Main and Belay versus Two Tensioned Rope Systems in uncontrolled movements across a horizontal edge

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Abstract:

Main-Belay and Two Tensioned Rope Systems have been tested to compare their survival during a failure at an edge transition. No work has been done to test which is better during an uncontrolled horizontal movement at any time where the load is below the edge transition. Some "quick-look style" testing was done using a 200kg test mass and a 2m granite edge with both M-B and TTRS. In 10 tests no clear difference was found.

Introduction:

Over the last few years, there has been much discussion in Technical Rescue circles over the merits of Two Tensioned Rope Systems (TTRS) versus Main and Belay (M-B) systems and the various merits and drawbacks of each system. The British Columbia Council for Technical Rescue (BCCTR) style drop test where a 200kg mass is dropped 1m with 3m of rope in service is the current gold standard for testing system suitability as it represents a worst case scenario of a line or anchor failure during an edge transition. TTRS has shown better survivability during BCCTR drop tests over a sharp metal edge (Mauthner, 2014) using both TTRS and M-B systems. However it has also been shown that M-B systems can have equivalent survivability to TTRS in the same tests if the ropes in service are adequately protected (Gibbs 2015). While much effort has been expended on the BCCTR style drop tests relatively little has been done to test whether TTRS or M-B systems perform better in an uncontrolled horizontal movement over an edge. Forbes (2015) evaluated the result of uncontrolled horizontal movements across an edge using a variety of ropes but with only one rope in service. With TTRS, during uncontrolled horizontal movements across an edge, it would be expected that both ropes would suffer damage proportional to the load on each line. With M-B, it would be expected that the Main line would suffer much damage and the Belay none.

Materials and Methods:

A 200kg mass, composed of two sets of 5 20kg sandbags each inside a larger protective sack, was suspended from a tree approximately 5m from the test edge. A bolted anchor approximately 2m from the edge transition point was used to create an offset anchor (Figure 1and 2). A pulley was placed 3m below the edge transition point to keep the load directly below the main anchor. The two test lines were run from the main anchor, to a releasable point on the offset anchor and then to the load. For TTRS, approximately equal tension was set by hand before the test mass was released. For M-B, one line was taut, and the other had a small bight of slack. The test mass was lowered from the main anchor until the test lines (or line in the case of M-B) were carrying the entire load and sufficient slack was introduced to prevent the line from catching the load before the test lines. The releasable anchor was released, and as the load fell, the test lines were dragged across the edge under load until they were directly above the pulley. The edge used for the testing was a rough, quartzitic granite, slightly less than 90˚. The edge, while rough, did not contain any particularly sharp crystals. If a similar edge was encountered during normal operations efforts would be made to ensure the rope was protected using rollers or canvas. For all but the last two tests the rope used was 2014 Beal ACCESS UNICORE 11mm kernmantle low stretch rope. For the last two tests, South African manufactured Southern Rope 11mm kernmantle low stretch rope was used.
The tests were all conducted during one day, with the same person setting the lines each time. The test location was a disused granite quarry in Cape Town, South Africa. The test edge was approximately 2m of rough granite and the test ropes had an included angle of approximately 140° over the test edge when they were in a straight line between the main anchor and the test mass.

