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Sedimentation Study of Reservoir for Baglihar He Project

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SYNOPSIS

All reservoir formed by Dam on natural water course are subject to varying degree of sedimentation. The degree of sedimentation depends upon a number of factors such as intensity of rain, and its seasonality, relief, soil character, natural vegetation, cultivation etc. in the catchment of the proposed Dam . Generation and transportation of sediment in its catchment and water course is a complex phenomena. Reasonable prediction of sediment yield in the catchment and its deposition in the reservoir requires an extensive knowledge of transport of sediment, particle size distribution and its mode of transport. Very little progress on theoretical analysis of such transport in the reservoir has been made till date.

However certain empirical and semiempirical methods are in vogue in determination of capacity reduction of reservoir with time. Some of those methods are used here in predicting the anticipated sedimentation rate of Baglihar dam.

1.0 INTRODUCTION

1.1 The sedimentation of a reservoir is a complex phenomena and depends upon a number of variable controlled by nature and affected by human interference.

1.2 For proposed dam site at Baglihar , silt data is available at Premnagar, Dhamkund and Kanthan site for the period of 1968 - 90, 1964 - 90 and 1965 - 72 respectively. Premnagar is about 39 km u/s of Baglihar . Dhamkund is 28 km d/s of Baglihar whereas Kanthan is 33 km d/s of Dhamkund.

1.3 Analysis of suspended load data at three sites shows a high silt load at Dhamkund which may be due to additional silt generation in between Premnagar and Dhamkund but mainly due to high velocity at Dhamkund reach resulting in conversion of part of bed load to suspended load.

1.4 Hence for bed load estimation vis-a-vis suspended load being transported in the reservoir, above phenomena requires to be examined. The correlation study of discharge & sediment load has been done by long term data series.

1.5 Estimate of total load at three sites and generation of series for sediment load at Baglihar has been done and then Emperical Area Reduction method is used to estimate the life of reservoir.

1.6 Future study envisages the long term analysis of bed material at Baglihar Dam site, attempt to estimate the bed material load by using different theoretical and semiemperical methods available and also to attempt to develop a relationship of bed load vis-a-vis. Suspended load with velocity and hydraulic slope for different discharges. Attempt shall be made to apply HEC-6 model to such reservoir to study the sedimentation profile.

2.0 CHENAB RIVER BASIN

The Chenab river originates at an elevation of about 4900 m in the form of two streams namely Chandra and Bhaga in the Himalayan canton of Lahaul in Himachal Pradesh.The chandra starts from a large snowbed on the south eastern side of Bara Lacha and after flowing South East for about 90 km sweeps round the base of mid-Himalayas and joins the Bagha at Tandi after a course of about 185 km. Where as the other stream Bagha rises in the North-western slopes of Bara Lacha. The length of Bhaga upto the con fluence with Chandra is about 105 km. The combined stream is known as Chandra Bagha or Chenab. The river travels about 650 km before it enters Pakistan at Akhnoor. The basin is shown in Fig 1.

2.1 There are four no. of major Hydro electric projects proposed on main Chenab river, Dulhasti HE Project (390 MW) which is u/s of all the projects is under construction. Baglihar (450 MW) and Sawalkot (600 mw) are under active consideration for construction and then Salal (345 MW) located d/s of all other project has already being constructed and is generating power. The Baglihar project, for which the sedimentation study of Reservoir is discussed is in the Doda district of J&K state. It envisages diversion of river Chenab through a 2 km long tunnel for power generation. The diversion shall be achieved by constructing a concrete gravity

dam of 141 m height with FRL at EL 840.0 m. The Dam has total storage capacity of 400 Mcum with estimated live storage of 46 Mcum and the length of Reservoir is about 30 km.

3.0 HYDROLOGICAL DATA OBSERVATION SITE

Premnagar, Baglihar, Dhamkund and Kanthan are sites where Gauge Discharge and silt observation are made. The catchment areas are 15490 sq.km., 17325 sq.km.,18750 sq.km. and 19904 sq.km. respectively for the above mentioned sites on main Chenab river.However observation at Kanthan has been discontinued in recent past.

3.1 As there is no silt observation being made at Baglihar dam site ; Premnagar, Dhamkund and Kanthan silt data are the source of sediment analysis for Baglihar project. Further at all three sites only suspended silt are observed and no observation is made for bed load. Punjab type bottle samplers are used for silt observation. The sample thus collected are analysed for three ranges ; fine (less than 0.075 mm), medium (0.075 mm - 0.2 mm) and coarse (more than 0.2 mm). In order to account for lower trapping efficiency of the bottle sampler, a correction factor of 1.43 is applied to coarse and medium silt.

