The Cape Geodetic Standards & Their Impact on Africa

Tomasz Zakiewicz

The Chief Directorate of Surveys and Mapping
Department of Land Affairs

Mowbray (Cape Town), South Africa

Units of Length Measure at the Cape

Why is standardising of the unit of length so important?

- Measurement means the determination of any extent in terms of a suitable unit.
- It is not so significant how long a particular unit is.
- It is crucial that it means the same for everybody.
- Therefore, measurements must be standard and all units must be accordingly related.

A Little Very Old History

- Distance measurement was expressed initially by means of steps, stone's throw, days taken to travel.
- Pictures in Egyptian tombs, 5000 years old, show priests with wooden rods.
- Babylonians used the length of a human foot as a unit of measurement.
- The Greek units of length were derived from the Egyptian and Babylonian units.
- The Romans measures, adopted from the Greek, originated the European systems of measurement.

A Little History on the English and Metric Systems

- In the 1100s, the "foot of St. Paul" was inscribed on the base of a column of St. Paul's Church in London.
- Henry I (1068-1135) established a unit called "yard", being equal to 3-feet.
- In France, the metric system was adopted in the 1790s, during Napoleon's time.
- In 1799 the metre was required by law to be used in the Paris region.

What was the standard of metre initially?

✓ The metre was intended to be one ten-millionth part of the distance from the North Pole to the Equator when measured on a straight line running along the surface of the earth through Paris.

- Initially, the metre did not physically exist in a form of any bar.
- The "Toise of Peru" remained the national material standard in France.
- The "Toise of Peru" was an iron bar, reconstructed from an old "Toise" standard for the measurement of the Peruvian arc in the 1730s.
- The law defined the length of metre, that is its relation to the "Toise of Peru", hence the name "French Legal metre".

•1795 Borda, the Guardian of Standards, made two physical standards:

- "Metre of the Archives".
- "Module" - of the size of two "Toises of Peru" - regarded as the French standard of length.

Implication:

▪Duplicates of "Module" (the Toise) were issued to the European countries.

▪Thus, up to 1880, the whole of Europe, except England, referred its linear standards to the "Toise of Peru".

•1824 The Act of the British Parliament defined relation of a new standard yard to the metre.

•1866 Colonel Clarke determined the relation of the "Legal metre" ("Toise") to the "Imperial Standard Yard".

•1875 Decision was made to adopt an "International metre".

•1883 The sample of the "International metre" was produced from the "Metre of the Archives", and not from the Borda's "Module", then in use in Europe.

•1896 Benoit and Chaney found the ratio between "International metre" and the "English yard".

➢ It is apparent, comparing Clarke's and Benoit's values, that the "Legal metre" was 8 microns longer than the "International metre".

Note:

The history of the "metre", and the metric system, with its "Legal" and "International" metres, is not as simple as it might look from the above summary – it is, in fact, very confusing. As was once observed: "*To understand thoroughly the true relations between the old standards is beyond the reach of human endeavour".*

An Old Dutch Unit of Measure

- "Rhynland Rood" – the length of iron bar used by Snellius for his famous survey of an Arc in the 1620's.
- 1808 - Resolution of the King of Holland defined relation of Snellius' rod to the metre.
- "True Rhynland foot" = 1.030 British feet (Comparing the ratio of the British Act of 1824 and that proclaimed in Holland in 1808)
- "Rhynland Rood" was used in South Africa for 200 years, since 1652, when the Dutch East India Company settled at the Cape, till 1859, when the "Cape foot" was established.

Early Measuring System in South Africa

➢ 1685-1800, ten Government Surveyors performed surveys in the Cape and Stellenbosch districts.

➢ Their time of office overlapped and their rods were equal.

➢ Two rods of Government Surveyor Thibault (1800-1815), each 6-foot long (intended to be a total of one "Rhynland rood"), were regarded as the only standards for reference in the Cape Colony.

✓ Thus, although there was continuity in surveyor's standard, but there was no official standard, which situation led to discrepancy in surveys.

Establishment of the "Cape Foot"

- 1813 - The Chief Justice of the Court advised Governor Cradock of the differences, between surveys conducted in Cape Town, before and after 1800.
- 1844 - Surveyor-General Michell, and his Deputy Hertzog, investigated the state of the land measure of the Cape Colony.
- 1858 - Governor Grey appointed the Commission *"for the purpose of ascertaining and fixing the unit of land measure in the Colony of the Cape of Good Hope".*
  - ➢ The Commision, under leadership of Sir Thomas Maclear, examined Thibault's rods and found:

    1 Rhynland (Cape) foot = 1,033 English feet
- 1859 - Act No 9 established the "Cape foot", being equal to 1.033 English feet - the ratio in force till 1922, when it was slightly modernised in terms of the "International metre".

The Geodetic Standards at the Cape

✓ These consisted of two 10-foot iron bars, marked "A" and "B", constructed in England in 1838, and compared with the Royal standards in 1839.

- 1841-1848 – Sir Thomas Maclear undertook the verification and extension of Lacaille's arc of 1752.
- *To be noted*: No standard of reference existed in the Cape Colony prior to Maclear's survey.
- Bar B" was used for comparison with Colby base bars, during the measurement of Zwartland base, in 1840/41.
- 1842 – "Standard Bar B" was returned to England, and calibrated against the British standards.

