Application of Rosgen classification the Ziarat watershed, Gorgan

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Abstract It is important to Study the relationship between river's sediment and Hydraulic from the management, increasing the aquatic settlements, Succession and river's morphologic mature, management of the water resources and its erosion and sediment, river's Geometry relations, designating critical shear stress, the relations between shear stress And Velocity and Flow resistance and Determining Edibility potential of River bank. The basis for stream classification in this research was Rosgen stream classification (RSCS). 50 Reach have been chosen on the basis of stream orders and flow regimes and in each Reach of cross section, width/depth relation, entrenchment, average and maximum of Bankfull depth and width in the Watershed. The cross section was studies with measuring width and depth.the river bed particles sampling in the cross section or near to it in each reach and selecting 100 sample particles were measured and their frequency in each reach was specified. The cumulative frequency distribution of particle's average diagonal (D_{50}) in the Normal log was reached from calculating the particle's average diagonal. Reach slope was also determined with using Aerial Photos. The results show that the most frequency of entrenchment is in the Range of 1/4 (low). 48% of under study reaches have the average W/D, 70% have the average sinuosity, 24% high sinuosity and 6% low sinuosity. The type's frequency percent in the first level of Rosgen include type G with 48 %(most frequency), type B with 26%, type C with 20% and type D with 6 percent (lowest frequency) respectively. Also the results show that the most frequency of slope is in the of 0/02 to 0/039.from the view point of average size of particles the most frequency percent belongs to cobble and the least to clay and Silt.

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1. Introduction

The importance of river's morphologic classification is observed in predicting river behavior.

Improving the relation between river's sediment and hydraulic is important for special morphologic type and also river's morphological improvement, water resources and erosion and sediment management, relations of river hydraulic, designating critical shear stress, the relation between shear stress and flow speed, flow resistance, designating ability of erosion potential are important in improving and management of aquatic Habitats. There had been many studied for rivers classification.

Davis (1899) Classified the rivers according to evolution into 3 (young, mature, old). Leopold and Wolman (1957) parted the river into straight, braided, meandering patterns. Culbertson et al (1967) have presented a comprehensive classsification according to sediments size including: vegetation, braided pattern, sinuosity, meandering curve, channel bank height levee Formation, floodplain types. Khan (1971) has proposed a quantitative classification for sand bed rivers whose base was on sinuosity, slope and pattern of stream. To be including wide domain of river morphological specifications, Clear halz et al (1972, 1976), Galay et al (1973) and Molard (1973) have studied the Canadian rivers and the results presented a complete description of rivers deposits. Charch and Roud (1983) have a detailed description of placer deposit river channels which can use in other river classification. Nanson and Krock (1992) had studied the floodplain which contains the particle size, stream morphology and riparian particles.

River morphology in under the physical rules and would be affected directly by 8 factors namely, river width, depth, flow speed, discharge, slope, bed particles resistance, sediment load and sediment size (Leopold et al 1964).changing one of these variables will change the river pattern. Since the river morphology is the result of this balancing process, so the variables should be noticed as a criterion for river morphology classification. These variables are the basis for Rosgen classification (RSCS). The system of Rosgen classification has been gathered via field observation of hundreds of North American Rivers and with help of colleagues and researchers experiences in the Hydrology, Geomorphology, planet ecology, aquatic logy and river preserving. Rosgen classification has 4 levels, the level (I) has the geomorphic characteristics and level (II) contain the accurate study of river morphological characteristics with measuring in each

Reach. This calculating contains the compounding the gathered factors from level (I) and also the accurate average diagonal (D50) of river particles. Level (III) stress on river situation namely, riparian vegetation, sediment patterns, meandering patterns, flow regime, riparian erosion ability, existing debris flows and stream operation and resistance. Level (IV) will study the effective factors on the river morphology the relations, for example, designating the Manning Coefficient or the relation between discharge and sediment transport.This level will be evaluated by studying sediment transport, riparian erosion, shaping and destruction of biology information. For example fishes biomass, chirognomy and studying riparian planet coverage.

