



UNITED NATIONS EDUCATIONAL, SCIENTIFIC AND CULTURAL ORGANIZATION
INTERNATIONAL ATOMIC ENERGY AGENCY
INTERNATIONAL CENTRE FOR THEORETICAL PHYSICS
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SMR.1065 - 7

COLLEGE ON SOIL PHYSICS 14 - 30 APRIL 1998

"Soil Structure and its Stability"

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These are preliminary lecture notes, intended only for distribution to participants

SOIL STRUCTURE & ITS STABILITY

PHYSICAL SOIL DEGRADATION

15% {
- water erosion
- wind erosion
- chemical
- physical

1. SOIL COMPOSITION + HUMAN ACTIVITIES

2. SOIL STRUCTURE < good ?
bad ?

3. AGGREGATION & STABILITY

- NO
- SOIL & Water Erosion
 - INFILTRATION

AGGREGATION

- * MINERAL PARTICLES
- * ORGANIC MATERIAL
- * MOISTURE CONTENT
- * CHEMICALS (SALTS)

STABILITY

- * IMPACT OF RAINDROPS
- * ENTRAPPED AIR
- * MECHANICAL FACTORS (SOIL TILLAGE)
- * SWELLING/DISPERSION

DISPERSION

SLAKING

SEALING & CRUST FORMATION

AGGREGATE FORMATION

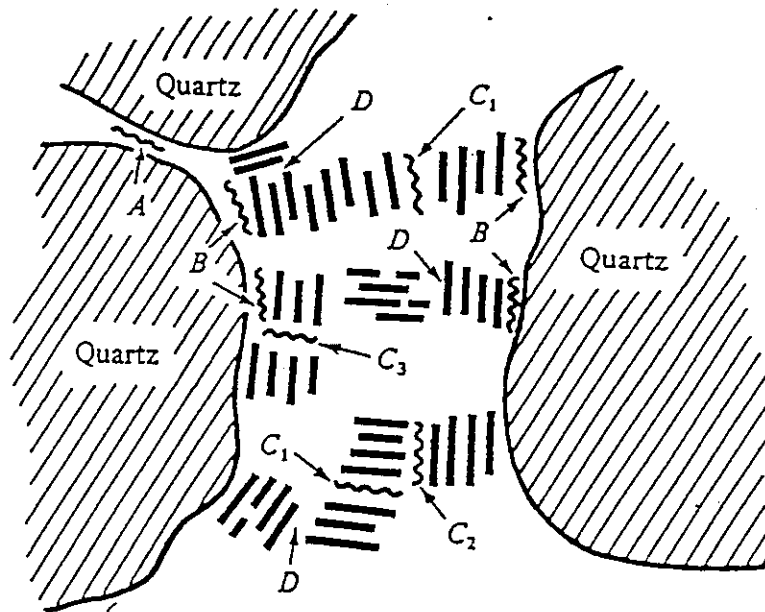


Fig. 8.2. Possible arrangements of quartz, clay domains, and organic matter in an aggregate (Emerson, 1959). Type of bond: A, quartz-organic matter-quartz; B, quartz-organic matter-domain; C, domain-organic matter-domain (C_1 , face-face; C_2 , edge-face; C_3 , edge-edge); D, domain edge-domain face.

