International Journal of Engineering & Technology
CENTRE OF PROFESSIONAL RESEARCH PUBLICATIONS
ISSN 2049-3444

International Journal of Engineering and Technology Volume 2 No. 9, September, 2012

Estimation of Bed Load Transport in River Omi, South Western Nigeria using Grain Size Distribution Data

A.A. Adegbola[1] and O. S. Olaniyan[2]
Department of Civil Engineering, Ladoke Akintola University of Technology, Ogbomoso

ABSTRACT

Representative bed material samples were taken from the two gauging sites on rivers omi for sieve analysis to obtain the grain size distribution of its bed materials. The analyses of the grain size distribution showed that the bed load accounted for 9% of the total estimated suspended sediment load of 1,703, 548.113 kg/annum in river omi. River omi bed material had a geometric mean particle size, D_{50}, of 0.4 mm. The river transported bed material of larger diameter downstream with higher mean diameter D_{50} of 0.60 mm. It is recommended that 9% of the total suspended load should be adopted as bed load estimate for sedimentation studies in similar river from south-western region of Nigeria.

Keywords: *bed load, sediment load, sieve analysis, transport, river omi*

1. INTRODUCTION

Bed load represent the lower portion of sediment load in natural rivers. Fluvial sediment load materials are transported by rivers. Sediment load can be divided into bed load and suspended load based on the mode of transport. Bed load is transported close to the bed where particles moved by rolling, sliding, or jumping. Turbulence aid suspended load transport most especially in an estuary and sea. Turbulence effect can also be noted in a river system that flows at high velocity (Olaniyan, 2009, Robert, 2010).

Sediment transport knowledge is important in river restoration, ecosystem protection, navigation, watershed studies and reservoir management. Xlaoqing, 2003 explained that bed load transport in natural rivers is a complicated phenomenon. Its movement is quite uneven in both the transverse and longitudinal directions which vary considerably. In practice, it is more complicated to estimate bed load discharge accurately than to measure suspended load.

Bed load can be measured directly by using bed load samplers. Direct measurements of bed load is done by placing samplers in contact with the river bed and account for accumulated sediment load within a period of time. The content of the sampler will be removed and analysed to estimate bed load discharge. Samplers used may be classified into basket-type, pressure-difference-type, pan-type and pit-type categories (Xlaoqing, 2003, Robert, 2010).

Direct measurement is characterized with some shortcomings such as varying efficiencies of the available samplers which is from 10 to about 150% for different types of samplers (Xlaoqing, 2003). Also, some sampler may collect bias sample in a soft benthic layer due to their weight. Indirect method of bed load measurement includes the various sedimentation process, tracer method, dune tracking and bed form velocimetry.

The US Army Corps of Engineers (1995) categorized total sediment loads into measured and un- measured loads. The measured load consist of suspended sediments that can be sampled with depth integrated hand held samplers while the unmeasured loads include some of the un accounted suspended load, within the lower 0.15 m depth portion of a sampled water column and the entire bed load (US Army Corps of Engineers, 1995; Otun and Adeogun, 2010). Since the bed materials represent the un measured loads, it is imperative to separate bed materials into its components. This can be achieved through particle size analysis to distribute the bed materials into suspended and bed loads

The limit particle size can be explained as diameter of the largest sediment particle maintain in suspension. Some researcher gives this values as ranging from 0.5 - 0.2 mm. The grain size distribution data are obtained from a cumulative size-frequency distribution curve which is drawn from particle size analysis. Methods for obtaining particle size analysis are size dependent.

Estimation of bed load from total suspended load is more practice by researcher in this field of study due to the complexity involved with bed load estimation. Mudi (1995) reiterate that bed load accounts for about 3 to 15% of the suspended load depending upon the nature of the bed materials. This research utilized the grain size distribution data to estimate the percentage of bed load transport in river omi, south western Nigeria.

