Study The Factors Affecting The Proposed Model To Calculate The Rate Lateral Migration Of The Tigris River In The Kut City

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Abstract

The proposed model depends on bank shear stress for the external riverbank, lateral bed slope, volumetric longitudinal bed load discharge per unit channel width, lateral to longitudinal bed load discharge ratio, bend scour factor, and stream power. In this research, was discussed factors affecting the proposed model used to calculate the rate lateral migration happening in the bank of the River Tigris in the Kut city.Several variables have been used to compute the factors mentioned them, among these variables, radius of curvature, top water width, depths of water, angle of bend, velocities of water, longitudinal water surface slope, and mean diameter of sediment particles. The proposed model shows that the migration rate decreases as the radius of curvature, top water width, angle of bend, flow velocity at bend entrance (unless it exceeds the flow velocity at bend exit), flow velocity at bend exit (unless it exceeds the flow velocity at bend entrance), and depth of water near the outer bank are increased. On the other hand, the proposed model shows that the annual migration rate increases as the flow velocity at channel centerline, flow depth at channel centerline, longitudinal water surface slope, mean particle diameter at channel centerline and near the outer bank, bank shear stress for the external river bank, volumetric longitudinal bed load discharge per unit channel width, lateral to longitudinal bed load discharge ratio, and bend scour factor are increased.

الخلاصة

يعتمد النموذج المقترح على إجهاد القص المسلط على الضفة الخارجية وميل القاع العرضي وتصريف الرسوبيات بالاتجاه الطولي و العرضي ومعامل تآكل الضفة الخارجية وقدرة الجريان. تم في هذا البحث مناقشة العوامل المؤثرة على النموذج الرياضي المستخدم لتخمين مقدار التآكل الحاصل في الضفة الخارجية لنهر دجلة داخل مدينة الكوت حيث استخدمت عدة متغيرات لحساب العوامل المذكورة منها نصف قطر الحنية والعرض العلوي للماء في النهر وتصريف النهر الكلي وعمق الماء في مواقع مختلفة وزاوية الحنية وميل سطح الماء العلوي ومعدل قطر جزيئة الرسوبيات في منتصف النهر وقرب الضفة الخارجية للنهر . وقد تبين من نتائج النموذج المقترح إن معدل الزحف يقل بزيادة كل من :- نصف قطر الحنية في خط المنتصف ، العرض العلوي للماء ، زاوية الحنية ، سرعة الماء في الماء في مخرج الحنية (مالم تتجاوز السرعة في المدخل) ، عمق الماء قرب الضفة الخارجية. على الجانب الأخر فقد اظهر النموذج المقترح إن معدل الزحف يزداد بزيادة كل من :- سرعة و عمق الجريان في خط المنتصف ، ميل سطح الماء العلوي معدل قطر جزيئه الرسوبيات الخارجية وتصريف الرسوبيات بالاتجاه الطولي والعرضي معامل تآكل الضفة الخارجية.

1. Introduction

Lateral migration generally occurs as the result of one of three processes(Parsons,2002): meander bend development, channel response to a flow obstructs that initiate bank erosion on the opposing bank, or an increase in bank erodibility (as occurs following removal of vegetation). In meander bend de the curvature of the bend accelerates flow and therefore erosion around the outer edge of the bend, and decelerates flow on the inside, which causes the inside of the bend (the point bar) to accumulate sediment, which further concentrates flow around the outer edge of the bend, and so on. Because erosion around the outer edge of a meander is generally counterbalanced in this fashion with deposition. There are bends that the migration rate has been measured in the reach of Tigris River within Kut city (Ayad,2007).

