



Dredging A Way Of Life



Offshore & Dredging Engineering

Dr.ir. Sape A. Miedema
Educational Director/Head of Studies:
Offshore & Dredging Engineering
& Marine Technology



THE DELFT SAND, CLAY & ROCK CUTTING MODEL

Problem definition: In 30 years many papers, a lot of redundancy, but what are the main issues.

Solution: Writing a book showing the main issues.



THE DELFT SAND, CLAY & ROCK CUTTING MODEL



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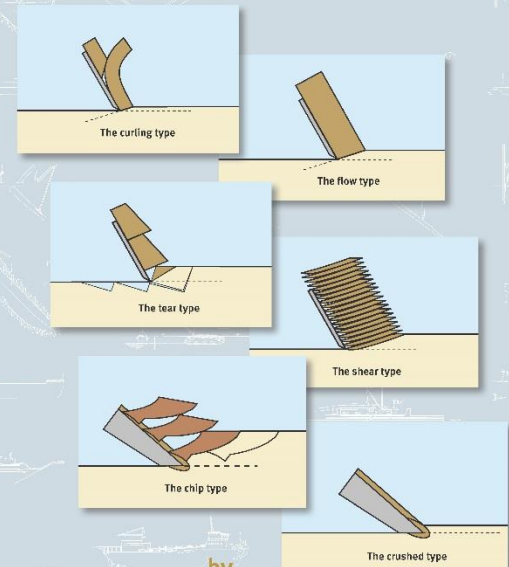
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The Delft Sand, Clay & Rock Cutting Model

S.A. Miedema

The Delft Sand, Clay & Rock Cutting Model



by

Dr.ir. Sape A. Miedema



Cutting Experiments

Hatamura Chijiwa Test Facility

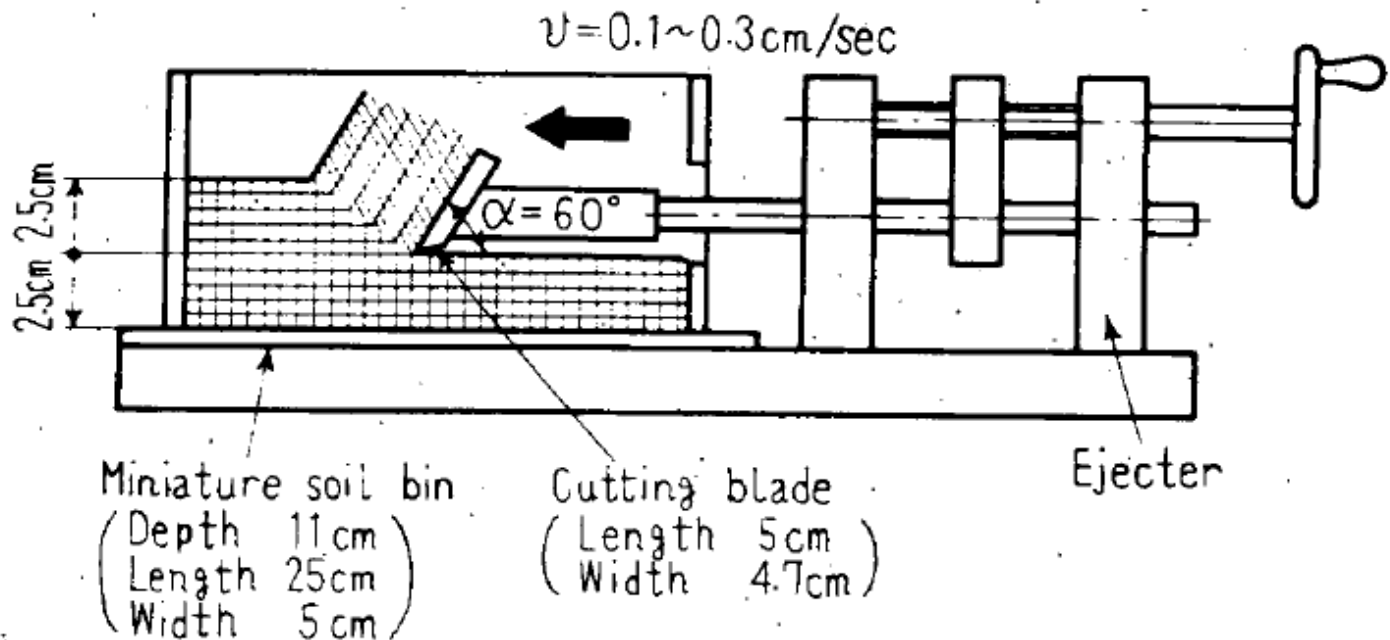
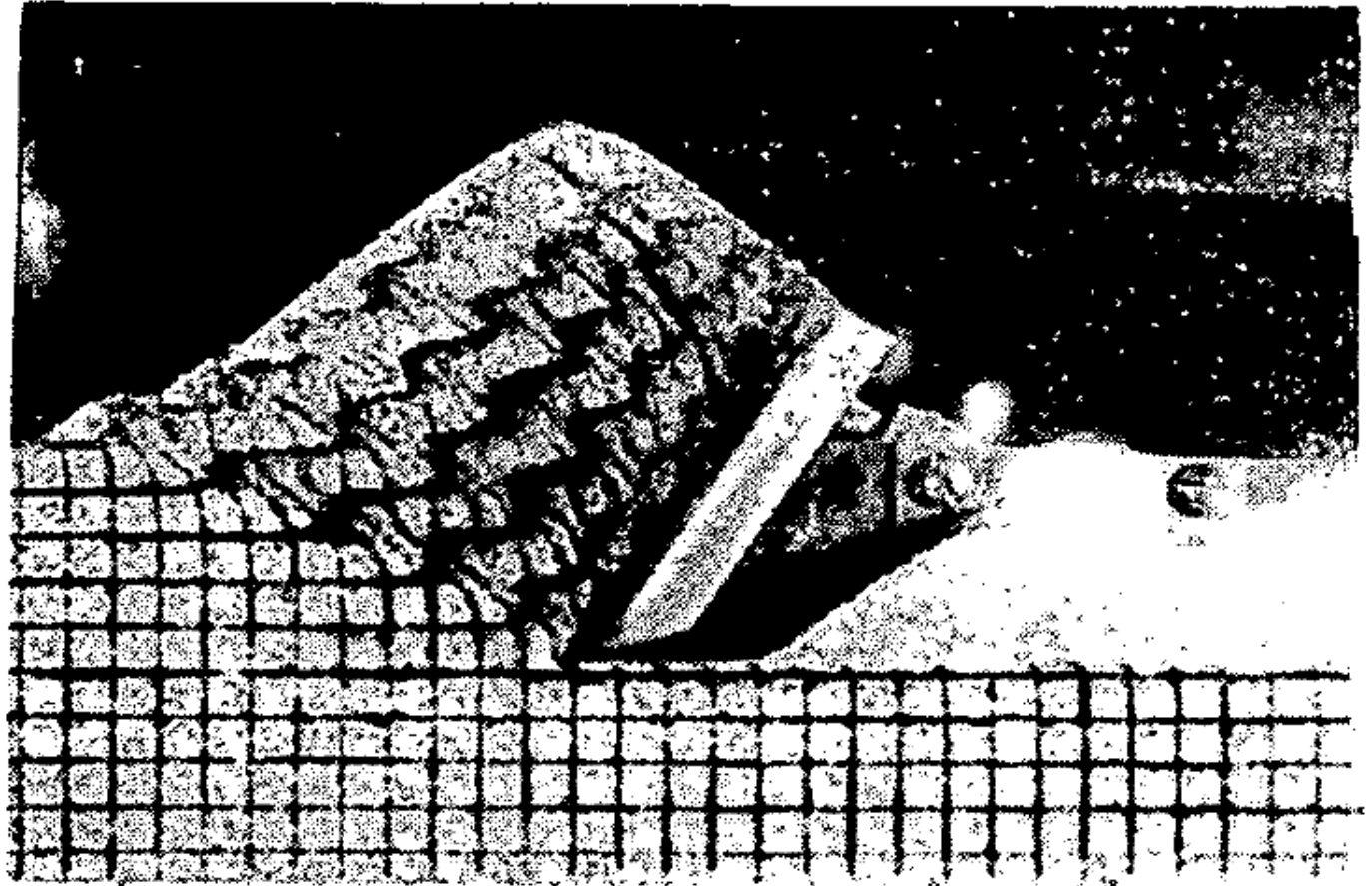


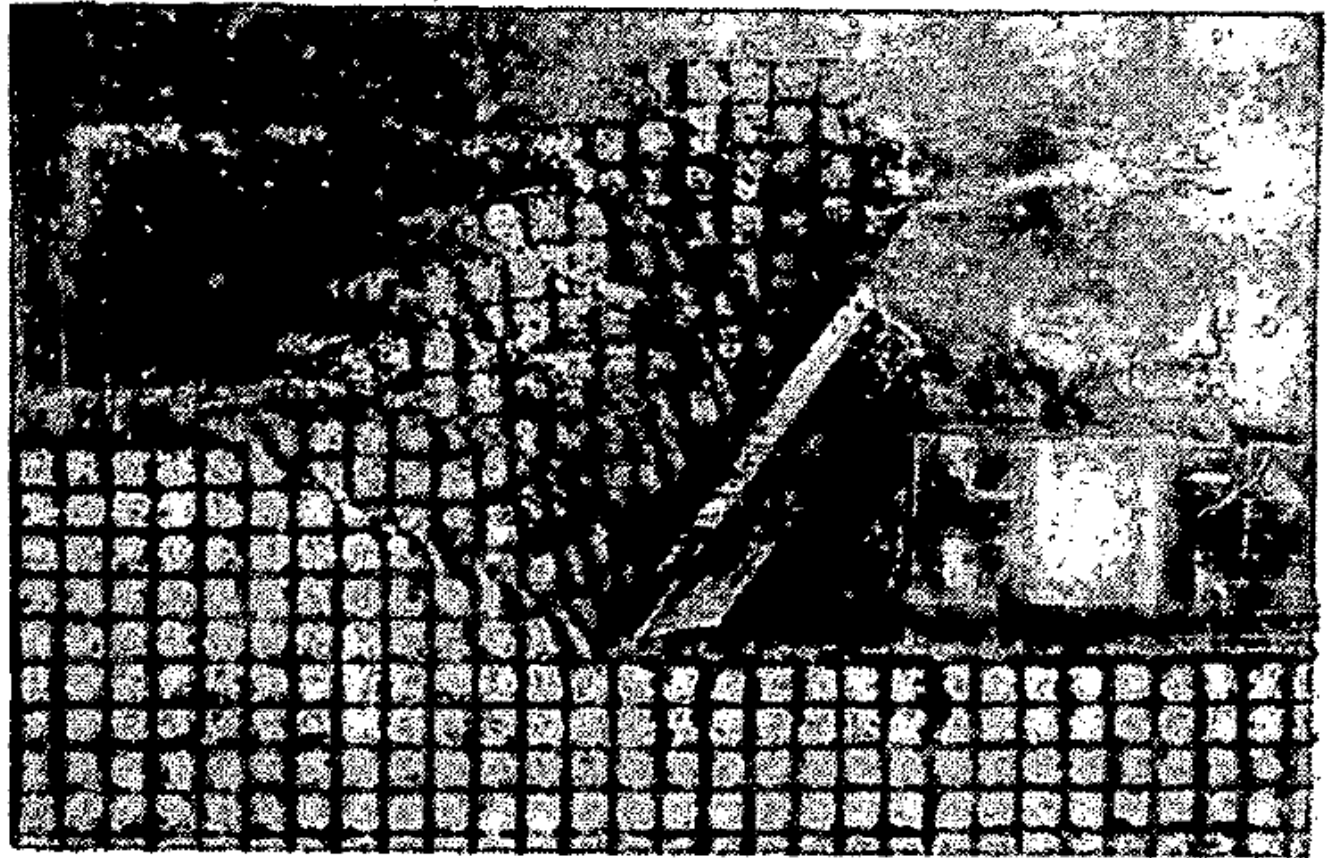
Fig. 2 Apparatus for investigating the deformation of soil by cutting.

