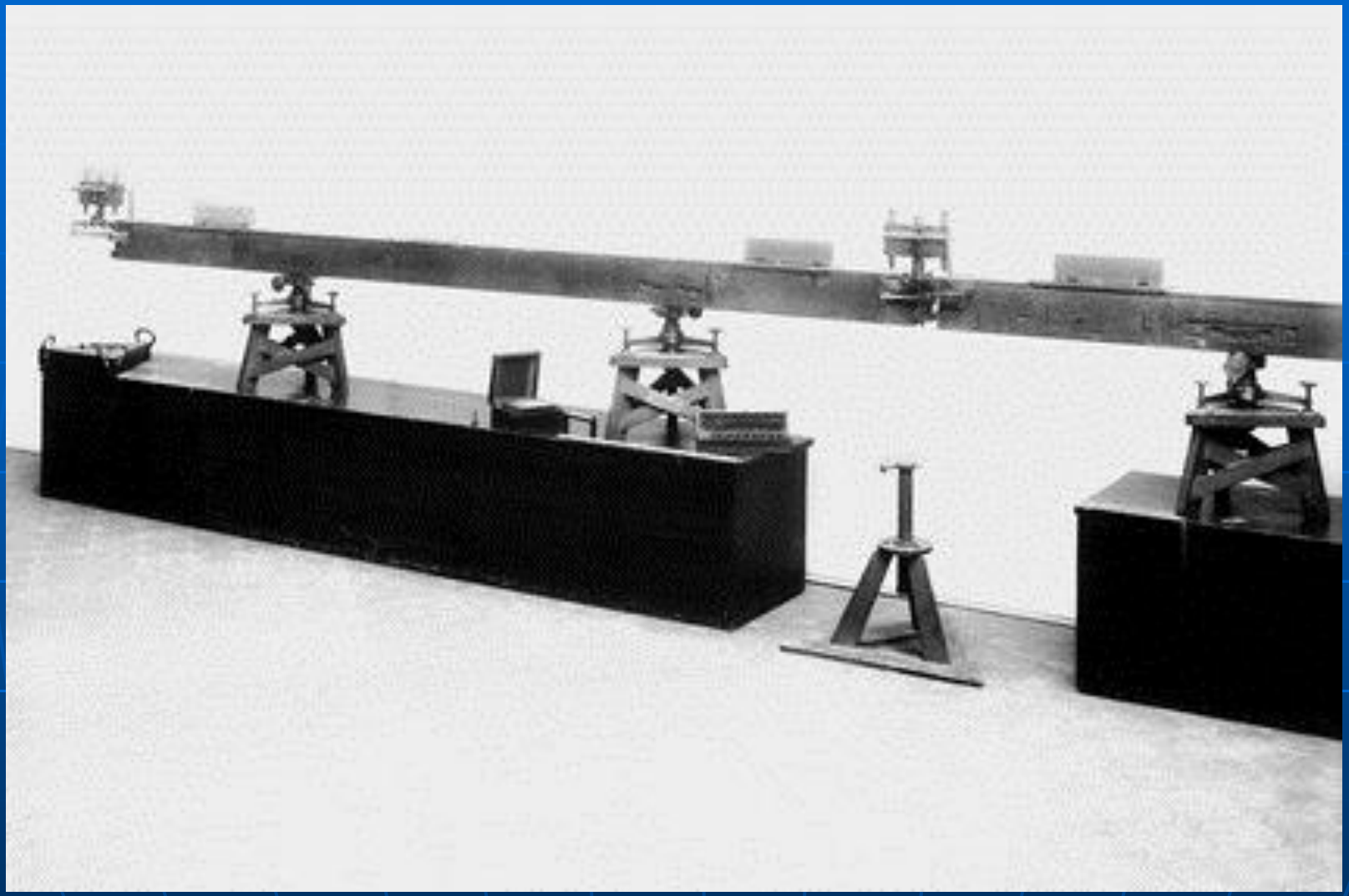


4. Quadrilaterals

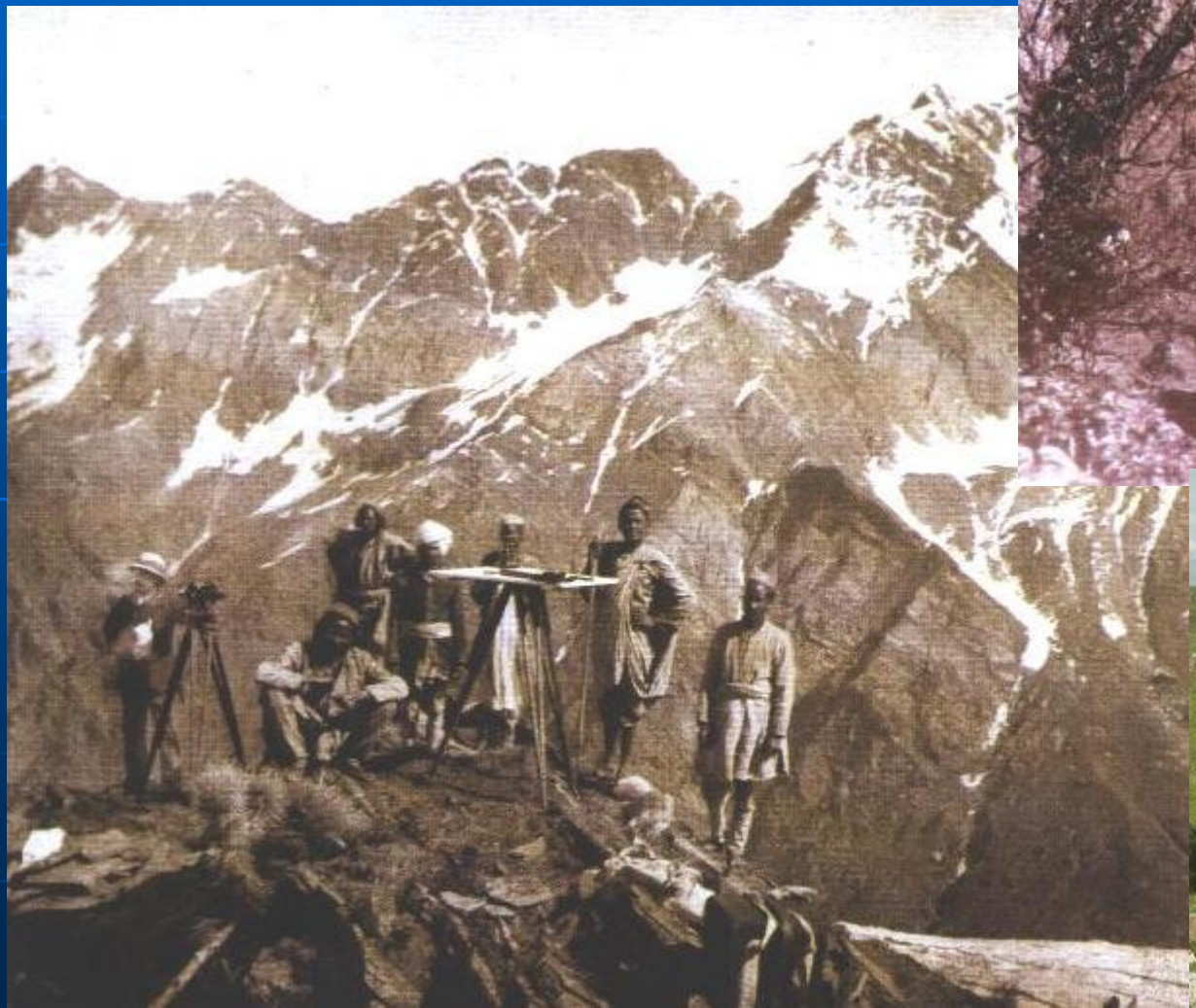
- Best suited in hilly regions
- Since the computed lengths of sides can be studied through the system by different combinations of sides and angles, the system is more accurate and strongest

