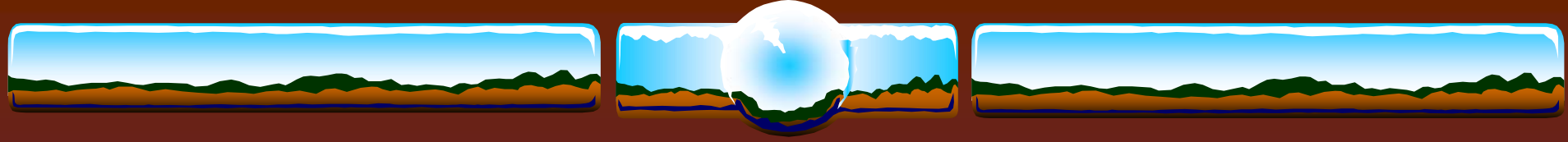
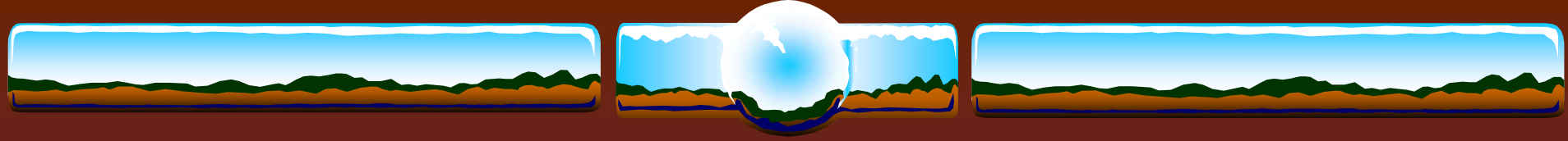


Recent research on the erodibility of subbases under concrete slabs

- Elsabé Ras* and Alex T Visser-
*Ndodana Consulting Engineers (Pty) Ltd

CONTENT

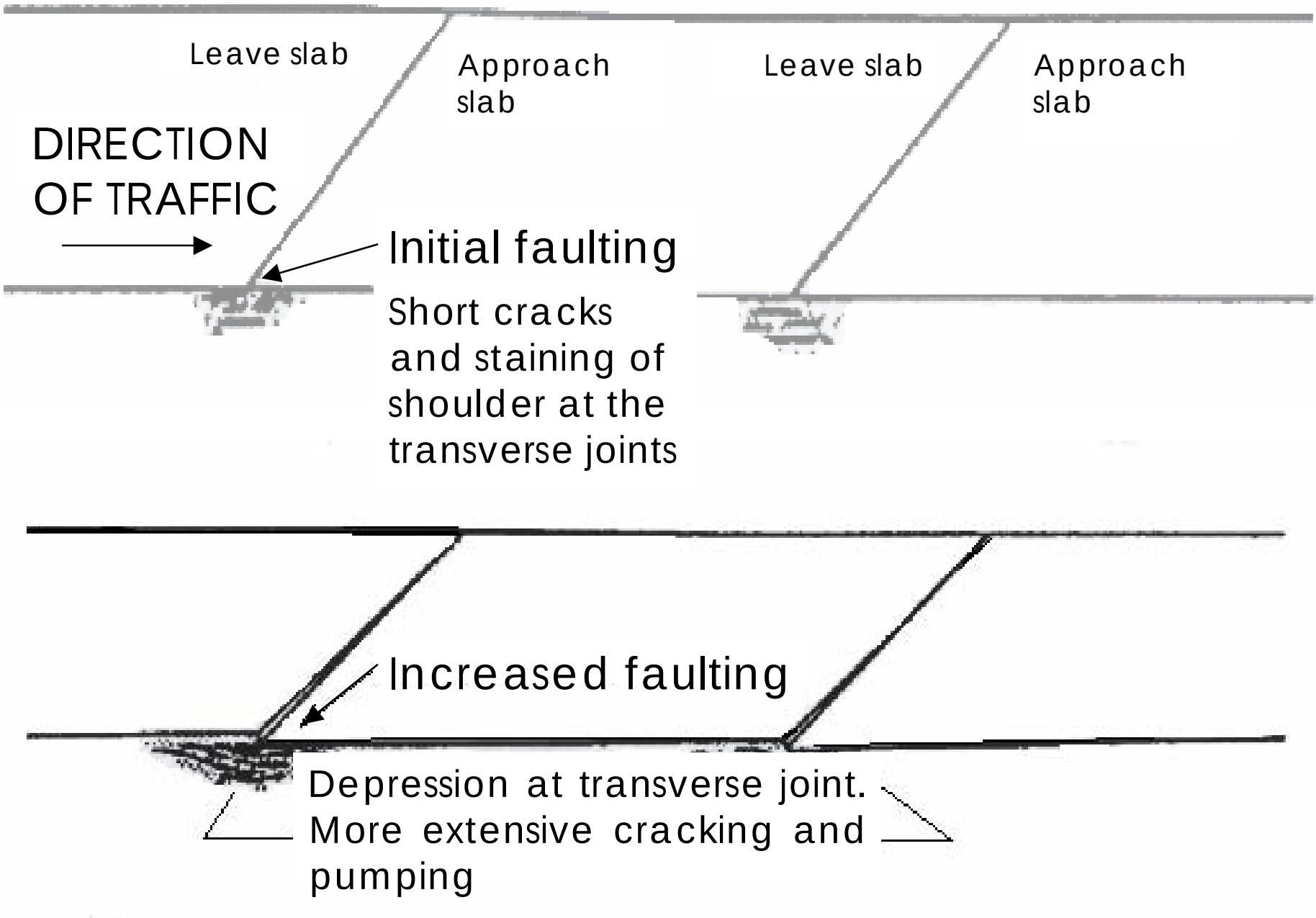
- Introduction
- Preliminary test protocol
- Results
- Suggested test protocol
- Conclusions