Hatamura Chijiwa Dry Quarts Sand



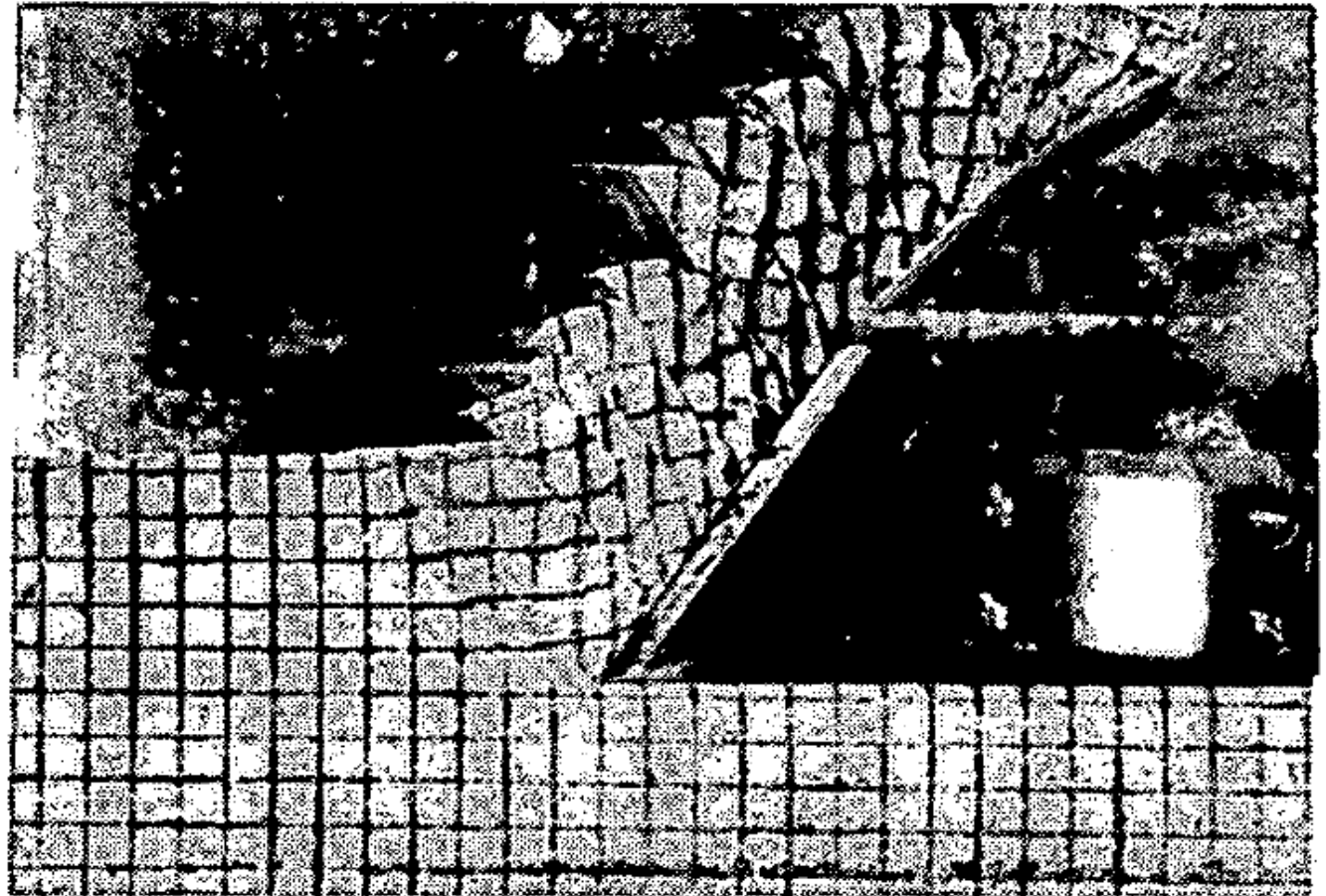
(a) Dry quartz sand

Hatamura Chijiwa Wet Quarts Sand



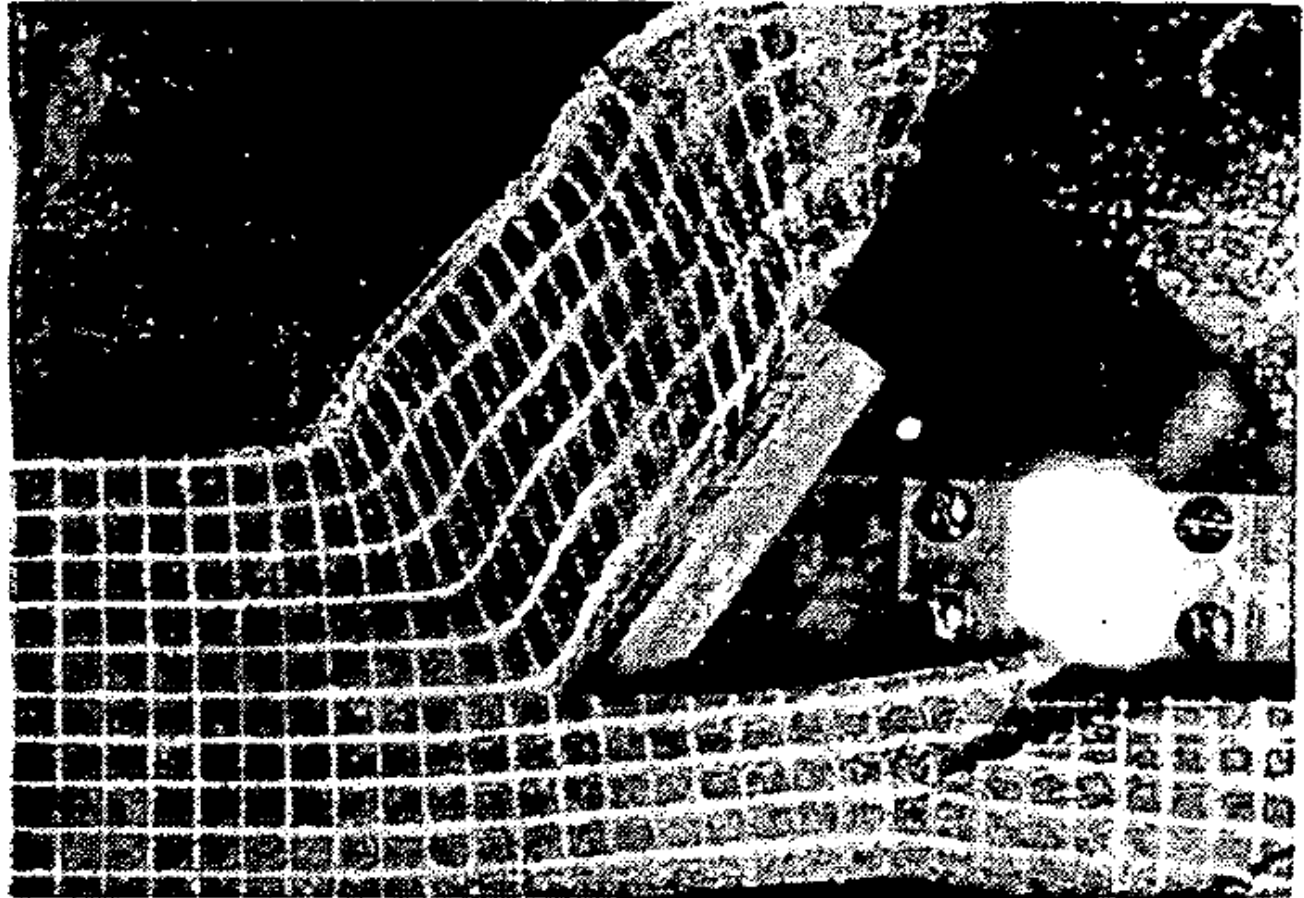
(b) Wet quartz sand

Hatamura Chijiwa Plastic Bentonite



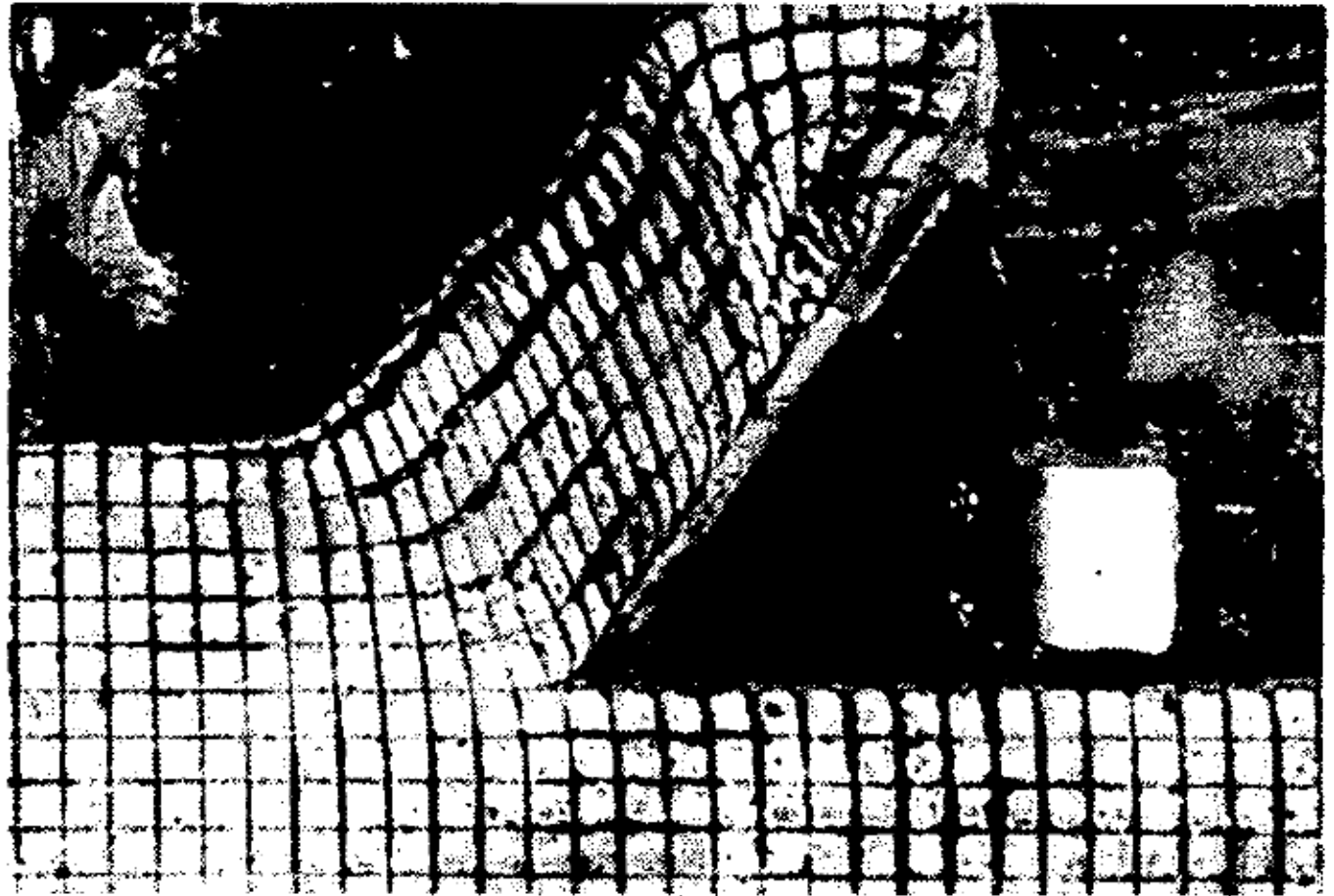
(c) Plastic bentonite

Hatamura Chijiwa Plastic Loam



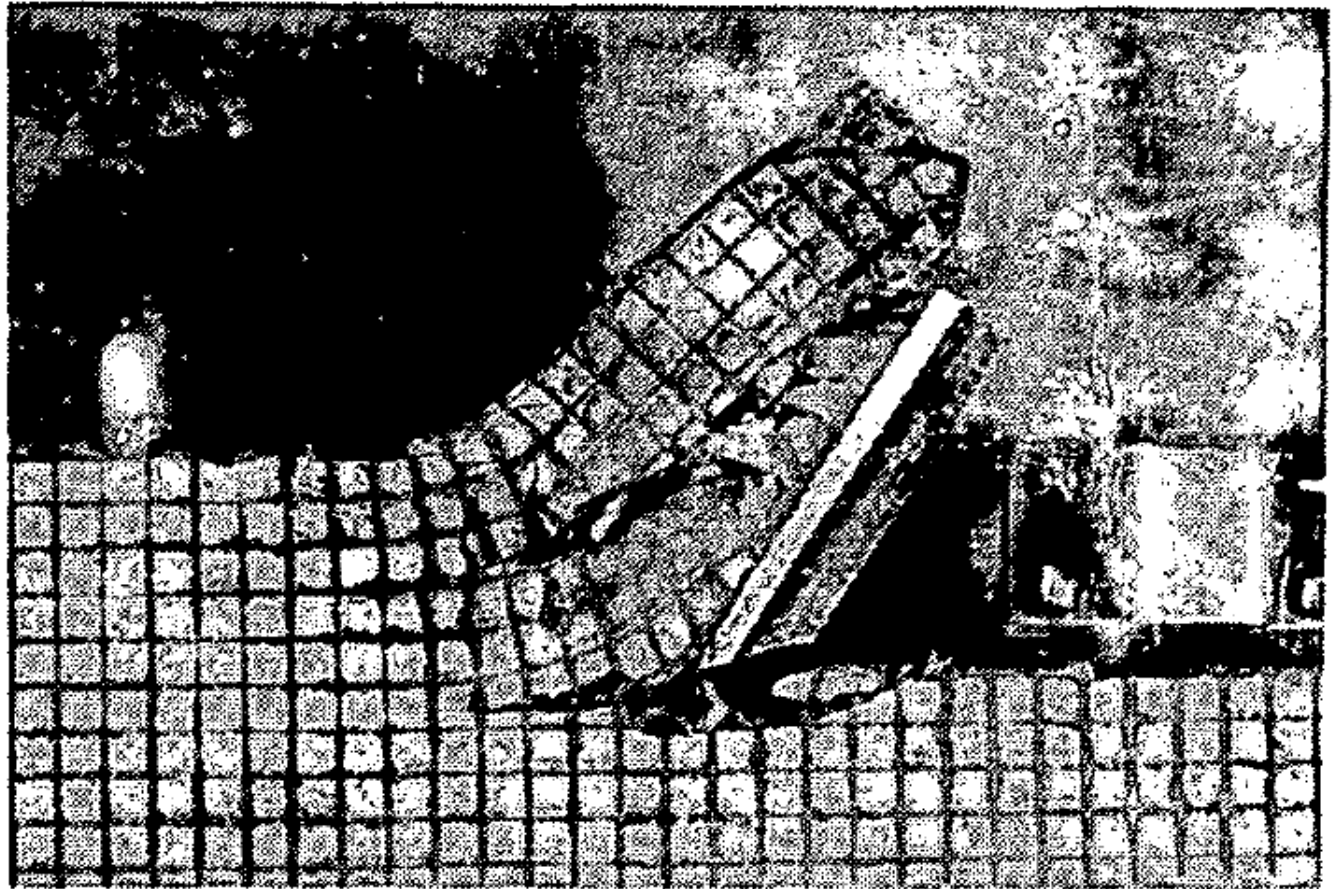
(d) Plastic loam

Hatamura Chijiwa Plastic Clay