In this research, the results obtained from applying the proposed model equation (1) (Ayad,2007) have been analyzed and discussed, taking into consideration factors that are affecting every individual variable included in the model. Upon the fact that no enough data are available, a hypothetical data has been used (Micheli et. al.,2004).

$$M = K\frac{q_L}{W}\left[6.002076771 \times \left(\frac{q_L \cdot \tau_b}{s_p}\right)^{0.193311422} \times \left(\frac{q_T}{q_L}\right)^{0.10119174} \times \left(\frac{R_c}{W}\right)^{0.016981} \times \left(\frac{H_o}{W}\right)^{0.184551481} \times A_s^{0.650226128}\right]$$

(1)

In which K=3.1536*10^7, τ_b =Bank shear stress; q_L =Longitudinal volumetric bed load per unit channel width ;q_T =Lateral volumetric bed load per unit channel length ;sp =Stream power; R_c =Curvature Radius at channel centreline; W =Top width of flow ;H_o =Bank height (depth of water near the outer bank); and A_s =Bend scour factor.

2. The factors affecting the proposed model

The proposed model depends on the following factors(Integrated Resources Management,2004):

- Bank shear stress, τ_b;
- Longitudinal volumetric bed load per unit channel width (q_L);
- Lateral volumetric bed load per unit channel length (q_T);
- Stream power (sp);
- Curvature Radius at channel centreline (R_c);
- Top width of flow (W);
- Bank height (depth of water near the outer bank, H_o); and
- Bend scour factor (A_s).

These factors are depending on the following individual variables:

- Angle of bend (Φ);
- Velocity at bend entrance (U_1);
- Velocity at exit of bend (U_2);
- Longitudinal velocity component at the channel centreline (U_c);
- Longitudinal slope of water surface(S);
- Depth of water at the channel centreline (H_c);
- Mean diameter of sediment particles at the channel centreline (d_{50c}); and
- Mean diameter of sediment particles near the outer bank (d_{50o}).

Therefore, the weight of effect of each individual variable has been tested to clarify how each variable affecting the physical and mathematical behaviour of the proposed model. Eleven individual variables have been considered through eleven trials every trial consist about 30 values, concentrating on one variable alternately, while the remaining variables are kept constant consequently as shown in Table (1).

Table (1) The Hydraulic Features of proposed Section (Ziyad,2004)

Rc m	W m	Φ deg.	Q m^3/sec	U_c m/sec	U_1 m/sec	U_2 m/sec	H_o m	d_{50c} mm	S	H_c m	d_{50} mm
1258	350	30	1250	0.65	0.82	0.76	7. 5	0.16	$6*10^{-5}$	6.5	0.16

3. Results and discussion

This derivation process and trial techniques for above listed variables are discussed as follows:-

3.1 Curvature radius at channel centreline (R_c)

Taking this factor as a variable with all other factors remaining constant and applying the specified methodology of analysis. The effect of radius of curvature (R_c) on (τ_b and $\frac{q_T}{q_L}$) are shown graphically in Figures (1 , 2) respectively , while the relationship between R_c and M for the proposed model has been shown in Figure (3). Results shown in Figures (1 and 2) indicate clearly that the radius of curvature (R_c) is a very effective factor on the bank shear stress, the longitudinal to lateral ratio of bed load discharge, and the annual migration rate, while this factor (R_c) has no obvious effect on the longitudinal bed load discharge, bend scour factor, and stream power. The proposed model can be summarized, as the radius of curvature increases, decreasing in bank shear stress, the ratio between lateral to longitudinal bed load discharge, and annual migration rate. However, the longitudinal bed load discharge bend scour factor, and stream power remains fairly constant.

3.2 Top water width (W)

Taking this factor as variable with all other factors remaining constant and applying the specified methodology of analysis. The effect of top water width (W) on the τ_b are shown graphically in Figure (4) while the relationship between W& M for the proposed model has been shown in Figure (5). Results shown in Figures (4, and 5) indicate clearly that the top water width is a very effective factor on the bank shear stress, and the annual migration rate. However, this factor (W) has no obvious effect on the longitudinal bed load discharge, the longitudinal to lateral ratio of bed load discharge, bend scour factor, and stream power. The proposed model can be summarized, as top water width increases, deccreasing in: bank shear stress, and annual migration rate is observed, while the longitudinal bed load discharge, the longitudinal to lateral ratio of bed load discharge, bend scour factor, and stream power remains fairly constant. The direct effect of bank shear stress (τ_b) on the annual migration rate (M) can be summarized as bank shear stress increases, increasing in annual migration rate is observed as shown in Figure (6).