+ WATER

* AGGREGATION

* STABILITY

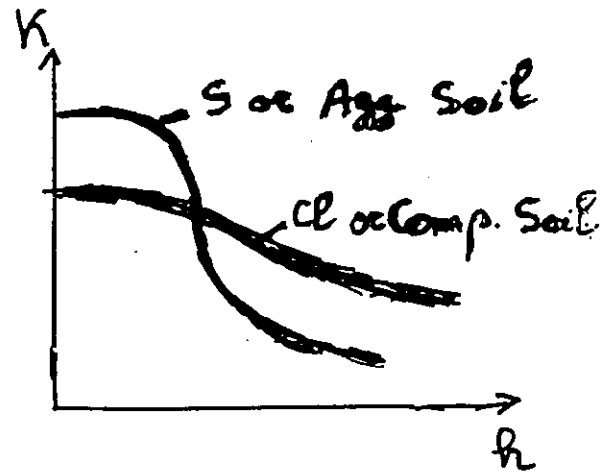
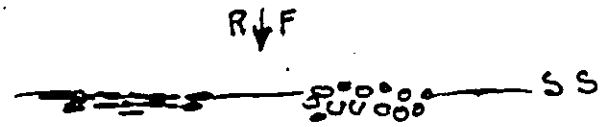
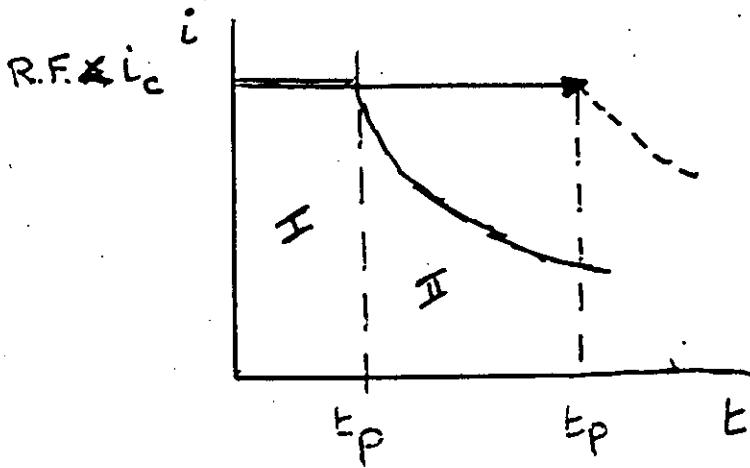
- WATER
- AIR
- HEAT

ECONOMY

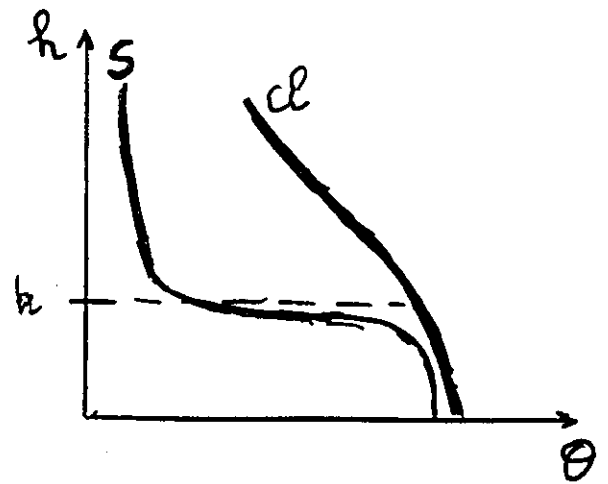
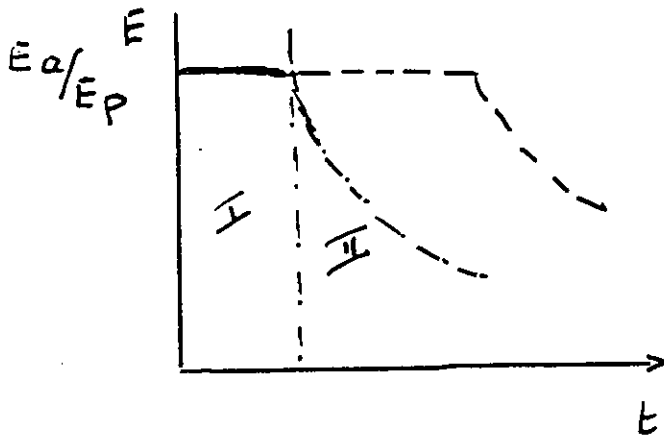
Importance of soil structure & its stability

I Aggregate stability (soil surface) (Rainfall Int.)