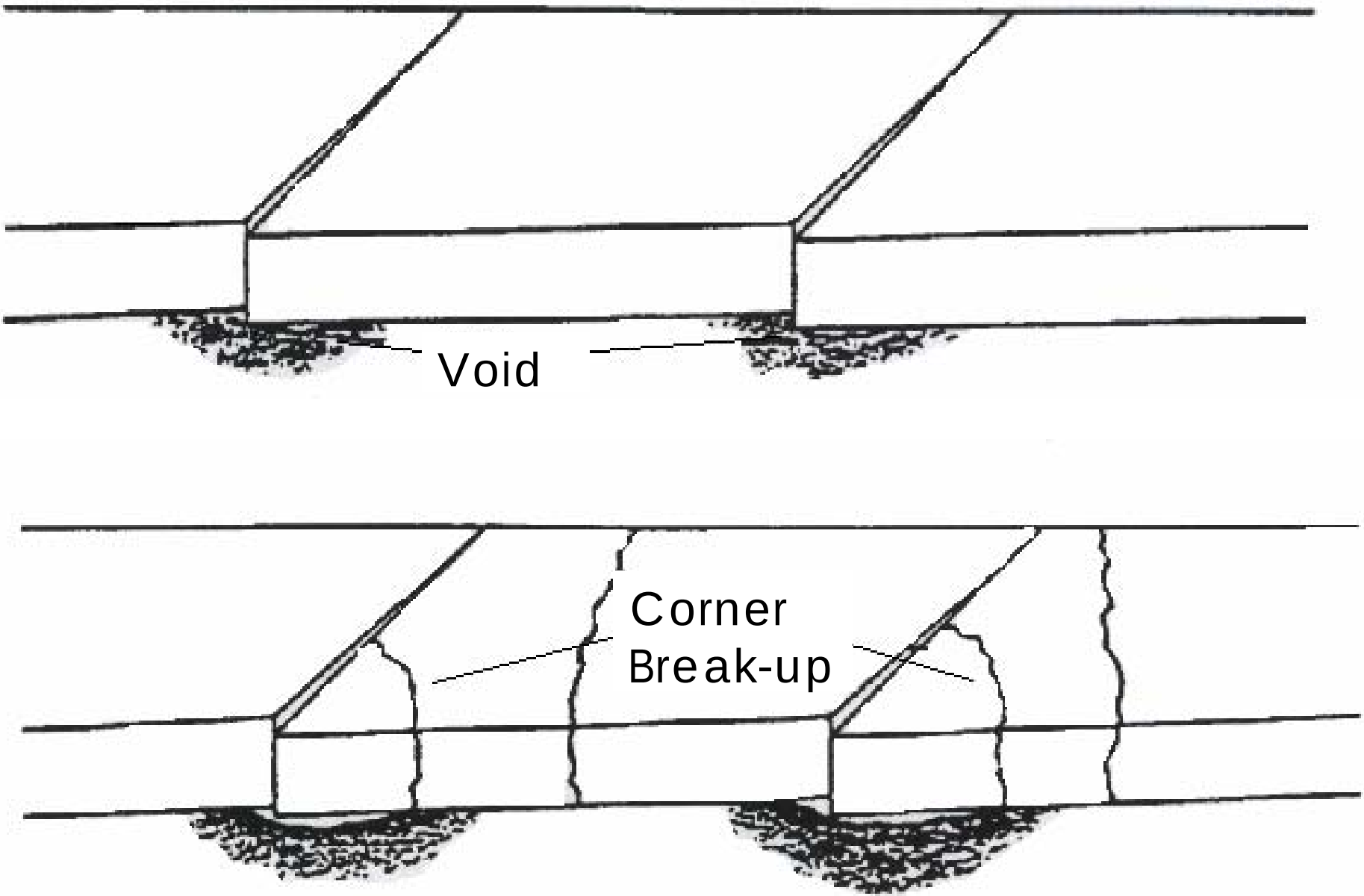
INTRODUCTION

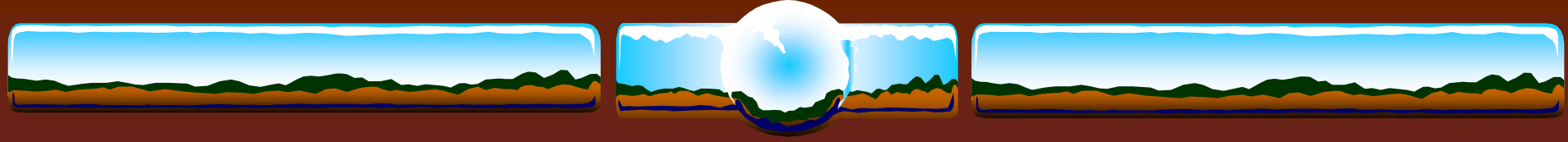
- Erosion of subbase material under rigid pavement common
- Erosion = pumping of water and material = void formation
- Voids imply loss of support resulting in pavement failure

STAGES OF FAILURE



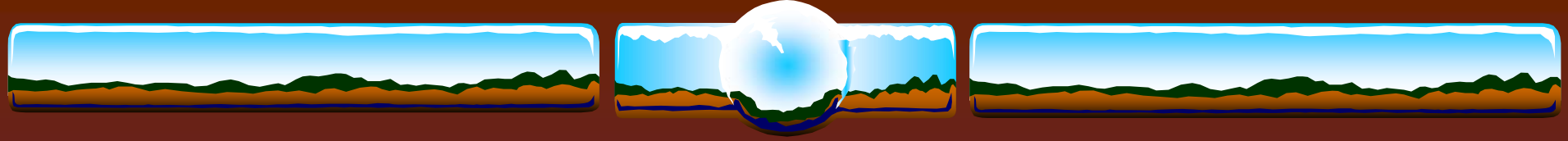
STAGES OF FAILURE (CONTINUED)





OBJECTIVES OF THE STUDY

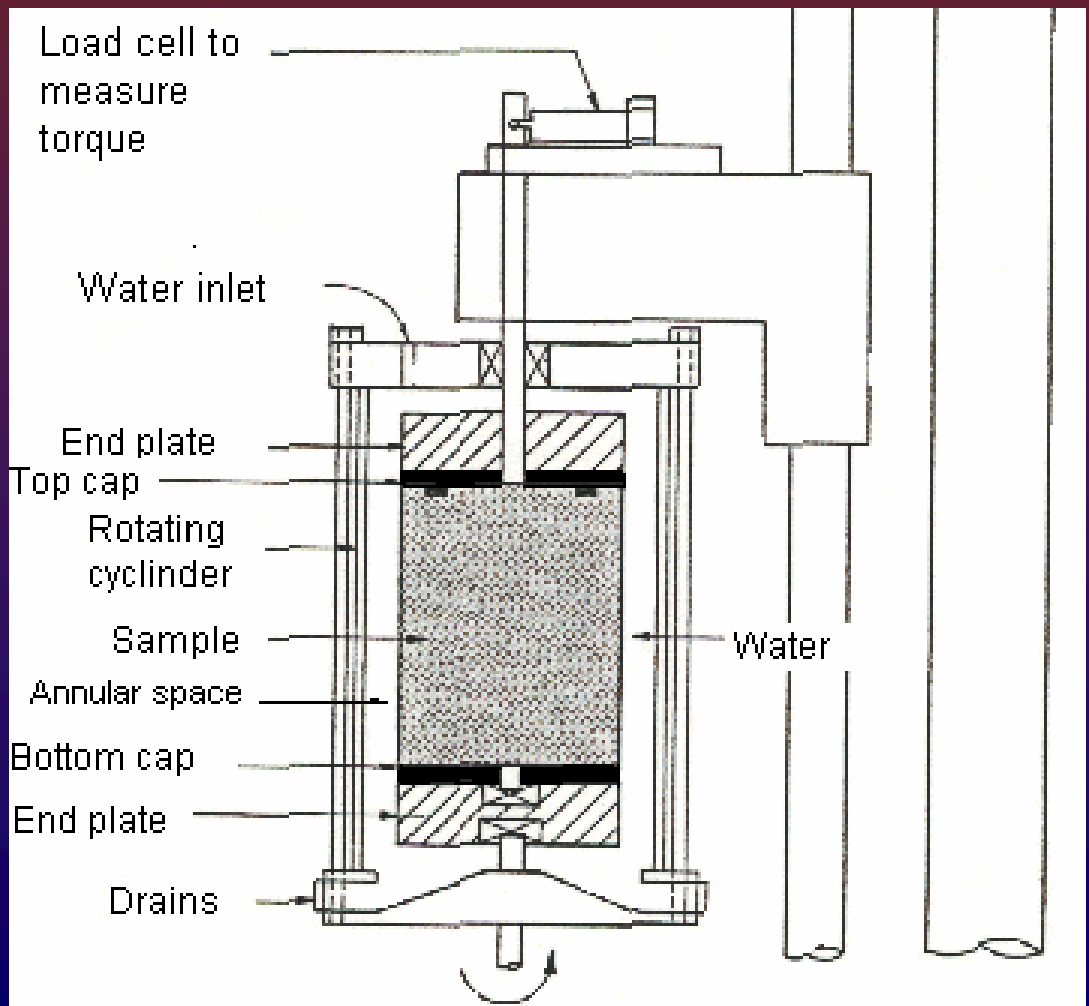
- To determine and verify the applicability of the RSD as a test procedure.
- To suggest limiting ranges or envelopes of erosion.