3.3 Angle of bend (Φ)

Taking this factor as variable with all other factors remain constant and applying the specified methodology of analysis, the effect of angle of bend (Φ) on the (τ_b and M) are shown graphically in Figures (7 and 8) respectively. Results shown in Figures (7 and 8) indicate clearly that the angle of bend is an effective factor on the bank shear stress, and the annual migration rate. However this factor (Φ) has no effect on the longitudinal bed load discharge, the longitudinal to lateral ratio of bed load discharge, bend scour factor, and stream power. The proposed model can be summarized, as angle of bend increases, deccreasing in bank shear stress and annual migration rate are observed, while the longitudinal bed load discharge, the longitudinal to lateral ratio of bed load discharge, bend scour factor, and stream power remains fairly constant.

3.4 Velocity at bend entrance (U_1)

Taking this factor as variable with all other factors remaining constants and applying the specified methodology of analysis. The effect velocity at bend entrance (U_1) on the (τ_b and M) are shown graphically in Figures (9 and 10) respectively. Results shown in Figures (9 and 10) indicate clearly that the velocity at the entrance of bend is an effective factor on the bank shear stress, and the annual migration rate. However this factor (U_1) has no effect on the longitudinal bed load discharge, the longitudinal to lateral ratio of bed load discharge, bend scour factor, and stream power per unit channel length. The proposed model can be summarized. As velocity at the entrance is increases decreasing in hank shear stress, and the value of annual migration rate are observed, unless the value of U_1 don't exceed the value of U_2 , but when the value of U_1 is exceed ,or equal the value of U_2 ,converting the relation between U_1 and τ_b and the relation between U_1 and M is observed, i.e. if $U_1 \geq U_2$ then the value of bank shear stress will be increase when U_1 is increase also the value of annual migration rate Will be increase when U_1 is increase. In addition, it is very clear that the values of longitudinal bed load discharge, the longitudinal to lateral ratio of bed load discharge, bend scour factor remains fairly constant.

3.5 Velocity at exit of bend (U_2)

Taking this factor as variable with all other factors remaining constant and applying the specified methodology of analysis shows that, the effect velocity at bend entrance (U_2) on the (τ_b and M) are shown graphically in Figures (11 and 12) respectively. Results shown in Figures (11 and 12) indicate clearly that the velocity at the exit of bend is an effective factor on the bank shear stress, and the annual migration rate. However, this factor (U_2) has no obvious effect on the longitudinal bed load discharge, the longitudinal to lateral ratio of bed load discharge, bend scour factor, and stream power per unit channel length. The proposed model can be summarized. As the velocity at the exit of bend is increases decreasing in the bank shear stress, and the value of annual migration rate are observed unless the value of U_2 doesn't exceed the value of U_1, but when the value of U_2 is exceeded ,or equalled ,the value of U_1 this will lead to convert the relation between U_2 and τ_b and the relation between U_2 and M i.e. if $U_2 \geq U_1$ then the value of bank shear stress will be increased when U_2 is increased also the value of annual migration rate will be increased when U_2 is increased. Also it's very clear that the values of longitudinal bed load discharge, the longitudinal to lateral ratio of bed load discharge, bend scour factor, remains fairly constant.

3.6 Depth of water near the outer bank (H_o)

Taking this factor as variable with all other factors remaining constant and applying the specified methodology of analysis. Results shown in Figures (13 and 14) indicate clearly that the depth of water near the outer bank is an effective factor on the bank shear stress, and the annual migration rate, respectively. However, this factor (H_o) has no obvious effect on the longitudinal bed load discharge, the longitudinal to lateral ratio of bed load discharge, bend scour factor, and stream power per unit channel length.. The proposed model can be summarized. As the depth of water near the outer bank is increases, decreasing in bank shear stress and the value of annual migration rate has been observed. Bank shear stress decreases is observed continually when the value of H_o has been increased. The relation between the values of H_o & M is converting when H_o increases continually; however, this increment will cause increasing in the value of annual migration rate. The previous behaviour can be justified. As H_o increases, increasing in H_o / W ratio is happened, predicted annual migration rate is acceptable unless this 0.05, but when this ratio exceeds this value (0.05) this will cause abnormal predicted value for annual migration rate.

