THE PAPUA NEW GUINEA UNIVERSITY OF TECHNOLOGY

DEPARTMENT OF MINING ENGINEERING

2021 SECOND SEMESTER EXAMINATION

THIRD YEAR MINERAL PROCESSING ENGINEERING

MN324 – Bulk Materials Handling in Mines

DATE: ***THURSDAY, 4TH NOVEMBER, 2021***

TIME: 12:50 AM

TIME ALLOWED: 3 HOURS

INFORMATION FOR CANDIDATES:

1. You have 10 minutes to read this question paper you **SHOULD NOT** begin writing during this period.
2. There are **FOUR** questions altogether. Answer **ALL FOUR** questions. Marks to each question are shown on the paper.
3. **ALL** answers must be written on the answer book provided. No other written material will be accepted.
4. Write your **NAME** and **NUMBER** clearly on the **ANSWER BOOK**. Do this **NOW**.

30

Question 1:

a. The study of bulk materials properties such as; (1) bulk density, (2) angle of repose, and (3) particle size distribution are important in bulk materials handling design. Explain concisely how any ONE of these affect material handling design.

(5 marks)

b. The ores from a gold mine is comprised of oxides and sulfides and are planned for processing through pressure oxidation and cyanidation methods at the mill. However to process refractory ore using this method has serious recovery issues depending on certain types of sulfides minerals present in the sulfide ores. The problematic ores are ores that contains higher levels of pyrite and galena, therefore in order to improve recovery the composition of the named sulfides in the feed must be equal to or less than 4%.

Consider that ore from a segment of the mine contains up to 10% galena-pyrite in the sulfide ores, explain how the ores from the mine will be practically handled to achieve the feed quality required by the mill in such situation. (Recommend a practical way of handling ore and justify your answer with appropriate calculation).

(5 marks)

c. Consider that a gold mine, is planned to process 800,000 tonnes of ore per year, and its operating schedule is; 3 shifts per day, 6 production hours per shift, 7days a week, and 48 weeks per year shift schedules. The process plant availability is estimated at 90% of scheduled production time, with scheduled major maintenance shutdown 3 times a year and each shut down involves 6 hours. However, general production surge variation between the mill and mine is estimated will averages 6 hours of production time as well. Therefore, it is planned that production surges from the mine and mill be catered for by a stockpile ahead of the milling process.

Given these; Design a conical stockpile with a single draw-point (i.e. recommend stockpile size) to be constructed ahead of the milling operations. It is known that the material has a density of 1750kg/m^3, and angle of repose of 38^0. The draw-point design is expected to result in an angle of draw-off of 45^0.

Useful formula; $R = \frac{Tan^2(A)}{(Tan\,A + Tan\,B)^2}$, *(all symbols carry the usual meaning)*

(7 marks)

QUESTION 2:

a) (i). State and describe with the help of neat sketches the two main flow patterns observed in bins/hoppers.

(ii). State and describe with the help of neat sketches the two main flow problems that occur in bins/hoppers which must be eliminated by proper bin/hopper designs.

(5 marks)

b) Consider that you are required to keep 140 tonnes of bulk materials as temporary bin/hopper storage to feed into a subsequent process at a desired controlled feed rate. The bulk material has the following properties;

- bulk density 2500kg/m^3
- Effective angle of friction is 55^0
- Internal angle of friction is 30^0
- Wall friction angle is 40^0
- Critical flow factor (ff_c) is 1.0
- Flow function is described by figure 1 below.

The design requirements based on space and headroom clearance are that;

- Mass flow design is most desired
- Conical hopper and a cylindrical bin
- Expected bin diameter to be 3.5m
- Hopper angle is 20^0 for mass-flow designs.

Design a mass-flow bin/hopper to contain 140 tonnes of the bulk solids described above. Your design must specify;

(i) Dimensions of bins/ hopper with neat sketches. (Justify your design)

(ii) Hopper discharge rate (m^3/minute) of the bin/hopper if the actual flow factor (ff_a) on discharge is said to be, ff_a = 1.2.