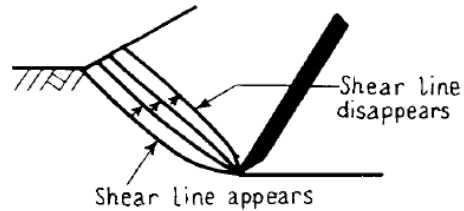
(e) Plastic clay

Hatamura Chijiwa Compacted Loam

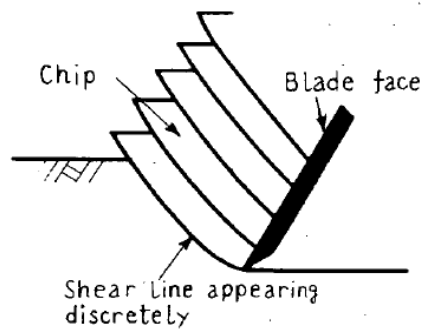


(f) Compacted loam

Hatamura Chijiwa Failure Types



(a) Appearance of shear line



(b) Accumulation of chips

Fig. 4 Shear type

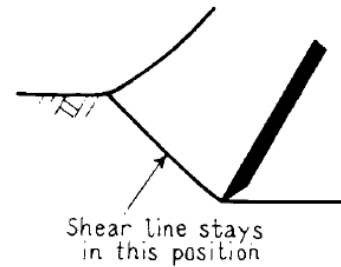


Fig. 5 Flow type

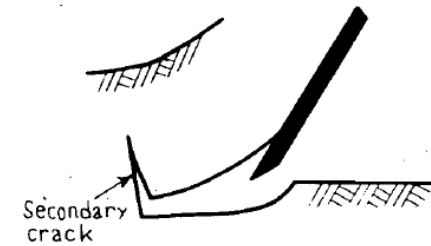
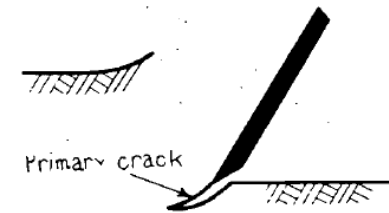
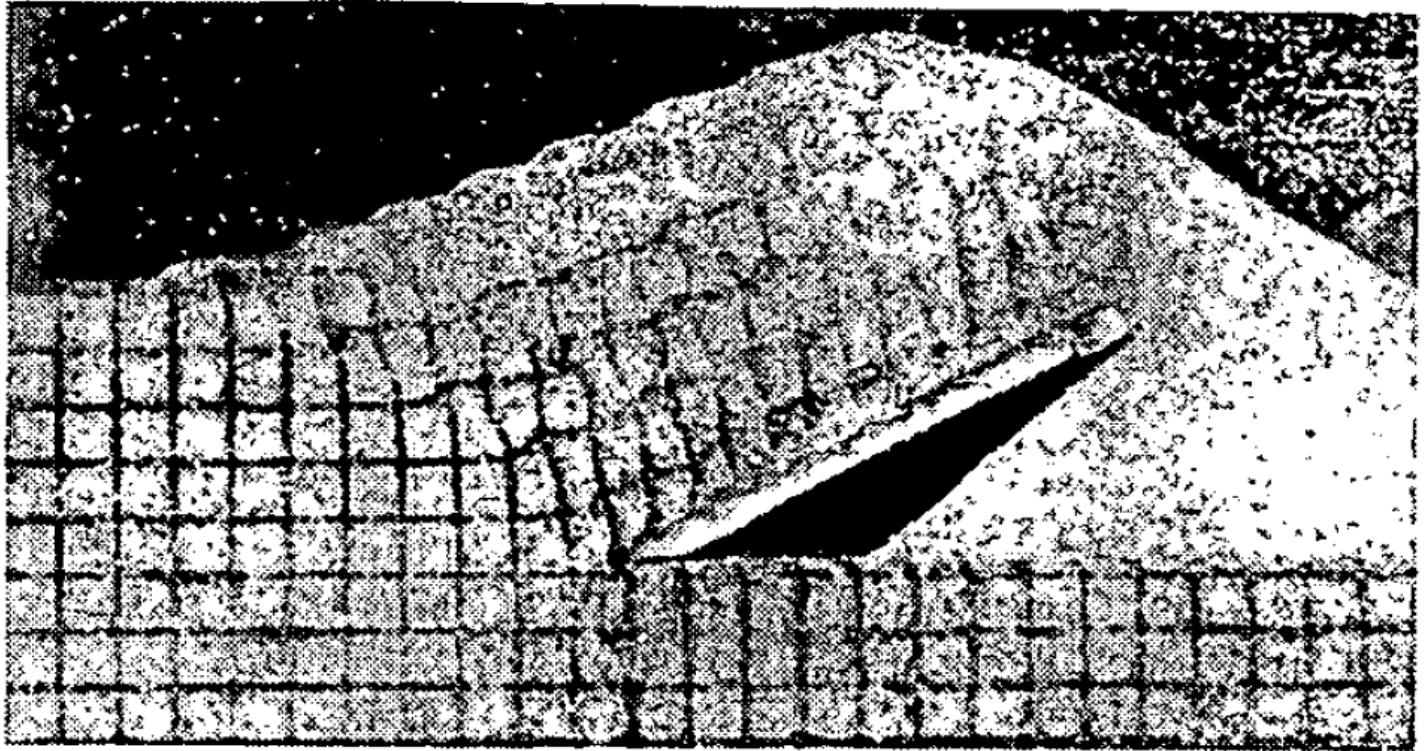