3.7 Velocity at the channel centreline of particular section (U_c)

When we take taking this factor as variable with all other factors remaining constants and applying the specified methodology of analysis. the effect velocity at the channel centreline of particular section (U_c) on the (q_T/q_L and M) are shown graphically in Figures (15 and 16) respectively. Results shown in Figures (15 and 16) indicate clearly that the velocity at the channel centreline (U_c) is very effective factor on the the longitudinal to lateral ratio of bed load discharge, and the annual migration rate. However, this factor (U_c) has no obvious effect on the bank shear stress, longitudinal bed load discharge, bend scour factor, and stream power. The proposed model can be summarized. As velocity at the channel centreline of particular section (U_c) are increases, increasing in:- the ratio between lateral to longitudinal bed load discharge, and annual migration rate are observed, while the bank shear stress, longitudinal bed load discharge, bend scour factor, and stream power remains fairly constant. The direct effect of q_T/q_L on the annual migration rate (M) can be summarized as, increases in lateral to longitudinal bed load discharge ratio, increasing in annual migration rate is observed as shown in Figure (17).

3.8 Depth of water at the channel centreline (H_c)

Taking this factor as variable with all other factors remaining constants and applying the specified methodology of analysis. The depth of water at he channel centreline (H_c) on the ($\boldsymbol{q_L}, \frac{\boldsymbol{q_T}}{\boldsymbol{q_L}}, \boldsymbol{A_s}$) are shown graphically in Figures (18, 19 and 20) respectively. Results shown in Figures (18, 19, 20, and 21) clearly indicate that the water depth at the channel centreline (H_c) is a very effective factor on the longitudinal bed load discharge, the longitudinal to lateral ratio of bed load discharge, bend scour factor, and the annual migration rate. However, this factor (H_c) has no obvious effect on the bank shear stress, and stream power. The proposed model can be summarized As the value of H_c is increases, increasing in:- longitudinal bed load discharge the ratio between lateral to longitudinal bed load discharge, bend scour factor, and annual migration rate are observed while the bank shear stress and stream power remains fairly constant.

3.9 Longitudinal slope of water surface(S)

If we take taking this factor as variable with all other factors remaining constant and applying the specified methodology of analysis. The longitudinal slope of water surface (S) on the (q_L , A_s , $\frac{q_T}{q_L}$, s_p and M) are shown graphically in Figures (22, 23, 24, 25 and 26) respectively. Results shown in Figures (22, 23, 24, 25 and 26) indicate clearly that the slope of water surface (S) is a very effective factor on longitudinal bed load discharge, the longitudinal to lateral ratio of bed load discharge, bend scour factor, stream power, and the annual migration rate. However, this factor (S) has no obvious effect on the bank shear stress. The proposed model can be summarized. As longitudinal slope of water surface (S) increases, increasing in: longitudinal bed load discharge, bend scour factor, stream power and annual migration rate is observed, also, value of S is increases, decreasing in the value of the ratio between lateral to longitudinal bed load discharge are observed, while the bank shear stress, remains fairly constant.

3.10 Mean diameter of sediment particles at the channel centreline (d_{50c})

If we take taking this factor as variable with all other factors remaining constant and applying the specified methodology of analysis. Results shown Figures (27, 28, and 29) indicate clearly that the mean diameter of sediment particles at the channel centreline (d_{50c}) is an effective factor on the longitudinal bed load discharge, the longitudinal to lateral ratio of bed load discharge, and the annual migration rate. However, this factor (d_{50c}) has no obvious effect on the bank shear stress, bend scour factor, and stream power. The proposed model can be summarized. As mean diameter of sediment particles at the channel centreline (d_{50c}) increases, decreasing in: longitudinal bed load discharge, the longitudinal to lateral ratio of bed load discharge and annual migration rate are observed, while the bank shear stress, bend scour factor, and stream power, remains fairly constant. The direct effect of longitudinal bed load discharge (q_L) on annual migration rate (M) can be summarized as, (q_L) decreases, increasing in M is observed, as shown in Figure (30).

