FoMRHI Comm. 2079 **John Downing**

Low Cost Braided Lute Bass Strings 101

A case for metal cored braided silk lute bass strings is made in Comm. 2013 ('Gansars, Catlines, Pistoys and Lyons – Those Silken Lute Strings' with corrections in Comm.2019). To test the feasibility of the proposals, a series of experimental strings made from commercially available lead cored fishing lines, was started in 2014 with some success. Unfortunately this work was halted, uncompleted in October 2015 and since then has not been continued. This Comm. reports on the experimental results so that others might, with little effort and cost, make their own lute bass and mid range strings of this type (Note 1).

A viable lute bass string costing only a few cents to make is surely an attractive proposition?

Lead wire is a good core material for this application, relatively low cost with a specific gravity of 11.35 (a bit denser than pure silver) and ultimate tensile strength of only 12 Mpa (compared to the historical alternatives: pure silver – 170 Mpa, and pure gold – 100 Mpa) so will stretch under load, without work hardening, to allow the braided jacket to take most of the string tension. Pure gold wire is now prohibitively expensive so today is not really a practical alternative for this type of string.

Materials

Lead cored braided fishing line is made by a number of manufacturers in various diameters and breaking loads. It is designed for trolling – i.e. pulling the line behind a slow moving boat. The lead core allows an attached baited hook to sink to greater depths than possible with a conventional fishing line. The jacket of a line is machine braided ('Maypole' braid) from nylon filament. For troll fishing, the lines, sold on 100 yard (91 metres) or 200 yard (183 metres) spools are dyed distinctive colours every 10 linear yards (9 metres) so that an angler can readily determine the depth being fished.
The lines tested in this experimental program were:

1) 'Sufix' 12 lb, diameter 0.54 mm, core diameter 0.40 mm, linear mass 1.38 gm/metre
2) 'Sunset – Tel-a-Depth' 27 lb, diameter 0.80 mm, core diameter 0.55 mm, linear mass 2.63 gm/metre.
3) 'Mason' 45 lb, diameter 0.87 mm, core diameter 0.50 mm, linear mass 2.65 gm/metre.
4) 'Sunset – Tel-a-Depth' 63 lb, diameter 0.95 mm, core diameter 0.46 mm, linear mass 2.30 gm/metre.

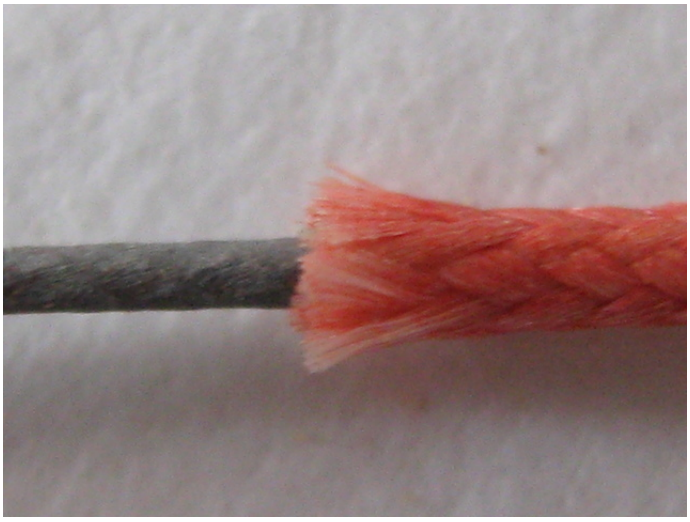
Line diameters were measured with a micrometer so are only a close approximation due to the difficulty in measuring soft textile thicknesses. Note also that line diameters reduce somewhat at working tension by between about 2% and 4%.
The core diameters of these lines vary and it can be seen that the ratio of core diameter to outside diameter of the lines is not constant even from the same manufacturer. Line and core diameters are not specified by the manufacturers so must be determined after purchasing a spool. However, the cores may be readily removed and replaced with cores of larger diameter if required or interchanged between braided jackets. Cores stripped from lines have a rough suface – presumably indented by the jacket during the braiding process?

To protect a finished lute string against abrasive wear and safely seal the potentially toxic lead core within the braided jacket, the string must be saturated with a flexible varnish (Note 2). The varnish used in these experiments was the established and readily available 'Tru Oil' varnish designed for finishing wooden gun stocks – a simple to apply, fast drying wiped on finish. The varnish was diluted 50%/50% varnish/thinners and two wiped on coats applied with the string at about 3 Kg tension, allowing the varnish to dry between coats.