- Sir David Gill commenced the “Geodetic Survey” forty years after Maclear’s measurements. “Cape Standard Bar A” was still kept at the Cape Observatory as a reference standard.

✓ Here, it must be observed, with great satisfaction, that, the 167 years old “Cape Standard Bar A”, the monument of the Geodetic Survey of South Africa, is still in a good shape, and is preserved, for viewing, in the museum of the Chief Directorate: Surveys & Mapping, Mowbray.

Gills wrote:

“*This standard, which was used by Sir T.Maclear, is a rectangular iron bar 64.5 millimetres deep and 38 millimetres broad.*

For a distance of 50 millimetres from its extremities it is cut down to half its height…”

“A spirit level, in length about 9.5 inches, is attached to the middle of the upper surface of the bar by adjusting screws….” (Maclear)

Among other precious historical items, which date back to the Geodetic Survey of South Africa, and now in the possession of the CDSM, there are 10-foot long iron bars, used for the measurement of the baselines, during the surveys of the Cape Colony and Natal, in 1883-1892.

The bars (3.05m x 4.2cm x 3.0cm) were enclosed in a mahogany boxes, with the ends of the bars projecting from it.

In 1902-06, these bars were employed during the Transvaal and Orange River Colony surveys, to measure Ground Standard Bases (146.3m long), which were established at every baseline, to serve as a check for the Jäderin wires, and which were measured both with the wires and the steel bars.

Interestingly, in 1913-1916, the same steel bars were used, on loan from the then Union of South Africa, for the measurement of baselines, during the survey of the Primary Triangulation of Malaya (now Malaysia).

- Two sets of marks defined the length of the “Cape Standard Bar A”:
  1. The original distance, during Maclear’s survey, was defined between two dots, in small bounded round surfaces of gold.
  2. The distance, between the centres of the lines (beside each dot), engraved at Gill’s request, in 1884.
- 1886 – In Paris, Benoit standardised the “Cape Bar A” in terms of the “International metre”.
  - Hence, all the lengths of the base measuring bars, and, consequently, all the geodetic baselines, were known in the “International metres”.

- In order to reduce the results of the Geodetic Survey, and define them in English units, Gill used Clarke's 1866 ratio, the only metre-foot ratio available at that time, which connected the British foot with the "Legal metre".
  - Hence, the Cape standards (10-foot bars) were not converted to British feet, but to a fictitious unit, now called the "South African Geodetic foot".
  - Hence, all results, which are published in feet in the "Report on the Geodetic Survey of South Africa", are in S.A.G. feet. (1 S.A.G. foot = 0.3047972654 Int. metre)
  - As a result, the ellipsoid became the "Modified Clarke 1880 ellipsoid", with parameters:

a = 20926202 S.A.G. feet = 6378249.145326 Int. metres

b = 20854895 S.A.G. feet = 6356514.966721 Int. metres

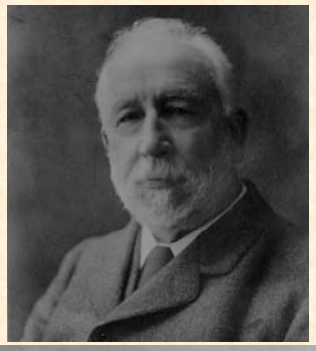
- All the inconvenience, caused by "unintentional" introduction of an extra unit to the Geodetic Survey, could have been avoided if Gill would have determined the relation of the "International metre" to the "English foot" himself – especially, since such a possibility existed:

❖ In the 1940's, D.R. Hendrikz, from the then Trig. Survey Office, determined such a ratio (Int. metre/foot), based, entirely, on the data delivered from the "Cape Standard Bar A", by measuring the small distances (± 0.2mm), between the dots and the lines, and using previous statistics of Airy and Benoit.

His ratio agreed very well with Benoit's (1896) and Sears' (1928) ratios.

- Without doubt, Gill, scientific adviser to the Geodetic Survey, and man of genius, could have done this determination as well. If this would have happened, the somewhat confusing history of the South African measurement system would have been less complicated.

Sir David Gill

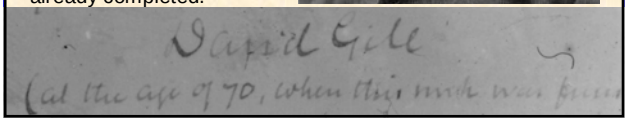


In his handwriting:

(*At the age of 70, when **this** work was finished*……)

He passed away the following year, on the 24th January 1914.

The Geodetic Survey of South Africa was then already completed.



In conclusion:

- The Cape Datum became the origin of the Geodetic Survey in South Africa, hence, also the origin of the 30th Meridian Arc.
- An extension of the Cape Datum established the 1950 Arc Datum, thus, also resulting in the "spread" of the "Modified Clarke 1880 ellipsoid" over the African continent.
- The 1950 Arc Datum was regarded as the first step to a common geodetic datum for Africa, and it is still in use.
- Until the long desired aim, to unify all the geodetic datums in Africa and to create a uniform, ITRF based, co-ordinate system, has been finally achieved, the "remains" of the Cape geodetic standards will still be visible in the Africa.

Thank you

for your attention