STANCES: IS IMPROVING POSSIBLE?

by Vittorio Bedogni

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CONSIDERATIONS ARE REFERRED TO STANCES ON

"ADVENTURE TERRAIN"

(multi-pitches ruote)

WHERE THE ANCOR POINTS STRENGTH EVALUATION

IS A DIFFICULT TASK ...
SOME CONSIDERATIONS ON
STANCES SET UP

DIFFERENT IDEAS –

FEW SHARED CONCEPTS
THE STANCE HAS TO BE CONCEIVED FOR THE WORSE SITUATION THAT IS:

• First runner not yet placed
• Theoretical Fall Factor 2
SHARED POINTS:

S A R E N E

• SOLID ANCHORS
• REDUNDANCY
• EQUALIZATION
• NO EXTENSION
THE ACTIVITIES

C.A.I CSMT made for long time (since from 2008 !) a remarkable job in comparing fixed or mobile ("magic X") anchor points connections:

- 605 tests (Torre di Padova, Laboratorio, Arco, ...)

- Detailed mathematical model for numerical simulations
THE ACTIVITY (cnt.)

Operative conditions analysed:
mobile ("magic X") connection vs. fixed connection

- Different operative conditions
- Rope blocked at the connection vertex
- Classic belaying with Italian hitch (belayer standing)
THE ACTIVITY (cnt.)

Operative conditions analysed:
(mobile “magic X”) vs. fixed connection)

- Body belaying with dummy runner
- Possibility of one anchor failure
An offset is always existing!

Half meter offset already make difference
Platform when the belayer is standing (terrace)

3D load cell

Feet basis when the belayer is hanging (ledge)
NUMERICAL TOOLS
A numerical model is important because all the physical details can’t be get clearly from the experimental data.
MODEL MAIN FEATURES

- Two dimensions model.
- Masses positions from a double integration over time of the accelerations derived from the dynamic equilibrium.
- Masses of the rope and of the triangle cord neglected.
MODEL MAIN FEATURES (cont.)

- Friction vertex karabiner /cord described by the “capstan friction equation”.
- Rope/cord behaviour described by Zener modified model (non-linear).
- Knots deformation as a function of the applied load (best fitting of experimental data).
COMPARISON BETWEEN NUMERICAL AND EXPERIMENTAL RESULTS
THE VERTEX DYNAMICS
COMPARISON BETWEEN MOBILE AND FIXED CONNECTION

MAXIMUM LOAD INVERSION ON THE ACHOR POINTS

~ 25%

Left anchor : blue
Right anchor : green

4907
6165
Anchors distance = 0.5  L cord = 1  H fall height = 4  Offset = 1
In the **fixed connection** the upper load is sustained by the anchor opposite to the offset.

In the **mobile connection** the situation is inverted.
THIS REMARCABLE FEATURE APPEARS WHEN THE BELAYER IS STANDING, (ALLOWED BY THE RELEVANT VERTEX MOBILITY), AND TENDS TO REDUCE WHEN THE BELAYER IS HANGING
Mobile vs fixed Connection
LOAD ANGLE EFFECT (NO ANCHOR FAILURE)

MOBILE CONNECT.
LOWER LOADS
NOTE:
WHEN THE LOAD ANGLE INCREASES:

- MOBILE CONNECTION:
  THE UNBALANCE REMAINS CONSTANT
  (DEPENDING ONLY ON THE FRICTION COEFFICIENT)

- FIXED CONNECTION:
  THE UNBALANCE INCREASES
WHEN NO ANCHOR FAILS
«MAGIC X» ROPE BLOCHED AT THE VERTEX (video clip 3)
BODY BELAYING WITH DUMMY RUNNER (video clip 4681)
BODY BELAYING *WITHOUT* DUMMY RUNNER
(video clip 4684)
PROBLEMS IN BODY BELAYING WHEN NO DUMMY RUNNER IS APPLIED

very long rope hand slippage, possible ground impact
WHEN ONE ANCHOR FAILS
BELAYER STANDING – BRAKE AT VERTEX – MOBILE CONNECTION (video clip 20)
BODY BELAYING – FIXED CONNECTION (video clip 31)
BODY BELAYING
MOBILE CONNECTION (video clip 38)
TYPICAL ANCHOR FAILURE SITUATION (plot recording)

MOBILE CONNECTION
BRAKE CLIPPED TO THE VERTEX – BELAYER HANGING
Test file # 4

- total Stance load
- left anchor
- right anchor

slippage
The peak force is largely due to the belayer’s “fall”.

It is noticeable the loss of gripping in the belayer’s hand.
FACTS
CONNECTION COMPARISON

NO ANCHOR FAILURE
MOBILE CONNECTION: GOOD LOAD EQUALIZATION

FIXED CONNECTION: BAD LOAD EQUALIZATION
CONNECTION COMPARISON

ANCHOR FAILURE
LEADER “FALL” – MOBILE CONNECTION
Club Alpino Italiano
Centro Studi Materiali e Tecniche
LEADER “FALL”− FIXED CONNECTION
CONCLUSIONS

- LOWER LOADS WITH MOBILE CONNECTION ("MAGIC X") WHEN NO ANCHOR FAILS

- UPPER LOADS WITH MOBILE CONNECTION ("MAGIC X") WHEN ONE ANCHOR FAILS
IN ALL SITUATIONS A STRETCHABLE CORD USED IN THE TRIANGLE IS BETTER BECAUSE:

- BETTER LOAD BALANCE ON THE ANCHORS (LOWEST LOAD)
- IN CASE OF ONE ANCHOR FAILURE, BETTER ABSORPTION OF THE BELAYER “FALL” ENERGY
SUGGESTED IMPROVEMENTS
THE OPPOSITE BEHAVIOR OF THE ANALYSED CONNECTIONS SUGGESTS TO SEPARATE THE GENERATED LOADS:

- LOAD DERIVED BY THE LEADER FALL
  → MOBILE CONNECTION
- LOAD DERIVED BY THE BELAYER «FALL»
  → FIXED CONNECTION
FUNCTION SEPARATION

BELAYER STANDING

BELAYER HANGING
ADVENTURE TERRAIN: TWO HALF ROPES
ADVENTURE TERRAIN: TWO HALF ROPES
REFERENCES

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