3.2 Suspended Sediment Load At Premnagar

The following table gives the percentages of Fine, Medium and Coarse particles at Premnagar :

	Fine %	Medium %	Coarse %
As observed	51.00	31.90	17.10
After applying correction factor of 1.43 to C&M	42.15	37.65	20.20

The annual average suspended sediment load comes to be 2015 Ha-m (0.130 Ha-m/sqkm/year)

3.3 Suspended Sediment Load At Dhamkund

The following table gives the percentages of fine, medium and coarse particles at Dhamkund :-

	Fine %	Medium %	Coarse %
As observed	42.30	30.40	27.30
After applying correction factor of 1.43 to C&M	33.90	34.80	31.30

The annual average suspended load comes to be 3196 Ha-m (0.1704 Ha-m/sq.km./year)

3.4 Suspended Sediment Load At Kanthan

The following table gives the percentages of fine, medium and coarse particles at Kanthan :-

	Fine %	Medium %	Coarse %
As observed	42.90	34.00	23.10
After applying correction factor of 1.43 to C&M	34.45	39.00	26.55

The annual average suspended load works out to be 2984 Ha-m (0.150 Ha-m/sq.km./year). As the data series at Kanthan is for shorter period (about 7 years) the same can not be used with reasonable degree of reliability for sedimentation study as in case of Premnagar and Dhamkund. The cross-section of discharge observation site of Premnagar & Dhamkund are shown in Fig.2.

4.0 ANNUAL AVERAGE TOTAL SEDIMENT LOAD

4.1 Annual average suspended sediment load per sq.km. of catchment area for Premnagar & Dhamkund are 0.130 Ha-m/sq.km/year and 0.1704 Ha-m /sq.km./year and for Kanthan with limited data base it is 0.150 Ha-m/sq.km./year.It appears that there is a quantum jump of sediment load per sq.km. of catchment at Dhamkund compared to at Premnagar. Co-relation between Discharge and suspended sediment load for Dhamkund and Premnagar have been developed and drawn vide Fig. 3 & 4. In Fig 5 both the curves have been combined as it can be seen that both curves are almost parallel showing a high sediment load for all discharges at Dhamkund than at Premnagar. It has also been observed that for all discharges the average velocity at Dhamkund is higher than that at Premnagar, this shall be resulting in higher bed shear velocity at Dhamkund. Higher bed shear velocity at Dhamkund is likely to transfer a certain quantity of bed load or coarse particles near bed into suspended load. This also become apparent as we found that coarse particle fraction at Dhamkund increases to 27% from 17% at Premnagar and again reduces to 23% at Kanthan.(without correction factor). This mainly explain the reason of sudden increase of suspended load at Dhamkund, though other reason may be contribution of sediment by slips and slides in between the reach of Premnagar and Dhamkund. At this stage with the informatioin available it is difficult to make any logical assessmemt of bed load at both the sites on the basis of velocity etc., however it can be safely presumed that the percentage of bed load to suspended load at Dhamkund shall be less than that at Premnagar.

4.2 In absence of further data and information no theoretical analaysis was attempted for assessing the bed load. So for both Premnagar & Dhamkund the bed load has been taken as 20% of suspended load for the purpose of this study.

5.0 SEDIMENTATION OF RESERVOIR

5.1 Details of the method i.e. (i) Area increment method and (ii) Empirical area reduction method for estimating sedimentation of reservoir are given in CBIP Technical Report no. 19 .

5.2 Trap efficiency is calculated by using Brune's curve.

The capacity inflow ratio of the reservoir

$$\frac{C}{I} = \frac{\text{Gross Capacity}}{\text{Average Annual Runoff}}$$

$$= \frac{400 \text{ Mcum}}{20401 \text{ Mcum}} = 0.02$$

This ratio corresponds to a trap efficiency of 60% with middle curve of Brune.

5.3 The average annual sediment inflow at Baglihar dam was calculated by two different data base.

(i) The average annual sediment inflow at Premnagar was extended to Baglihar dam site by using catchment area proportion factor of 1.118. Sediment load comes out to be 2703 Ha-m. including 20% bed load.