The following are some useful formulae to help your calculations (all symbols carry the usual meaning);

$$Ba \geq \frac{2\sigma_{yc}}{\rho_b\, g},$$

$$Q_v = \frac{\pi B^2}{4}\left(\frac{Bg}{4\, tan\theta_{ch}}\right)^{1/2} x \left(1 - \frac{f_{fc}}{f_{fa}}\right)^{1/2},$$

(10 marks)

QUESTION 3:

a. Consider that a copper mine is to use belt conveyor as an alternative cost effective way to transport ore from the pit to the mill over a distance of 950m to the secondary crusher stockpile at the mill at an inclination of 8^0 against gravity. The combination of belt-width and belt-speed that gives the optimum belt conveyor operation is 1000mm and 2.6ms^{-1} respectively. Properties of the material include; crushed ore is lumpy and moderately abbrassive, bulk density is 2200kg/m^3, angle of reposose is 37^0, and angle surcharge is 25^0. The idlers to use are of 127mm sizes, and 3-roll idlers sets manufactured for average duty roles. (Also use additional information provided).

Determine;

(i) The expected productivity (t/hr) of the belt conveyor (show your workings to gain marks).

(ii) Power required at the drive drum if the carry capacity is assumed to be 2,672 tonnes per hour.

(iii) Motor power of a motor having an efficiency rating of 95%.

Useful formulae:

$Bmin = 1.11 \left(\frac{m_s}{\rho_b\, k_s\, U\, v}\right)^{0.5} + 0.056$,

F_{fb} = 0.025 x Mc x g; M_c = [m_{ic} + m_{ir} + (2 x m_b x cos α)] x L

F_{fL} =0.025 x M_L x g x L; F_{st} = (m_s/v) x g x H; F_N = K_{SR} x F_H

(all symbols carry the usual meaning)

(5 + 6 + 2 marks)

QUESTION 4:

a) Describe so as to distinguish between a settling slurry and a non-settling slurry. (5 marks)

b) Mine tailings from the mill at a copper-gold mine is to be transported by a heterogeneous slurry over a distance of 200m to the tailing pond. The inlet elevation is 1710 RL and the outlet elevation is 1706 RL, and minor head loses due to bends, vulves and pipe pittings is 5m. The slurry has the following properties; slurry viscocity is 4.0cp (centi-poise), yeild stress is 35dyne/cm^2, concentration of solids by volume is 30%, slurry transport velocity is 1.5m/s. Solids S.G is 2.4 and particle shapes are predominantly spherical. Other parameters to consider in design includes; pipe internal dia. is 15cm, pipe relative roughness is 0.00001, and water is to be used as the carrier fluid whose viscousity is 1.016cp.

Given the above conditions:

(i). Estimate the friction factor

(ii). Calculate the total pump discharge pressure (show your workings clearly)

(iii) Determine the critical velocity

(iv) Calculate tonnes of tails delivered per hour

Note: Usueful Formulae, use where appropriate. Also use appropriate charts to help with your work (all symbols carry usual meaning)

$$Re = (\rho\, v\, D)/\mu$$

$$H = f \times (L/D) \times (v^2/2g)$$

$$\frac{J - J_w}{J_w C_v} = 81 \left[\frac{gD(S_s - 1)}{v^2} \frac{1}{\sqrt{C_d}}\right]^{1.5}$$

$$NHe = (\tau_y/\mu_{sl}) \times (D/v) \times Re$$

$$S.G_{sl} = 1 + Cv\,(S.G_s - S.G_w)$$

Unit conversions

1cp = 1 x 10^{-3} Pa s, Pa s – Pascal seconds

1dyne = 1 x 10^{-5} N (kgm/s^2)

(7 + 5 + 5 + 3 marks)

(use appropriate charts below to help your working)

