# The Cord of Desire

*The following is an amalgam of writings from Sin, professional kinbakushi, educator of Kannōnawa, author of Year of The Bakushi and technical consultant to 天つ縄 Amatsunawa.*

One of the biggest problems with our particular *scene* is, in the scheme of things, it's relatively tiny. To get product commonly manufactured in bulk into smaller quantities is an uphill struggle. You want how many metres? Sorry, we only start at 26 tonnes. Put into perspective, for 8 lengths of 8 metres that's 21,000 considered *standard* sets of rope. Our world isn't big enough.

Enterprising individuals hand-wind yarn into strands to rope and provide the flourishing market with product tailored for use. Others have acquired large rolls intended for industrial applications and sought to provide a feel more comfortable by eliminating the Jute Batching Oil. All should be commended, as these individuals care passionately enough to seek to do something positive about it. Unfortunately, the issue of volume has remained; our market's demands are puny compared to industrial supply.

Volume affects price. The purchase of e.g. Grade 4 Tossa batched with cheaper JBO to yarn and twisted to rope in standard quantities of 26 tonnes will be approximately a fifth compared to only 3 tonnes of Grade 1 manufactured with zero contamination. But then, how does one factor the additional costs and time of removing this unwanted oil, and what does the significantly lower quality of the jute, the impurities in the yarn, and the processing do to the rope?

I've worked for many years, visiting jute growing sites, yarn batching and spinning mills and many rope manufacturers. Even if there was demand for, say a ø6mm product, the next customer would ask for ø5mm, ø4mm, or whatever, where requirement is again a fraction.

I deal with the technical director of a jute grower and mill in West Bengal with 50 years experience, an octogenarian former owner of a Dutch natural fibre rope factory, and the owners of a specialist natural fibre rope maker in Japan, and one in Europe. With these experts, I discuss the technical specifications and production of plant, yarn and rope for the precise application of prolonged human skin contact with the strength to safely suspend. For correct answers, all the facts should be contained within the questions; the truth laid out bare on the table; precisely how it will be used.

Then we've got the nasty matter of dermatotoxicology. Ever had that nasty rash, itching, that feeling after being in contact with a rope something isn't quite the way it should be with your delicate skin?

Rope in this field of interest doesn't have quite the history some suggest it may have. We've used whatever we could get our hands on. Back in the mid-1980s, I used cotton, because I could get it. I didn't acquire my first jute until 2001 from a shop in Tokyo. It felt awesome. It also left the lady I used it with, with horribly blotched flesh. Not all was as it first appeared.

Jute presents the best possibility for the intended purposes of aesthetics, feel, handling, strength, low extensibility, low dermatological reaction and ease of untying and retying knots, etc. But, it can also come with a hidden danger: mineral oil.

It may be the nicest material to work with, but jute isn't the strongest. If you're going to use it, you need to pay strict attention to the factors that'll give the best strength, and added knowledge of how to maintain integrity. Many will absorb the styles of others at workshops, etc., but how many know that much about their main tool?

It starts with filament quality; where they're taken from the plant; how long they are; how fine; how free of impurities. Coarse fibres limit the cross-sectional integrity of a spun yarn. Fine, long fibres are more flexible and pliable - ideal for rope, and are more effectively spun into yarn. Impurities are weak points, so only the very highest grade should be used to make rope to support a person safely off the ground.

Inspect your rope meticulously. Take a length, check the outside, then unwind the strands and the yarns. You may find complete breaks, dark bark and waste, specks, long ruddy cuttings from the weaker root base with the durability of paper, and habijabi tangles. Together with the short fibre loss, these will compromise the strength; any imperfection is a weak point.

Everyone should be aware of the potential hazards associated with the batching medium JBO used extensively in jute yarn spinning to bind the filaments together; mineral oil containing hydrocarbons in the $C_{15}$-$C_{20}$ range with conclusively confirmed toxicology in published papers.

We're prepared to teach safety and consent, but seem somewhat happy to ignore this danger, akin to missing one ingredient of the fire triangle.

JBO is used in the spinning of jute yarns because it's readily available and cheap, and many mills are comfortable using it because the end product is intended for industrial; agricultural, horticultural, biodegradable applications.