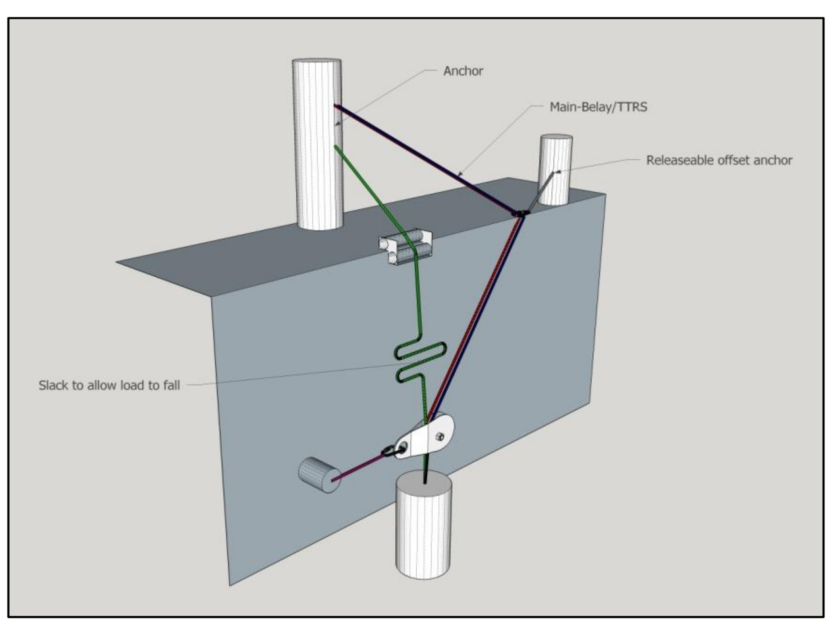


Figure 1: Sketch of test setup

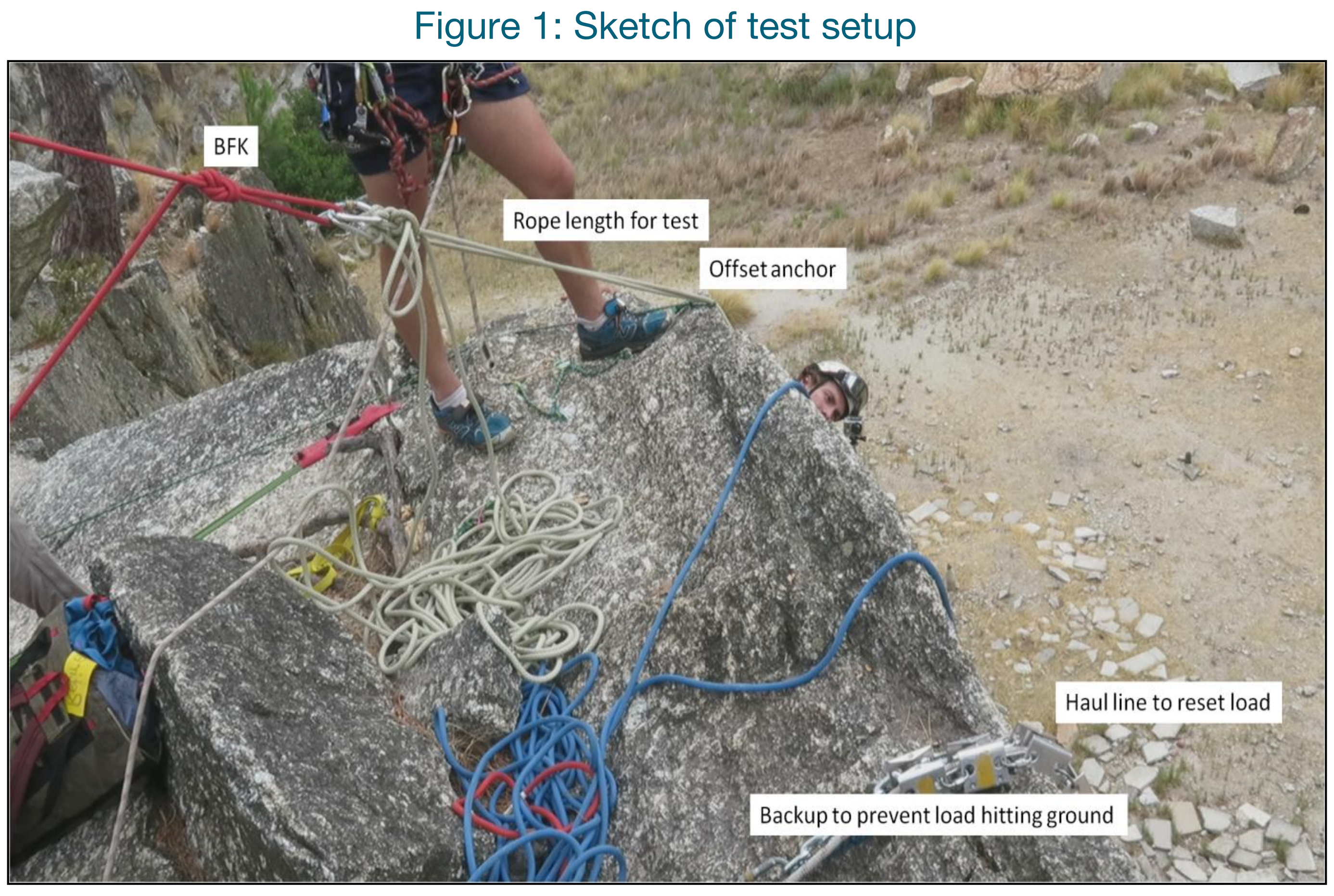
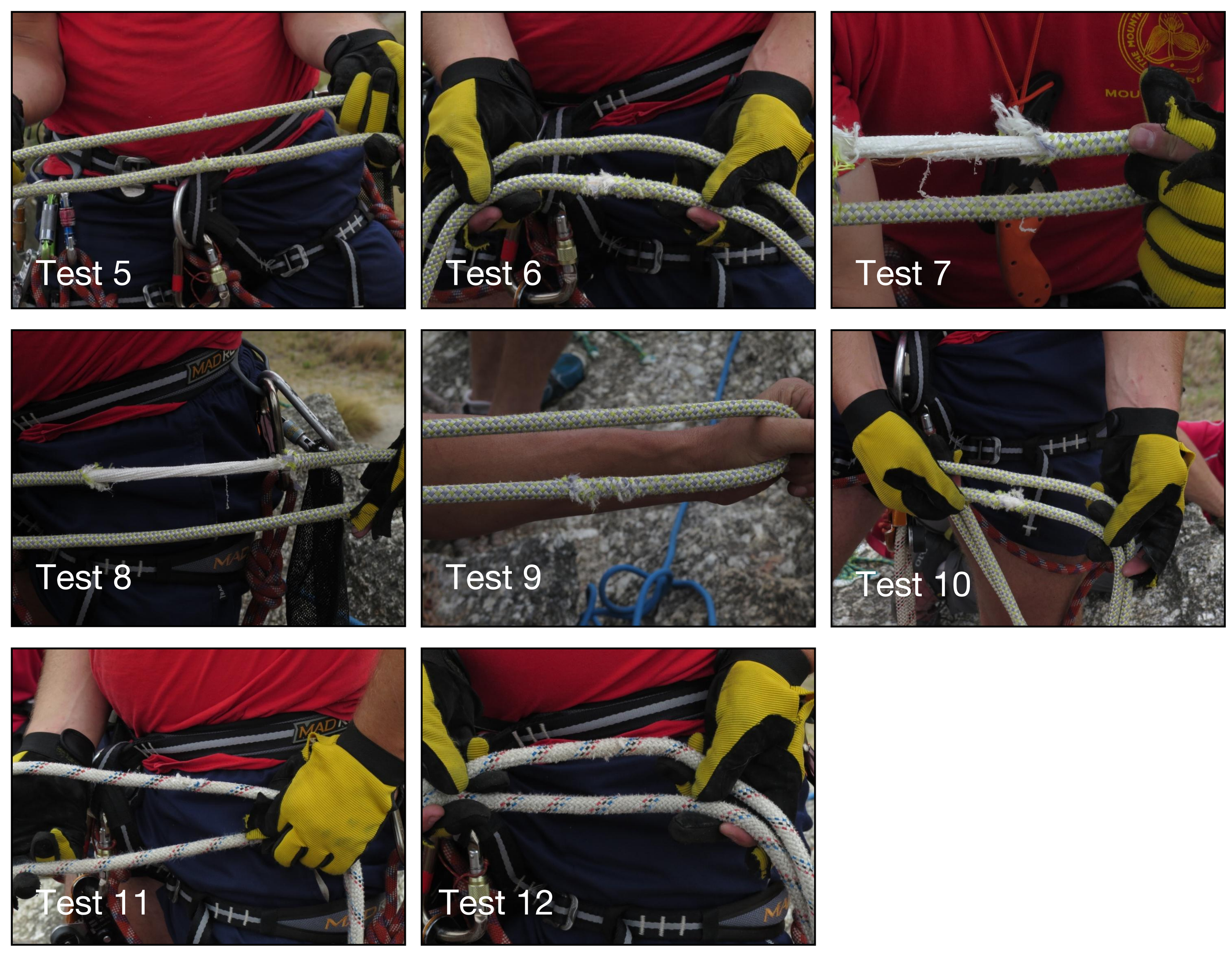