1. Infiltration



2. Evaporation



II Compaction (mechanization)

SS H₂O compaction



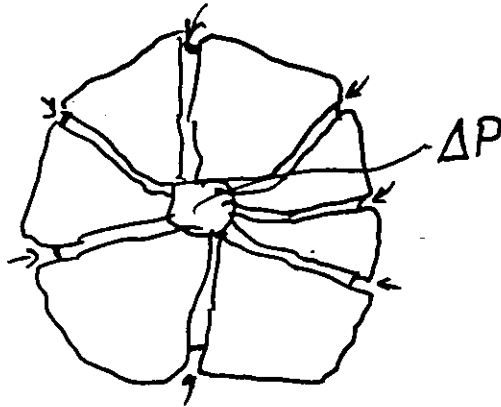
STABILITY of AGGREGATES

VS

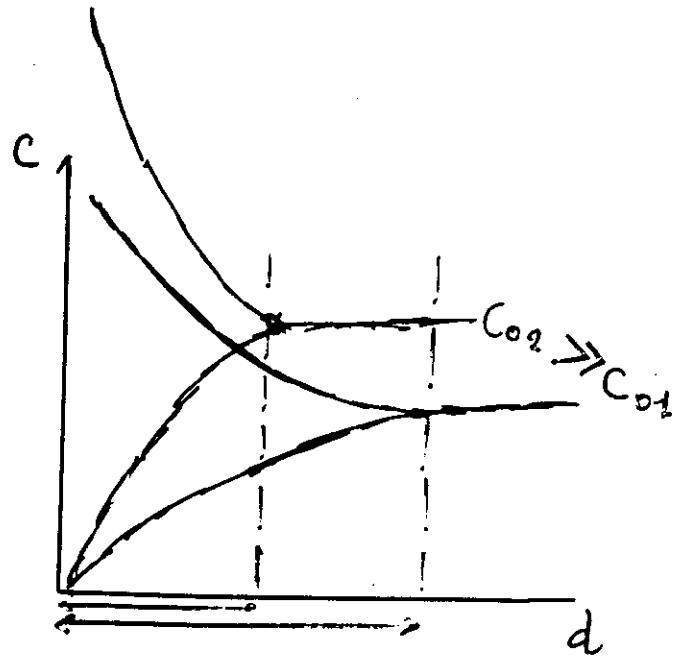
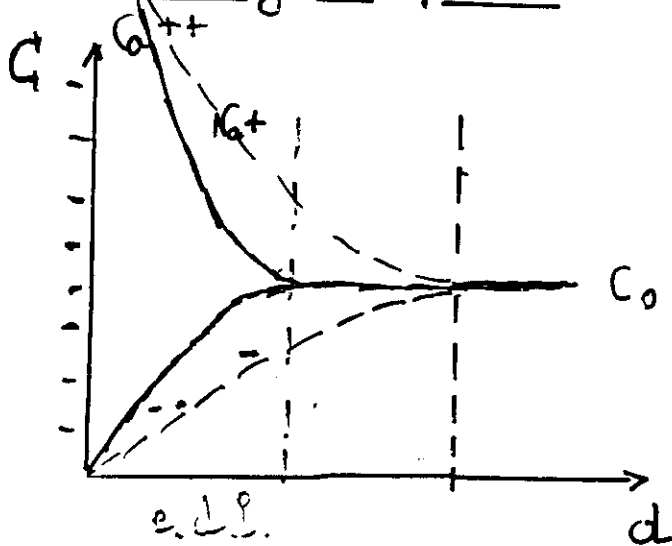
1. Impact of raindrops

$$\frac{1}{2} m v^2$$

2. Entrapped air



3. Swelling / Dispersion



STABILITY

- o.m.
- products of microbial origin
- sesquioxides
- substitutes: soil conditioners

1. evaluation of initial status

2. subjecting aggregates to destructive forces

→ wet sieving

→ rainfall simulation

3. comparison initial & final status

EVALUATION OF AGGREGATE STABILITY

- * DRY & WET SIEVING TECHNIQUE
- * ONE DROP METHOD
- * RAINFALLSIMILATOR
- * PERMEABILITY TEST
- * CONSISTENCY - INDEX " C_{5-10} "