3.11 Mean diameter of sediment particles near the outer bank (d_{50o})

To study the effect of this factor, all other factors have been considered constant . Results shown in Figures (31 and 32) indicate clearly that the mean diameter of sediment particles near the outer bank of bend (d_{50o})is an effective factor on the bend scour factor, and the annual migration rate, this factor (d_{50o})has no obvious effect on the bank shear stress, longitudinal bed load discharge, the longitudinal to lateral ratio of bed load discharge, and stream power. The proposed model can be summarized. As mean diameter of sediment particles near the outer bank of bend (d_{50o})increases, decreasing in: bend scour factor and annual migration rate is observed while longitudinal bed load discharge, the longitudinal to lateral ratio of bed load discharge, and stream power remains fairly constant. The direct effect of bend scour factor (As) on annual migration rate (M) can be summarized as, (As) increases, increasing in M is observed, as shown in Figure (33).

4. Conclusions

According to the results obtained from applying the proposed model equation (1) for Tigris River within Kut city are as below:-

- The radius of curvature increases, increasing in: the bank shear stress, lateral bed slope, the ratio between lateral to longitudinal bed load discharge, and annual migration rate are observed while the longitudinal bed load discharge, bend scour factor, and stream power remained fairly constant.
- As the water width increases, increasing in: the bank shear stress, and annual migration rate, while the lateral bed slope, longitudinal bed load discharge, the longitudinal to lateral ratio of bed load discharge, bend scour factor, and stream power remained fairly constant.
- The angle of bend increases, increasing in: bank shear stress, and annual migration rate are observed while the lateral bed slope, longitudinal bed load discharge. the longitudinal to lateral ratio of bed load discharge, bend scour factor, and stream power are remained fairly constant.
- The velocity at the entrance (U_1) increases, decreasing in bank shear stress, and the value of annual migration rate, unless the value of U_1 does not exceed the value of U_2 but when the value of U_1 exceeds, or equals ,the value of U_2 ,converting the relation

between U_1 and τ_b and the relation between U_1 and M are observed i.e., if $U_1 \geq U_2$ then the value of bank shear stress will be increase when U_1 increased also the value of annual migration rate will be increased when U_1 is increased. Also it's very clear that the values of lateral bed slope, longitudinal bed load discharge, the longitudinal to lateral ratio of bed load discharge, bend scour factor, remained fairly constant.

- The velocity at the exit of bend (U_2) increases, decreasing in bank shear stress, and the value of annual migration rate are observed unless the value of U_2 do not exceed-the value of U_1, but when the value of U_2 is exceeded or equal to the value of U_1 this will convert the relation between U_2 and τ_b and the relation between U_2 and M i.e. if $U_2 \geq U_1$ then the value of bank shear stress will be increased when U_2 is increases also the value of annual migration rate will be increased when U_2 is increased. Also it's very clear that the values of lateral bed slope, longitudinal bed load discharge, the longitudinal to lateral ratio of bed load discharge, bend scour factor, remained fairly constant.
- The depth of water near the outer bank (H_o) of bend increases, decreasing in bank shear stress and the value of annual migration rate has been observed. So, bank shear stress decreases as observed continually when the value of H_o has been increased. The relation between the values of H_o and M is converted when H_o increases continually; however, this increment with cause increasing in the value of annual migration rate. The previous behaviour can be justified. As H_o increases, increasing in H_o/W ratio happened , the value of predicted annual migration rate was accepted value unless this ratio exceeds 0.05, but when this ratio exceeds this value (0.05) this will cause abnormal predicted value for annual migration rate.
- The velocity at the channel centerline of particular section (U_o) increases, increasing in: lateral bed slope, the ratio between lateral to longitudinal bed load discharge, and annual migration rate are observed, while the bank shear stress, longitudinal bed load discharge, bend scour factor, and stream power remained fairly constant.
- The depth of water at the channel centerline (H_c) increases, increasing in: lateral bed slope, longitudinal bed load discharge the ratio between lateral to longitudinal bed load discharge, bend scour factor and annual migration rate are observed while the bank shear stress and stream power remain fairly constant.
- The longitudinal slope of water surface (S) increases increasing in: lateral bed slope, longitudinal bed load discharge. bend scour factor, stream power and annual migration rate are observed also, value of S is increases, decreasing in the value of the ratio between lateral to longitudinal bed load discharge are observed, while the bank shear stress, are remained fairly constant.
- The mean diameter of sediment particles at the channel centerline (d_{50c}) increases, decreasing in: lateral bed slope, longitudinal bed load discharge, the longitudinal to lateral ratio of bed load discharge and annual migration rate are observed, while the bank shear stress, bend scour factor, and stream power, are remained fairly constant.
- The mean diameter of sediment particles near the outer bank of bend (d_{50o}) increases but decreases in: bend scour factor and annual migration rate are observed , while lateral bed slope, longitudinal bed load discharge, the longitudinal to lateral ratio of bed load discharge, and stream power remained fairly constant.
- Bank shear stress increases, increasing in annual migration rate is observed.