(ii) It was found and discussed previously that average annual suspended load as determined at Dhamkund seems to be on higher side. However both Premnagar and Dhamkund load were interpolated to determine the suspended load at Baglihar and then again increased by 20% for bed load. Hence average annual load including bed load comes as 3216 Ha-m (0.186 Ha-m/sq.km./year)

5.4 For doing the sediment distribution study the area capacity curve at damsite was tabulated and then capacity versus depth was plotted on double log graph and reservoir was found to be Type II (Flood foot hill type) as per classification by Borland and Miller of U.S.B.R. and shown in Fig. 6.

5.5 By using average annual sediment load as determined in 5.3 (i) the sediment distribution study was carried out by Empirical Area Reduction method. The details of the same and computer print out could not be shown here due to lack of space. However it was found that after 18 years of deposition the new zero elevation is RL 812.56 and after 19 years it is RL 819.25. Hence sedimentation upto RL 814.80 i.e. intake invert level shall take more than 18 years.

5.6 Using average annual sediment load as determined in 5.3 (ii), the sediment distributioin study was carried by the same method. It was found out that with increased sediment load the new zero elevation reaches RL 811.58 after 15 years. Hence sediment desposit upto RL 814.80 i.e. intake invert level shall take more than 15 years.

6.0 CONCLUSION

6.1 Sediment distribution study for the proposed reservoir of Baglihar dam was taken up by Empirical Area reduction method.

6.2 Sediment load of Baglihar dam site was calculated by using suspended load data at Premnagar & Dhamkund. It was also observed that suspended load at Dhamkund shown are considerably higher than Premnagar. The reason for the same was analysed and was felt to be due to increase in shear velocity at Dhamkund.

6.3 The reduction of capacity of reservoir was studied for varied load and its effect was observed.

6.4 Further detail study of the sedimentation of Baglihar dam is proposed to be taken up in future with continuous analysis of bed material, data on hydraulic slope & velocity at both sections to estabnlish a relationship of bed load with suspended load after the stretch. It is also proposed to apply HEC-6 model to assess the likely bed profile with time after sedimentation.

7.0 REFERENCES

Life of Reservoir,
Technical Report No. 19, C.B.I.P. 1977

Memorandum on Sediment Transport and Reservoir Sedimentation of Baglihar Dam, N.H.P.C. New Delhi, 1990.