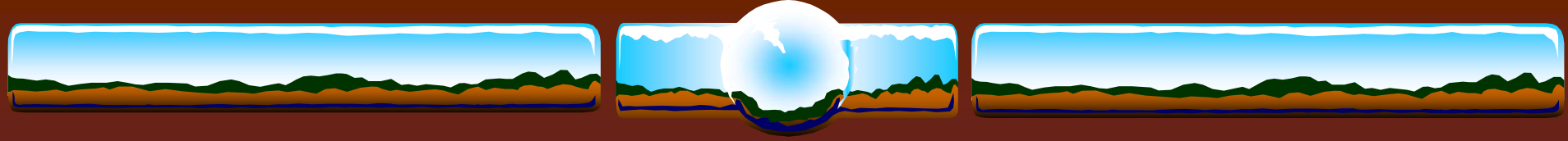


ROTATIONAL SHEAR DEVICE (RSD)

- Background
  - Developed in 1960's at University of Texas
  - Modified and used in other research projects

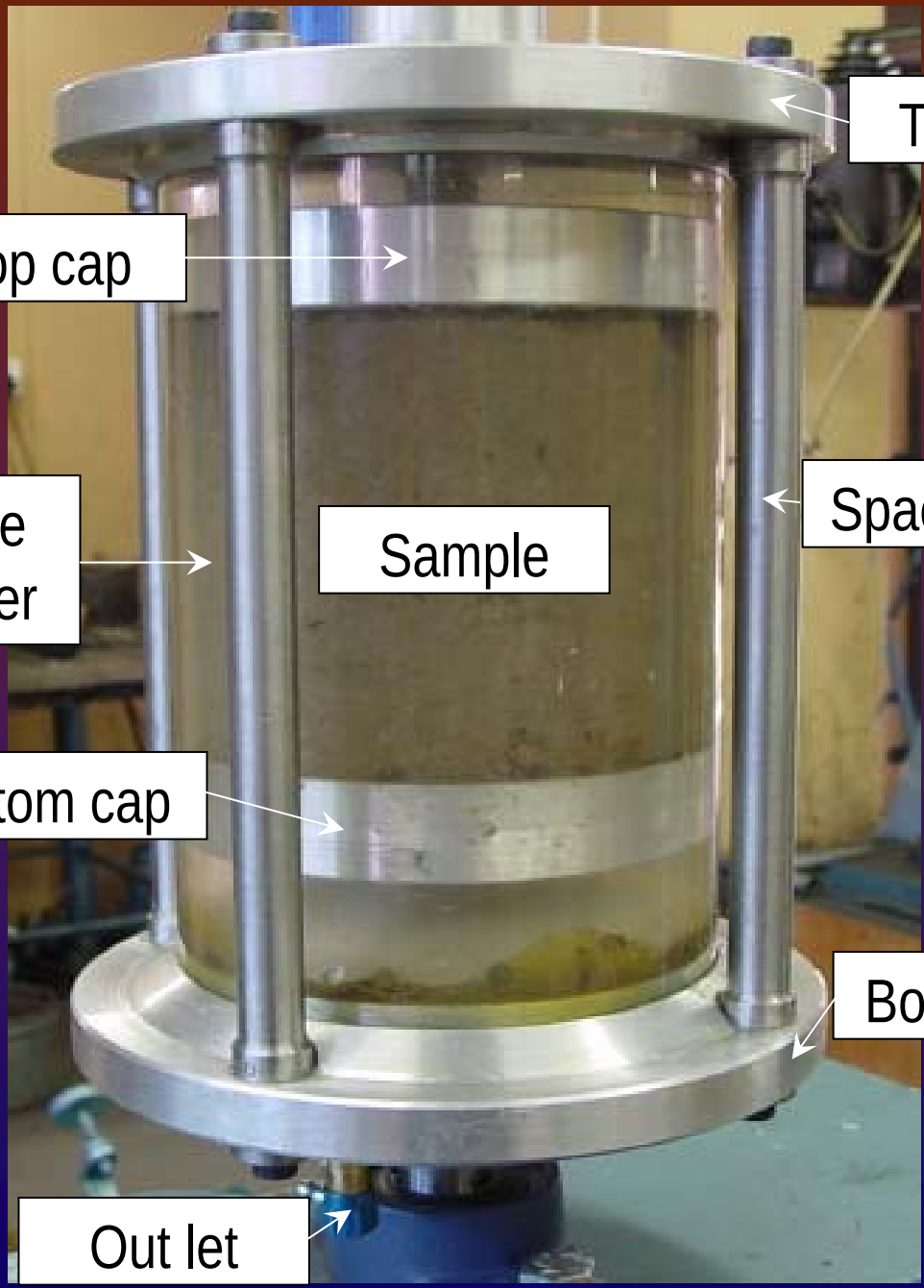
RSD AS USED BY VAN WIJK (1985)