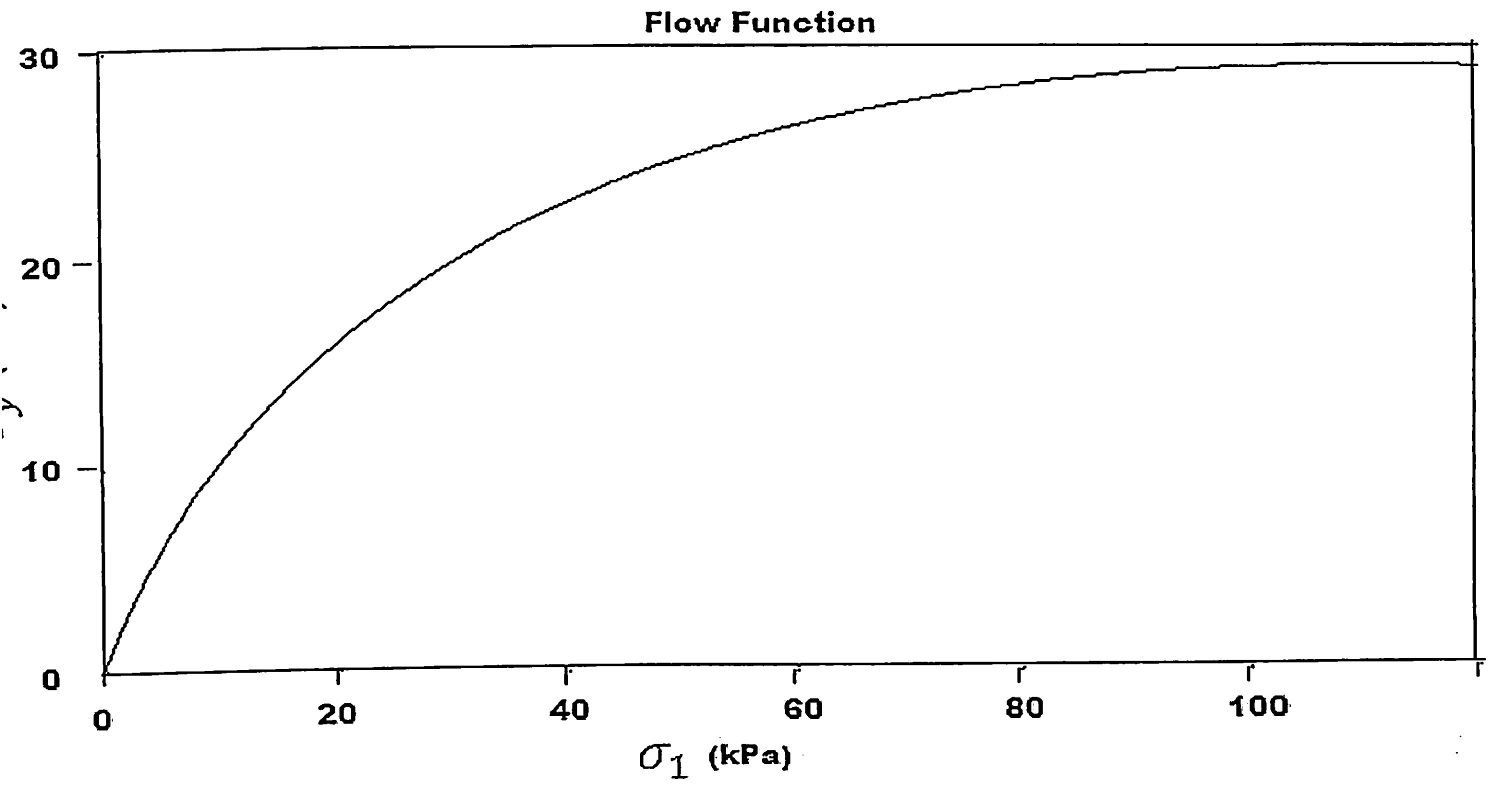
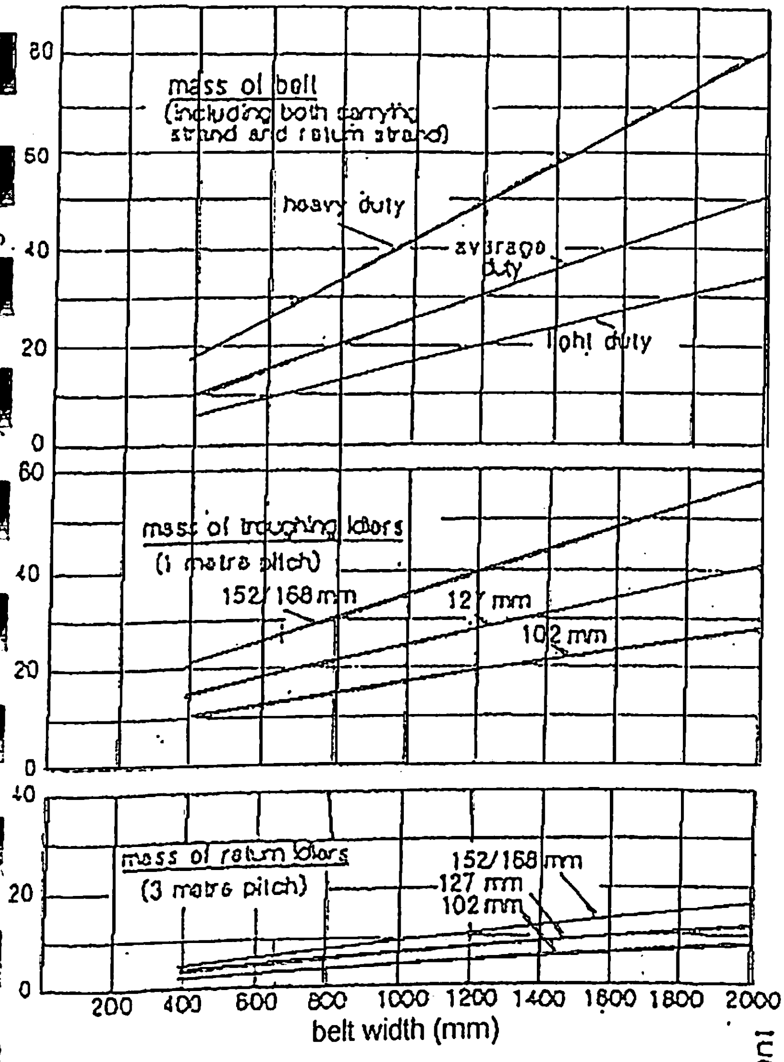