Fig. 6 Tear type



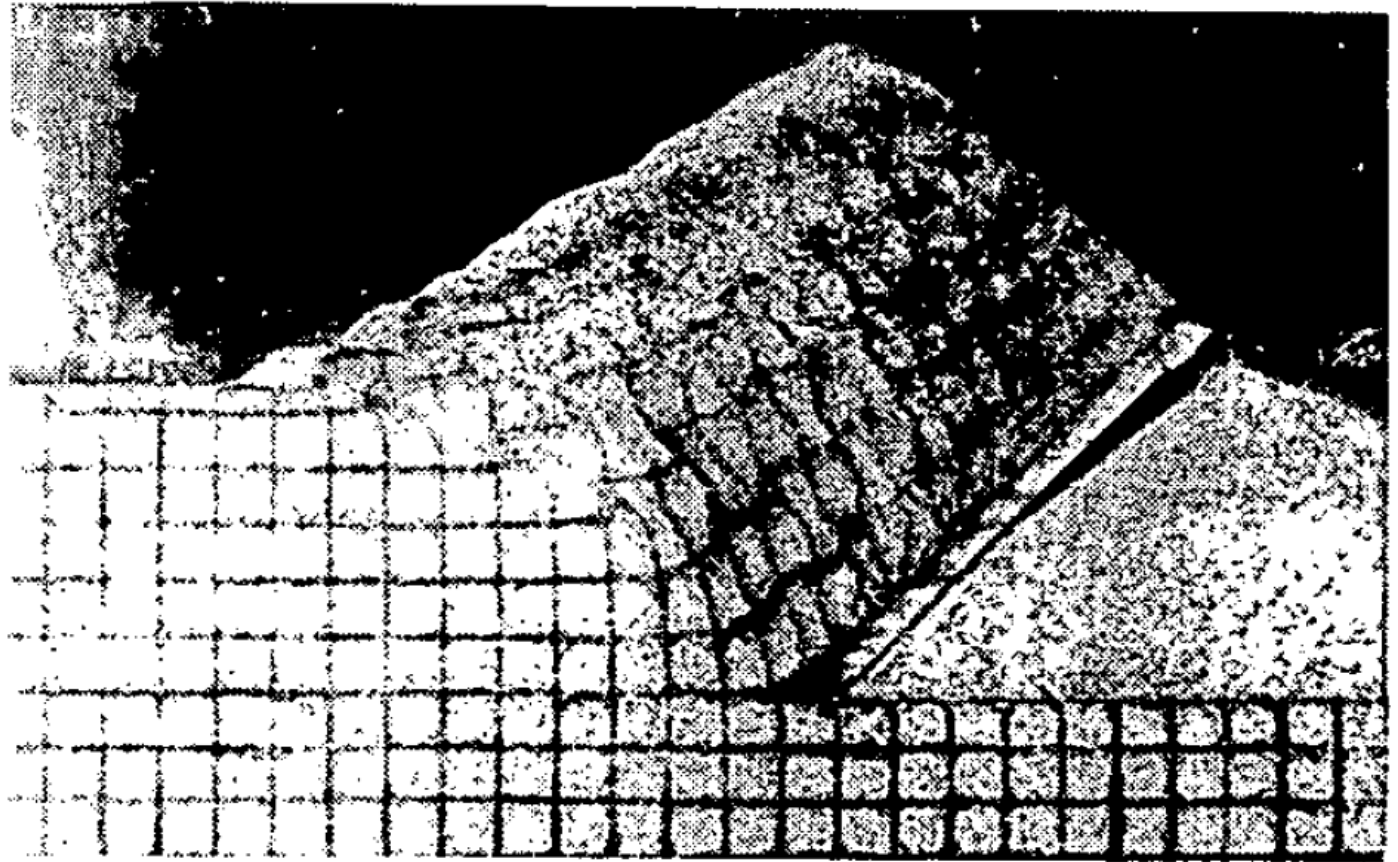
Cutting Mechanisms in Sand

Hatamura Chijiwa Dry Sand 30 deg.



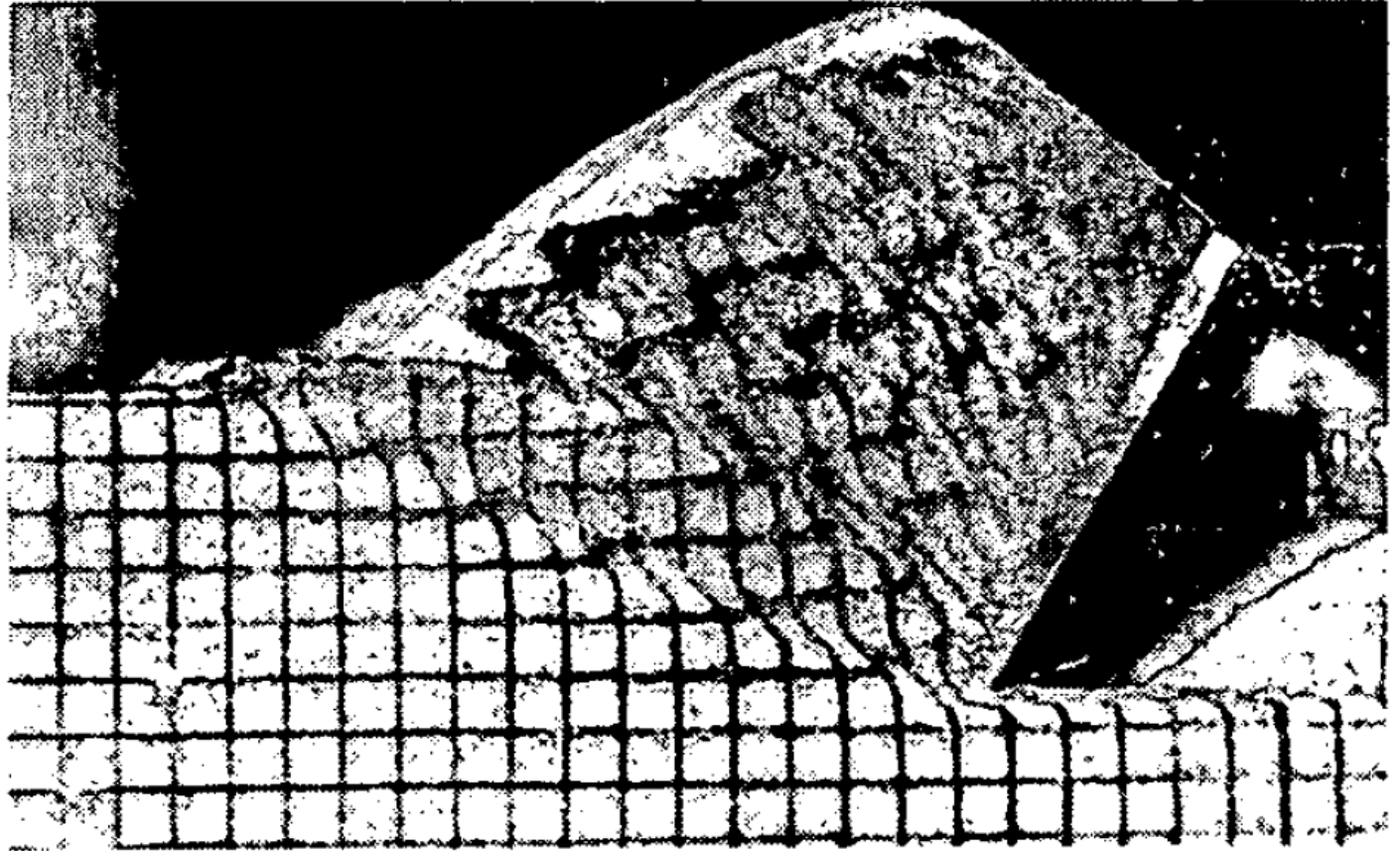
(a) Cutting angle $\alpha = 30^\circ$

Hatamura Chijiwa Dry Sand 45 deg.



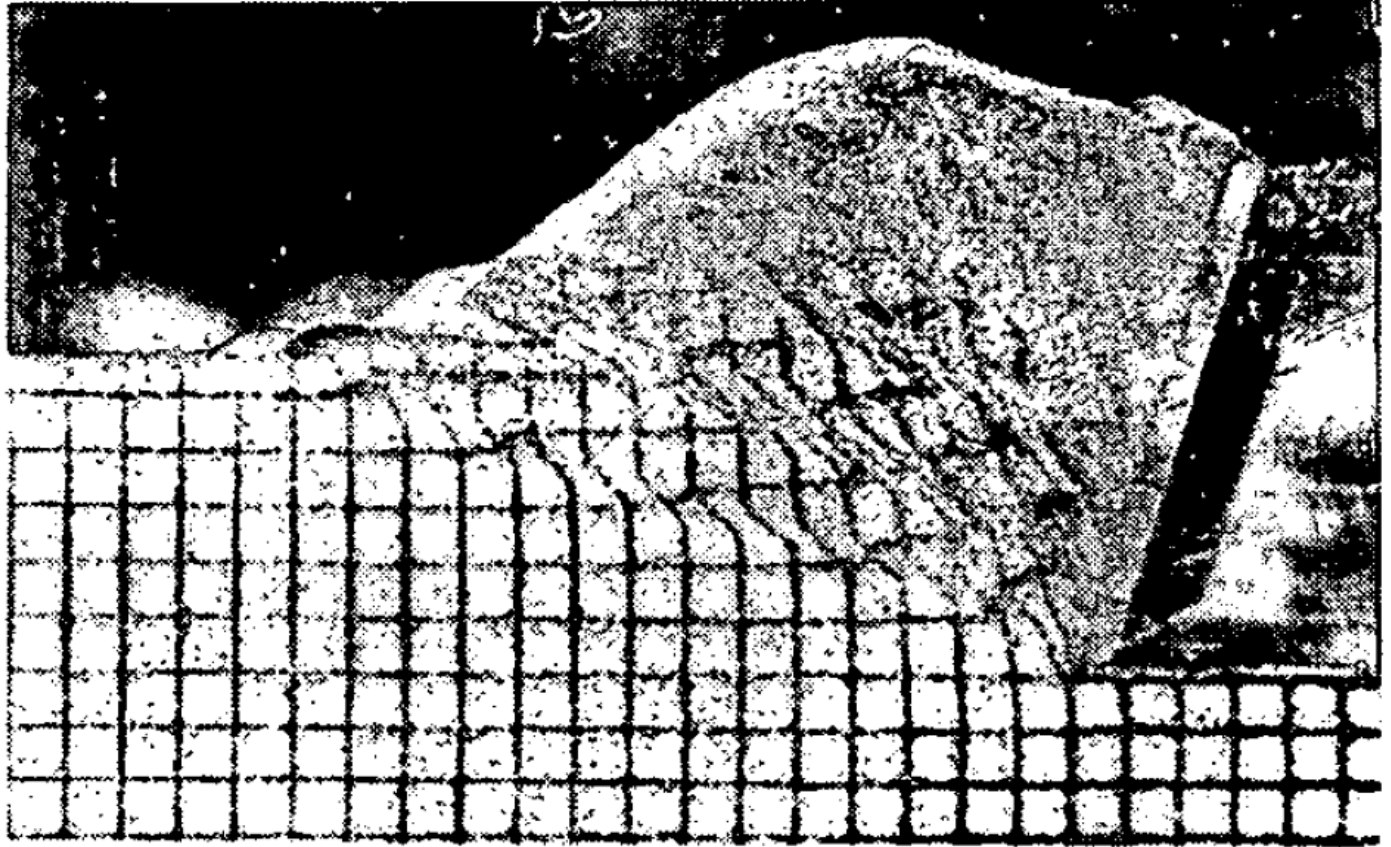
(b) Cutting angle $\alpha = 45^\circ$.

Hatamura Chijiwa Dry Sand 60 deg.