- Lateral to longitudinal bed load discharge ratio increases, increasing in annual migration rate is observed.
- Longitudinal bed load discharge increases, increasing in annual migration rate is observed.

References

Ayad, K.H.,(2007),"**Sedimentation treatment at the intake of Wasit thermal power station",** Ph.D. thesis ,University of Technology, Department of Building and Construction Engineering ,Baghdad, Iraq.

Integrated Resources Management,(2004),"**Channel Migration Zones**", Executive Report-Best Available Science, Vol.I, Department of Natural Resources and Mines, the State of Queensland, (From Internet).

Micheli, E.R., Kirchner, J.W., and Larsen, E.W., (2004), **"Meandering River",** Lecture Six Department of Earth and Planetary Science, University of California.,(From Internet).

Parsons, R., (2002), **"Flow Separation in Meandering Bends",** Ph.D Thesis, Department of Geography, University of Sheffield. (From Internet).

Ziyad Abdul-Bari K. Kubba,(2004),"A model for the hydraulic behaviour of natural river bends", Master Thesis, University of Technology, Department of Building and Construction Engineering ,Baghdad, Iraq .

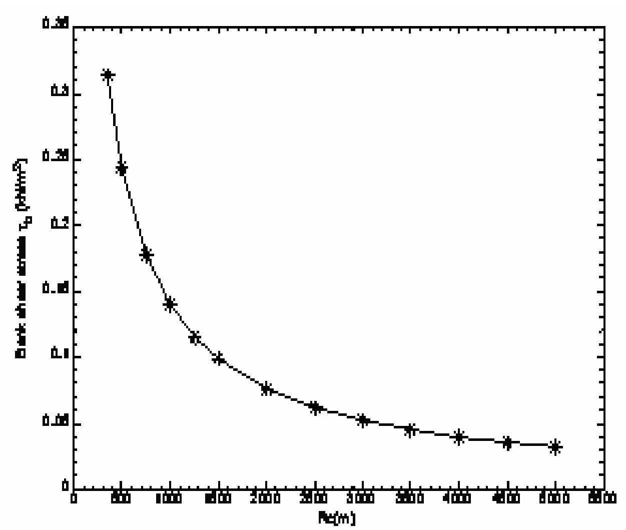


Figure (1) The Relationship between (R_c& τ_b)

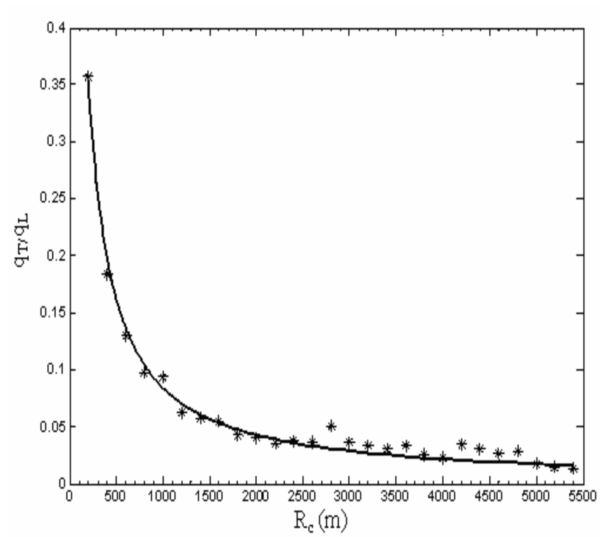


Figure (2) The Relationship between (R_c& q_T/q_L)