Levels (I) AND (II) will be used to reach the Rozgen classification. This system contains 8 types of channels (G, F, E, DA, C, B, A) in the level (I) and will be studied according to entrenchment, Width/depth, sinuosity and channel slope. Further description about channel types is in the table no.1. Channel particles were numbered on the basis of average diagonal of particles to bed block1, rock2, cobble3, .4, gravel 5, silt/clay6 and so the 42 main types of rivers will be designating.

With calculating particle distribution frequency of each type, its class will be reached via comparison of the data with RSCS table. The out of designated domain level (I) slopes can be classified into level as the (II).

According to channel base slope, the steep slopes more than 10 percent will be shown with “a+”. The slopes between 4 to 10 percent will be shown by “a”. And the slopes between 2 to 4 percent by “c” and “c-“for slopes less than 0/1 percent.Since ziarat river is one of the main water resources of Gorgan city and there have been no study in system classification, so this research has been done for studying Rosgen stream classification on the Ziarat river and by using the data there can be practical decisions in the retrieving the river.

1.2Instrumentation:

1.1.2- Introducing the area

Ziarat watershed area is one of the 14th Garasou watersheds in the Golestan province which is located in the 36’58” 36° to 36’11” 46° north height and 23’55” 55° to 31’10” 54° east length. Average height is 1708 meter, its area is 98/7 km^2 and the length of river is 19/2 km.The average of annual rainfall is 575 mm and the average of annual warmth is 7/5 °C. The Eva transpiration is 409 mm and its potential is 846mm.also the rate of annual discharge is 0/543m^2 per second. Ziarat planet coverage is Chestnut and Beech. The vegetation of range is poor to average in the back heights. Farms were dry farming with low crops in which in the different season's necessary corps for villages were planted. This area has a more critical situation than other areas from the soil depth and erosion view point. The surface erosion of this area was because of slope, bed rock kind and also excessive and unprincipled use of earth. Also, the existing Keuper in this area has caused the low penetrability and high potential of waste water production which has caused surface flows and more erosion. In the middle parts of watershed, the debris flows, old and new landslides were happened because of Keuper layers in that area.

2. Material and Methods

The necessary data were gathered from 50 reach in the area. The length of each reach is 20 to 30 times longer than water mark Height or it is equal to 2 times longer than roll wave of a channel.

The reaches were selected according to channel kinds and flow regime in the channels and the cross section of channel, width/depth, and entrenchment, average and maximum of water mark were selected in each reach. The cross section of channel was studied by measuring the width and depth of channel. A 15meters transect and a pebble count was used for measuring the width of channel and depth of it. Then the width of water mark was reached with using the height of it. The potential height of flood was also reached by doubling the water mark height. From the cross section or near to it, a reach was selected for sampling the stream bed particles by accidental- systematic method in transect. The diagonal of the particles were done by using a Pebble Count, and then the size of each particle was compared. In this classification, the size of each level can be calculated by doubling the last level (2, 4, 8, 32, 16,…).the cumulative distribution frequency of average diagonal of particles (D50) in scale normal log was reached from the measuring bed particles average diagonal and was used as a bed particles dominant size in that reach and so for it was used in the level (II) Rosgen classification. The reach slope also was calculated by using 1:25000 maps in the area.

3. Results

1.3. Entrenchment levels

The results show that the most frequency (48%) is in 1/4 Range (low) which is related t type G. and the least frequency of entrenchment (0/06%) is related to braided streams (Type D).