Alternative Materials

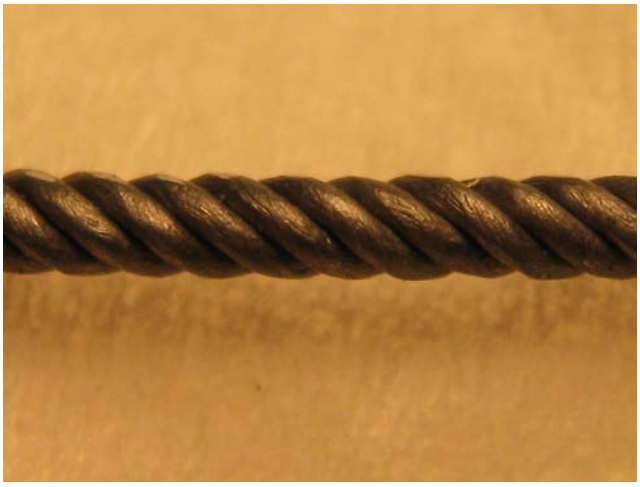
Nylon braided cord with fabric core is available at low cost in a variety of diameters (0.4 mm, 0.5 mm, 0.8 mm, 1.0 mm, 1.4 mm, 1.5 mm, 2.0 mm and 3.0 mm) and colours as 'Chinese Knotting Cord'.
When working with short lengths of a metre or so it is a simple matter to pull out the core and replace it with pure lead wire fed manually, bit by bit, into the empty braided jacket. The braided jackets are flexible enough to expand in diameter to receive a variety of core diameters.
Pure lead wire of suitable diameter is available from fishing suppliers - used by fishermen for fly tying - available in diameters 0.25 mm, 0.38 mm, 0.51 mm, 0.64 mm, 0.74 mm and 0.89 mm (0.010" to 0.035") at reasonable cost per 0.5 ounce (14 gram) or heavier spools. Also available is a lead free alloy alternative – a bit more expensive but with a density of only about 60% of that of lead.
Lead wire may also be twisted in two or more strands to make larger diameter cores without work hardening but with a relatively lower density per unit length than a solid wire.