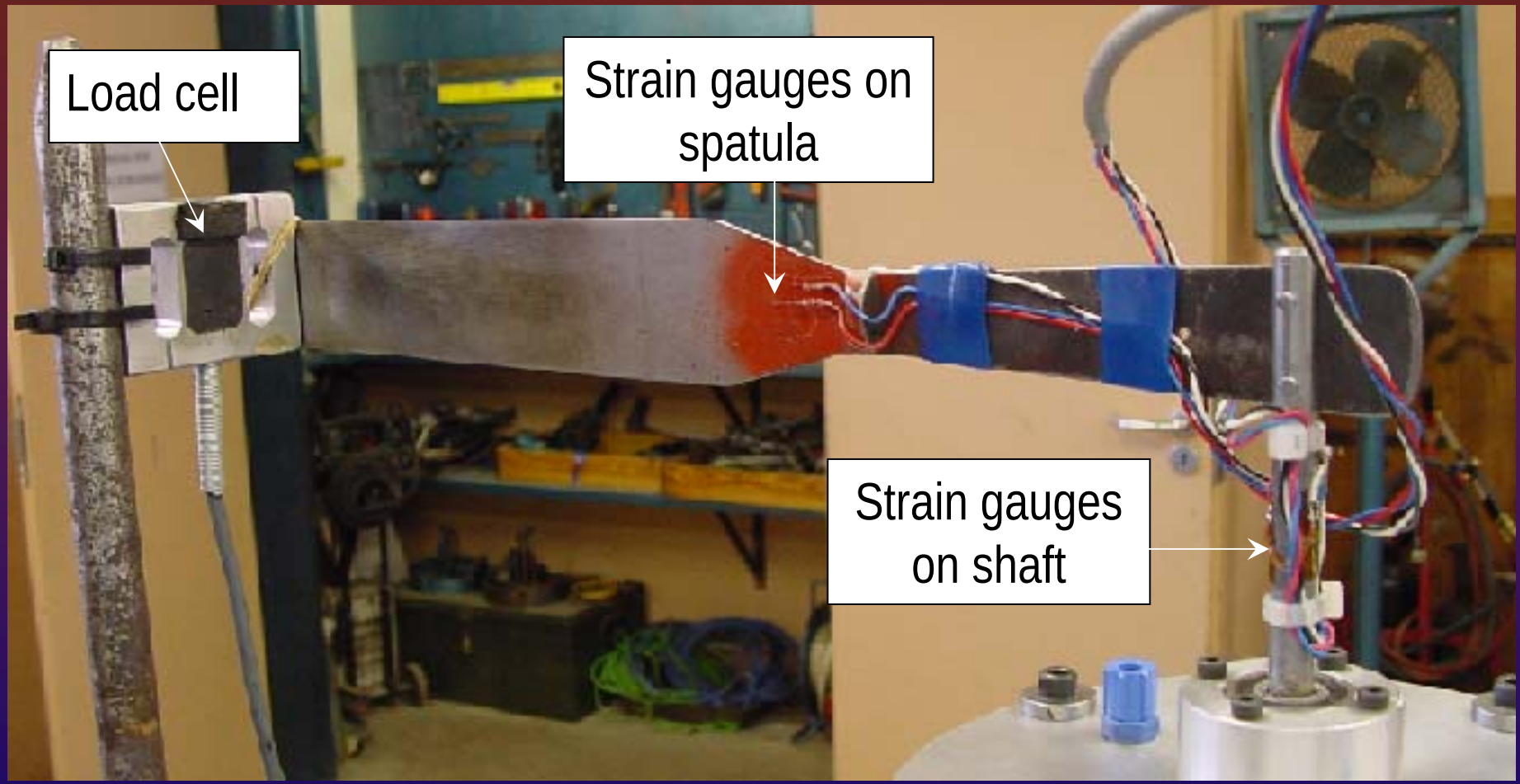




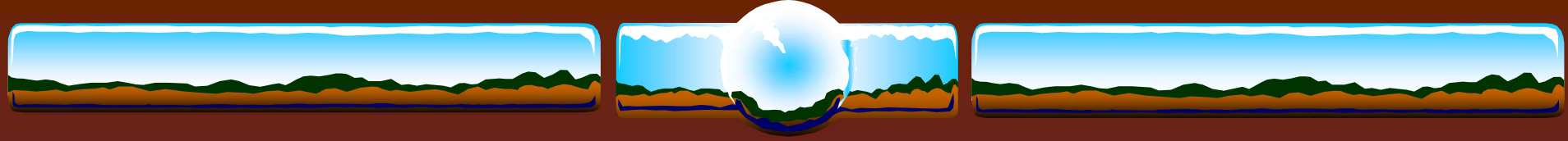
DESIGN PRICIPLES

- Hydraulic principles
- Laminar flow assumed
- Condition change from laminar to turbulent
- Erosion takes place when shear forces exceeds shear strength of material


Top disc
Top cap
Annular space filled with water
Sample
Spacer bars
Bottom cap
Bottom disc
Out let

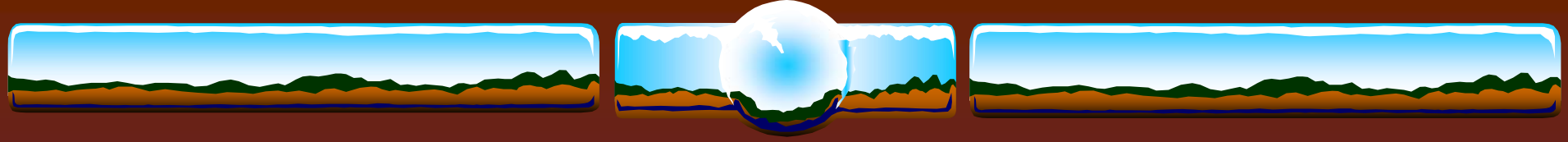

Load cell
Strain gauges on spatula
Strain gauges on shaft

Final set-up of the RSD as used during tests



PREPARATION OF SPECIMENS

- G1 quality granite, quartzite and dolomite
- Maximum particle size of 9.5mm
- Wet-dry durability, Method A19 (TMH1:1994), 101 mm diameter, 117 mm high.
- Cement content of 2, 4 and 6%
- Cured for 7 and 28 days (A19, TMH1:1994)

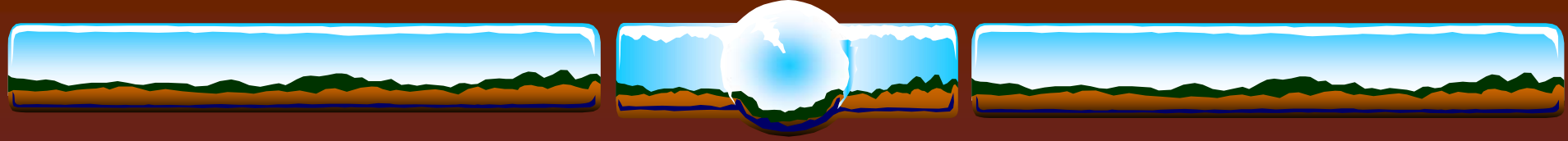


PRELIMINARY TEST PROTOCOL

- Samples soaked for 24 hours in water bath
- Thereafter removed and placed inside the RSD.
- The device filled with water and rotated at 11 different rotational speeds, namely; 500, 750, 1000, 1250, 1500, 1750, 2000, 2250, 2500, 2750 and 2800 revolutions per minute (rpm) for two minutes at each speed.

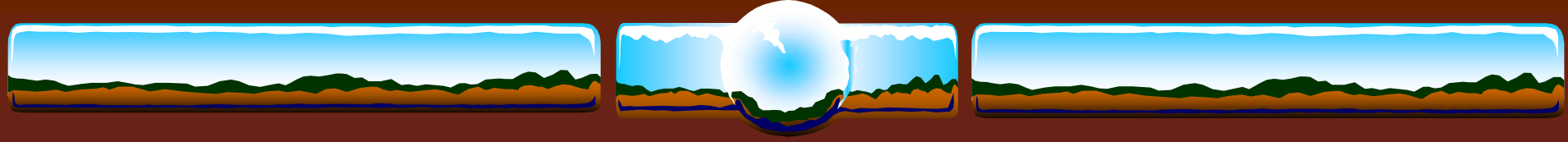
PRELIMINARY TEST PROTOCOL
(Continued)

- The device was drained at the end of the 22 minute cycle and the eroded material oven dried
- The device was re-filled with water, and rotated for 10 minutes at each of the above-mentioned rotational speeds.