Figure 1 – Flow function

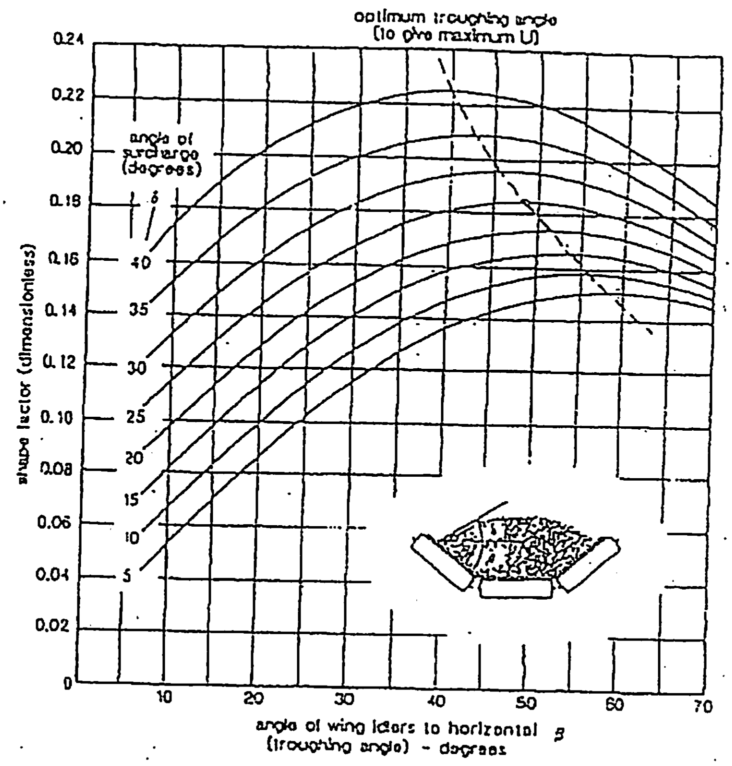
(Show working on the graph on the attached leaflet for marking)

