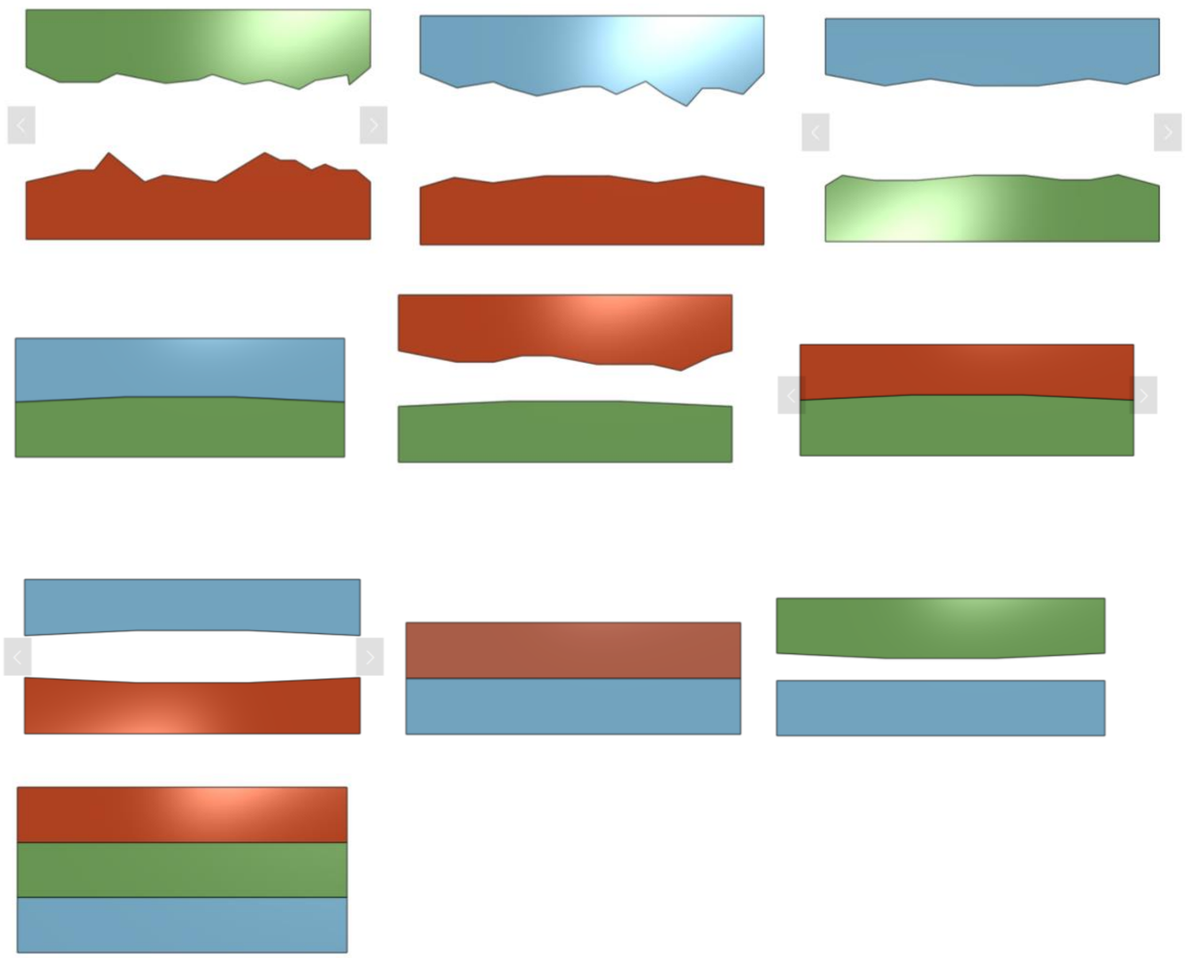
Precision metrology 14_Flatness measurement

## Flatness Measurement

:to measure the deviation from a reference plane

: ▱ | 0.02 Flatness Tolerance (ISO)

### (1) Joseph Whitworth's 3 Surface Method



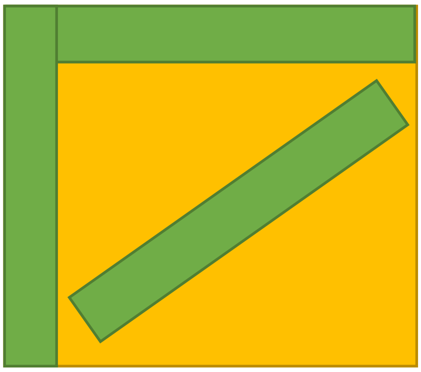
Source:Eric Weinhoffer, great precision from 'nothing'

### (2) Flatness check with a reference surface

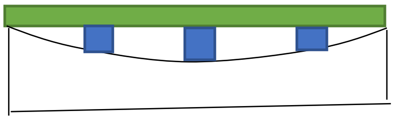
(Innovation with Engineers' Blue and Hand Scraping)