PRELIMINARY TEST PROTOCOL
(Continued)

- After the completion of the 10 minute cycles, the samples were removed from the RSD and placed along with all the eroded material in an oven at 71C for 24 hours.
- Strain readings were measured every 10 seconds during a cycle.

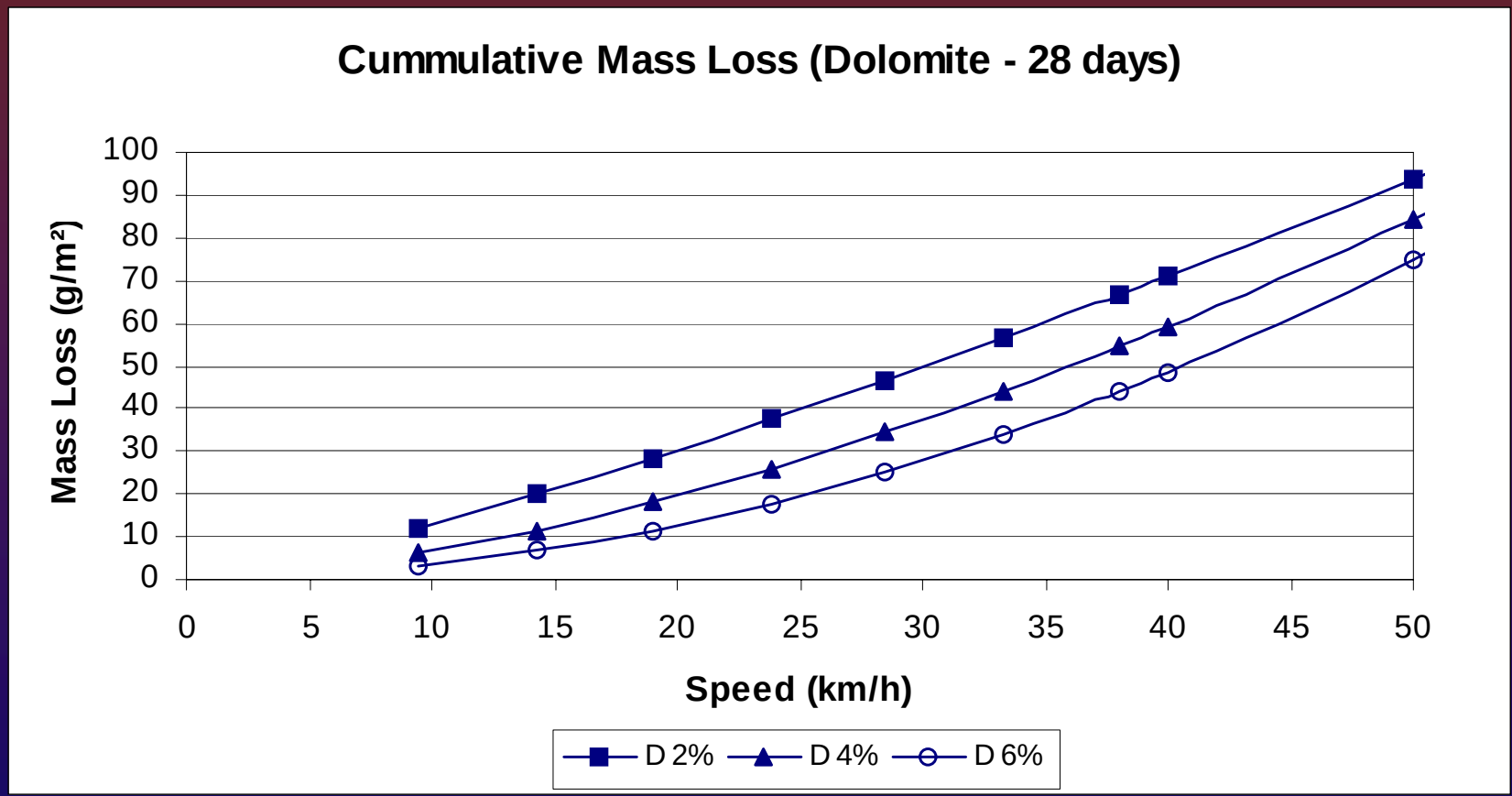


PRELIMINARY TEST PROTOCOL
(Continued)

- Calculations from measured data provided the following:
  - shear stress vs speed
  - mass loss vs time and
  - mass loss vs speed