Appropriate Design Charts

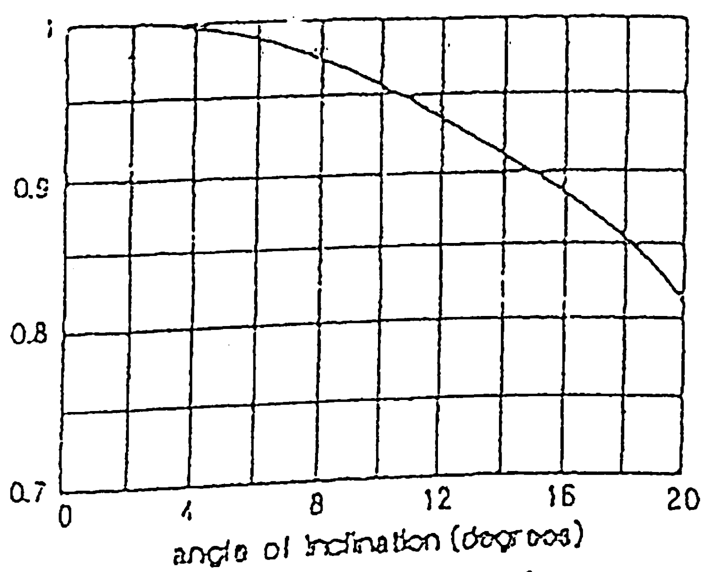
A: Belt Conveyors



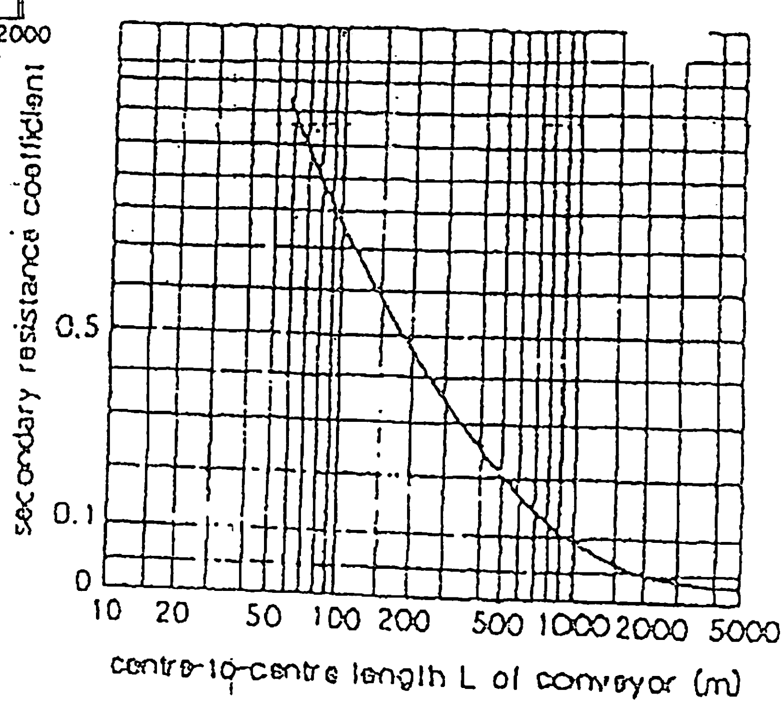