Nylon Braided Lead Cored Fishing Line



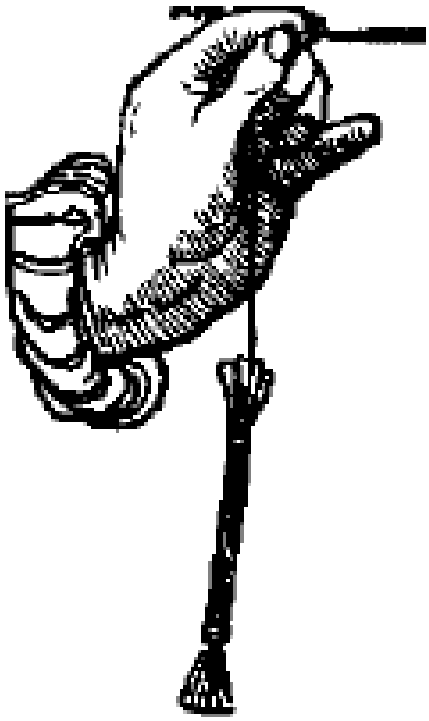
Exposed Single Strand Lead Core

Exposed Two Strand Twisted Core



4 Strand Twisted Lead Core

27 lb Braided Lead Core

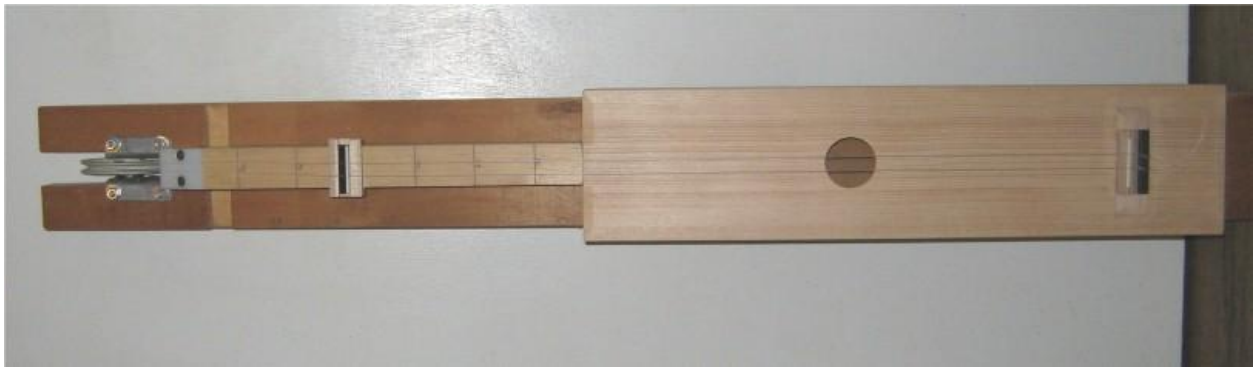


Hans Gerle 'Musica Teutsch' 1532

A Knot of Lute Strings

Test Apparatus

Braided lead cored line is a composite material so the pitch/tension characteristics of each lute string for a given vibrating string length were determined experimentally on a simple test rig – a sound box with the string tied to a bridge and passing over a sliding nut/fret set to the required vibrating string length. A weight box tied to the free end of each string under test applied a measured string tension directly – the rig being mounted vertically and the string being lightly pressed against the nut/fret while plucking the string gently with a leather plectrum (the nylon pulley at the bottom of the rig acted only as lateral guide for the string). At each setting several readings were taken to achieve consistent readings. The load on each test string was adjusted to achieve a target tonal pitch value measured using a digital tuner. The sustain at each value, determined by ear, was measured with a stop watch.



String Test Rig

Test Results for 60 cm Vibrating String Length, Pitch Standard A440 Hz

Sufix 12 lb line, string outside diameter 0. 54 mm, single core diameter 0.4 mm.
Pitch B 124 Hz – tension 3.1 Kg – sustain 15 seconds
Pitch A# 117Hz – tension 2.8 Kg
Pitch A 110Hz – tension 2.4 Kg
Pitch G# 104 Hz – tension 2.2 Kg
Pitch G 98 Hz – tension 1.9 Kg – sustain 12 seconds

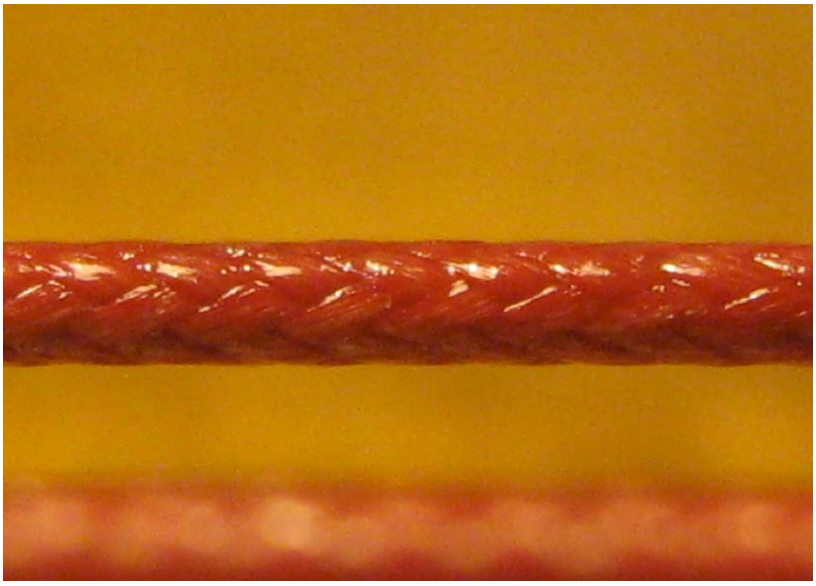
Sunset 27 lb line, string outside diameter 0. 80 mm, single core diameter 0.55 mm.
Pitch F 87 Hz – tension 2.9 Kg – sustain 12 seconds
Pitch E 82 Hz – tension 2.6 Kg
Pitch D# 78Hz – tension 2.3 Kg
Pitch D 73 Hz – tension 2.1 Kg
Pitch C# 69 Hz – tension 1.9 Kg
Pitch C 65 Hz – tension 1.7 Kg – sustain 8 seconds

Mason 45 lb line, string outside diameter 0.87 mm, single core diameter 0.5 mm.
Pitch F# 93 Hz – tension 3.3 Kg – sustain 12 seconds
Pitch F 87 Hz – tension 3.0 Kg
Pitch E 82 Hz – tension 2.7 Kg
Pitch D# 78 Hz – tension 2.3 Kg
Pitch D 73 Hz – tension 2.1 Kg
Pitch C# 69 Hz – tension 1.8 Kg

Sufix 63 lb line, string outside diameter 0.95 mm, single core diameter 0.46 mm.
Pitch G 92 Hz – tension 3.2 Kg – sustain 8 seconds
Pitch F# 93 Hz – tension 2.9 Kg
Pitch F 87 Hz – tension 2.6 Kg
Pitch E 82 Hz – tension 2.3 Kg – sustain 5 seconds
Pitch D# 78 Hz – tension 2.0 Kg – pitch instability
Pitch D 73 Hz – tension 1.8 Kg – pitch instability