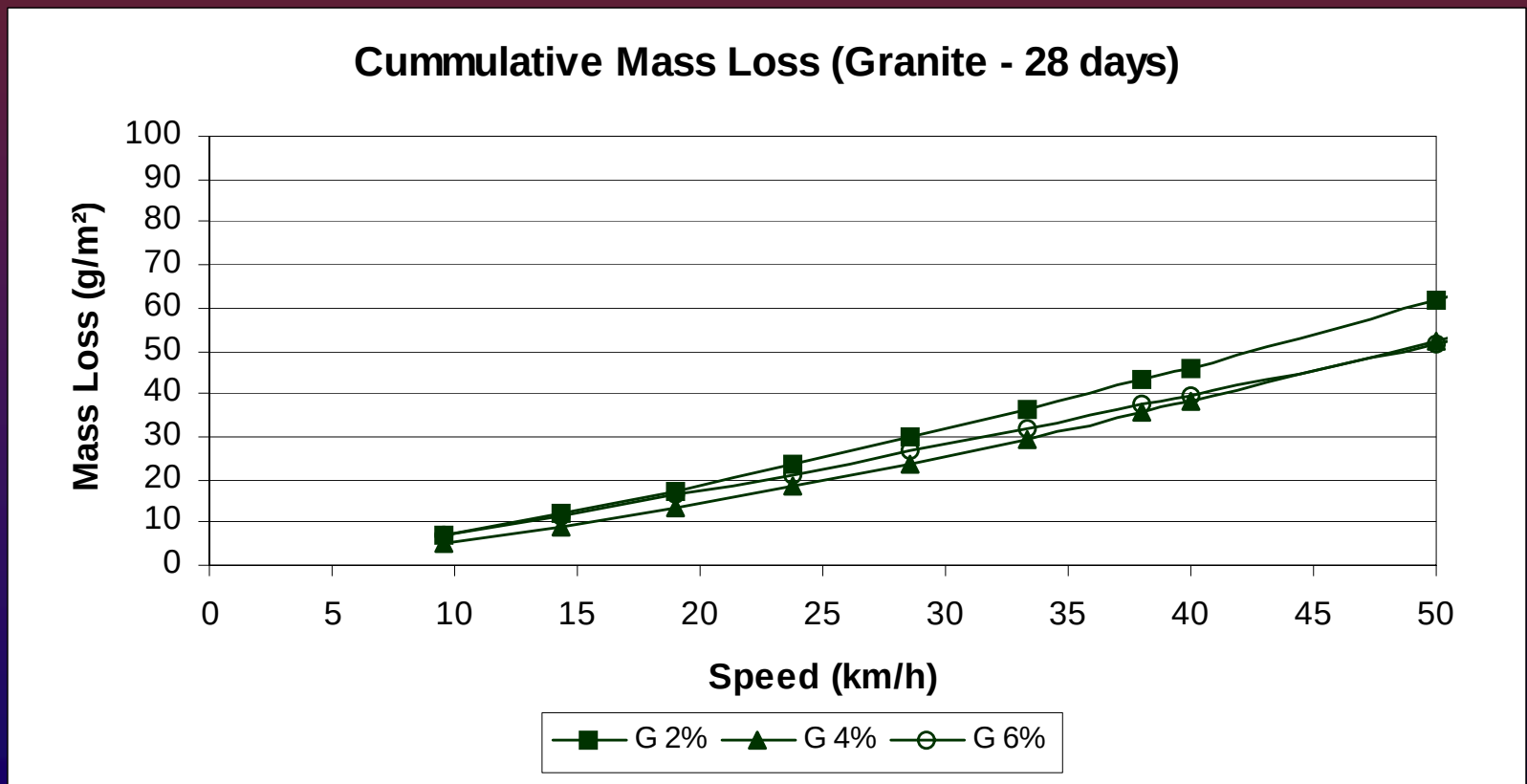
VISUAL OBSERVATIONS

MASS LOSS VS SPEED



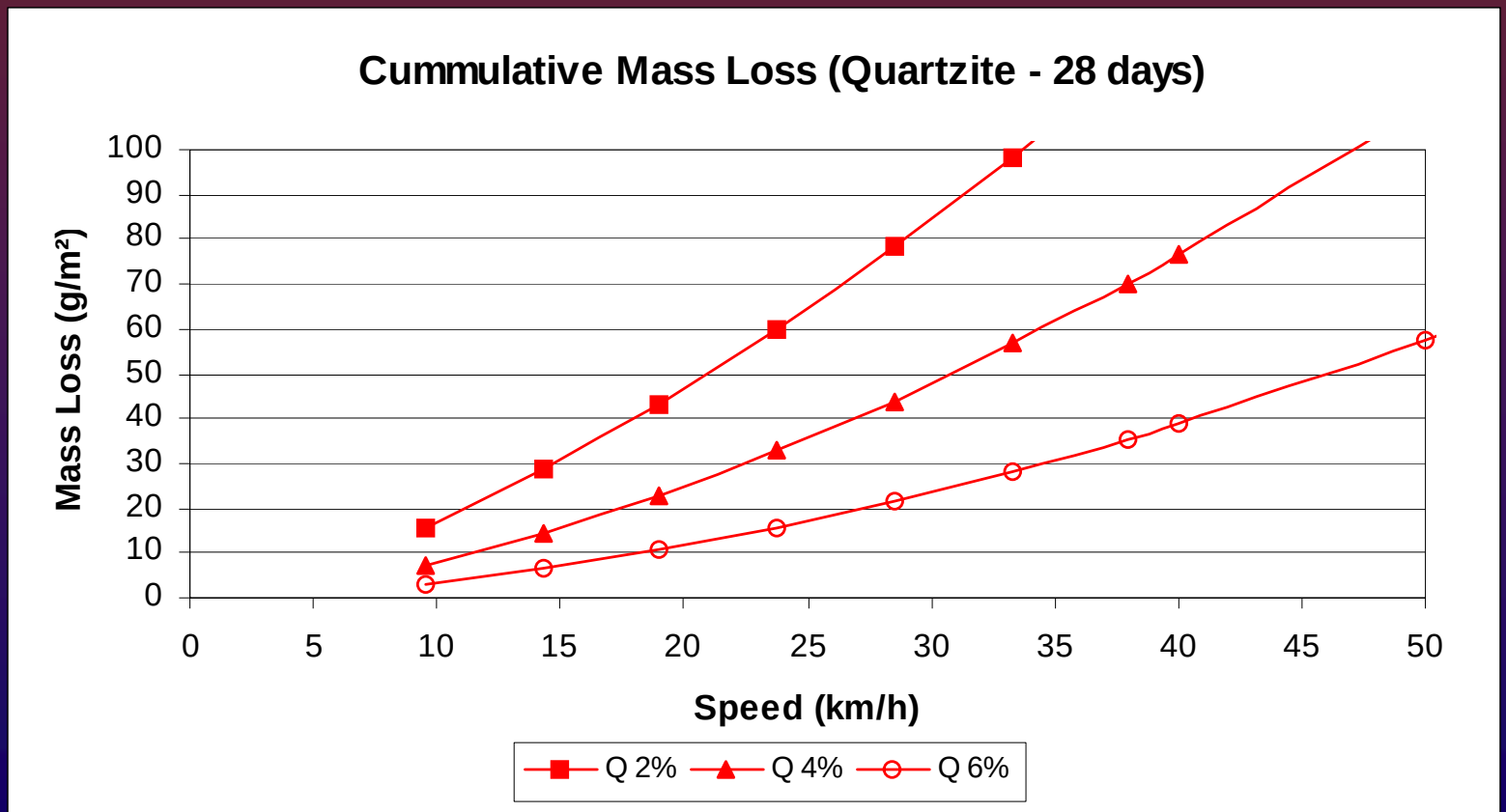
MASS LOSS VS SPEED

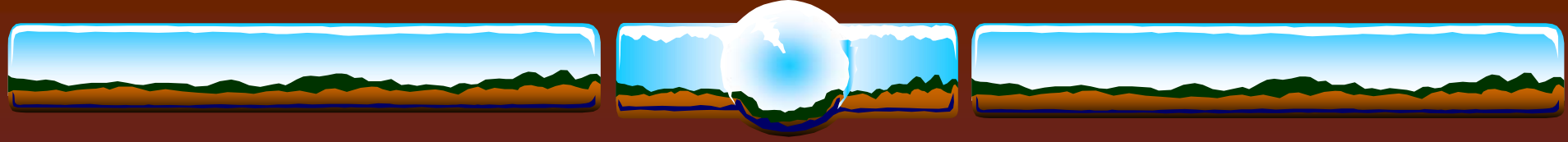
(Continued)



MASS LOSS VS SPEED

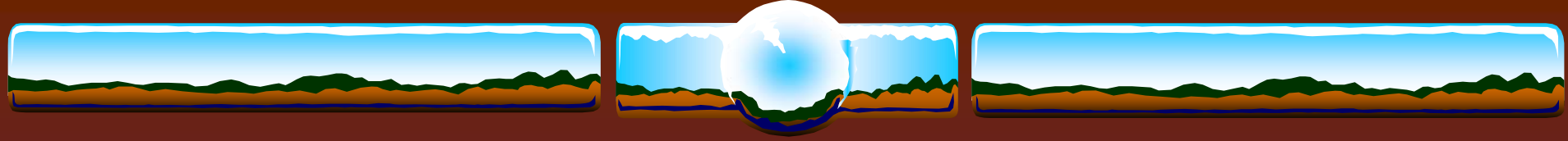
(Continued)