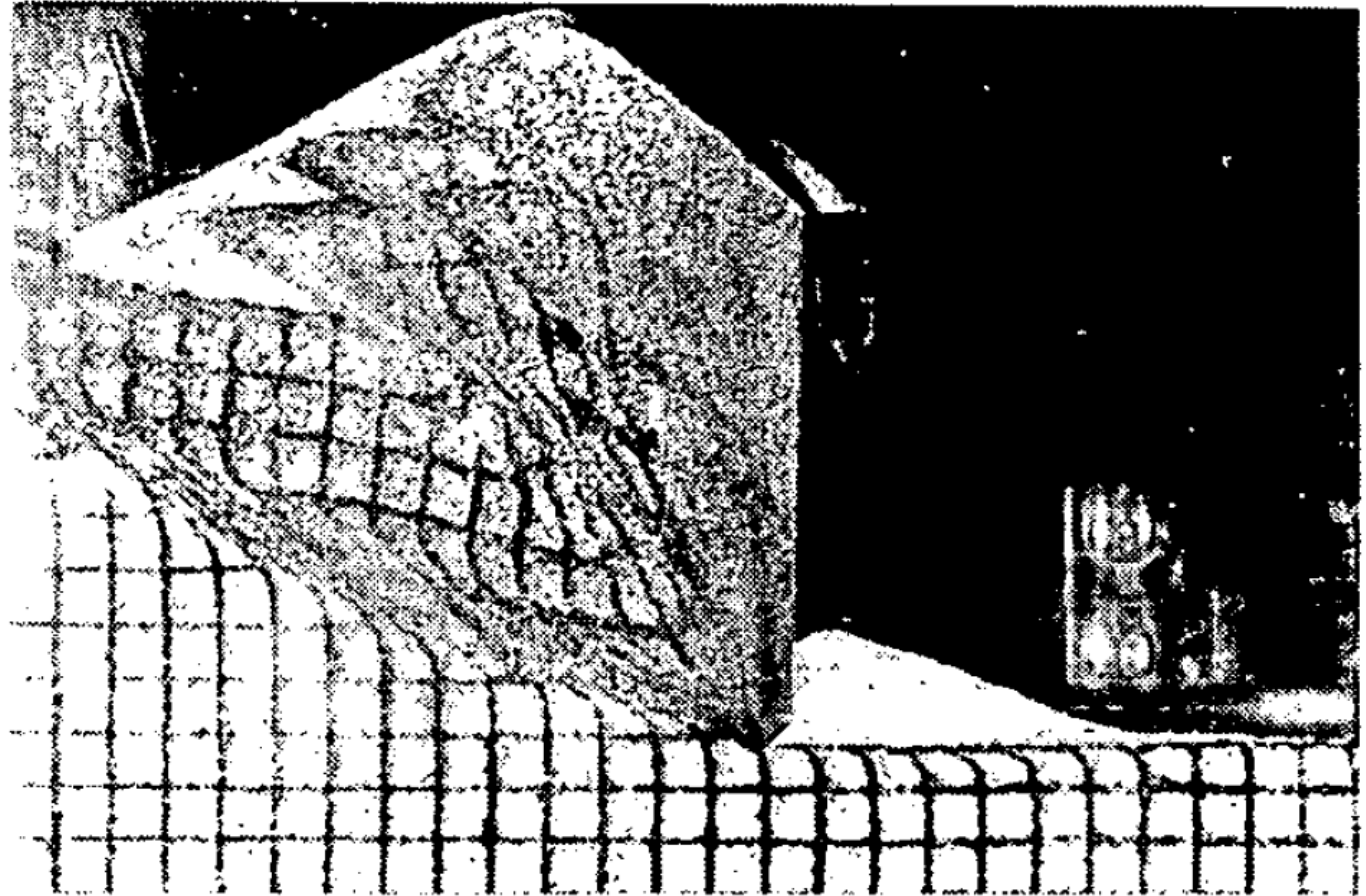
(c) Cutting angle $\alpha = 60^\circ$

Hatamura Chijiwa Dry Sand 75 deg.



(d) Cutting angle $\alpha = 75^\circ$

Hatamura Chijiwa Dry Sand 90 deg.

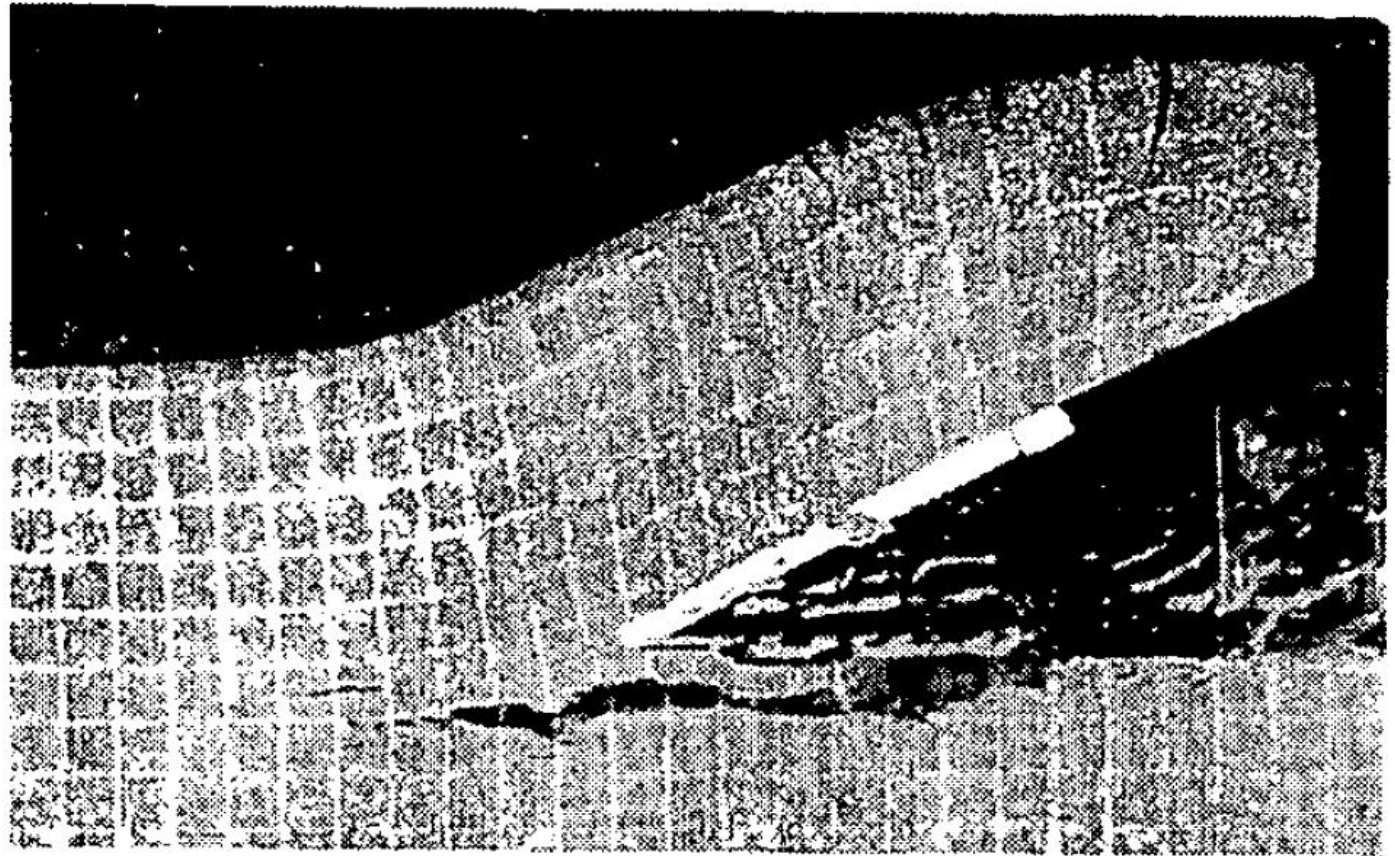


(e) Cutting angle $\alpha = 90^\circ$



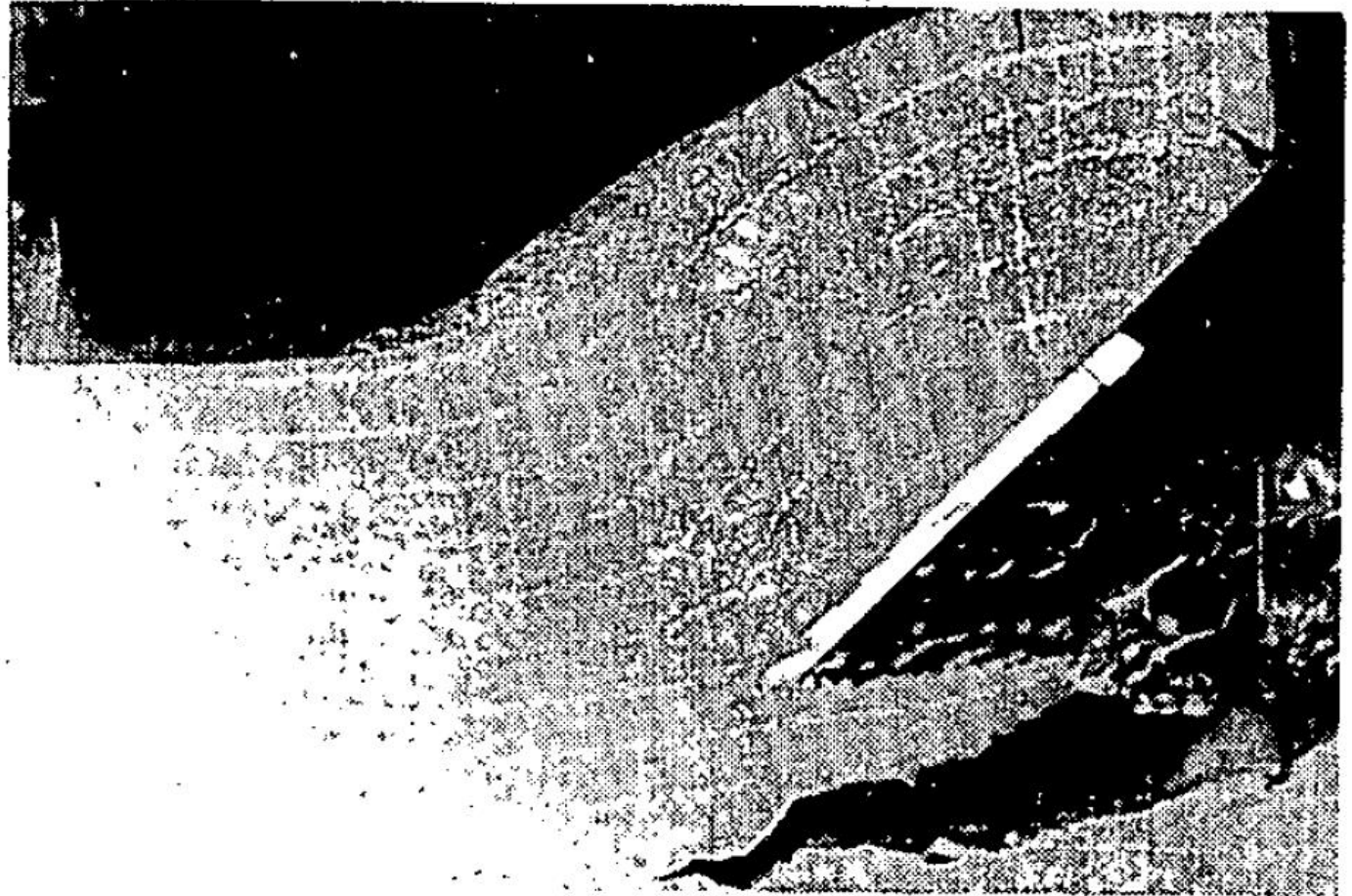
Cutting Mechanisms in Loam

Hatamura Chijiwa Plastic Loam 30 deg.