Figure 2: Actual test setup

Results:

A video of the tests is available on Youtube: https://youtu.be/_Cpo-gnPeEQ

Test	Type	Result
Pretest 1	TTRS	Rigging issues made test inconclusive. Nothing cut, no noticeable damage
Pretest 2	TTRS	Rigging issues made test inconclusive. Nothing cut, noticeable damage to sheath
3	TTRS	No testing issues. No noticable sheath damage
4	M-B	Sheath of Main destroyed and core exposed. Belay undamaged
5	TTRS	Noticeable sheath damage to one, fluffing on the other
6	M-B	Sheath of Main halfway damaged. Belay fluffed slightly
7	TTRS	Sheath of one destroyed with core exposed, noticeable fluffing on the other
8	M-B	Complete sheath damage to main. Belay undamaged
9	TTRS	Heavy sheath fluffing on one. Other undamaged
10	TTRS	Sheath damage to one, other light fluffing
11	M-B	Sheath of main damaged but no core exposed, Belay undamaged
12	TTRS	No noticeable damage to either rope
13	Drop	Drop onto badly damaged section of Unicore with 200kg test mass



Discussion:

This is only a quick-look style evaluation and should not be seen as a definitive study with definite conclusions however, what it is possible to ascertain is that: M-B systems survive an uncontrolled horizontal movement across an unprotected edge with sheath damage to the main line varying between moderate and complete, and no damage to the belay. No damage was seen on the core strands of the rope. For TTRS the damage is distributed unevenly across both ropes seemingly irrespective of relative degree of loading of the ropes (every effort was made to load the ropes evenly), with sheath damage varying between negligible and total. No damage was seen on the core of the rope.

With no completely cut through ropes and no available method of evaluating residual strength of the damaged rope it is simply not possible to decide which system performed better. The test edge's lack of any particularly sharp crystals and wear caused by the testing may also have contributed to the lack of definitive outcomes. The Beal ACCESS UNICORE is a softer rope with a good hand and knotability while the Southern Rope is a much harder rope, with a poor hand. The harder rope seemed to perform a little better but as only one test per system was conducted with Southern Rope those results cannot possibly seen as representative.

Conclusion:

Rescue systems are far more robust than we think they are. Neither M-B nor TTRS can be selected as having performed better in our testing but they can both certainly survive what would be a seen as a very catastrophic failure were it to occur during a rescue operation.

References:

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Mauthner, Kirk. "Moving Beyond 10:1 SSSF." Introduction force Limiting Systems and Managing the Right Risk at the Right Time, Proceedings of the International Technical Rescue Symposium 2014
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