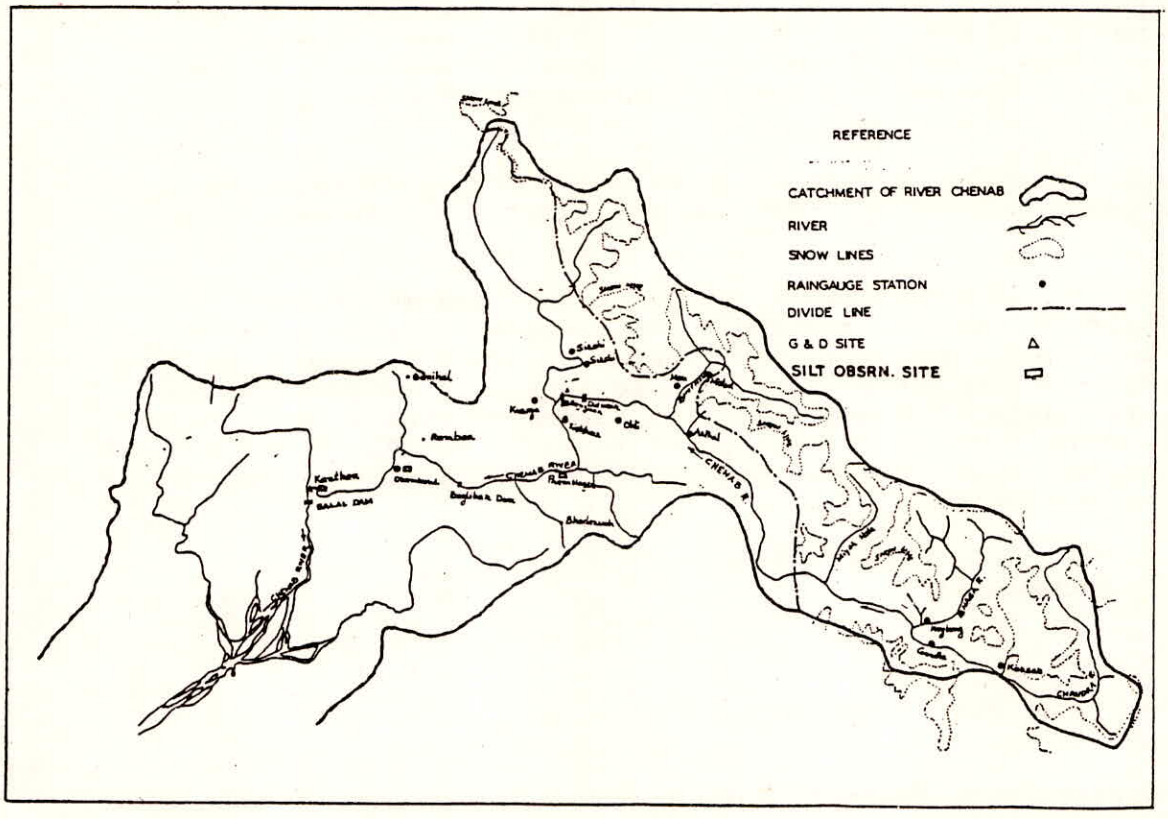
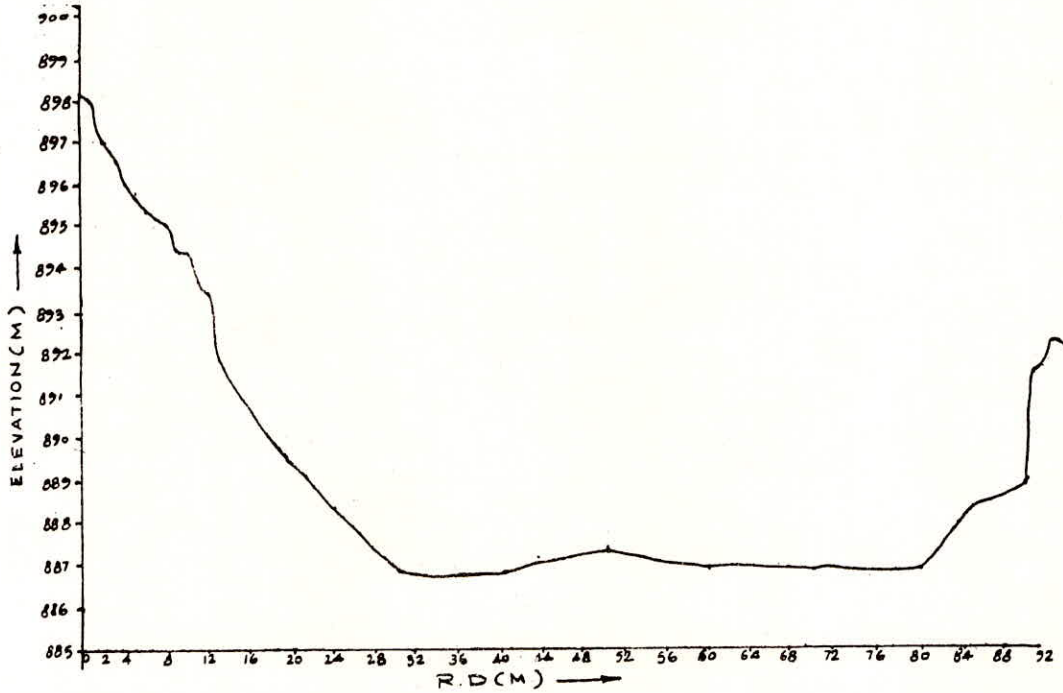