(3) Straight edge with slip gauge

Edge on the surface



Slip gage inserted



Height check

with slip gauge

(4) Surface measurement with CMM (Coordinate measuring Machine)

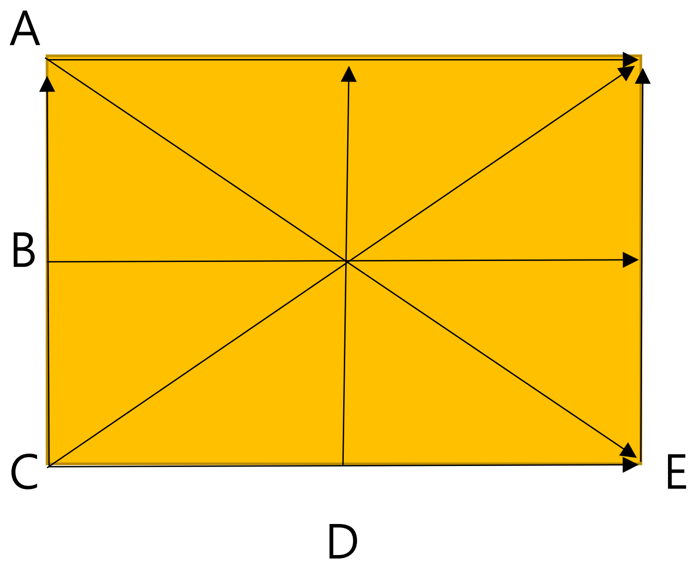
:To measure the surface profile with a precision CMM


Source: Dukin

(5) Incremental angle measurement method with devices such as Level, Autocollimator, laser interferometer

:To measure the incremental angle along the generators

① <u>Diagonal or Union Jack Method</u>




-Straightness error measurement along 8 generators

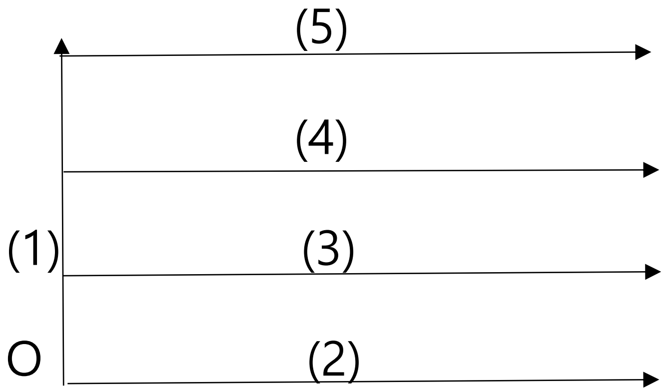
-Assume A,C,E have the same height as zero.

-The same closing error at the centre intersection.

(Discuss Pros and Cons!)

(3:4:5? Edge area? Small surface?...)

② Open Rectangle

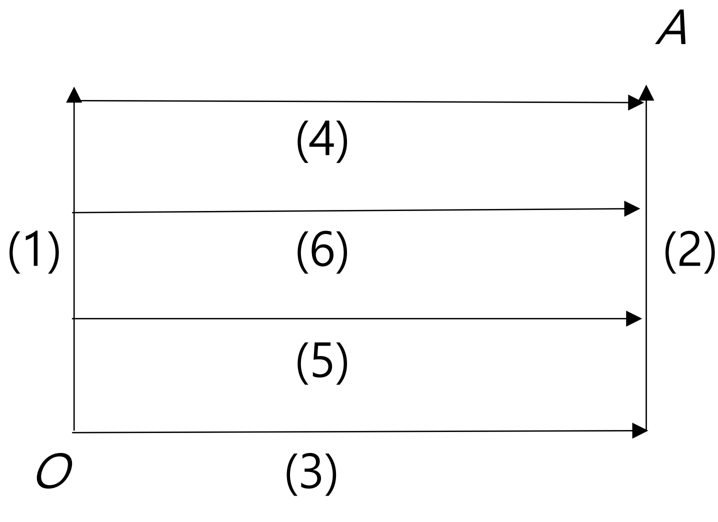



-Rectangular measurement starting from O

-No closing error

-Errors in the angle measurement directly affect to the height due to non-redundant measurement

③ Rectangular Perimetre Longitudinal (RPL) method



-Rectangular measurement starting from O

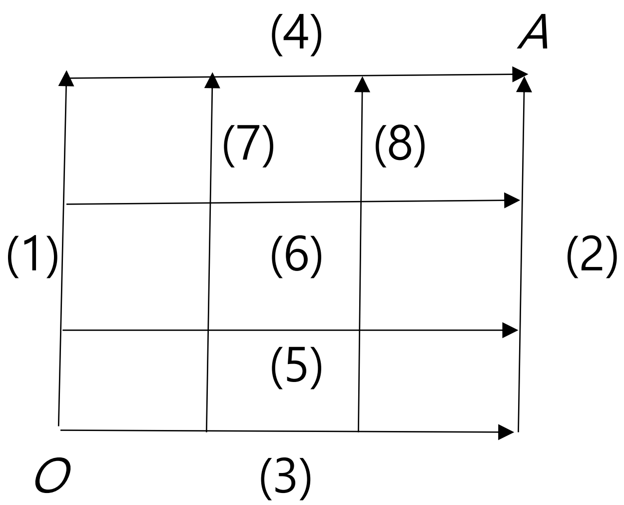
-Closing error at A= [(1)+(4)]-[(3)+(2)], to estimate the uncertainty of measurement