DRY & WET SIEVING TECHNIQUE

1. DRY SIEVING

$$M.W.D._d = \left[\sum_{i=1}^{i=n} m_i \bar{d}_i \right] \frac{1}{\sum_{i=1}^{i=n} m_i}$$

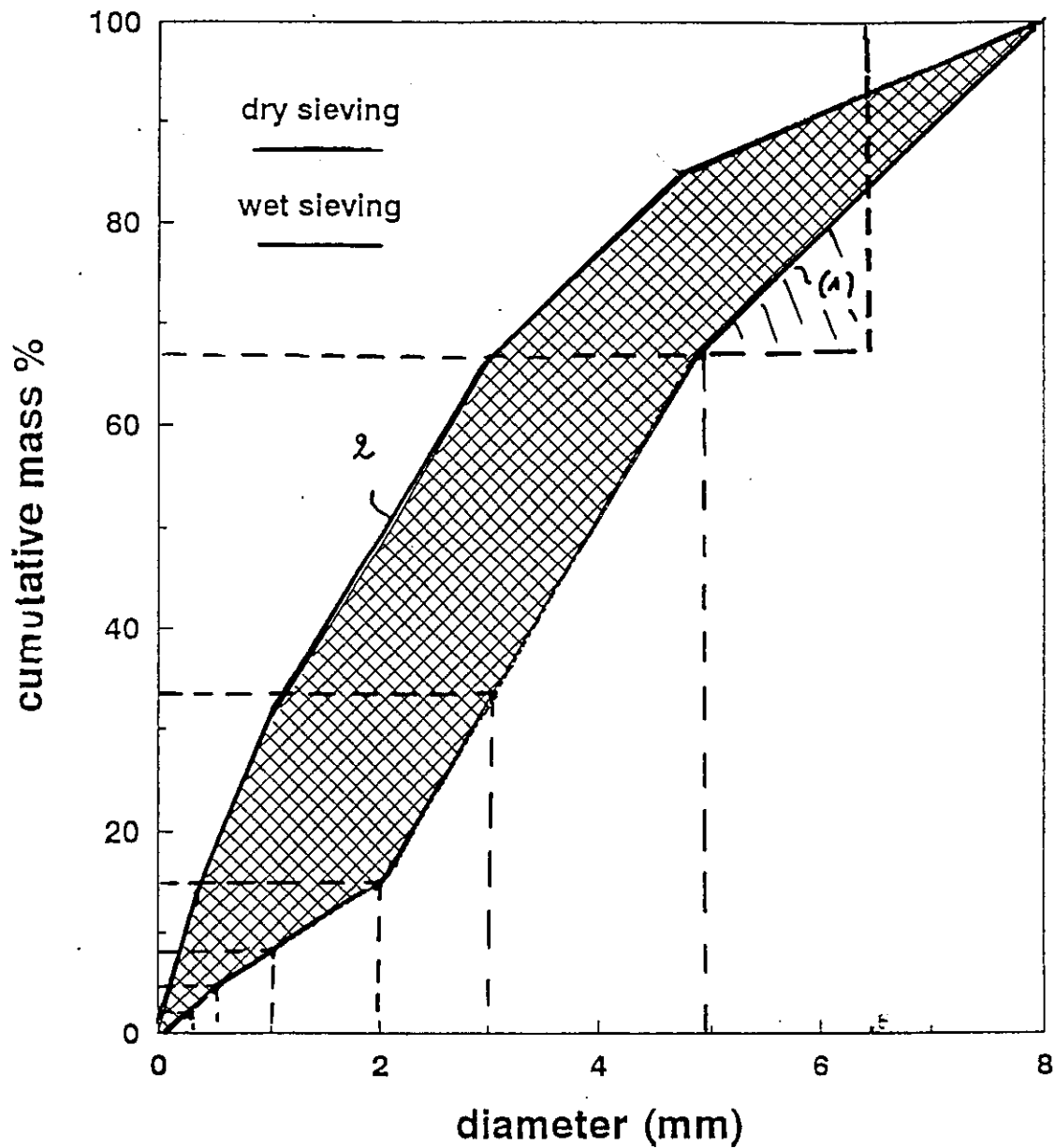
2. WET SIEVING

$$M.W.D._w = idem$$

$$I.S. = M.W.D._d - M.W.D._w$$

$$S.I = 1/I.S._1$$

AGGREGATE STABILITY



(1) aggregation % (> 2 mm)