FIG. 1 CATCHMENT PLAN OF CHENAB RIVER



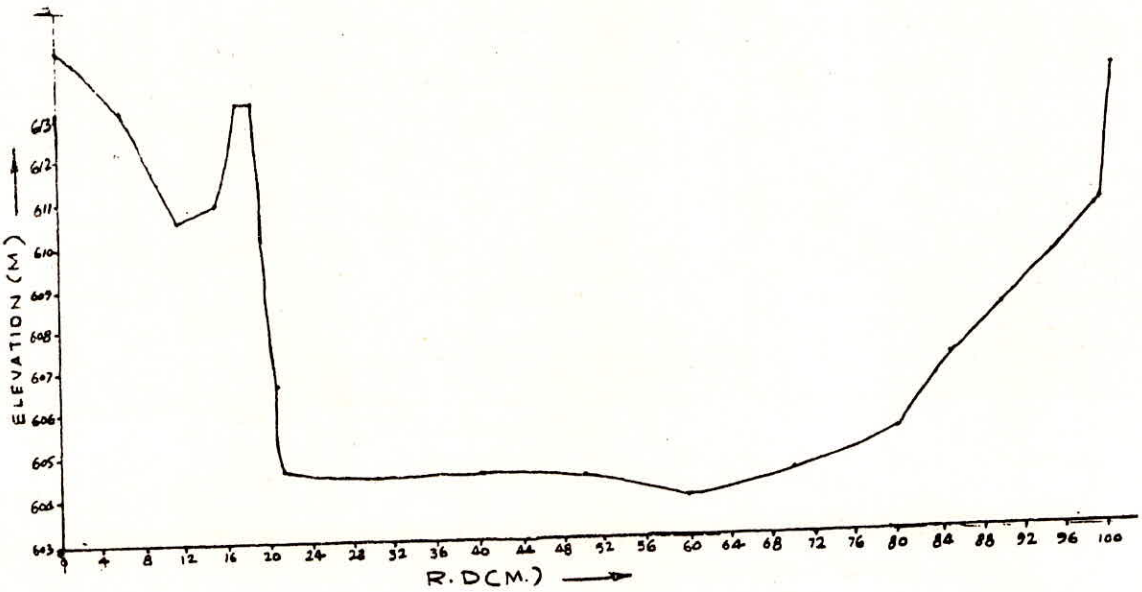


FIG. 2(i) X-SECTION OF RIVER CHENAB AT G&D SITE PREMNAGAR

FIG. 2(ii) X-SECTION OF RIVER