2. METHODOLOGY

2.1 Study Area

This research is designed for River Omi located within Iddo Local Government area of Ibadan. It lies between longitude 3^0 55′ and 4^0 00′ East and Latitude 7^0 00′ and 7^0 05′ North of the equator. The river is about 14.5 km with frequent flooding experience like August, 2011 flooding in Ibadan. The catchment area of the river is 123.53 km^2. The river ranges between 0.50 – 2 m spot height and 19 km from the source to the study area (Adegbola and Olaniyan, 2012).

Adegbola and Olaniyan, 2012 explained that river Omi is an alluvial river with channels and flood plains that are self-formed in unconsolidated or weakly-consolidated sediments. The morphology of an alluvial river reach is controlled by a combination of sediment supply, substrate composition, discharge, vegetation, and bed aggradations (See Figure 1.1). River Omi is very useful to the inhabitants for domestic, agricultural and waste disposal purposes. Some of the bridge and culvert on the river has been swept away due to frequent flood occurrence.

2.2 Study Approach

The total sediment loads consist of both measured and unmeasured sediment loads. This study quantifying these two components and then accounting for the bed load portion of the unmeasured sediment.

2.3 Quantifying Measured Sediment Loads

The US Army Corps of Engineers (1995) and Ongley (1996) established Equation (1) for estimating the measured suspended sediment load Qs in kg/day.

$$Qs = K .c. q \quad (1)$$

Where :

Q_s = sediment discharged (kg/day), c = sediment concentration (mg/l), q = water discharge (m^3/s), and K = 86.4. The value of c is obtained as the concentration of the sampled sediments from a turbidity record, q is obtained from an established stage-stream flow relationships (rating curve) for the gauge stations at river omi.

Adegbola and Olaniyan (2012) reported the hydrology of the river omi from their research and established a rating curve for the rivers (see Table 1). Current measurements on the river conform to the obtained values from the rating curve.

2.4 Quantifying Unmeasured Sediment Load

The unmeasured sediment loads discharged at the gauging sites on river omi was estimated by using Colby approach as described by Otun and Adeogun (2010). The obtained results is shown in Table 2.

2.5 Sampling of Bed Materials

The bed load component of the unmeasured sediment is accounted for by analyzing the bed materials sampled at the gauging sites. The bed material samplers designed by the US Federal Interagency Sedimentation Project are expensive and not readily available in the country. An improvised one similar to Van veen grab sampler and Ponar sampler was improvised. The scoop was designed such that it has top and bottom length of 0.4 and 0.3 m respectively, and a width of 0.15 m. It has a shutter with lead weight attached so that it closed under the weight once the wire tension is released.

The scoop was used to take bed material samples at the gauging site by positioning it at an angle on the stream bed and the wire pulled in order to raise the shutter. The sampler was used to scoop the bed material from top two inches of the streambed to obtain a quantity of sample. Bed material samples were taken for sampling verticals ¼, ½, ¾ width of the river cross-section. The obtained samples were mixed together and part of the mixture was taken to the laboratory for analysis.

2.6 Laboratory Analyses of Samples

Sieve analysis was carried out by oven-drying the representative sample from which 100 g was weighed and put in a set of U.S. Standard Sieve with electronic shaker and then shaken vigorously for 15 minutes. The sediments retained on each sieve were weighed and recorded. From the records particle graduation curves were plotted to determine their particles sizes and their percentages (see Figure 2).

2.7 Distribution of Grain Sizes

The river bed materials were then distributed into sub groups using U.S. Standard Sieve grain sizes (in millimeter), so that the unaccounted suspended sediment load and the bed load could be quantified using the limit particle size of 0.35 mm in line with Otun and Adeogun (2010) observation.