This doesn't imply using rope containing JBO will result in skin cancer. 10-15% of lung carcinoma sufferers will never have smoked, while many on 20 cigarettes per day won't show any symptoms, and we're not exactly painting the JBO on ourselves like the poor defenceless lab mice.

Individuals have developed methods to reduce or eliminate JBO content out of rope. However, jute is a vegetable plant fibre, and soaking, boiling, steaming or baking it isn’t going to improve its integrity. Rather, the opposite.

Some jute yarn is produced for household goods, where the kerosene-type stench of JBO isn’t acceptable. The most obvious is carpet backing (CB) that’ll be predominantly used for weaving on Van de Wiele CRM, CRT, CRX, etc. looms. They are of a lower grade, with significantly shorter filaments and different twist dynamics specific for weaving, not for twisting into rope.

With the correct grade and twist dynamics applied, this still leaves jute, corchorus olitorius (Tossa) or corchorus capsularis (white) with the same consequence: some oil is required for batching at spinning, otherwise the filaments won’t bind properly and cohesion will be compromised.

Processing out unwanted JBO is not only a major hassle, but also jeopardises overall strength. Natural fibre contracts when wet as the filaments swell and fatten. With tension applied, as rope dries it returns to roughly the same length. It's like a sponge in this respect, only it won’t shrink so much after the first time as filaments become more unstable, compromised by the action.

Understanding the hygroscopic behaviour of plant fibres, one has to account for variability of properties depending on the batch, grade, variety and even the location they’ve come from within the plant. Fibre absorbs moisture, and there’s a direct link between this hydrophilic behaviour, weakening of the microstructure, and reduction of shrink and expansion over the first cycles. If you’ve processed oil out of rope and heard it crackling and crunching when load is applied, you’ve heard the sound of micro-tears between filaments.

In terms of rope for our use, this suggests fibres shouldn’t be made fully wet, because shrinkage and expansion of the first cycle, being the most aggressive will compromise overall strength, and liquid content will reduce or remove the binding medium used to spin the yarn. It’s one thing to wipe down the outside of a natural fibre rope with a damp cloth, and a totally different proposition to soak, boil, steam or bake right through.

The flip side is oil and wax, so long as it doesn’t go rancid, or penetrate too much into the rope to make it greasy, heavy and/or unusable. In this respect, plant fibre is a little like human hair; dried out and brittle it can be easily broken and damaged, whereas a little softening can make it pliant and flexible and help to maintain its core strength, giving it body.

Vegetable Oil Treatment (VOT) application as a substitute to JBO is also not without complexity. Certain mills will use palm oil, or mix it with lower grades of ricinoleic castor or soybean oil, etc., and these can lead to unwelcome rancidity.

In order to eliminate the chances of the oil content becoming rotten long after it's been applied and the yarn made into rope, it's crucial soybean seeds are thoroughly cleaned and dried before being cold or expeller pressed, as heat at this stage of the extraction process has proven to encourage responsible oxidants. Expeller-pressed soybean oil retains more tocopherols and phytosterols to provide natural antioxidants that prevent rancidity - applied biochemistry in action.

Oil type and grade are only parts of a complex puzzle of components, another being % by application. After extensive trials, it was discovered the optimum is between 3 and 4%. Interesting, because most industrial jute rope has yarn with up to 6% JBO content. A few years ago I dealt with a buyer who'd purchased rope with >8% JBO that was so greasy, he found it impossible to process out and had to trash the entire shipment.

Then there's the coating, often absent in industrial yarns, where hairiness is immaterial to the application. A common choice is PVA (polyvinyl alcohol), a colourless, odorless, water-soluble synthetic polymer used extensively in papermaking and textiles. It's that slightly starchy-stiff feel many like to remove by washing new clothes before wearing. It can be replaced using a 2% 9:50 tapioca starch:water mix; amylum extracted from the cassava root to keep the yarn and rope 100% food grade, recyclable and sustainable.

Like artists and their brushes, we all have our peculiar ways we like our rope finished; how we coat it or secure the ends, etc. By pre-applying the correct amount of the correct oil ahead of the yarn spinning stage, the correct softness, pliancy and long-term body and strength of the rope is retained inside the relatively tightly wound core. Deep at this level is where it's difficult for the personal touch of the final coating to penetrate without the rope becoming greasy, heavy and unpleasant to use.