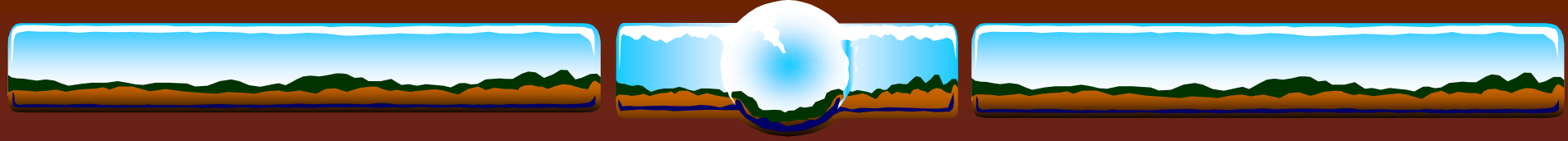
MASS LOSS

Vehicle speed (km/h)	Rotational Speed (rpm)	Dolomite (mm)			Granite (mm)			Quartzite (mm)		
		2%	4%	6%	2%	4%	6%	2%	4%	6%
		2303 kg/m³	2324 kg/m³	2359 kg/m³	2018 kg/m³	2054 kg/m³	2057 kg/m³	2024 kg/m³	2067 kg/m³	2071 kg/m³
9.5	500	0,018	0,014	0,005	0,011	0,011	0,011	0,011	0,011	0,011
14.3	750	0,038	0,014	0,014	0,007	0,007	0,007	0,007	0,007	0,007
19.0	1000	0,063	0,033	0,019	0,019	0,019	0,019	0,019	0,019	0,019
23.8	1250	0,063	0,042	0,035	0,030	0,030	0,030	0,030	0,030	0,030
28.5	1500	0,077	0,052	0,039	0,011	0,011	0,011	0,011	0,011	0,011
33.3	1750	0,096	0,075	0,057	0,011	0,011	0,011	0,011	0,011	0,011
38.0	2000	0,096	0,075	0,057	0,030	0,030	0,030	0,030	0,030	0,030



PRELIMINARY CONCLUSIONS

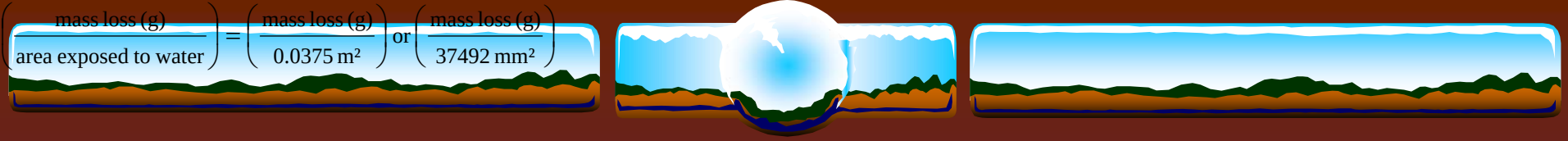
- Observations from preliminary test protocol
  - No conditioning of samples – eliminate 2-minute cycles
  - Relative sharp increase in all calculated relationships at 33.3 km/h (1750 rpm) after total of 40 to 70 minutes
  - Device tends to rotate off balance at speeds exceeding 33.3 km/h – practical limit of test



SUGGESTED RSD TEST PROTOCOL

(Granular Material)

- Test the specimen by rotating it at 33 km/h (1750 rpm)
- Drain the device after 90, 120, 240, 360 and 480 minutes of rotation
- Oven dry the material collected at each time interval
- Weigh the material and determine mass loss (g/m^2 or g/mm^2) for each time interval.
- Determine the thickness of the void caused by mass loss of the sample for each interval from.
- Add the void measurements to obtain the cumulative total void dimension.



SUGGESTED RSD TEST PROTOCOL

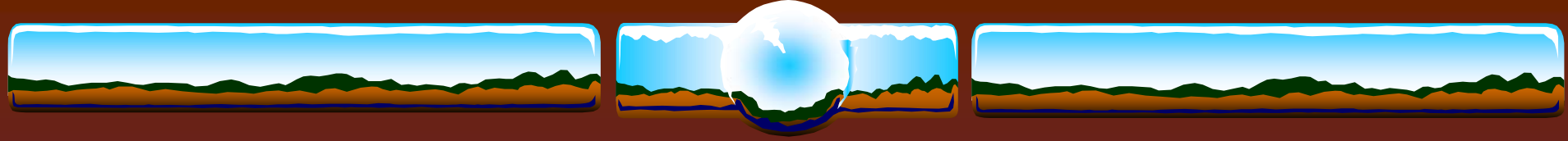
(Asphaltic)

- Soak in a water bath for 2 days at 60 °C
- Test specimen by rotating it at 33 km/h (1750 rpm)
- Drain the device after 240, 360 and 480 minutes of rotation.
- Oven dry the material collected at each time interval
- Weigh the material and determine mass loss (g/m² or g/mm²) for each time interval.
- Determine the thickness of the void caused by mass loss of the sample for each interval from.
- Add the void measurements to obtain the cumulative total void dimension.

VERIFICATION OF RSD TEST PROTOCOL

(Granular Material)

- N3, Heidelberg test section
- One sample successfully cored, but in a fragile condition
- Rotated for 20 minutes at 33.3 km/h (1750 rpm)
- Mass loss 92.7 g or 4.9 mm (2055 kg/m³)



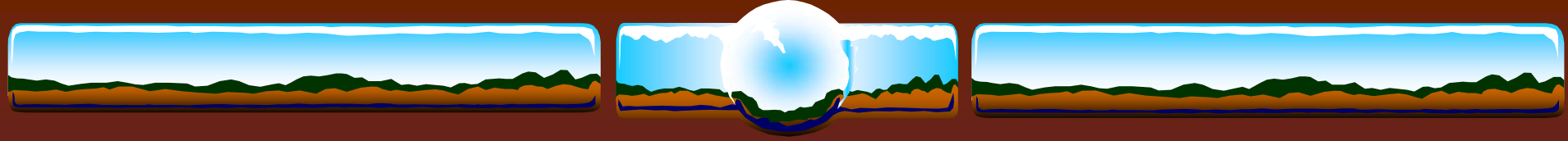
VERIFICATION OF RSD TEST PROTOCOL

(Asphaltic Material)

- Quartzite Hornfels material
- Binder content of 5% and void ratio between 4.41% and 4.93%
- Mix design has high stripping potential
- Compacted with 40 ton press
- Material loss after 240 minutes, washed clean of bitumen
- Sample 1 – 480.11 g or 0.2 mm (2350 kg/m^3)
- Sample 2 – 546.79 g or 0.23 mm (2362 kg/m^3)