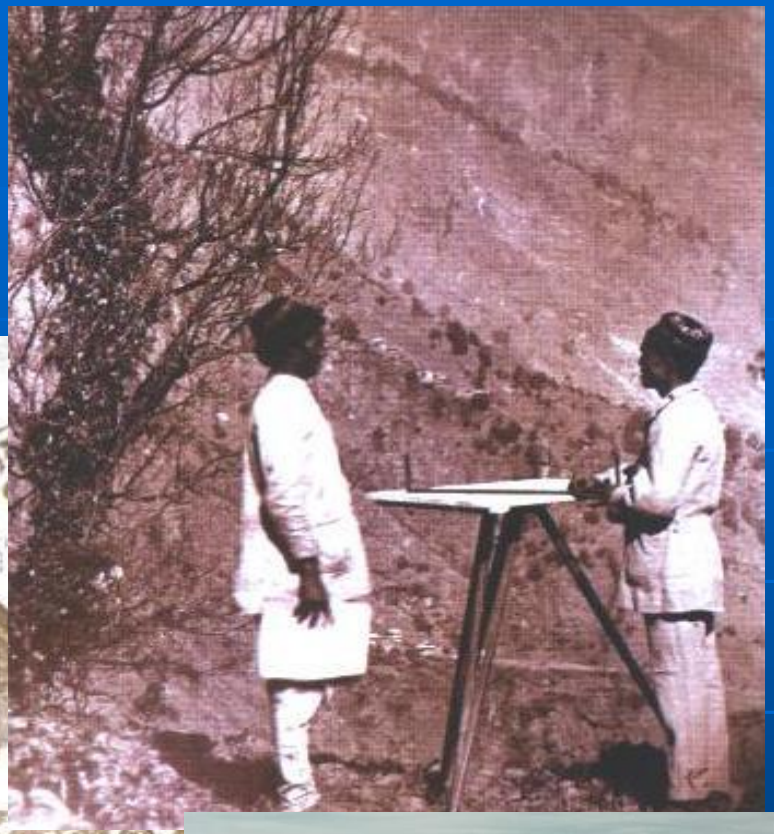


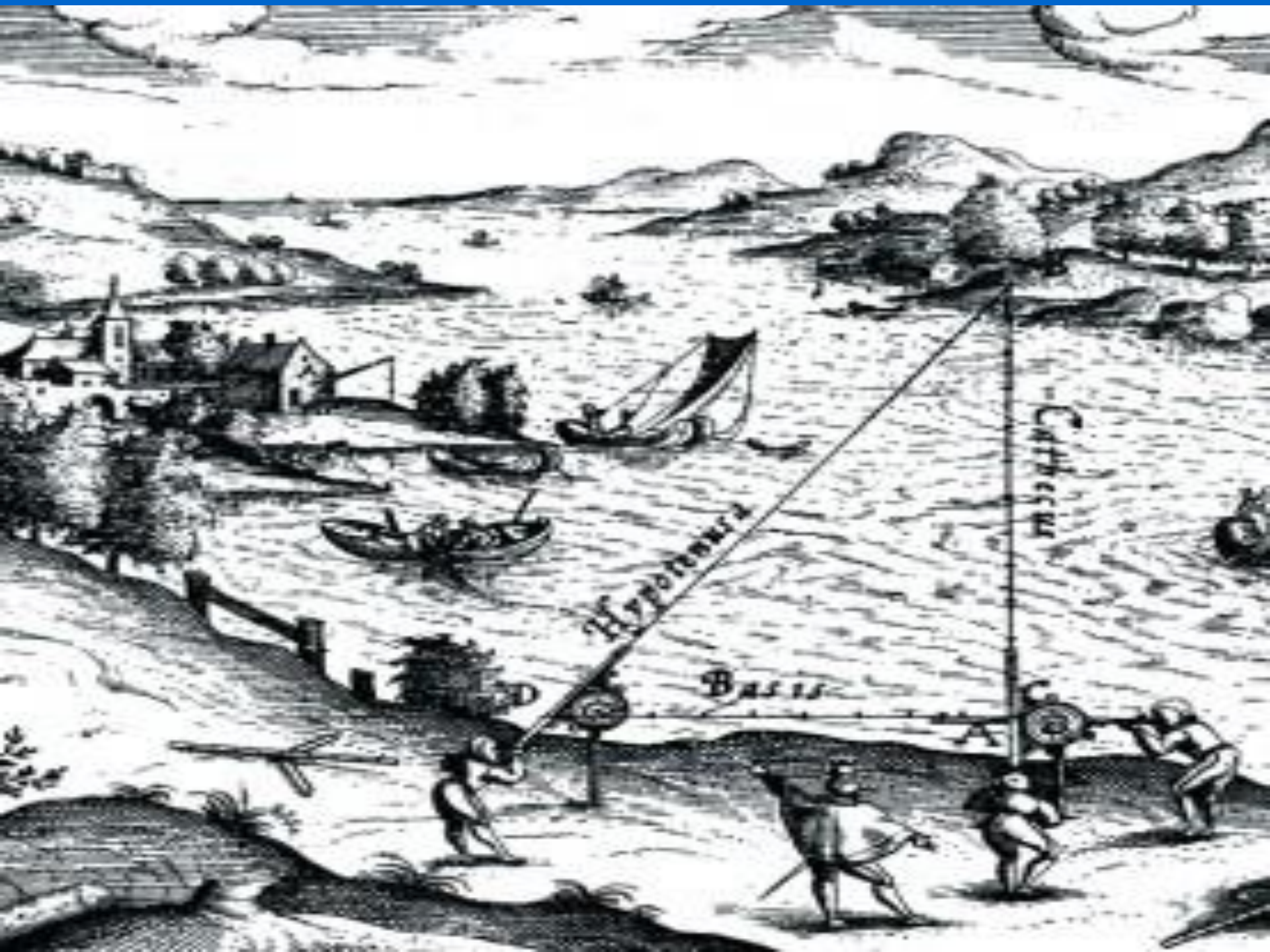
Indian Triangulation system

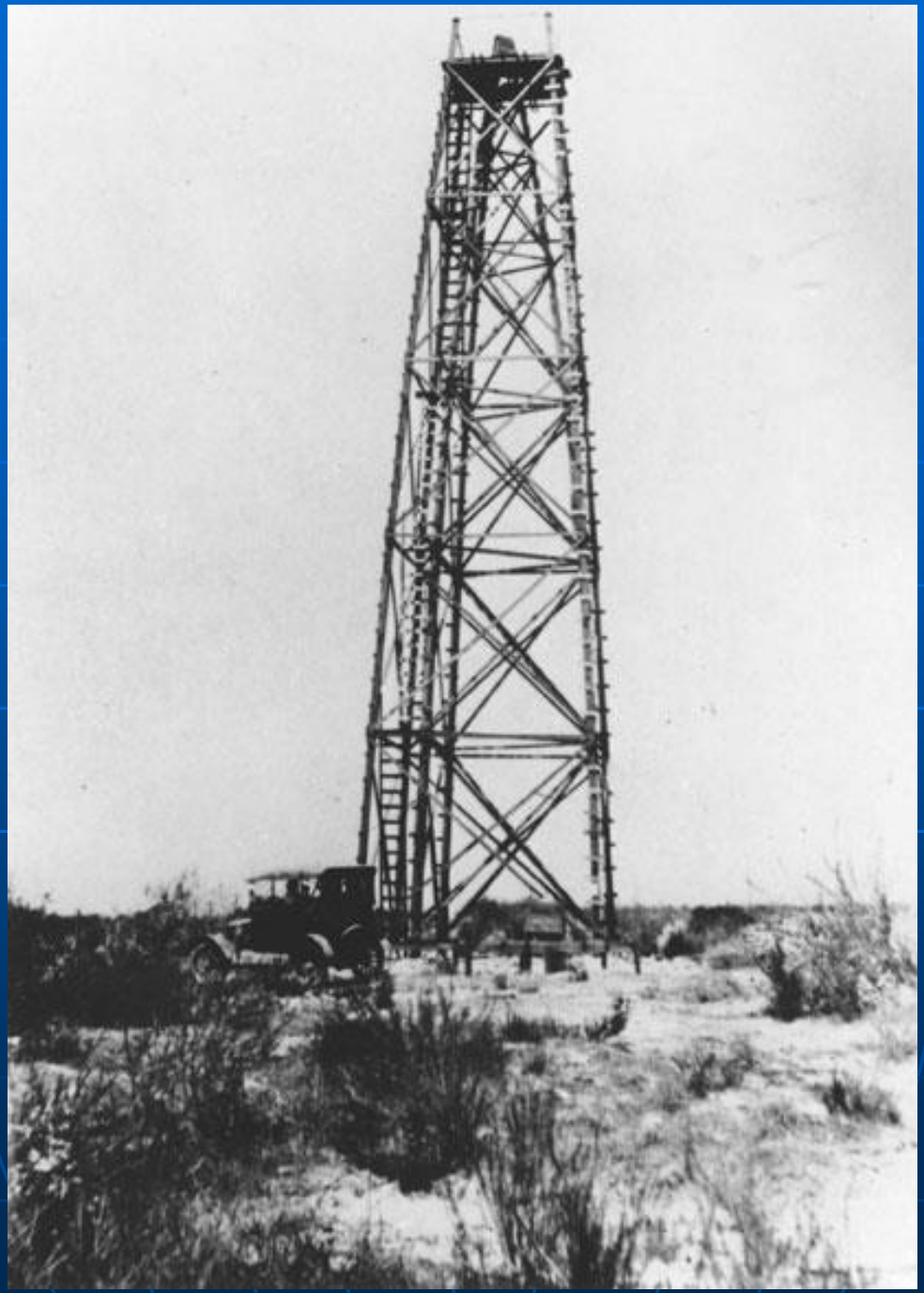


Early Methods

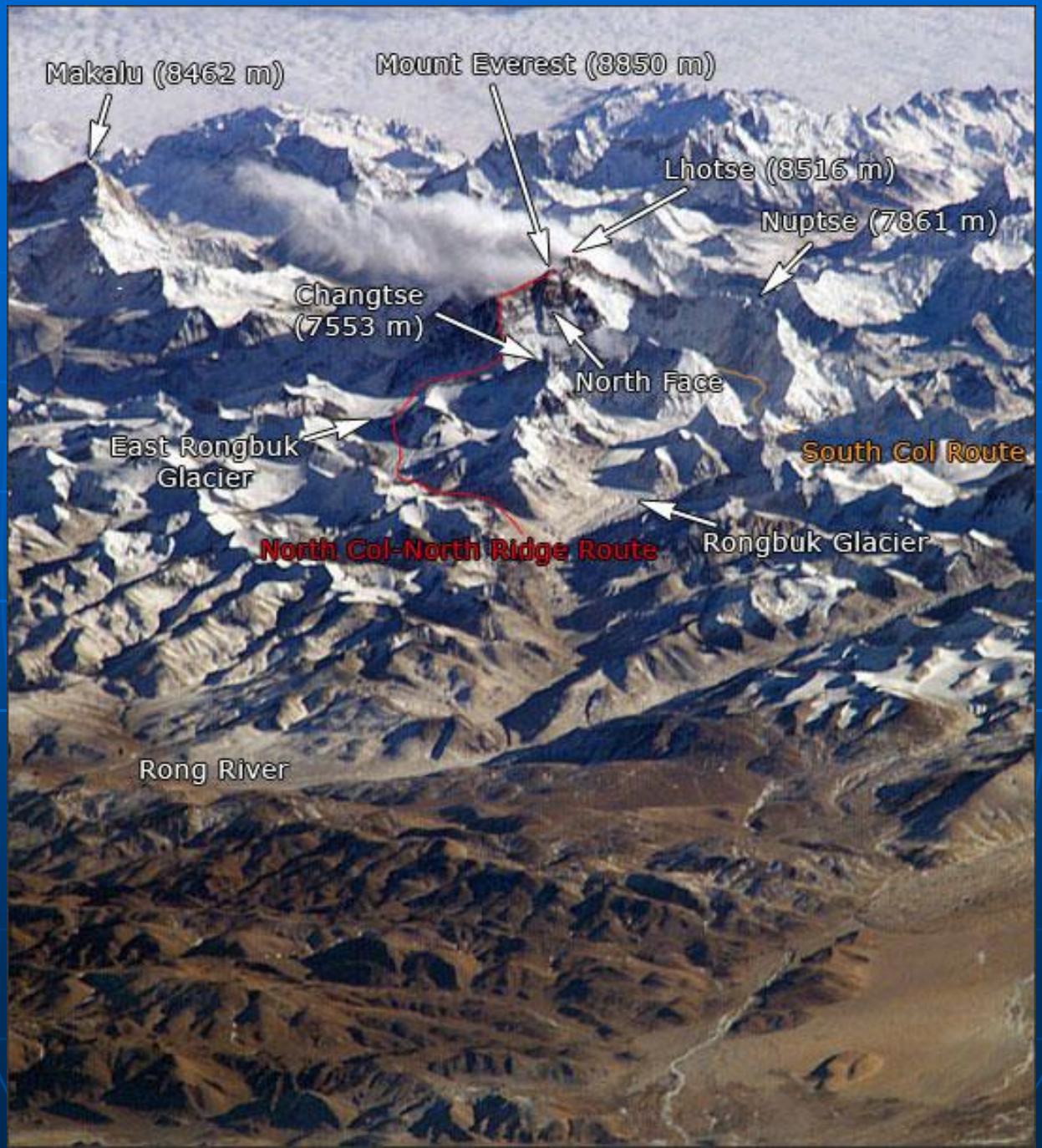





Hypotenusa
Basis
Catheti






Makalu (8462 m)
Mount Everest (8850 m)
Lhotse (8516 m)
Nuptse (7861 m)
Changtse
(7553 m)
North Face
East Rongbuk
Glacier
South Col Route
North Col-North Ridge Route
Rongbuk Glacier
Rong River

Criteria for selection of layout of triangles

1. Simple triangles should be preferably equilateral.
2. Braced quadrilaterals should be preferably approximate squares.
3. Centered polygons should be regular.
4. Arrangement should be such that the computations can be done through two or more independent routes.
5. Arrangement should be such that at least one route and preferably two routes form well-conditioned triangles.
6. No angle of the figure, opposite a known side should be small, whichever end of the series is used for computation.
7. Angles of simple triangles should not be less than 45°, and in the case of quadrilaterals, no angle should be less than 30°. In the case of centered polygons, no angle should be less than 40°.
8. Sides of the figures should be of comparable lengths. Very long lines and very short lines should be avoided.
9. Layout should be such that it requires least work to achieve maximum progress.
10. As far as possible, complex figures should not involve more than 12 conditions.