Mean Weight Diameter (dry sieving) ——— I :

(2) Mean Weight Diameter (wet sieving) ——— I :

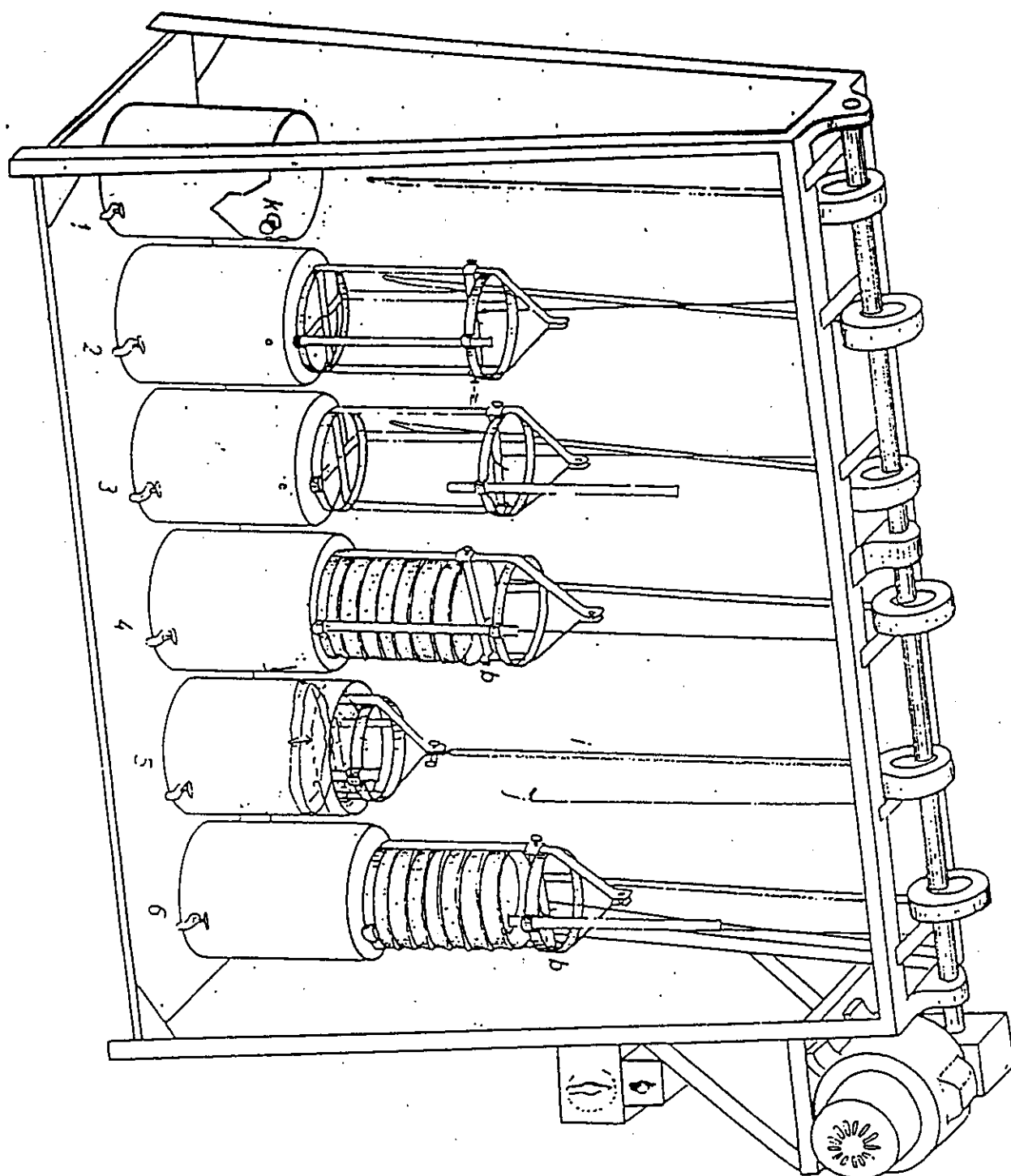


Fig. 4. Wet sieving apparatus.