Asphalt sample in RSD

Eroded asphalt sample



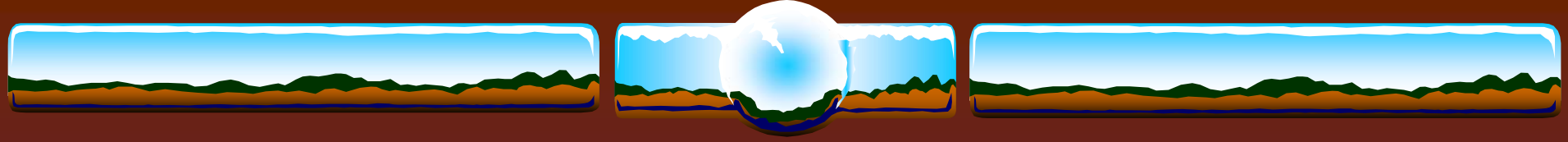
SUGGESTED EROSION RANGES

- Background:
  - From HVS tests at Hilton KZN on N3

    High erosion = 12 – 18 mm

    Medium erosion = 6 – 12 mm

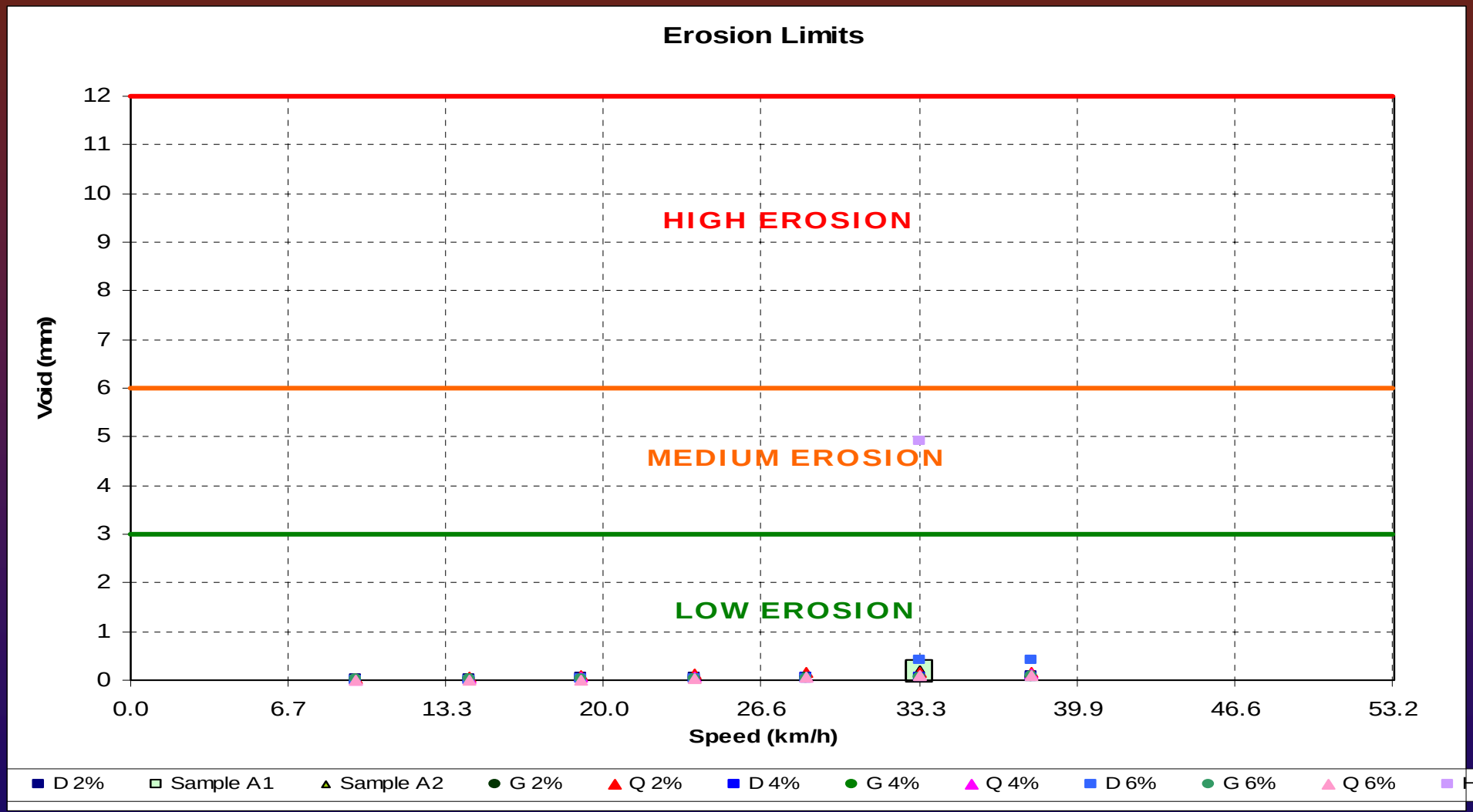
    Low erosion = 0 – 6 mm
  - Slab stabilisation at void thicknesses of less than 3 mm
  - Faulting noticable when 2.5 mm, diamond grinding when 4 mm is reached

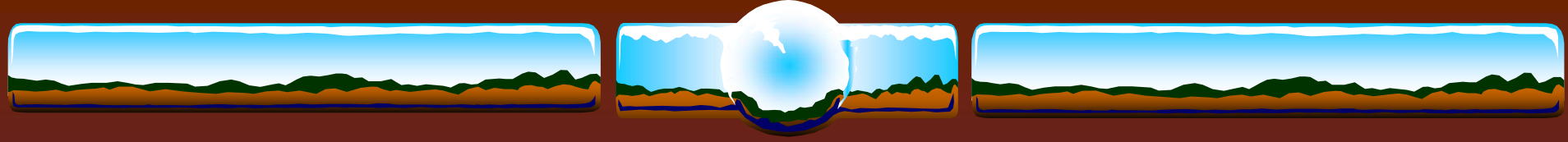


SUGGESTED EROSION RANGES

(Continued)

- For RSD test result interpretation:
  - Low erosion = 0 – 3 mm void
  - Medium erosion = 3 – 6 mm void
  - High erosion = 6 – 12 mm void


Erosion Limits
HIGH EROSION
MEDIUM EROSION
LOW EROSION
Void (mm)
12
11
10
9
8
7
6
5
4
3
2
1
0
0.0
6.7
13.3
20.0
26.6
33.3
39.9
46.6
53.2
Speed (km/h)
D 2%
Sample A1
Sample A2
G 2%
Q 2%
D 4%
G 4%
Q 4%
D 6%
G 6%
Q 6%

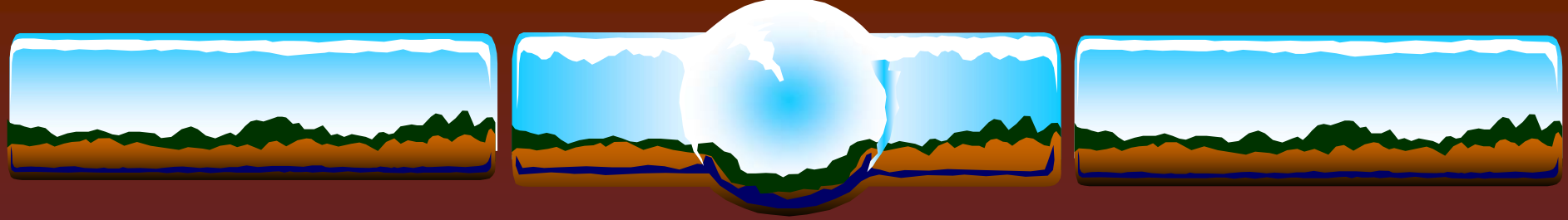


CONCLUSIONS

- Test protocol suggested for granular and asphaltic material has merit.
- High quality material and % cement stabiliser resulted in low erosion measured.
- Field observation indicate significantly higher erosion losses. Materials in the field are poorer than tested, or deteriorate with time.

CONCLUSIONS
(CONTINUED)

- Suggested limiting ranges or envelopes need to be calibrated with lower quality stabilised subbase materials
- Suggested limiting ranges or envelopes could be used as interim guide based on available information.



Thank you