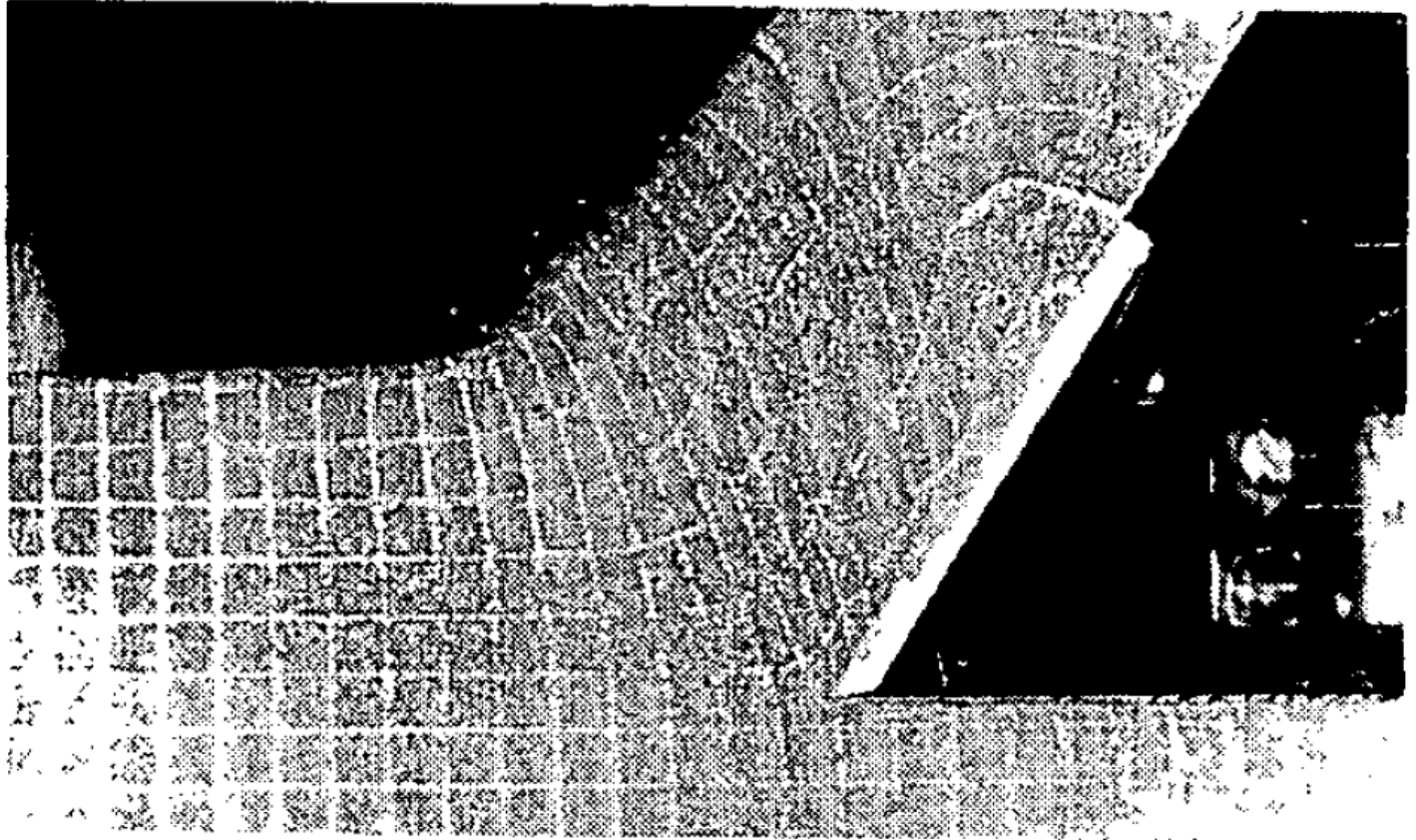
(a) Cutting angle $\alpha = 30^\circ$

Hatamura Chijiwa Plastic Loam 45 deg.



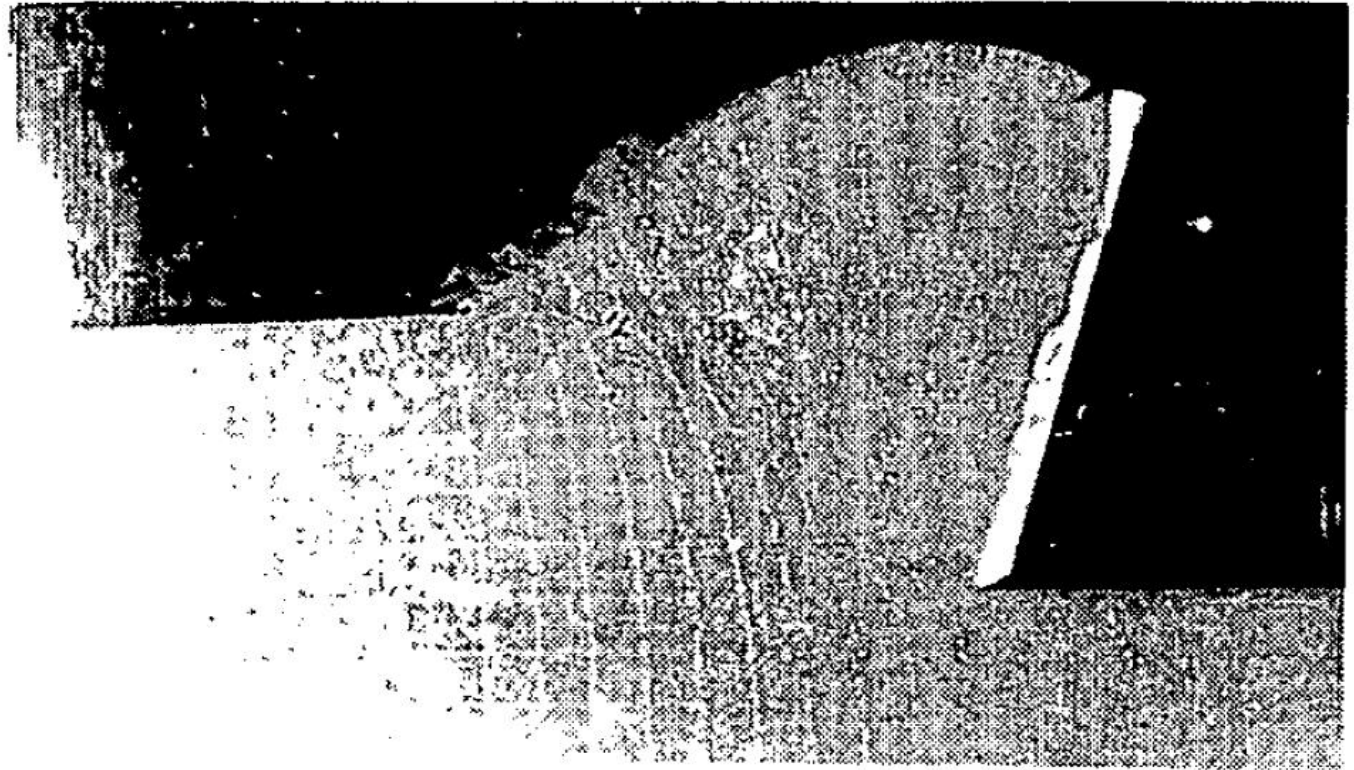
(b) Cutting angle $\alpha = 45^\circ$

Hatamura Chijiwa Plastic Loam 60 deg.



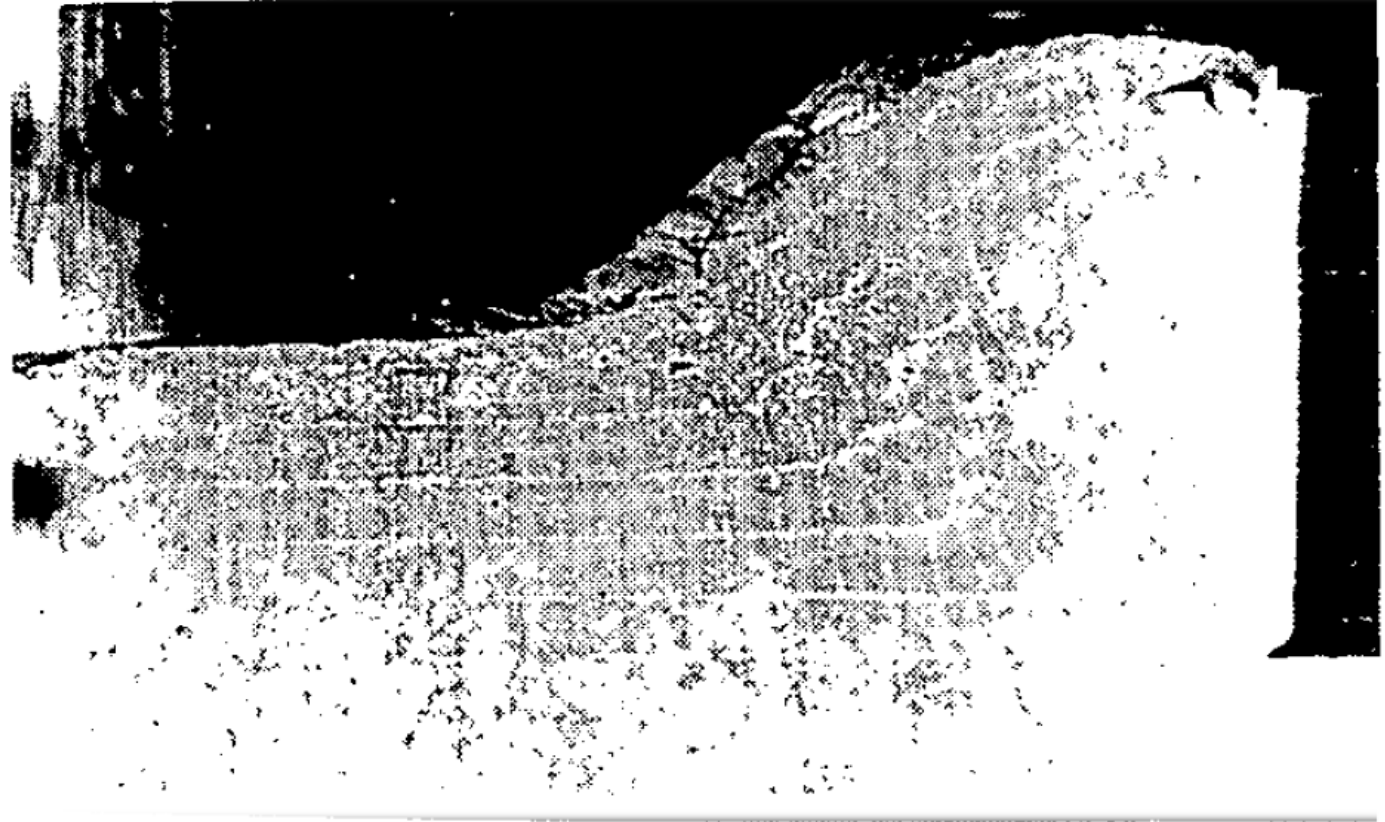
(c) Cutting angle $\alpha = 60^\circ$

Hatamura Chijiwa Plastic Loam 75 deg.