According to the U.S. Standard Sieve grain size distribution, the following sediment particle sizes were used: gravel (5.0 to 50), coarse sand (2.0 to 5.0), medium sand (0.4 to 2.0), and fine sand (0.07 to 0.4). The research employed the following grain size distributions: grain size diameters (D) of particles greater than medium sand that is, grain sizes that are wholly coarse sand and gravel (fine and coarse) (that is, D > 2.000); D of particles that are wholly medium sand (that is, 2.000 > D > 0.600); D of particles that are mixture of medium sand and fine sand (that is, 0.600 > D > 0.200) and lastly, D of particles that are wholly fine sand and silt/clay (that is, 0.200 > D) (Otun and Adeogun, 2010).

The percentage of the latter grain size distribution contain fine sand and very fine particles such as silt and clay which represent the unaccounted suspended sediments in the bed materials analyzed (see Table 3). The sum of the fractional percentages of the other grain size distributions implies the percentage of the unmeasured sediment loads representing the bed loads. The estimated total annual load on River omi is shown in Table 4.

Furthermore, the average grain size for each of the size distribution was determined and compare with the limit particle size of 0.35 mm. This was done to confirm the grain size distributions of the bed materials into unaccounted suspended sediment and bed loads.

3. CONCLUSIONS AND RECOMMENDATIONS

The bed load component of the total sediment load transported from river omi has been evaluated using grain size distribution of the bed materials of the rivers. The following conclusions were made from the study:

- The total annual sediment load of around 1,543, 540.113 kg/annum transported from river omi has been sub divided into important practical terms; annual suspended sediment load of 1,404, 621. 5 kg/annum and annual bed load of 138,918. 610 kg/annum.

- Bed load transport in river omi accounted for 9% of the total suspended sediment load.

- Hence this bed load percentage of 9% could be of practical use in further sedimentation studies on neighboring river with similar hydrology. This is in agreement with the observation of Otun and Adeogun (2010) and Mudi (1995) that bed load accounts for about 3 to 15% of the suspended sediment load depending on the nature of a basin.

- River omi bed material has a geometric mean particle size, D_{50}, of 0.40 mm and transports bed materials of larger diameter downstream with higher geometric mean particle size.

However, it is recommended that the bed load percentage of total load transport in the river should be investigated periodically. This is because a change in the river flow hydraulics and hydrology of the basin might influence the amount of bed load transport.

REFERENCES

[1] Adegbola, A.A and Olaniyan, O.S (2012). Temporal Variation of Sediment Transport in River Omi, South Western Nigeria. International. Journal of Applied Engineering Research 4(7), pp. 421- 431.

[2] Adeogun, B. K., Igboro S. B. and Ibrahim F. B. (2011). Estimate of Bed load Transport in Kubanni Watershed in Northern Nigeria using Grain size Distribution Data. International Journal of Water Resources and Environmental Engineering Vol. 3 (5), pp. 102-108. http://www.academicjournals.org/ijwree.

[3] Olaniyan, O.S. and Adegbola, A. A. (2012). River Geometry Computation On River omi South-Western Nigeria. LAP Publisher, Germany.

[4] Adeogun, B. K (2008). Quantification and Characterization of Fluvial Sediment Deposits into Kubanni Reservoir, Unpublished M.Sc. Thesis. Ahmadu Bello University, Zaria.

[5] Otun, J. A, Adeogun, B. K (2010). Analysis of Fluvial Sediment Discharges into Kubanni Reservoir, Nigerian J. Technol., 29(2): 64-75.

[6] Robert, R. H (2010). Measurement of Bedload Transport in Sand-Bed Rivers: A look at Two Indirect Sampling Methods, US Geological Survey Scientific Investigation Report 5091.

[7] US Army Corps of Engineers (1995). Sediment Measurement Techniques (Em 1110-2- 4000; Ch 8). www.usace army.mil.

[8] Xlaoqing, Y (2003). Manual on Sediment Management and Measurement. Operational Hydrological Report No 47. WMO-948, Secretariat of the World Meteorological Organization-Geneva-Switzerland.