Most wish for rope that's easy and light to handle, doesn't generate dermatological problems, is strong enough for the intended purpose and doesn't leave a dust of dry, short-filament fibre loss to get up noses, into eyes and lungs, or need constant vacuuming.

How we finish ropes being idiosyncratic; personal and special, my preference is a 5:1 blend of 100% jojoba oil-beeswax gently melted together, and when cool enough to get onto my fingers, yet still soft as warm butter, to lightly dab a hazelnut size over the outside per roughly 8 metres, and work it into the external surfaces by hand. I've used both almond and Oshimatsubaki oil, but worry about rancidity with the former, and price of the latter.

The reason for my blend is simple: too much oil to wax content makes the mix penetrate too deep into the fibre; sucked in to make it heavier and greasy, while too much wax makes the rope sticky and difficult to work with.

My predilection is for rope that's particular to each lady I work with, avoiding cross usage so it comes alive, special, personalised with her own skin oil. If she isn't vegetarian or vegan, I'll also apply a final light coat of 100% Bayū; refined horse oil taken from the synovial sac supplying oil to the mane. You can get really nasty, high water content rubbish from China, but I use the best from Hokkaidō, and as it's the closest to natural human skin oil, it can help accelerate the softening process.

Rope made for industrial applications doesn't really need to be high grade. It can have variations in mineral oil content, defects: bark, waste, specks, cuttings, dust and habijabi tangles that have little effect on its prime purpose - biodegradeability. From the growing of the crop through cutting, retting, carding, sorting, grading, batching, spinning and winding to rope, nobody ever considered it would be used for extended human skin contact.

It's taken years of research, accumulating contacts and knowledge to finally home in on a product, uniformly machine-made on uncontaminated lines. A product where, from the plant to the final rope, every last detail is under control and can produce something many would like to see available: a series of diameters of soft, smooth and strong pliant affordable jute rope of the highest premium grade with zero defects or contaminants.

The feel of the twist and lay is very significant. The best is firm, yet soft, due to fatter filaments of the highest grade jute having compliance, and the correct oil content giving body. Also, very low hairiness; a combination of the filament length and fibre quality of the grade, the correct oil content in yarn spinning, the coating, and old tricks in winding rediscovered in research. A rope you don't need to flame.

Additionally, if each strand has a guide core of twisted yarn around which the remaining yarns are wound, the grade of jute, the body, filament length, % oil content and yarn twist give far more strength compared to lower grade jute ropes. The guide core allows the external wrap to make the rope firm, but retain softness, so it doesn't feel like overly tight lay ropes you regularly find that feel like corrugated concrete. It also helps to avoid recoil, and because the rope is machine wound, it's homogenous.

Because of this body to weight, when you hear it come down and slap on tatami it's distinctive compared to other rope; like a tuned drum, and the body also helps longevity.

Much conjecture has been speculated on the breaking strength of a natural fibre rope, and the advice of the International Standards Organisation is to not publish any. But, longer filaments are stronger than shorter. Fatter are too. Conditioned, pliant, rich and full bodied are significantly stronger than dry, brittle and weak lower grade fibres. Getting the correct type and content oil into the yarn filaments at spinning gives a rope that's consistent right the way through, and not just on the outer surfaces and the immediate filaments underneath.

Any imperfection is a weak point, and lower grades always have plenty. If you get a length of rope and start to unwind and check it, you'll find them.

The ultimate grade of Tossa is slightly more expensive and stronger than the ultimate grade of white jute, due to corchorus capsularis filaments being slightly lower in diameter to corchorus olitorius. But, the ultimate white jute is already stronger than grade 2 Tossa, and more expensive, as lower grade Tossa is far more readily available. A Grade 3 industrial Tossa rope you can pick up for peanuts at the high street vendors in Japan is priced accordingly.

How tight or loose is your rope? How long is a piece of string? How does one determine what is what and which is which? Some say a *standard* for ø6mm rope has *tight* below 16.8mm, a ratio of 2.77, *loose* above 21.0mm, a ratio of 3.50, and presumably *medium* as somewhere in between.

The factory in Japan, and Amatsunawa's partner rope maker in Europe, explained there's no such *standard*, and how was the diameter and lay length being measured. This left much confusion, and naturally, I needed a definitive answer.