(d) Cutting angle $\alpha = 75^\circ$

Hatamura Chijiwa Plastic Loam 90 deg.

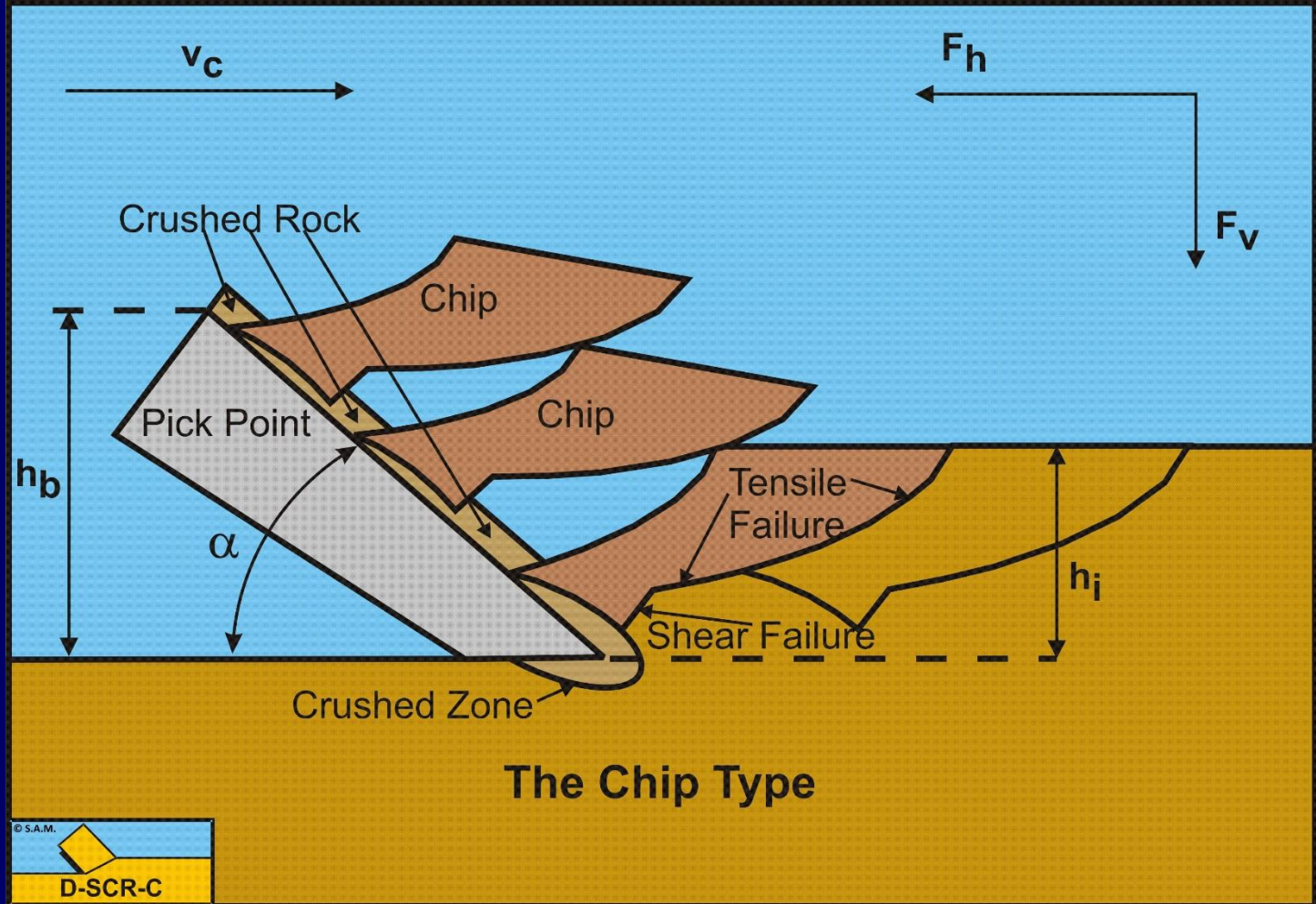


(e) Cutting angle $\alpha = 90^\circ$



Cutting Mechanisms in Rock

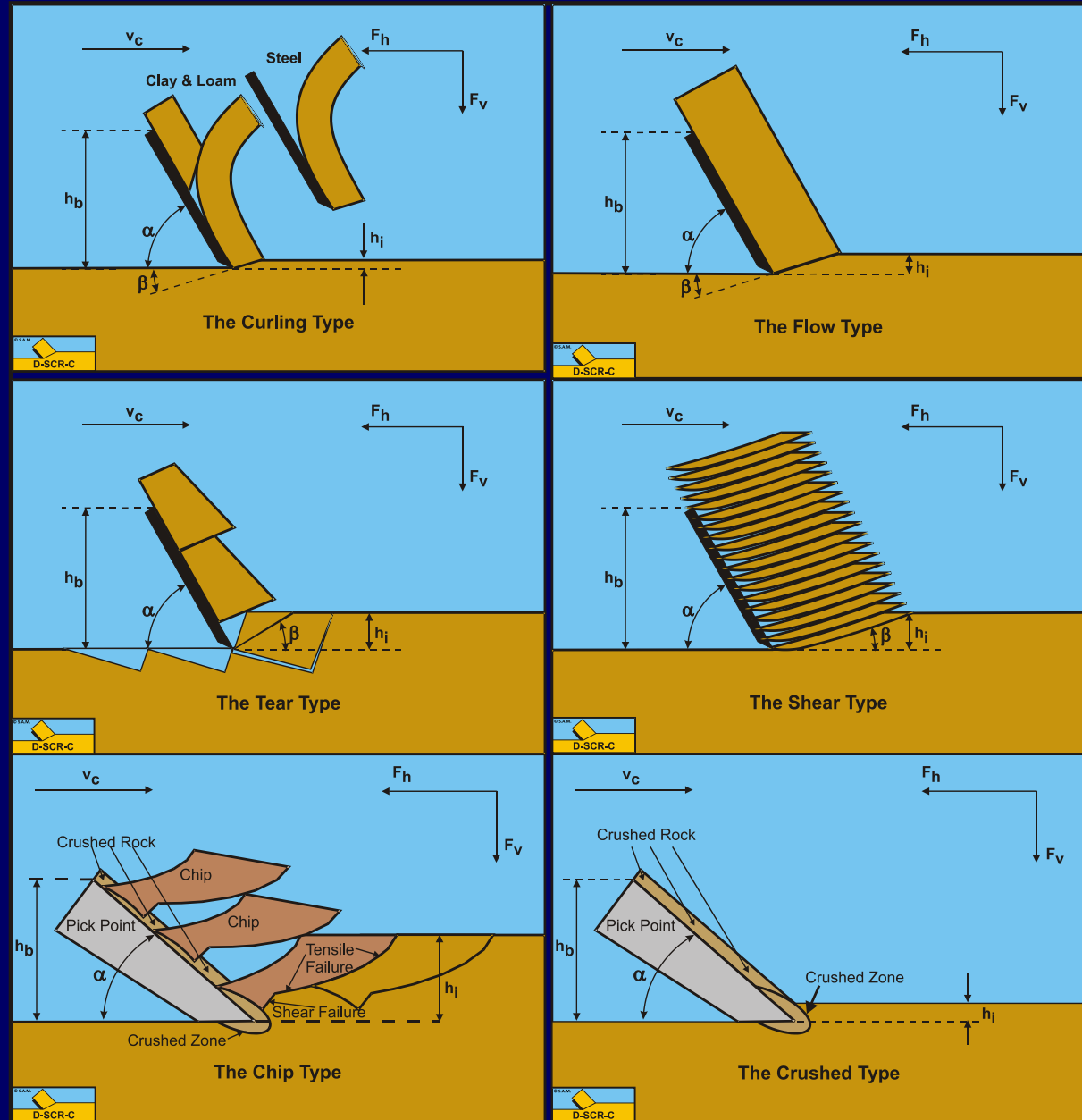
Cutting Mechanisms in Rock





Cutting Mechanisms

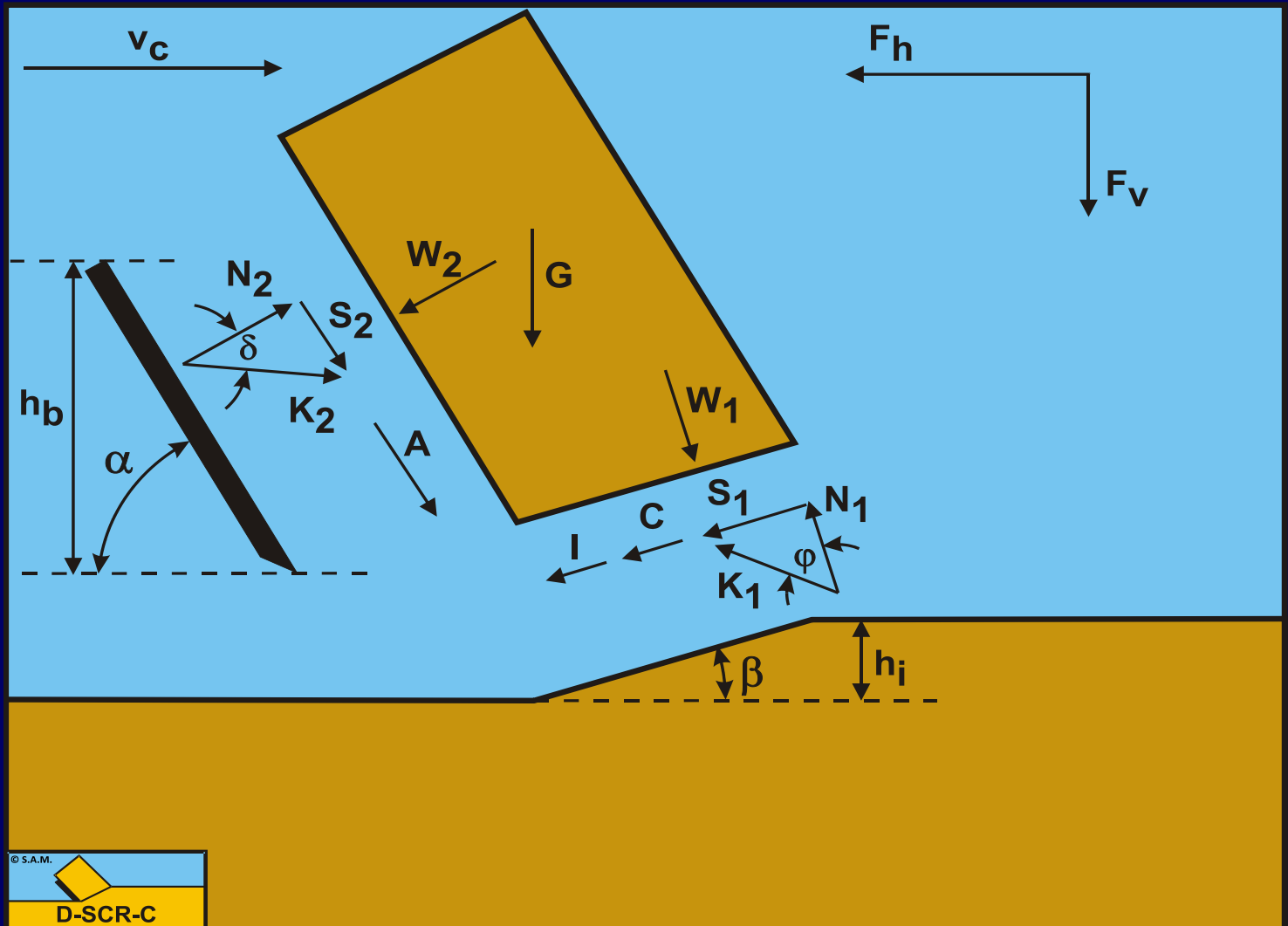
Cutting Mechanisms





Cutting Forces

Forces on the Layer Cut



Resulting Equations

$$K_2 = \frac{W_2 \cdot \sin(\alpha + \beta + \varphi) + W_1 \cdot \sin(\varphi) + G \cdot \sin(\beta + \varphi)}{\sin(\alpha + \beta + \delta + \varphi)}$$

$$\frac{+I \cdot \cos(\varphi) + C \cdot \cos(\varphi) - A \cdot \cos(\alpha + \beta + \varphi)}{\sin(\alpha + \beta + \delta + \varphi)}$$

$$F_h = -W_2 \cdot \sin(\alpha) + K_2 \cdot \sin(\alpha + \delta) + A \cdot \cos(\alpha)$$

$$F_v = -W_2 \cdot \cos(\alpha) + K_2 \cdot \cos(\alpha + \delta) - A \cdot \sin(\alpha)$$