CHENAB AT G&D SITE DHAMKUND

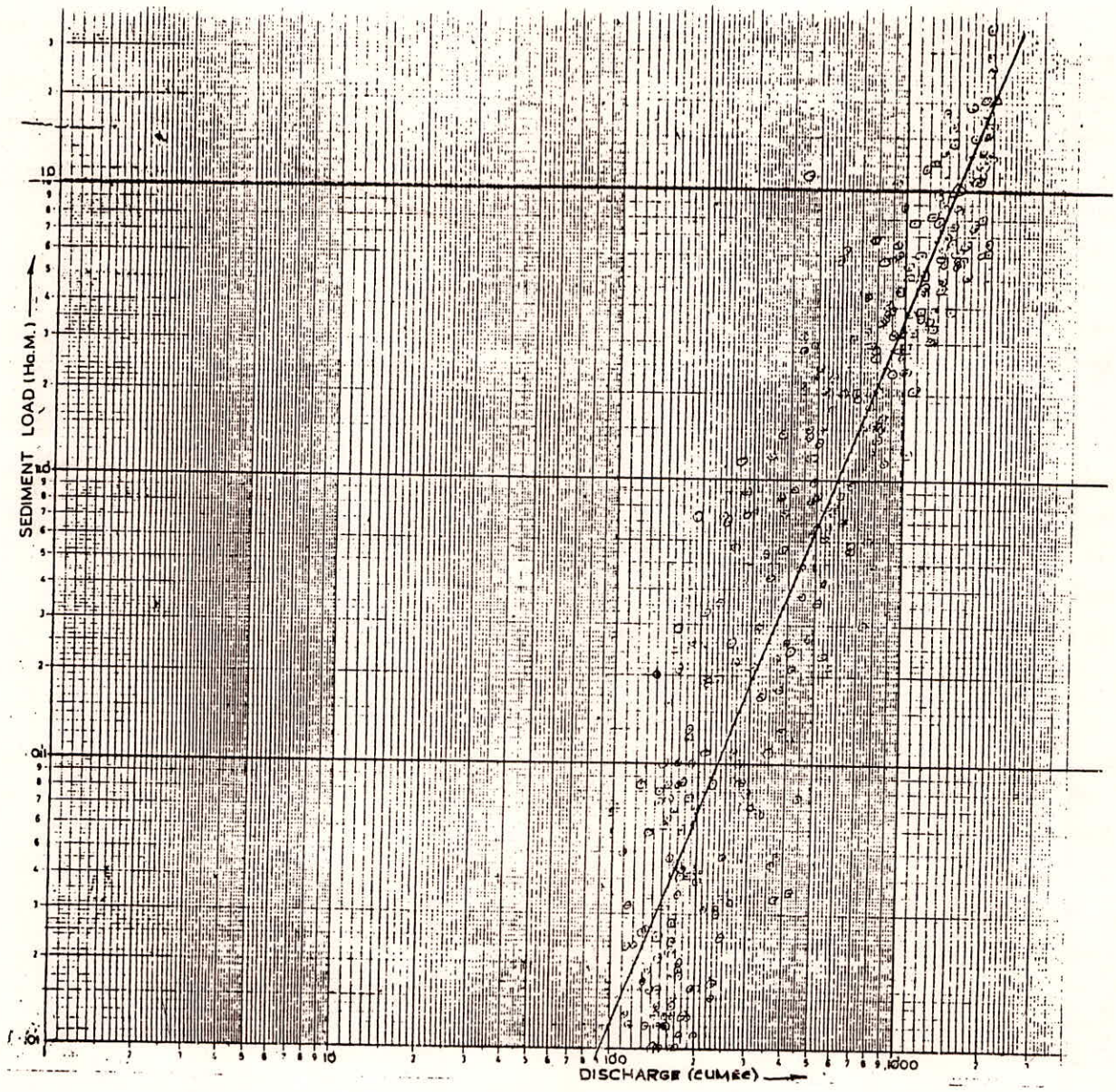


FIG.3 AVG. 10-DAILY DISCHARGE Vs AVG. 10-DAILY SEDIMENT LOAD AT DHAMKUND SITE