Unit mass of belt and idlers



Shape factor (U), area correction factor

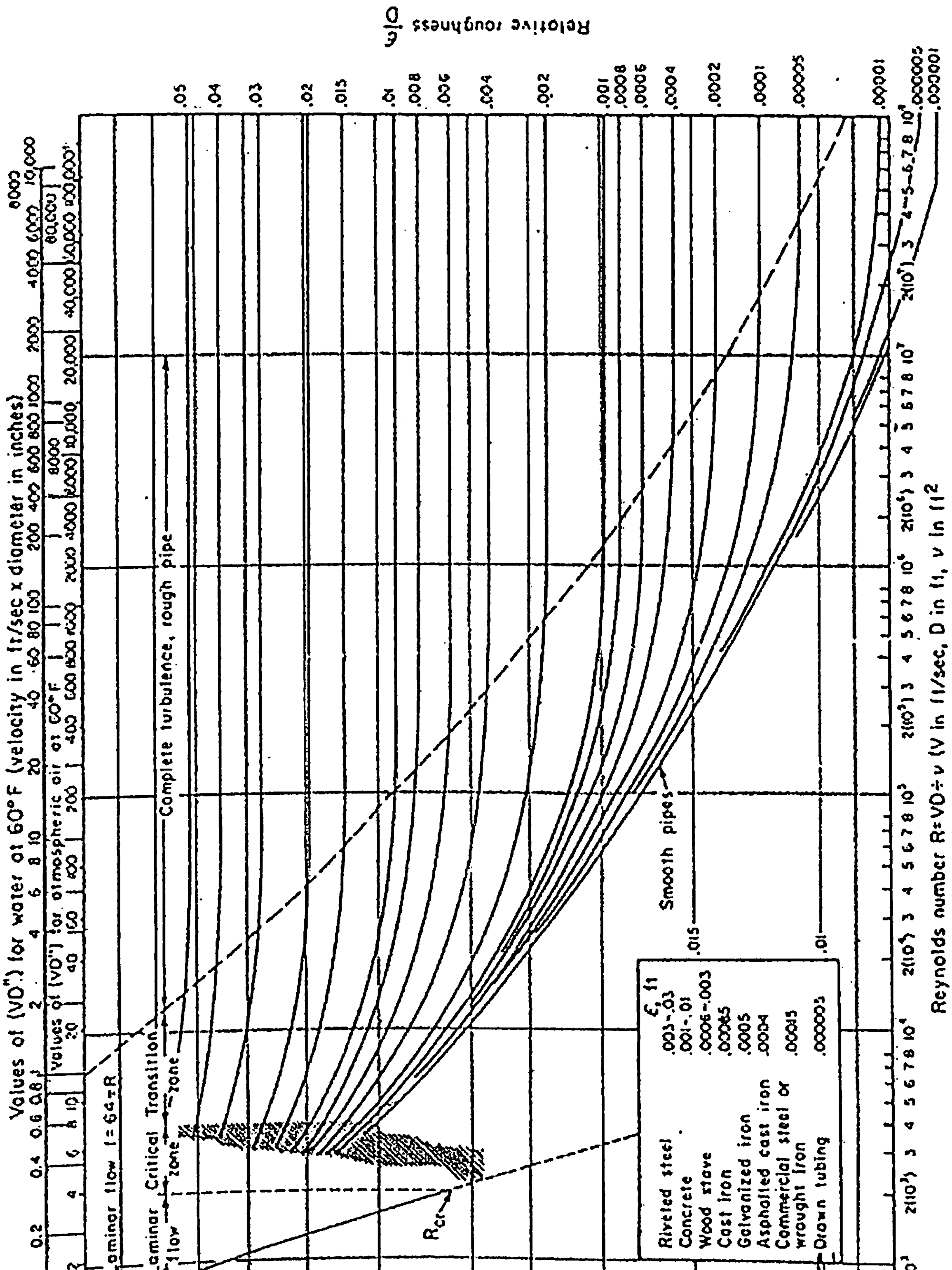


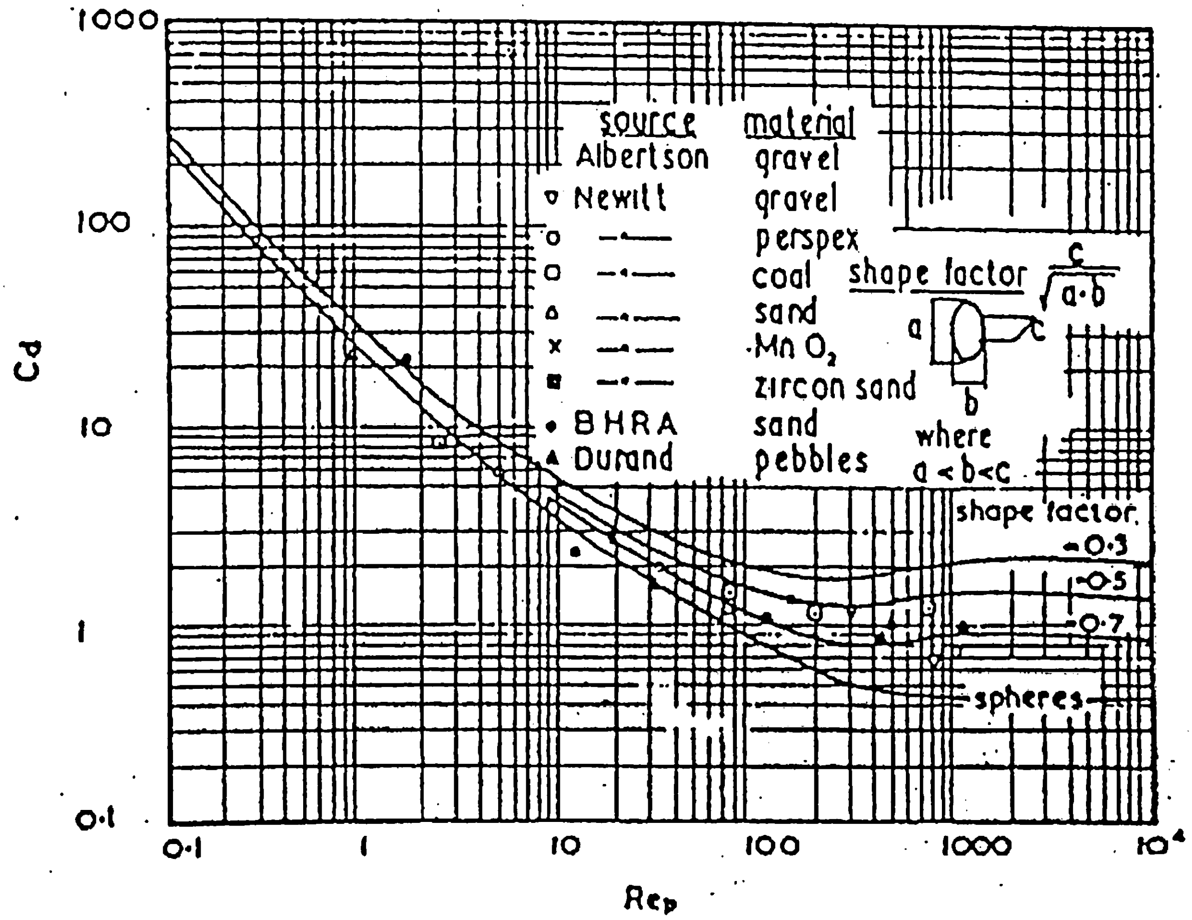
Slope factor (k_s), area reduction factor