Table no.1: necessary factors for reviewing each type and a summary of type's geomorphologic characteristics

geomorphologic characteristics	type
Deep entrenchment, very mid gradient (4-9/9%),low W/D, no sinuosity	A
Average entrenchment, low sinuosity, average W/D, steep gradient (2-3/9%)	B
low entrenchment, high sinuosity, large W/D, mid gradient (0/1-2%), riverbed morphology, riffle pool	C
Low W/D and entrenchment, mid gradient (less than 2%), high sinuosity, riffle pool	E
Low W/D, average sinuosity, steep gradient and sluice riverbed morphology, step pool	G
No entrenchment, high W/D (more than 40), low sinuosity(less than 1/2), downward gradient (0/1%-2%)	D
Low entrenchment and W/D (more than 12), high sinuosity(more than 1/4), downward gradient (less than 0/02), high sinuosity and sluice riverbed morphology, riffle pool	F
More resistance than type D, low entrenchment(more than40), average to high W/D and sinuosity, mid gradient (less than 0/5), riffle pool	DA

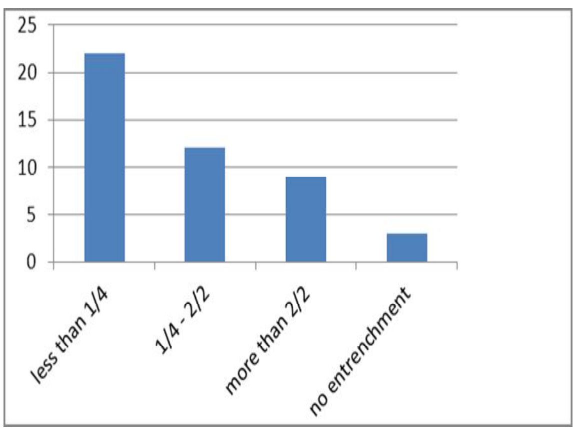

Chart 1: distribution frequency of entrenchment levels among 50 reaches

2.3. Width/ Depth

The results show that 48 percent of reaches had the average width/depth(less than 12). The frequency percentage and entrenchment had the same value because there is just type G in the entrenchment domain less than ¼. 6 percent of the reach has the high width/depth (greater than 40). A reach with entrenchment less than ¼ has a width/depth of 13 which with respect to ±2 domain for correcting the width/depth, this reach will be located to a low domain of W/P.

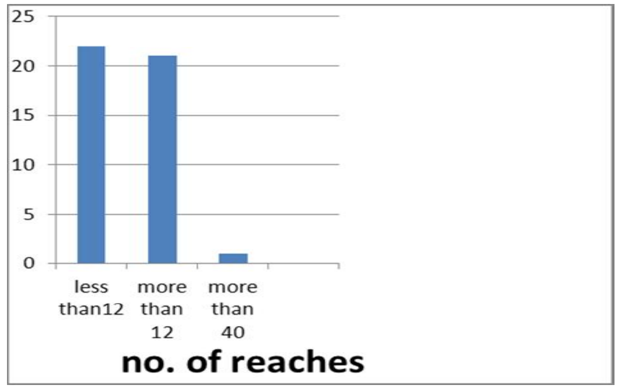

Chart 2: distribution frequency of width/depth among 50 reaches

3.3. Sinuosity

The results show that 70 percent of the reaches under study have the medium sinuosity (1/2-1/4). 24 percent of than have a high sinuosity (more than 1/4) and 6 percent have the low one (less than 1/2). Two reaches with average entrenchment and width/depth have the sinuosity 1/1 and 1/3 which with respect to ±0/2 domain for correcting sinuosity, they can be categorized in type B.

4.3. Level (I) types in Rosgen classification

According to entrenchment and width/depth of 4 types (B, C, D, G) among 8 types in the level (I) Rosgen classification, it was concluded that the type's frequency was as follow. Type (G) by 48 percent (the most frequency), type (B) BY 26 percent, type (C) by 20 percent and type (D) has the fewer amounts among others.