-Closing error distribution, to equally distribute along (1)+(4) and (3)+(2) such that closing error at A=0

-Height calculation along the frame generators (1),(4),(3),(2)

-Height adjustment along inner generators (5),(6) ; using the frame generators

④ <u>Rectangular Perimetre Longitudinal Transverse(RPLT)</u>




-Rectangular measurement starting from $O$

-Closing error at A= [(1)+(4)]-[(3)+(2)], to estimate the uncertainty of measurement

-Closing error distribution, to equally distribute along (1)+(4) and (3)+(2) such that closing error at A=0

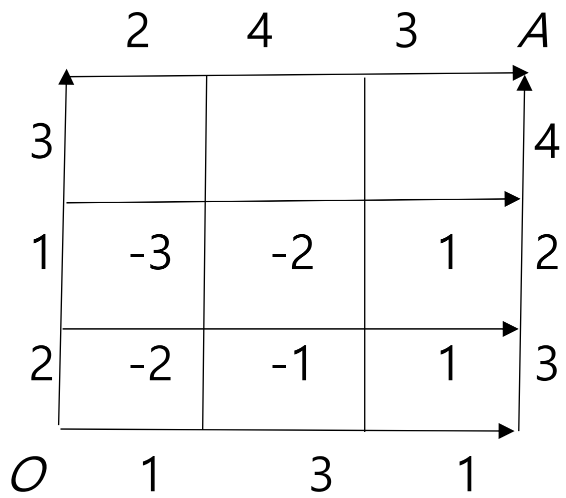
-Height adjustment along inner generators along (5),(6),(7),(8), based on the frame generators.

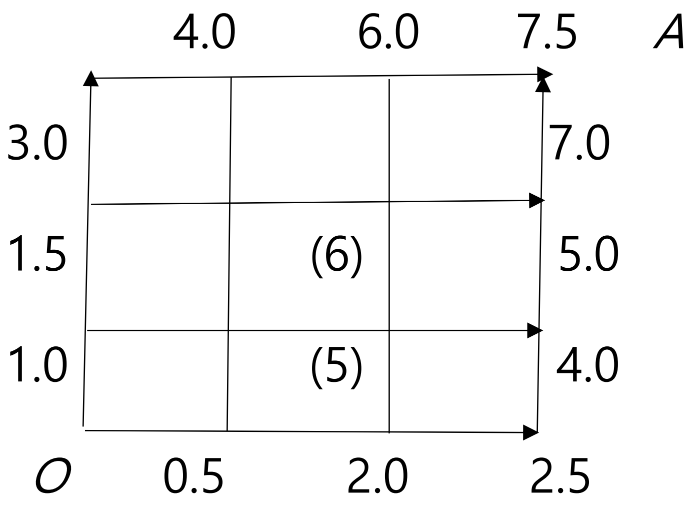
-Average height of longitudinal and transverse directions at inner points along the (5),(6),(7),(8)

Flatness measurement data (RPL method)

Step length, d=10cm=0.1m

Angle Unit=1 sec=5urad=5um/m=0.5um/0.1m






Closing error at A=Height ┌ - Height ┘ = 7.5-7.0=0.5um, and it is possibly due to drift or error during the measurement. Thus total of ±0.25um can be equally distributed along the 6 generators each.

For ┌ generators, adjusted height, h*=h-0.25N/6, and N=sequence of generator from O,

and they are 0.958, 1.416, 2.875, 3.833, 5.791, 7.25.

For ┘ generators, adjusted height, h*=h+0.25N/6, and they are 0.542, 2.083, 2.625, 4.167, 5.208, 7.25.

After the frame generators are adjusted according to the closing error, the inner generators are adjusted as follows;

For the generator (5), the height can be calculated, and they are 0.958, -0.042, -0.542, -0.042 from left to right. The difference at the far-right node = 4.167-(-0.042)=4.209, and this is also equally adjusted at each node along the generator (5). Thus adjusted height,

h*=h+4.209N/3, where N is the sequence from the far-left node; and they are 0.958, 1.361, 2.264, 4.167

For the generator (6), the height can be calculated, and they are 1.416, -0.084, -1.084, -0.584 from left to right. The difference at the far-right node = 5.208-(-0.584)=5.792, and this is also equally adjusted at each node along the generator (6). Thus adjusted height,

h*=h+5.792N/3, where N is the sequence from the far-left node; and they are 1.416, 1.846, 2.777, 5.208.

Thus all the height data are determined, and the height measurement procedures are completed.

The measured height data are;