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Best foot forward: on the determination of the lengths of archaic units

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13.1 Introduction

Attempts to find the lengths of units of measurement used in ages long ago fall into two categories, which may be described as intuitive and objective. The *intuitive* approach starts from some pre-known value or values and checks whether these fit particular cases under consideration. It echoes the archaeologists search for 'parallels', but ignores the dangers of such an approach in a numerical study. The *objective* approach is based upon an analytical and statistical study, and tries to avoid pre-judging the result. This paper tries to follow the objective course and eliminates as far as possible subjective or intuitive lines of enquiry.

13.2 Assumptions

All workers in this field make assumptions although many do not acknowledge, or recognise that they have done so. The following is put forward as a list of the assumptions which are commonly made and which should have a considerable influence upon the thinking of the investigator.

It is assumed that

1. At the age in question some form of graduated measuring device existed and craftsmen had the skill to use it.
2. The production methods were consistent with the accuracy of the measuring device.
3. There was a rationale to the choice of dimensions which is discoverable.
4. Over the intervening period of time the surviving objects have remained dimensionally stable.
5. An accurate modern measuring device is used with a sound measuring technique.
6. The object still retains well defined features to measure.

13.3 Data collection

In assembling a body of data to study, careful thought should be given as to what to measure and how to measure it. But at the collection stage it is better not to be too restrictive as suspect material may be weeded out prior to analysis. Suggested guide lines for the data collection are as follows

1. Measurements should be made on the prototype if at all possible. Working from site drawings introduces one stage of possible errors and published drawings are at the far end of a chain of processes, each link of which is a source of error.
2. The parts of a structure chosen for measurement should be original and not part of any alterations or additions. Such subsequent work may have had to fit particular requirements which are no longer evident. Only the original work will have allowed a fairly free choice of dimensions.
3. Measurement should be to points whose definition equates to the accuracy of the measuring technique.
4. The units used for measurement should be in a completely different system from that which might have been used for the original. Using the metric system will usually take care of this requirement.
5. The measuring equipment used should be accurate. Steel tapes should be used, and too often even these have been so badly used that they are no longer accurate. Do not be misled by the seeming simplicity of linear measurement, accuracy means taking care.
6. A large number of measurements should be taken. It is easy to take too few, but practically impossible to take too many. Usually it is difficult to find enough points of the required quality to use for measurements.

13.4 Data analysis

The method of analysis chosen should have the following characteristics

1. It should be objective and not show bias towards any preconceived ideas about the length of unit.
2. The method should be flexible enough to search over a range of possibilities and to allow variation of the range and search interval.
3. The data should be analysed as a whole, and not looked at bit by bit. This will prevent piecemeal rejection of negative evidence which in total may be significant.
4. The reliability of the result should be quantifiable and not expressed on a subjective scale.
5. The data used in the analysis should be independent. It should not be possible to calculate any one value from any of the others.
6. The method of analysis should be validated by testing it with data which comes unquestionably from a system of units which are known.

13.5 Rationale

As stated above, one of the assumptions made is that there was some method or system used for the choice of the original sizes and that it is discoverable. This is a fundamental assumption, since otherwise there could be no systematic search for a unit. Almost all investigators agree that when given a free choice, the original craftsmen when deciding major dimensions would choose round numbers or numbers associated with some number base, e.g. decimal or duodecimal. Also when settling sizes for smaller features and detail use would be made of common fractions.

13.6 Proposed method of analysis

The method here proposed is a search over a range of values using the principle of least squares as a criterion for the 'best' result. Such a method is only practicable if it is done on a computer. It has been programmed in BASIC and used on a Spectrum. Undoubtedly this does not give the fastest result, but to those who find this irksome there should be no problem in writing a program in another language and using it on a faster machine. The user is allowed to exercise choice over the details of the search, and expected to use judgement over the final result. This latter facility is useful when the computer results may point to more than one possibility. The procedure is as follows:

1. User chooses
   (a) Range of trial values, e.g. 25–36 cm.
   (b) Trial value intervals, e.g. 0.1cm.
   (c) Fraction of units originally preferred (if appropriate).
2. Program
   (a) Divides first trial value into first measurement.
   (b) Examines quotient and finds residual between it and nearest whole number plus preferred fraction.
   (c) Squares residual
3. Program continued
   (a) Repeats whole of 2 for each measurement.
   (b) Sums squares of residuals for all measurements.
   (c) Calculates Variance and Standard Deviation
4. Program continued
   (a) Repeats 2 and 3 for each trial value
   (b) Prints each Trial Value, Variance and Standard Deviation.
5. User
   (a) Studies printout
   (b) Chooses further trials if required
   (c) Chooses likely unit using values provided and any other available evidence.

13.7 Validation

The first attempt at validation made use of measurement data taken from a late Victorian/Edwardian Maltings building. The analysis gave the unit of length as 34.6 cm! However after much consideration it was realised that this was a well made brick building and brickwork is always specified in units of the length of a brick, or half a brick. A brick and a half plus a joint width is within 2 or 3 mm of 34.6 cm. It seems likely that in this case a module of 1.5 bricks was used for purposes of detailing. This is a useful reminder that materials used and craft practices may have an important bearing in this subject.

The next attempt at validation used measurements from a building constructed in 1900, this date was carved in a prominent position. It was well constructed in ashlar masonry, well away from any other building so that there had been no constraint on the choice of dimensions when it was built. It was possible to get 14 independent measurements on this structure. When they were analysed a unit length of 30.4cm had decidedly the lowest values of Variance and Standard Deviation, a result in close agreement with the length of the Imperial Foot.

13.8 Field application

The method has been used on the Saxon parts of St. Paul's Church at Jarrow. Here it was possible to get 11 independent measurements. Upon analysis the length of the unit of measurement was found to be 28.0cm. Rather than relying too heavily on such a precise figure it is probably better to say that the unit was 28 cm plus or minus 0.1 cm.

This result makes an interesting comparison with the 'Yeavering' foot put forward by Hope-Taylor with a value of 28.1 cm. Unfortunately this value is not supported by any real analytical approach, the few details which are given concerning its derivation being highly subjective.