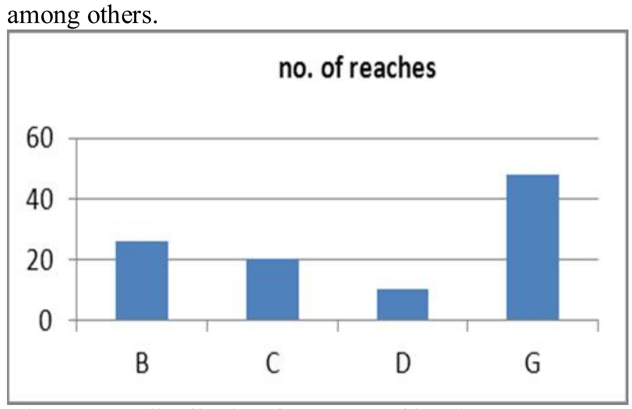

Chart no. 3: distribution frequency of level (I) types among 50 reaches

5.3. Gradient

The most frequency (46%) of channel slop is in the domain of 0/02 to 0/039. The less frequency is in the domain of 0/04 to 0/099 which is related to type

B. the changes in the slope in high in the type B in such a way that one reach is in a domain less than 0/02 and 5 reaches in the 0/02 to 0/039 domain and 7 reaches in the 0/04 to 0/099. The most frequency in a slope domain among level (I) of Rosgen classification levels is related to 0/02 to 0/039 slopes in the type G. 18 of 50 reaches are located in this domain. Also In the type C 8 reaches are in the level fewer than 0/001 which have the most frequency after type G. the less frequency is related to domain less than 0/02 in the type B which has just 1 reach. There is no 0/02 to 0/039 domain in type C and no level less than 0/001 in the type D.

6.3. Average size of bed particles

The most frequency (38%) of average size of stream bed particles is Cobbles. Gravel 30%, Boulder 16%, sand 8% and silt and clay 2% (the less frequency). The most frequency of the average bed Particles are among level (I), which is in the type B which can be seen in the 7 reaches.

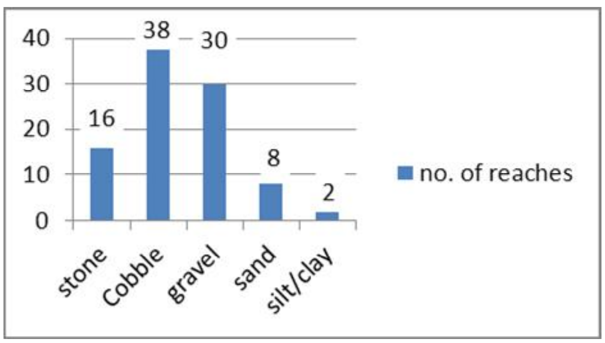

Chart4: distribution frequency of stream bed particles among 50 reaches

7.3. According to received criterion, the percentage of level (II) types of Rosgen classification are as follow: 7 reaches belong to type B3a which is the most dominant one among types in the level (II) Rosgen classification. 6 reaches are belonging to type G4 of Rosgen classification. Since type G among level (I) has the most frequency but in the level (II) because of stream bed particles Boulder, type B3a is the dominant type in the level (II). In no reach, the cobble has a dominant particle. In the type B, 11 reaches has the frequency of cobble and 2 reaches have boulder. The bed particles of 7 reaches in the type G is sand, 6 reaches gravel, 6 reaches boulder and 5 reaches of cobble. bed particles size of 7 reaches from type C includes: gravel, 2 reaches of cobble and 1 reach of silt/clay. Also, the size of bed particles of 2 reaches from type D is gravel and 1 reach cobble.