Sufix 63 lb line, string outside diameter 1.17 mm, double max. twist core diameter 0.8 mm (two single strands 0.46 mm diameter).
Pitch D 73 Hz – tension 3.2 Kg – sustain 10 seconds
Pitch C# 69 Hz – tension 2.9 Kg
Pitch C 65 Hz – tension 2.5 Kg
Pitch B' 62 Hz – tension 2.2 Kg
Pitch A'# 58 Hz – tension 2.0 Kg – sustain 6 seconds

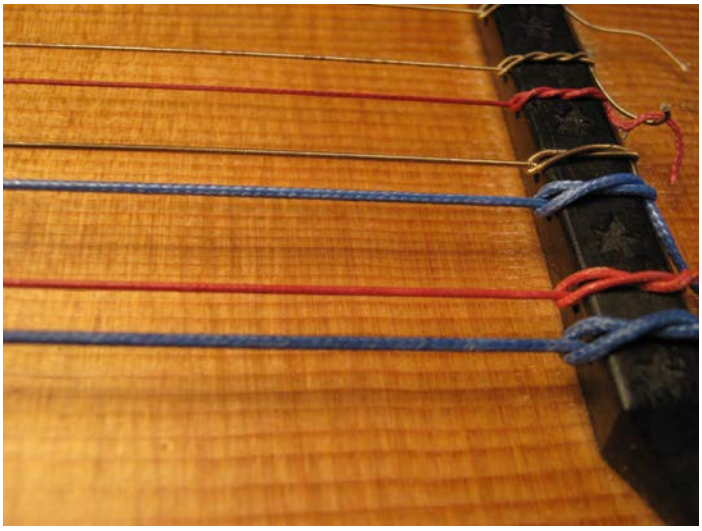
Note that the results for the Sunset 27 lb line and Mason 45 lb line are practically identical.



Sunset 27 lb Lead Core Braided Lute String

The above varnished lute strings were tested on a seven course 'Hieber' lute in f' 349 Hz, 60 cm vibrating string length, mounted alongside Pyramid plain and wound nylon strings for comparison, as follows:
7th course Sufix 63 lb, 2 strand twisted core, pitch A'# 58 Hz
7th course Sunset 27 lb single core, pitch D# 78 Hz
6th course Sufix 63 lb single core, pitch F 87 Hz
5th course Sufix 12 lb single core, pitch A# 117 Hz

The 7th course was then strung with a unison pair of the Sunset 27 lb strings pitch D# 78 Hz (see Comm. 2013).



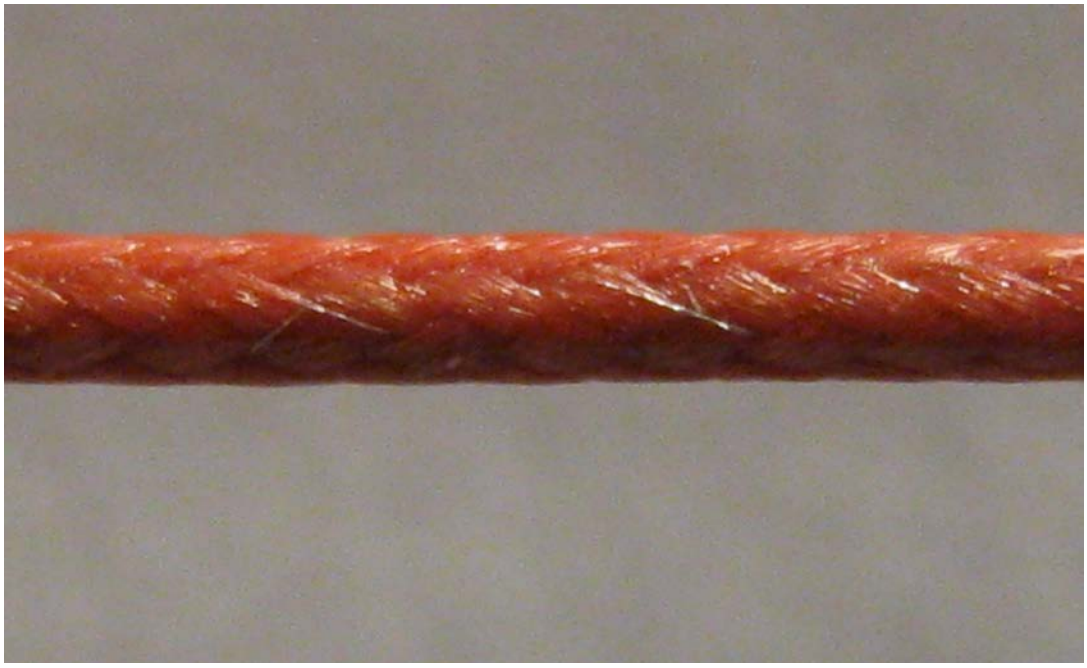
Four months later the strings were examined for abrasive wear under magnification. At that time the lute was being played daily for about an hour each day – strings plucked with finger tips (not nails).
No wear was evident on the 7th course Sunset 27 lb unison pair.
The fifth course Sufix 12 lb string had a bright tone similar to a Pyramid wound string. It showed signs of 'hairiness' over a short distance at the plucking location although this did not seem to affect acoustic performance – the string fretting in tune to the 8th and final fret on the fingerboard. Although the abrasive wear looks terrible under magnification the hairs are microscopic in diameter relative to the string diameter and low in density relative to that of the lead core,