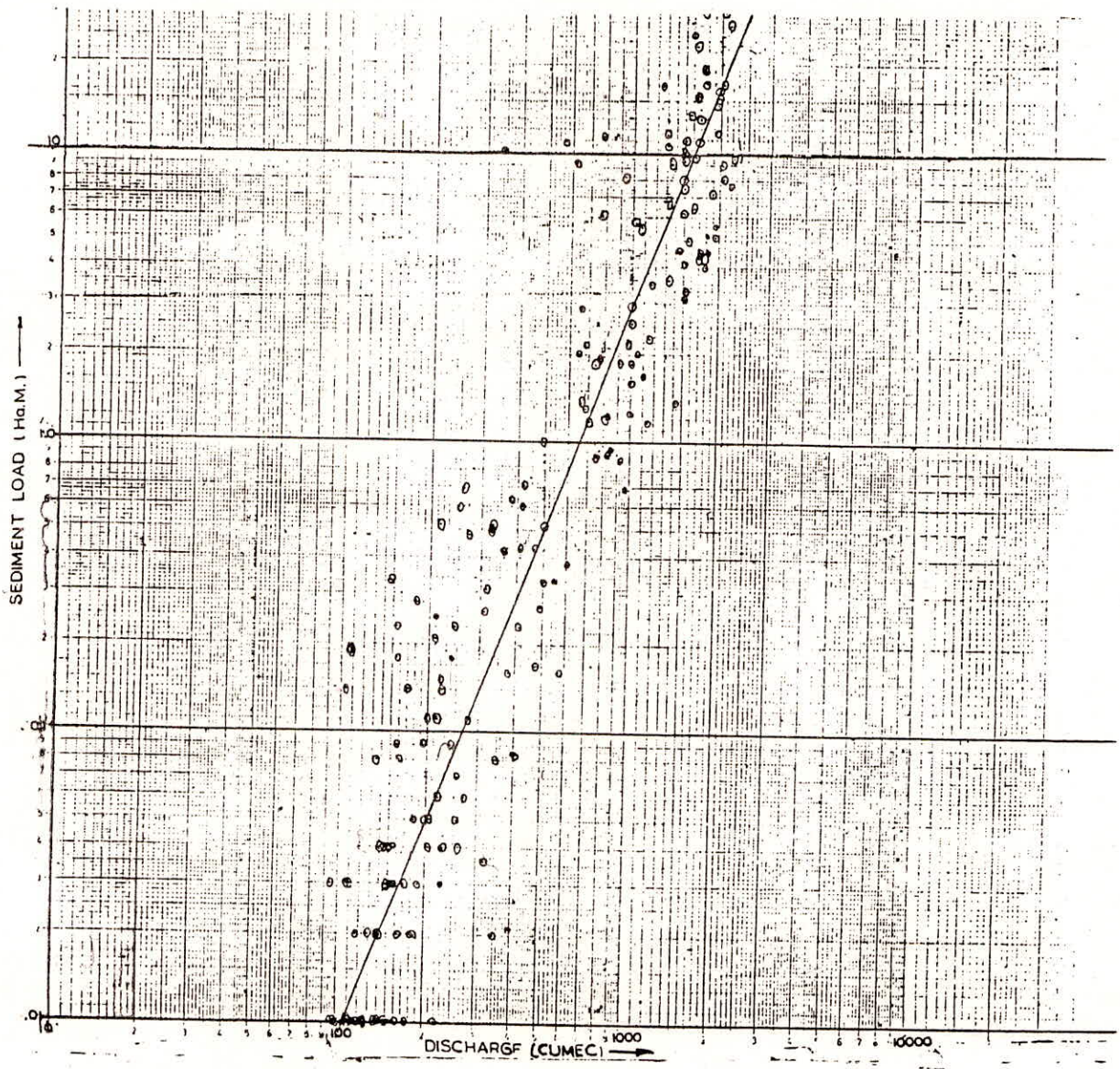


FIG. 4 AVG. 10-DAILY DISCHARGE Vs AVG. 10-DAILY SEDIMENT LOAD AT PREMNAGAR SITE

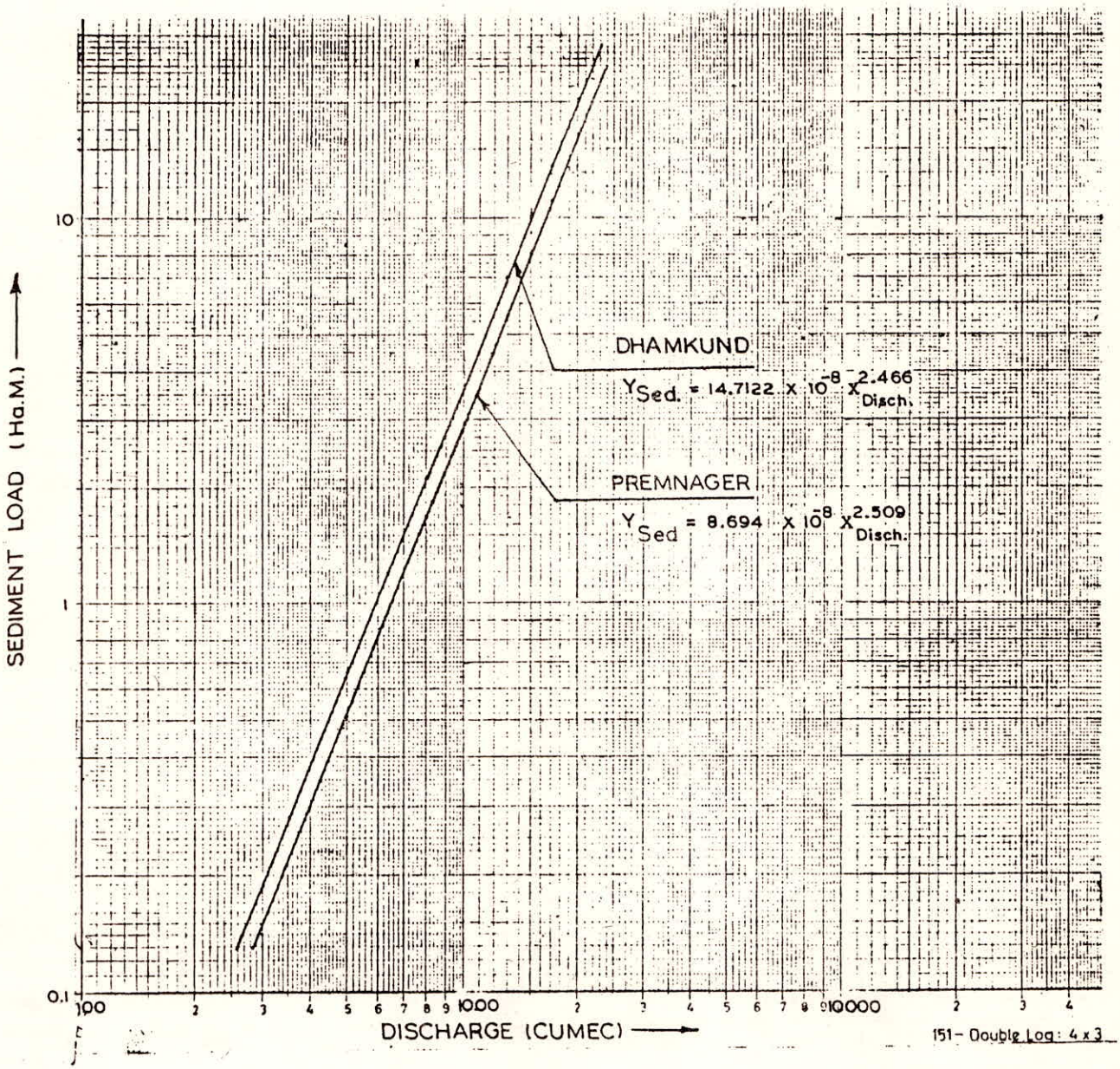