Just the measurement of diameter in a pliant, compressible medium is fraught with complication, especially when it's a spiral of 3 strands. The factories informed me the diameter is the diameter of a circumscribed circle that encloses all strands, and extremely difficult to measure in a springy natural fibre 3-strand rope with two flat surfaces of a typical two-dimensional gauge like a caliper.

Of paramount importance is the measurement tool and avoidance of compression. The contact faces of the caliper must be wide and long enough to reach longitudinally to encompass enough strands, and be able to slide up and down the rope, touching, but without blocking. Only then is the true diameter possible to record. Imagine the rope is 6 strands; effectively hexagonal in cross-section. The hexagon is measured over the peaks, not the flats.

Natural fibre ropes spun from yarn and wound on rope making machinery may vary in thickness from batch to batch in production, so you only have a small section of the presented product to take a measurement from, and the proceeding or next batch may again be different. It therefore becomes easy to imagine how the phrase "How long is a piece of string?" came into common use, as we're dealing with multiple variables.

Returning to lay ratio. Without wishing to identify other products, we carefully measured a selection of availability, e.g. Amatsunawa Grade 2 1-ply white was ø6.58mm with a 27.88mm lay, a ratio of 4.24 in a rope that's very slightly tight, but others would deem loose. A well known North American raw Grade 4 1-ply Tossa marketed at ø6mm measured ø7.02 and 20.16, a ratio of 2.88 and extremely tight. A commonly available Grade 3 1-ply Tossa from high street vendors in Japan was ø6.35 and 29.38, a 4.63 ratio many Japanese would consider standard, but some westerners would call loose. A UK supplier's raw Grade 5 2-ply Tossa was exactly ø6mm and 20.0, a ratio of 3.33, yet as tight and hard as the aforementioned American product. An Italian supplier's Grade 3 3-ply 6mm white was 7.5 and 31.5, a ratio of 4.2 and still relatively tight.

The nicest rope, in my opinion, is the Japanese Grade 1 1-ply historic piece Amatsunawa has reverse engineered to reproduce with rediscovered methods to be the ideal product for the application. It measured ø6.41 with a 29.01 lay, a ratio of 4.52. Ideally, the strands of a rope should not be able to be easily birdcaged (opened) between finger and thumb, but not be too tight as to not open with slight force between two hands.

Of great interest is how the plies and twists per inch (tpi) of the yarn itself has a bearing on the hardness of a rope, and how strand twist dynamics further impacts this. Multiple ply yarns tend to make rope feel harder even with higher lay ratios. If the yarn and/or the strands are wound tight and the final rope lay ratio longer, the rope feels loose and prone to birdcage. Correspondingly, if the yarn and/or strands are wound looser the rope can feel softer even with the final lay wound at a shorter, tighter ratio.

In an industrial product these factors are relatively unimportant, especially in rope that's prime purpose is to biodegrade into soil. The trick therefore, is to set up the twist dynamics of all three levels: yarn, strands and rope to make a balance where the rope feels soft and yet is homogeneous, strong and unlikely to birdcage.

For example, you can manufacture a rope using higher lb count 3-ply yarn twisted with a tight tpi in tightly wound strands with a long lay ratio, and it'll feel as hard as nails and still readily birdcage. You can instead use a lower lb count single ply yarn with a loose tpi, loosely wound strands, and a very short lay ratio, and it'll feel much softer, yet tighter, but be prone to vicious recoil (the tendency to curl back on itself; corkscrew; intertwining around/with a second parallel rope - precisely how most of us use the rope in application). This makes handling very awkward. The skill is in getting the correct balance between all these parameters, not just the lay ratio alone.

Ultimately, lay length is then just the same as any other parameter of a natural fibre rope: highly variable depending on a multitude of other factors, and tight and loose subjective by individual interpretation.

But, how strong is a piece of string? It's that persistent question, one that because of the way we're using rope, and due to the dangers of failure, and what that would mean to our poor passive partners, we'd all like answered.

The ISO has a raft of methods to qualify the testing of natural fibre filaments and yarns: ISOs 1144:2016, 1973:1995, 2060:1994, 2061:2015, 2062:2009, 5079:1995, 6939:1988, 6989:1981, 17202:2002, etc., but when it comes to rope manufactured from, effectively, a vegetable, like ascertaining how strong a cucumber might be, they're pretty absolute in their advice not to attempt such folly.

