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Essence of Silt Factor for Scour Calculation Around Bridge Foundation

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By

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ABSTRACT

Foundation of river bridges on alluvial soil is decided largely based on hydraulic data and subsoil strata. The subsoil strata is represented by a numerical value called silt factor. This factor plays vital role as the foundation level depends upon soil strata underneath, which is examined based on the bore log data. Bridges are very costly due to various reasons and the depth of foundation is one of them. There is need to optimise the depth of foundation to a pragmatic level, which can be constructed safely without undue delay as per construction practices. Any variation in foundation level at later date plays crucial role in the overall cost of the bridges and affect the completion time of the project. It is highlighted that pre construction investigation should be given more attention to avoid any lapse in construction programme. Data analysed based on investigation need to be reviewed in term of construction trend in the area. The importance of silt factor has been discussed in this paper. An accurate estimation of the same helps in completing the structure in less time without time and cost over run.

Key words :- Silt factor, scour, Alluvial soil, Soil mixed with boulder, Normal scour depth.

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INTRODUCTION

1.0 Foundation level for bridges are finalized based on the hydraulic parameters and the nature of bed material underneath. The subsoil is rated in term of silt factor, which is a numerical value. It indicates the type of bed material from clay to heavy sand. Gravel and Soil Mixed with Boulder (SMB) falls beyond this range. Foundation level is fixed below the scour level after considering the grip length. The scour depth is determined by using the Indian codal formulae which incorporates the silt factor within it or on the basis of results of model study wherever carried out. In bridges the hydraulic parameters such as the discharge, velocity need to be estimated accurately as it has direct bearing on the depth of scour. This involves lot of financial bearing and affects overall completion of bridge Project. Stress has been laid in this paper to highlight the essence of silt factor used for calculation of scour.

SILT FACTOR

2.0 Silt factor plays a significant role in determining the scour depth and also the founding levels for the foundation of the bridge structures. Due to lack of adequate bore hole data and also various uncertainties associated therewith, bridge engineers are confronted with a difficult job of choosing an appropriate value of silt factor. This assumes importance because the present code used for design of bridge foundation guidelines caters for a maximum silt factor of upto 2.42, which is applicable for heavy sand only. Since the silt factor has a significant role to play in finalising foundation depths, it suffices to say that identification of correct silt factor poses a problem wherein the selection of this important parameter is left to the judgement, discretion and experience of the designer. For calculation of silt factor in any type of soil, the soil strata is examined in greater depths and values are calculated in table 1 & 2. A worked out example of silt factor is given below:-

Sample1 **Table 1**

Dia. Of sieve	Weight retained gms	Percentage retained	Average size of sieve	Col. (3) x(4)	(Mean diameter $\frac{\text{Col-5}_{mtr}}{100}$
1	2	3	4	5	6
2.360	293	29.30	-	-	
1.180	313	31.30	1.7700	55.401	79.136/100=0.7913
0.600	172	17.20	0.8900	15.308	
0.425	109	10.90	0.5125	5.586	
0.300	39	3.90	0.3625	1.413	
0.150	59	5.90	0.2250	1.327	$K_f = 1.76\sqrt{m} = 1.5656$
0.075	9	0.90	0.1125	0.101	
Pan	6	0.60	-	-	
	1000	100.00	-	79.136	

Sample2 **Table 2**

1	2	3	4	5	6
2.360	49	4.90	-	-	
1.180	190	19.00	1.7700	33.630	78.424/100=0.7842
0.600	295	29.50	0.8900	26.255	
0.425	253	25.30	0.5125	12.966	
0.300	83	8.30	0.3625	3.008	
0.150	104	10.40	0.2250	2.340	$K_f = 1.76\sqrt{m} = 1.5587$
0.075	20	2.00	0.1125	0.225	
Pan	6	0.60	-	-	
	1000	100.00	-	78.424	

Silt factor = 1.5656 + 1.5587 / 2 = 1.5622

The Sample calculation of mean diameter of silt is based on mathematical expression of averaging.

ROLE OF SILT FACTOR IN ESTIMATION OF SCOUR

3.0 The scour depth is calculated based on Indian Road Congress[1] (IRC) formulae.

$$D_{sm} = 1.34 \left(\frac{D_b^2}{K_{sf}} \right)^{1/3}$$

D_b = Design discharge per meter width
K_{sf} = Silt factor for representative sample of bed material
D_{sm} = Mean scour depth

This formula is applicable upto heavy sand only. For material having heterogeneous stratification in the river where material is comprises soil mixed with boulder, result are compared with actual observation at site or from experience on similar structure nearby and their performance. Model study is also carried out for bridges on requirement and scour depth is finalized accordingly. Trend of normal scour calculation with a fixed discharge of 50 cubic mtr per sec with a different value of silt factor using the IRC formula has been shown in table 3.