FIG. 5 COMPARISION OF RELATIONSHIP BETWEEN AVG. 10-DAILY DISCHARGE & AVG. 10-DAILY SEDIMENT LOAD AT PREMNAGAR & DHAMKUND

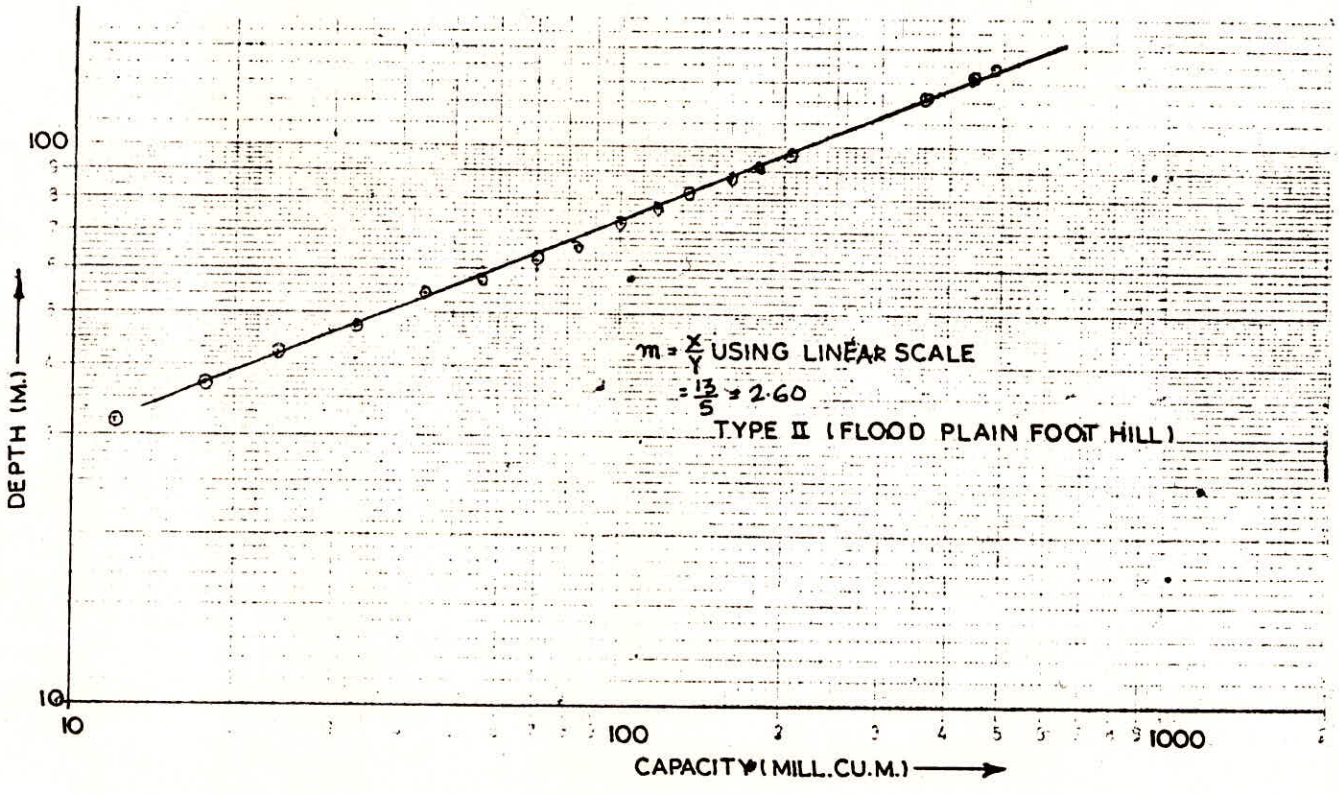


FIG.6 DEPTH Vs CAPACITY PLOT