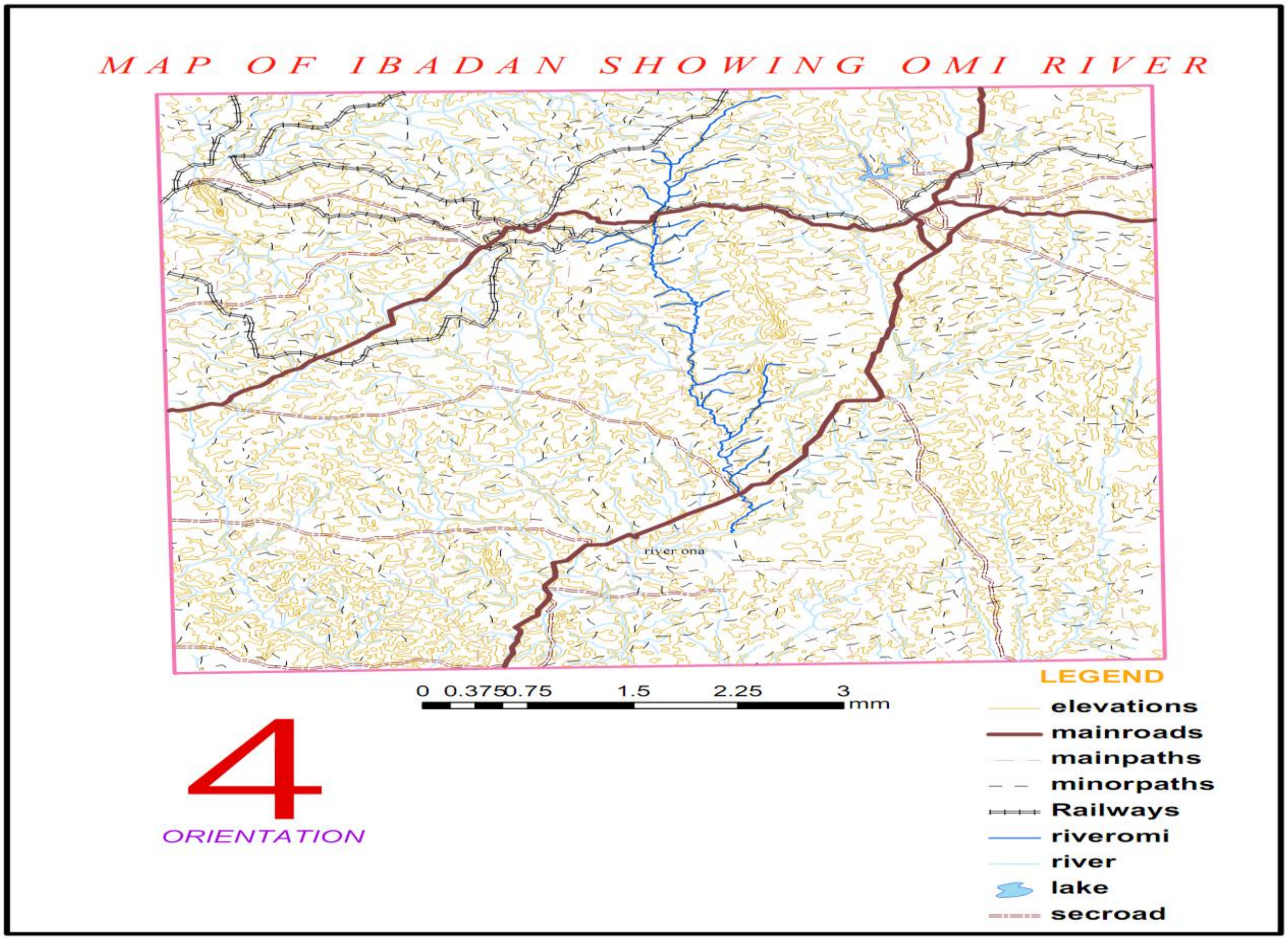

Figure 1. Figure showing Map of River Omi

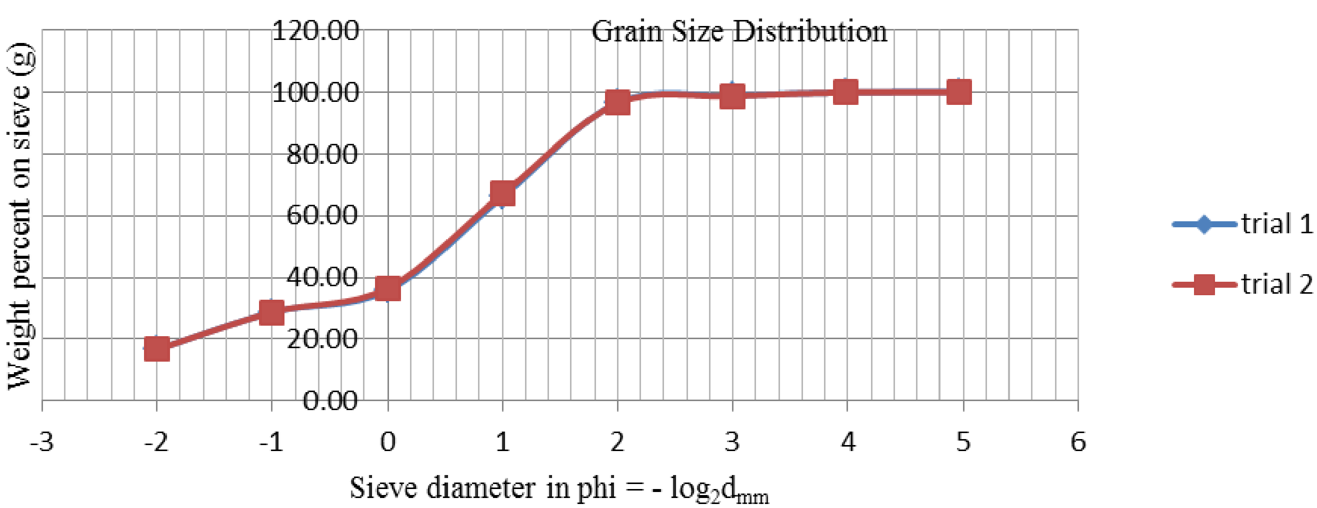

Figure 2. Grain size Analysis

Table 1. **Discharge across River omi**

Months	Total Daily Inflow (m^3/day)
June	1555200
July	1565600
August	1551744
September	1623456
October	1391904
November	987552
December	531360
Total	**1518912**

Table 2. Seasonal Sediment Load (kg/annum) Transport in River omi

Month	Measured sed.load Kg/month *10^3	Unmeasured sed. Load (kg/month)*10^3	Total (kg/day) *10^3
Jan.	1.003	1	2.003
Feb.	0.898	1	1.898
March	5.002	1	6. 002
April	8.670	5	13. 670
May	9. 351	5	14. 351
June	15. 62	6	21. 620
July	77. 210	13	90. 210
Aug.	61. 671	13	74. 689
Sept.	996. 331	69	. 363
Oct.	297. 388	36	90. 405
Nov.	63. 405	5	63. 418
Dec.	10. 049	2	10. 060
Total	**1,546. 548**	**157**	**1, 703. 548**

Table 3. Grain size Distribution on River omi Bed Materials

Grain size(mm)	Average grain size (mm)	Percentage distribution
D > 2.000	-	17.29
2.000 > D > 0.600	0.920	32.5
0.600 > D > 0.200	0.360	39.3
0.200 > D -	-	

D_{50} = 0.40 mm, D_{65} = 0.90 mm, D_{95} = 1.90 mm

Table 4. Estimation of Total Annual Load on River Omi

TSS Load (ton/year)		
Measured	Unmeasured	Total bed load (unmeasured)
1546.548	15.7	141.3