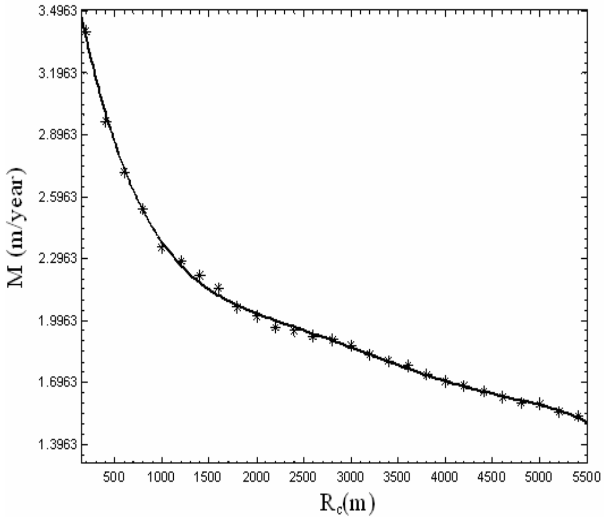


Figure (3) The Relationship between (R_c& M)

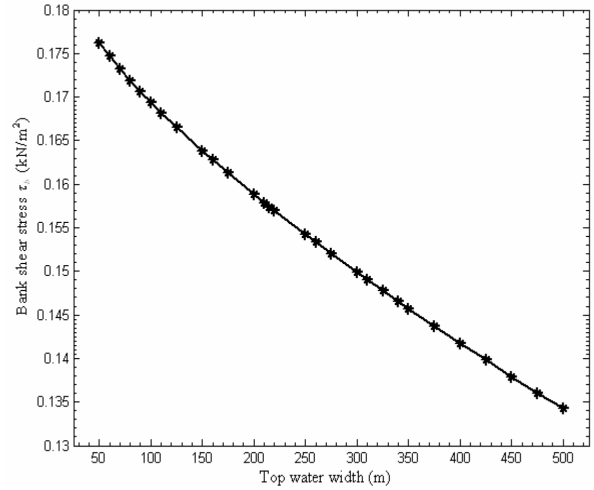


Figure (4) The Relationship between (W & τ_b)

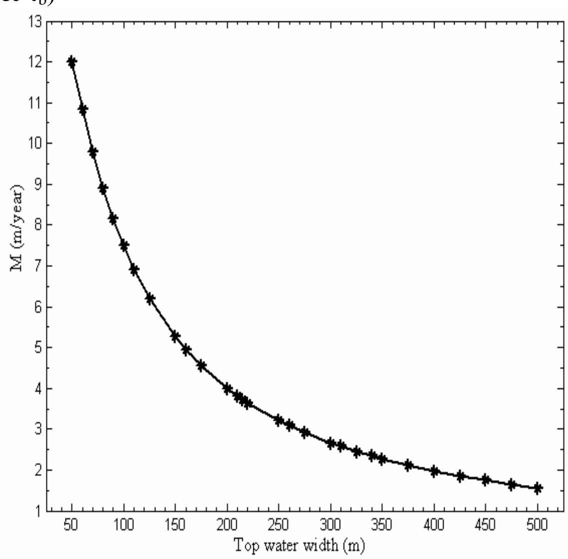


Figure (5) The Relationship between (W& M)