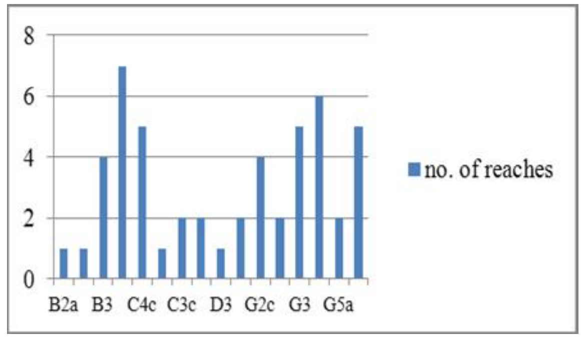

chart 5: level II typeS distribution among 50 reaches 1

4. Conclusion:

According to received results, the most frequency of entrenchment is in the low domain of it which is related to type G of Rosgen classification and the less frequency of entrenchment is related to braided streams of type D. the entrenchment is a demonstration of the relationship between and valley and ground shape and can be known as a capacity the degree to which it is incised in the valley floor of the valley (Clair Hals et al, 1972). The degree of entrenchment is equal to Flood-prone width ratio to bank full width. Totally, entrenchment can affect the water depth and also sediment transport. This factor can specify the narrowness and wideness of channel. According to the results of 48 percent of reaches have an average width/ depth ratio and 6 percent of other reaches have a wide width/depth. The width/ depth ratio is a factor which depends on water depth, flow speed and channel relative roughness. This ratio, demonstrates the dimension and shape as a fraction of water mark width to channel depth average. Water mark can be shown as a maximum current flow which is existed during the days of a year and often is related to discharge with a reverse distance of 1/5 years. If the width/ depth ratio is less than 12, this is low and vice versa.

The relation of length to valley length or valley slope to stream slope is called sinuosity.

It is popularly said that in the case of decreasing the valley slope and size, the sinuosity will increase. The amount of sinuosity is under effect of control of the bed rock, road, plant cover type and other factors. Leopold and Longbin (1966) had shown that meandering curvature and its radius can be reached by calculating the meandering Wavelengthand sinuosity of the channel. The geometric characteristics of meandering is related to sinuosity so, is very important in the Rosgen classification.

Sinuosity depends on the stream channel slope balance during the time and water energy and sediment transport. The results show that 70 percent of the reaches have an average sinuosity, 24 percent a high and 6 percent low sinuosity.

The slope also, affects the flow speed, sediment transport, and water depth and channel width. The most channel slope frequency are in the 0/02 to 0/039 domain and the less frequency in the 0/04 to 0/099 domain which belongs to type B. the slope domain changes are high in the type B in such a way that in a reach in a domain less than 0/02, 5 reaches in the 0/02 to 0/039, 7 reaches in the 0/04 to 0/099 domain. The most frequency in a slope domain among level (I) types is related to slopes among 0/02 to 0/039 in the type G. 18 of 50 reaches are in this domain. 8 reaches are in the level below 0/001 in type C which has the most frequency after type G. the less frequency is related to domain below 0/02 in type B which has its own reach. There were no domains of 0/02 to 0/039 in the type C and below 0/001 in the type D.

The channel particles size shows the bed roughness which affects the flow speed. The bed particles on the bank will affect not only sediment transport and stream hydraulic but also, shape, pattern and channel profile. In this research, the most frequency of average size of the bed particles is related to cobble and then, gravel, cobble, sand and silt/clay. The reason for high frequency of boulder and cobble in the reaches under study is large floods and rather a steep slope of in the Ziarat watershed. High bank erosion is another reason for these large floods. The most frequency of bed particles among types (I) is related to type B which is in the 7 reaches. According to entrenchment and width/depth of 4 types (G, D, C, and B) of 8 types of level (I), it was the frequency of the types was received. Type G had 48 % the most frequency, type B had 26%, type C 20% and type D 6% the less frequency.

According to the latest results, frequency of level (II) contains 7 reaches of type B3a which is the most dominant one. 6 reaches were in the G7. Since type G in the level (I) had the most frequency but in the level (II) because of monotonous bed particles (cobbles), type B3a is the dominant type. In no reach the bed block existed as dominant bed particles. In type B 11 reaches has the frequency of cobble and 2Boulder. The bed particles of 7 reach in type G is sand, 6 gravel, 6 boulder and 5 cobbles. The bed particle size of 7 reaches of type C contains gravel, 2 reaches cobble and 1 silt/clay. Also, the bed particle size of 2 reaches of type D is gravel and 1 is cobble.