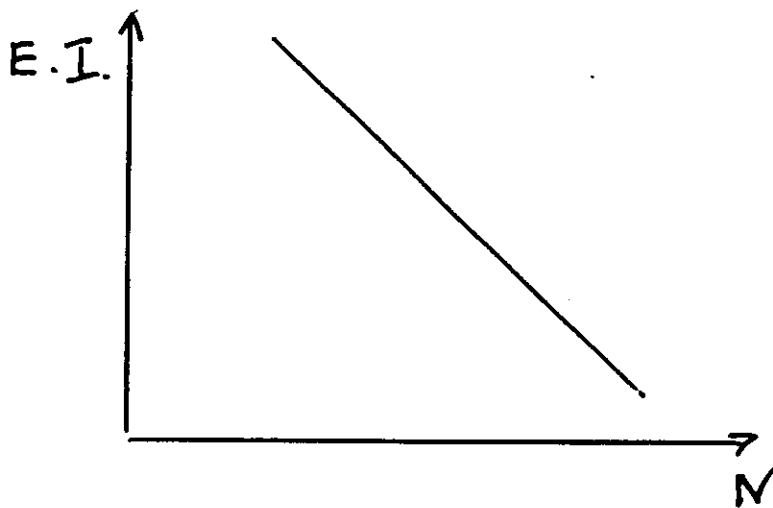
ONE DROP METHOD

$$E.I. = \sum_{i=1}^{i=N} \left[\frac{1}{2} m_i v_i^2 \right]^{-1}$$

m = MASS OF RAINDROP

v = FALL VELOCITY

N = NUMBER OF RAINDROPS



K.E. EXPRESSED PER UNIT MASS OF SOIL

$$S.I. = \frac{N \frac{1}{2} m v^2}{\sum_{i=1}^{i=N} M_i}$$

"1/2 m v^2"