Which Terms in Which Soil

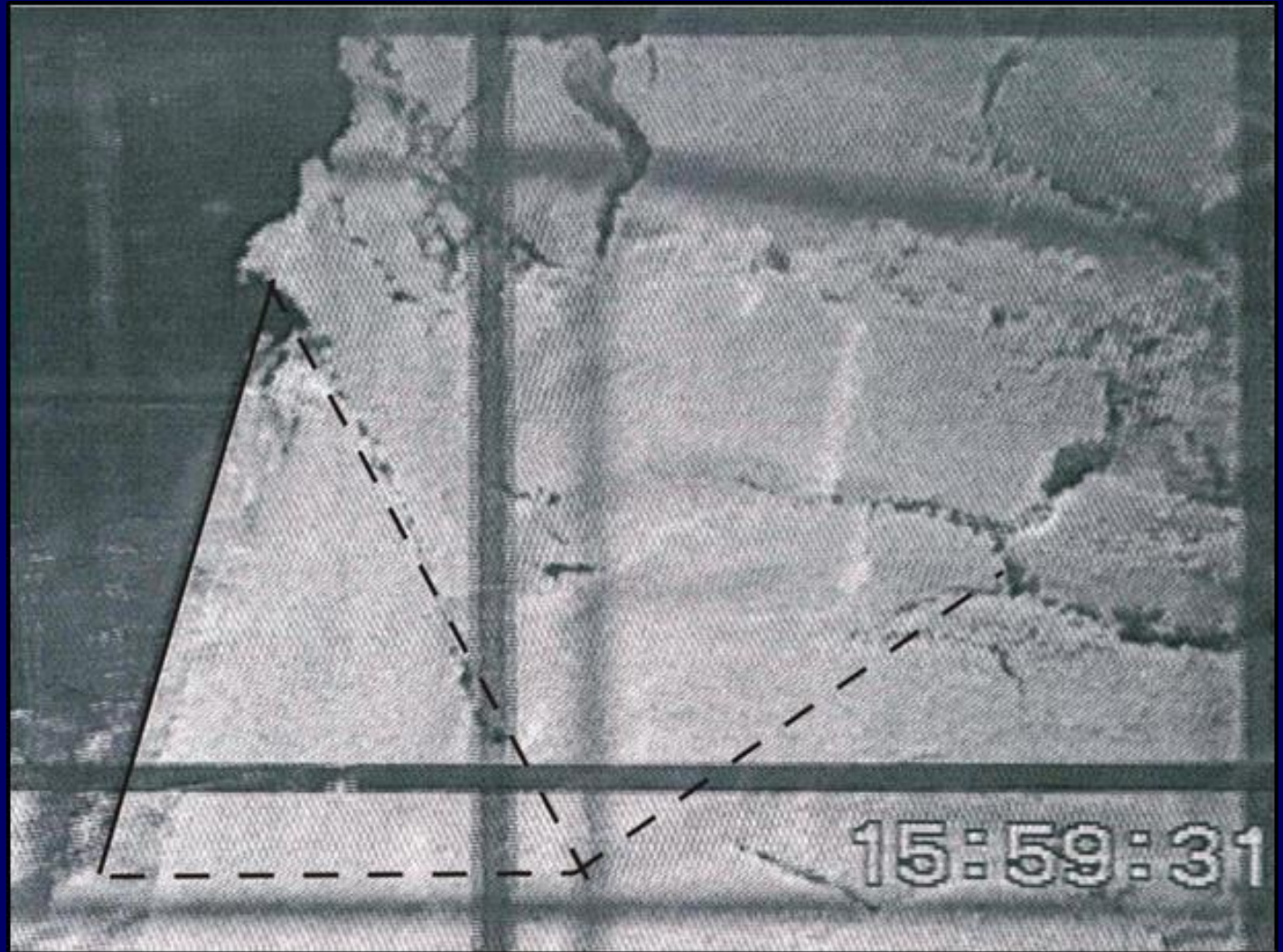
Table 1. The influences for each type of soil.

	Gravity	Inertia	Pore Pressure	Cohesion	Adhesion	Friction
Dry sand						
Saturated sand						
Clay						
Atmospheric rock						
Hyperbaric rock						

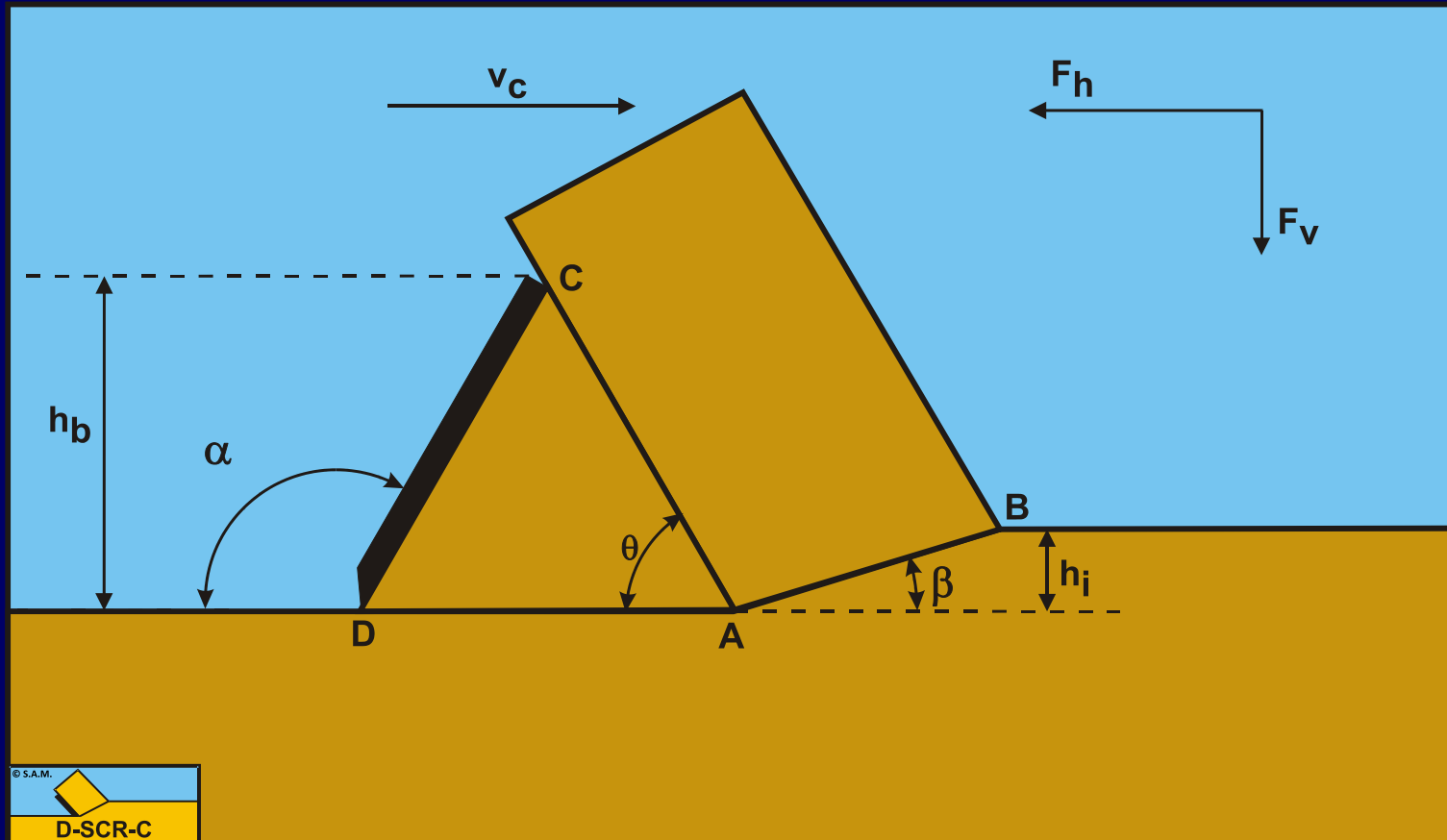


Cutting Forces with Wedge

A Wedge in Dry Sand

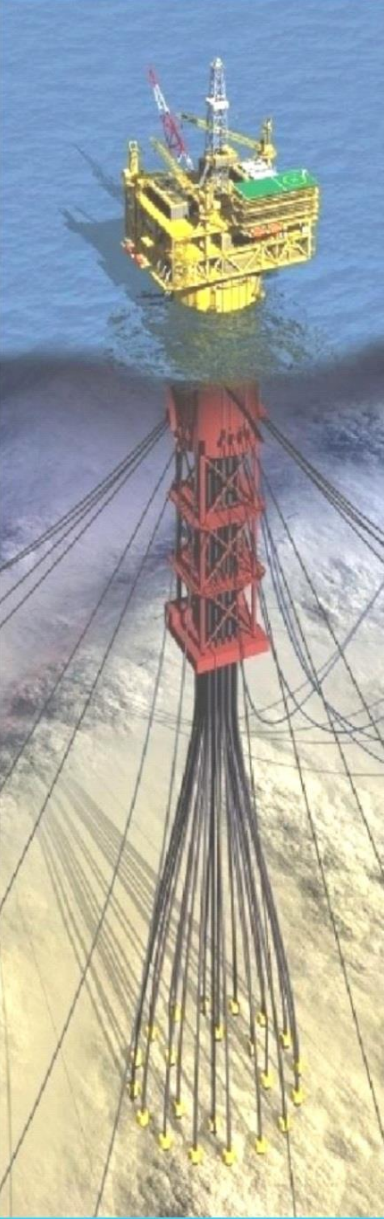


Wedge Definitions



CONCLUSIONS

- 6 cutting mechanisms are identified for ‘small’ blade angles.
- Dry Sand: The Shear Type.
- Saturated Sand: The Shear Type.
- Clay & Loam: The Flow Type, The Curling Type & The Tear Type.
- Atmospheric Rock: The Tear Type (Brittle Tensile), The Shear Type (Brittle Shear) & The Chip Type (Combination of Brittle Shear & Tensile).
- Hyperbaric Rock: The Crushed Type (Cataclastic Failure).





Questions?