TABLE – 3

SCOUR DEPTH FOR DISCHARGE OF 50 M^3/Sec/m (Db)

Silt Factor	Dsm
.50	22.91
.60	21.56
.85	19.19
1.00	18.18
1.25	16.24
1.50	15.88
1.75	15.09
2.00	14.43
2.25	13.87

2.42	13.54
3.00	12.60
4.00	11.45
5.00	10.635
9.00	8.74
13.00	7.73
17.00	7.073
19.00	6.82
20.00	6.70

ESSENCE OF SILT FACTOR

4.0 Essence of silt factor for scour calculation can be further represented in graphical form as indicated below where it is seen that after a value of silt factor of 8 the value of mean scour is not changing much and likely to almost constants for a higher value of discharge.

SCOUR DEPTH VIS-A-VIS SILT FACTOR FOR DISCHARGE OF 50 M³/SEC/M

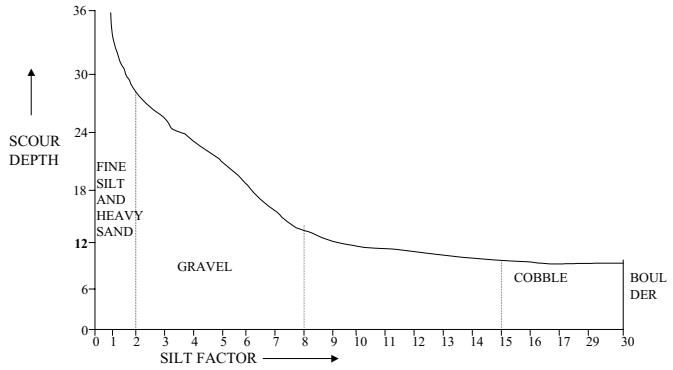

Fig-1

Most of bridges whether already completed or under construction have faced foundation problems especially in sinking of wells of multi span bridges. Whenever problems of sinking of well are faced, case is examined with reference to soil strata actually encountered. The task of subsequent review of foundation levels based on actual strata encountered (review of silt factor) need reprocessing of case. There are certain important points which require attention of bridge engineer for better planning of bridge foundation.

(a) Correct finalisation of silt factor at initial stage will be helpful to optimize cost of the bridge. This will also be helpful to stict to original time schedule as the there is no likely mismatch of strata.

(b) Cost of sinking of foundation can be avoided if there is no variation in soil parameter including silt factor.

(c) Foundation depth is required to be finalised as per the construction technology available in the country.

(d) Infact there is need to take a stock of situation about the construction methodology, in such a way that the proposal finalised should be executable on the ground.

(e) The completion of the particular project and related difficulties encountered be examined with reference to silt factor, as this is the only one major factors affecting the design scour. There are other factors affecting scour around bridge pier viz. Whether the flow is clear water flow or carries sediments, change in depth of flow, shape of pier nose, angle of inclination of pier, opening ratio, bed characteristics, stratification and effect of flow parameters. Apart from this there are other causes leading to scour as given table-4.

TABLE-4

	RIGID BEND	ERODING BEND	ABRUPT CHANGE IN FLOW DIRECTION	OBSTRUCTION (PIER/Abutment)	CONSTRICTION	CONFLUENCE	SUB SURFACE	CONTROL STRUCTURE	BRIDGE PIER
FACTORS AFFLCTING SCOUR	1. Radious of Curvatures 2. Length of bend	1. Raious of curvatures 2. Length of bend 3. Type of bank material	Degree of change in direction	Angle of scour	Degree of narrowing	1. Angle between tributories 2. Flow ratio in each channel	Slope of bedrock	1Downsteam depth	1 Width of pier

(f) Soil strata be studied in details and if required, the help of expert be also sought.

RECOMMENDATIONS

5.0 Various steps to be followed to arrive at correct value of silt factor are as follows:-

(a) Keep a drilling record of the entire bore log and assess the value of silt factor upto foundation level at initial stage.

(b) During construction of foundation better picture of soil strata can be seen and accordingly the silt factor can be further reviewed if it does not match with the calculation as finalised initially during subsoil investigation stage.

(c) Value of different silt factor value can be calculated for 2 to 3 of bore log details and average value can be adpoted.

(d) Wherever the silt factor value is not assessable, the soil strata actually encountered during execution is reviewed and practical aspect is kept in view and final value is arrived at.

CONCLUSION

6.0 Silt factor plays a important role in finalisation of foundation levels. In case of difficulties faced in finalising level of foundation based on silt factor concept, model study can also be reviewed if carried initially otherwise, experienced gained at previous bridges can be dove-tailed for future bridges for finalizing their foundation level. Efforts should be made to assess correct value of silt factor to optimise the depth of foundation and there will be no time and cost over run.

REFERENCE

1. IRC : 78-2000 – Standard Specifications and Code of Practice for Road Bridges, Section VII – Foundations & Substructure (Second Revision).