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Appendix:

Table no.2: size gradation for sediments in range of sand to boulders (Wentworth Scale)

Particle size class	Particle size (mm)
sand	2-0.063
Very Fine gravel	2-4
Fine gravel	4-8
Medium gravel	16-8
Coarse gravel	32-16
Very course	64-32
small cobble	64-90
Medium cobble	90-128
large cobble	128-180
Very large cobble	180-256
small Boulder	256-512
Medium Boulder	512-1024
Large Boulder	1024-2048
Very large Boulder	2048-4096

Table no 3: necessary factors for reviewing each type and a summary of the morphologic types

tream type	General description	Entrench-ment ratio	W/d ratio	Sinuosity	Slope	Landform/ soils/features
Aa+	Very steep, deeply entrenched, debris transport, torrent streams	<1.4	<12	1.0 to 1.1	>.10	Very high relief. Erosional, bedrock, or depositional features; debris flow potential. Deeply entrenched streams. Vertical steps with deep scour pools; waterfalls
A	Steep, entrenched, cascading, step-pool streams. High energy/ debris transport associated with depositional soils. Very stable if bedrock or boulder-dominated channel	<1.4	<12	1.0 to 1.2	.04 to .10	High relief. Erosional or depositional and bedrock forms. Entrenched and confined streams with cascading reaches. Frequently spaced, deep pools in associated step-pool bed morphology
B	Moderately entrenched, moderate gradient, riffle dominated channel with infrequently spaced pools. Very stable plan and profile. Stable banks	1.4 to 2.2	>12	>1.2	.02 to .039	Moderate relief, colluvial deposition and/or structural. Moderate entrenchment and width-to-depth ratio. Narrow, gently sloping valleys. Rapids predominate with scour pools
C	Low gradient, meandering, point bar, riffle/pool, alluvial channels with broad, well-defined flood plains	>2.2	>12	>1.2	<.02	Broad valleys with terraces, in association with flood plains, alluvial soils. Slightly entrenched with well- defined meandering channels. Riffle/ pool bed morphology
D	Braided channel with long- itudinal and transverse bars. Very wide channel with eroding banks	n/a	>40	n/a	<.04	Broad valleys with alluvium, steeper fans. Glacial debris and depositional features. Active lateral adjustment with abundance of sediment supply. Convergence/divergence bed features, aggradational processes, high bed load and bank erosion
DA	Anastomizing (multiple channels) narrow and deep with extensive, well-vegetated flood plains and associated wetlands. Very gentle relief with highly variable sinuosities and width-to-depth ratios. Very stable streambanks	>2.2	Highly variable	Highly variable	<.005	Broad, low-gradient valleys with fine alluvium and/or lacustrine soils. Anastomized (multiple channel) geologic control creating fine deposition with well-vegetated bars that are laterally stable with broad wetland flood plains. Very low bed- load, high wash load sediment
E	Low gradient, meandering riffle/pool stream with low width-to-depth ratio and little deposition. Very efficient and stable. High meander width ratio	>2.2	<12	>1.5	<.02	Broad valley/meadows. Alluvial materials with flood plains. Highly sinuous with stable, well-vegetated banks. Riffle/pool morphology with very low width-to-depth ratios
F	Entrenched meandering riffle/pool channel on low gradients with high width-to-depth ratio	<1.4	>12	>1.2	<.02	Entrenched in highly weathered material. Gentle gradients with a high width-to-depth ratio. Meandering, laterally unstable with high bank erosion rates. Riffle/pool morphology
G	Entrenched gully step-pool and low width-to-depth ratio on moderate gradients	<1.4	<12	>1.2	.02 to .039	Gullies, step-pool morphology with moderate slopes and low width-to-depth ratio. Narrow valleys, or deeply incised in alluvial or colluvial materials (fans or deltas). Unstable, with grade control problems and high bank erosion rates

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