N = NUMBER OF AGGREGATES

M = MASS OF AGGREGATE

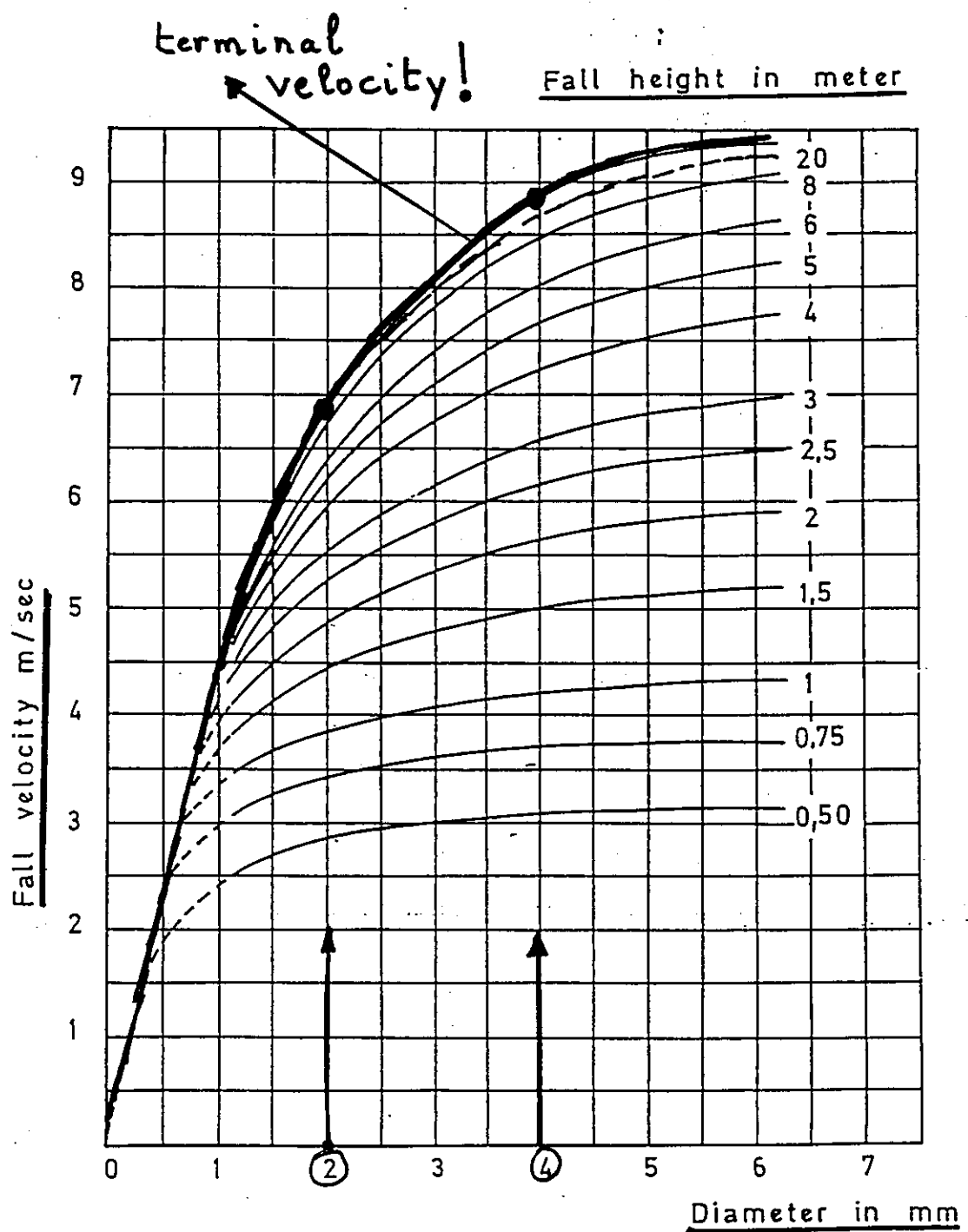


Fig.27 Relationship between dropdiameter and fall velocity for different fall heights (after LAWS, 1941)

RAINFALLSIMULATOR

$$K = A/R$$

K = ERODIBILITY

A = SOIL LOSS

R = EROSIVITY

PERMEABILITY TEST

$$K_{i\text{-water}} / K_{i\text{-air}}$$

$$K_s = K_i \rho g / \eta$$

UNIVERSAL SOIL LOSS EQUATION

$$A = R \cdot K \cdot LS \cdot C \cdot P$$

A = SOIL LOSS (TONS/Ha/YEAR)

R = RAINFALL EROSIVITY INDEX

K = SOIL ERODIBILITY FACTOR

L = LENGTH FACTOR

S = SLOPE FACTOR

C = CROP MANAGEMENT FACTOR

P = CONSERVATION PRACTICE FACTOR

SOIL CONDITIONERS

* **SOLUBLE ORGANIC POLYMERS/EMULSIONS ACTING
AS A CEMENTING AGENT BETWEEN THE PARTICLES**

* **INSURANCE**

* **SHOULD HAVE**

- **STICKY CHARACTERISTICS**
- **EASILY APPLICABLE**
- **LASTING ACTIVITY BUT DEGRADABLE**
- **NO PHYTOTOXIC EFFECT**
- **CHEAP**

SOIL CONDITIONERS

*** HYDROPHILIC**

- POLYACRYLAMIDE (PAM)
- POLYVINYLALCOHOL (PVA)

*** HYDROPHOBIC**

- BITUMENEMULSION
- POLYVINYLACETATE (PVAc)

APPLICATION EFFICIENCY

*** AGGREGATION [&] STRUCTURIZATION**

MOISTURE CONTENT

*** STABILIZATION**

AMOUNT

- SURFACE APPLICATION
- INCORPORATION