Worn Sufix 12 lb String – 5th Course

String after Flame Treatment

The hairiness presented an opportunity to test the procedure for removal of hairs from silk violin strings of the late 19th C 'Acribelle' type (these were mutifilament not braided construction) – by passing a string quickly through the flame of an alcohol lamp (Note 3). Done correctly the heat of the flame turns the silk hairs into minute balls of brittle carbon then removed by wiping the string.
Under this procedure nylon filaments do not carbonise but melt into minute balls stuck to the surface of the string. It is very easy to damage the integrity of the braid using this procedure. Is it worth attempting? Probably not with strings each costing around 20 cents to make!

The 7 course unison pair has now been in service for 34 months at the time of writing and although the lute is currently played less frequently shows very little visible sign of wear under magnification. It still sounds well (to my ear) without the brassy overtones common to modern nylon filament metal wound bass strings.



Worn Sunset 27 lb String – 7th Course

Test Results for Vibrating String Length 67.5 cm, Pitch Standard A440.

Sufix 12 lb line
Pitch A110 Hz – tension 3.1 Kg
Pitch G# 104 Hz – tension 2.7 Kg
Pitch G 98 Hz – tension 2.4 Kg
Pitch F# 93 Hz – tension 2.2 Kg
Pitch E 87Hz – tension 1.9 Kg

Sunset 27 lb line
Pitch E 82 Hz – tension 3.3 Kg
Pitch D# 78 Hz – tension 3.0 Kg
Pitch D 73 Hz – tension 2.6 Kg
Pitch C# 69 Hz – tension 2.4 Kg
Pitch C 65 Hz – tension 2.1 Kg
Pitch B' 62 Hz – tension 1.9 Kg

Mason 45 lb line
As for Sunset 27 lb line above.

Sunset 63 lb line, single core
Pitch F 87 Hz – tension 3.2 Kg
Pitch E 82 Hz – tension 2.9 Kg
Pitch D# 78 Hz – tension 2.6 Kg
Pitch D 73 Hz – tension 2.3 Kg
Pitch C# 69 Hz – tension 2.0 Kg
Pitch C 65 Hz – tension 1.8 Kg

Sunset 63 lb line, 2 strand twisted core.
Pitch C 65 Hz – tension 3.2 Kg
Pitch B' 62 Hz – tension 2.9 Kg
Pitch A'# 58 Hz – tension 2.5 Kg
Pitch A' 55 Hz – tension 2.3 Kg
Pitch G'# 52 Hz – tension 2.0 Hz
Pitch G' 49 Hz – tension 1.8 Kg

The above strings were intended for a six course lute in D, courses 4, 5 and 6 but a complete set was never made for testing.

Notes

1) Fine wire of pure metallic lead is made by an extrusion process under high pressure and cannot be drawn into a thread in the traditional way like silver and gold - so was not available to the ancients. However, narrow strips cut from thinly beaten sheet lead and twisted into a core would be an alternative historical alternative to extruded wire.
2) Lead shot used in shot gun cartridges and as fishing tackle sinkers or weights is banned as proven deadly when ingested by water fowl – the bird's digestive juices converting the metallic lead to toxic compounds of lead. Otherwise metallic lead is not poisonous to the environment if left alone. Such restrictions do not currently apply to lead cored fishing lines presumably because the braided jacket acts as a protective cover and, from experience, is found to be an unlikely food attraction to the birds.
3) ' they are apt also to fray and get ragged, and though it has been recommended when this is the case to draw the string quickly through the flame of a spirit lamp, to remove the frayed fibres, an Acribelle string once gone wrong, is ghastly with a ghastliness more easily imagined than described'. Ed. Heron Allen 'Violin Making as it was, and is', second edition, 1885.