If we want to get a sense of how strong our natural fibre rope might be, we can't even approach the certified analysis providers without being turned away; ridiculed. Part of the issue is the aforementioned plant fibre and its variability, metre to metre depending on impurities, filament length; basic heterogeneity.

A test for a homogeneous man-made cordage isn't representative of how we use our rope. How often do any of us use a single line (as opposed to doubled; 2 lines parallel) over a short distance, say a foot, or half a metre, and put all the weight on it between two fixed clamping points, i.e. not over a ring, a Karabiner, or attached to, or around another rope? How often do we, like myself, pull 2 parallel lines through the bight?

In the field of natural fibre rope manufacturing, nearly every producer has their own methods of measurement, albeit some permeating wider in the industry as skills move around.

One is the method of lay length measurement I've come across both in Europe and Asia. It's an extremely simple system, with a retention method one end and a wheel the other, over which the rope runs to be pulled taut by weight, stretching with ø (mm) x ø (mm) ÷ 8 (kg) load so a clear 1 metre length can be measured, e.g. for ø6.0mm, 6 x 6 = 36 ÷ 8 = 4.5kg, etc., and then (for a 3-strand rope) the total distance between 3 valleys (the dips between the bumps) over the entire metre divided to give the result. The nicest rope I like to work with has a lay ratio of ~4.5 (lay length divided by diameter).

Back to getting some feeling of strength in a natural fibre rope; some level of guidance of knowing how much force can be applied before it'll break and what factor should be limited into this. We need a method representative of how we use the rope, or even in extreme cases, how badly the rope may be treated - the lowest common denominator. In this way we can simulate close to real operating conditions.

Whatever test is devised, users have to factor safety margins based on experience, but I'd advise 1/5th of the lowest brake value might be considered unsound, and 1/10th somewhat comfortable. We could take an average, or measure *n* pieces and apply the lowest as a specification, until the next piece comes in under spec. The variables don't permit much logic beyond awareness.

Just like any other plant, jute is highly dependent on the weather during its growth, the timing of cropping, and the various processes before it reaches yarn spinning. Measuring the final strength when it's been made into a rope is akin to measuring the bubble diameter in a Champagne bottle.

As with Champagne, years matter; temperature, rainfall and humidity. The best jute is grown in a season where temperature stays within 24-37°C and has long periods at 34°C. Pre-monsoon low rainfall seriously impacts final quality of yarn and rope. A bad season will produce a lower quality fibre.

Jute is a fertility-exhausting plant; it requires fresh alluvial soil. Growing areas with clay or sandy soils produce sticky and coarse fibres respectively, and need fertilisers applied; chemicals that will be present, even in the rope.

Just like grapes, jute needs to be cropped at a peak moment and only the best selected for proceeding to processing. The softening of fibre by retting is critical. In slow moving, clear water at an even-temperature of 34°C the process can be completed within 8 days before bacteria or acidity can compromise the filaments. Vary by just 2°, the time may double, and bacteria may be present. Impair water quality and the fibres suffer and pick up contaminants. Labour skill plays a massive role.

In making yarn, the filament twist is critical to strength; the aim is an optimum between coherence and obliquity. A low twist is weaker, not necessarily due to fibre breakage, but because of slippage leading to catastrophic failure; tear. High twist compromises linear orientation; shear. For soft, strong rope, optimum yarn twist shouldn't be compromised.

All yarn is single-ply until it's counter-twisted with other yarns. If a rope strand is 12 single-ply yarns counter-twisted together, theoretically, it's 12-ply. If it's twisted for 6 x 2-ply or 4 x 3-ply of yarns of the same count, it's exactly the same mass, just constructed differently. Uniformity and softness may be lost in multiple-ply constructions as twist dynamics oppose and compound, making it knurl.

Hairiness is a bugbear. Jute grade quality and long filament orientation, straightened through carding and drawing to make the fibre parallel to the axis of the sliver has the greatest bearing on hairiness. Special yarn spinning techniques limit fibre protrusion. Further tricks are applied to avoid rope becoming hairy in twisting. The lower the grade of jute, the shorter the filaments, and the more hairy the rope will turn out. Then you may have to flame it, adding another chance to damage the integrity, feel and smell.

Rope is like Champagne. Do you proffer the finest for your partner, or pass them off with cheap plonk? Because, for us, it should be the cord of desire.

Best respects,
Sin