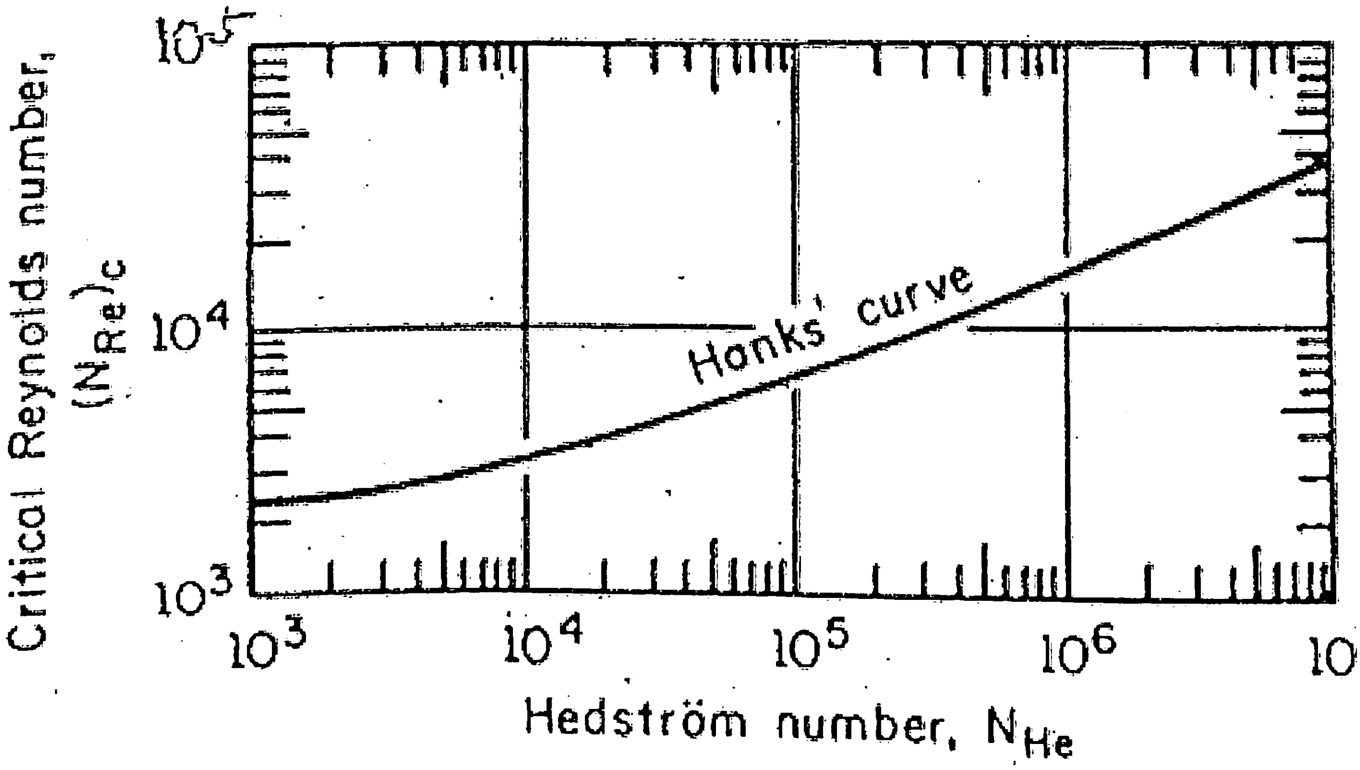


Secondary resistance coefficient

Slurry design charts:




1000
100
10
1
0·1
Cd
0·1
1
10
100
1000
10⁴
Rep
source
material
Albertson
gravel
Newitt
gravel
perspex
coal
sand
Mn O₂
zircon sand
BHRA
sand
Durand
pebbles
shape factor
c
√a·b
a
b
c
where
a < b < c
shape factor
0·3
0·5
0·7
spheres


Critical Reynolds number,
(N_Re)_c
10⁵
10⁴
10³
10³
10⁴
10⁵
10⁶
10
Hanks' curve
Hedström number, N_He