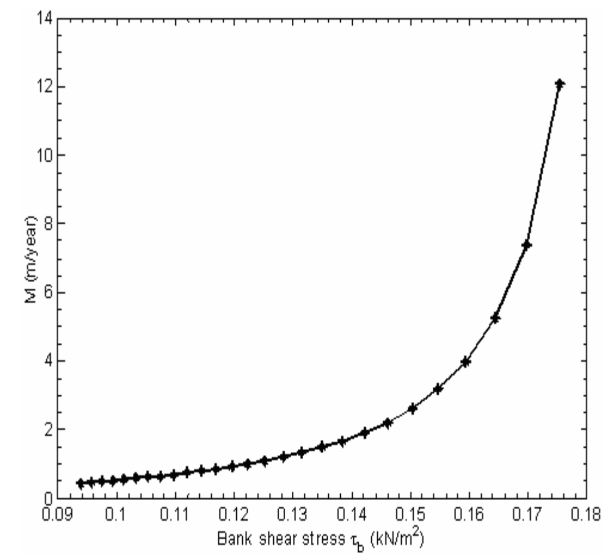


Figure (6) The Relationship between (τ_b & M)

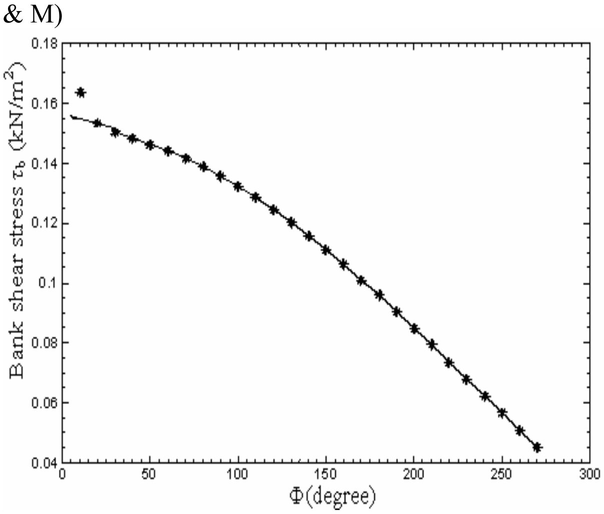


Figure (7) The Relationship between (Φ & τ_b)

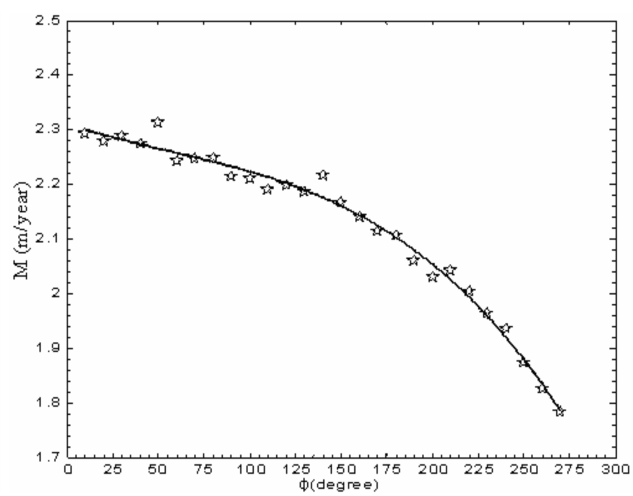


Figure (8) The Relationship between (Φ & M)

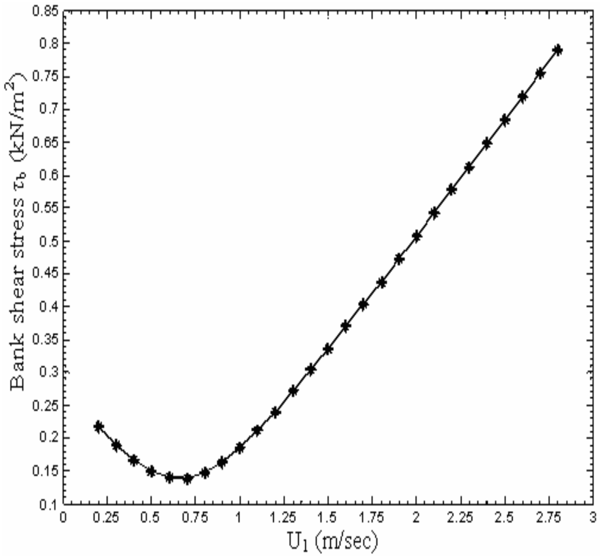


Figure (9) The Relationship between (U_1& τ_b)

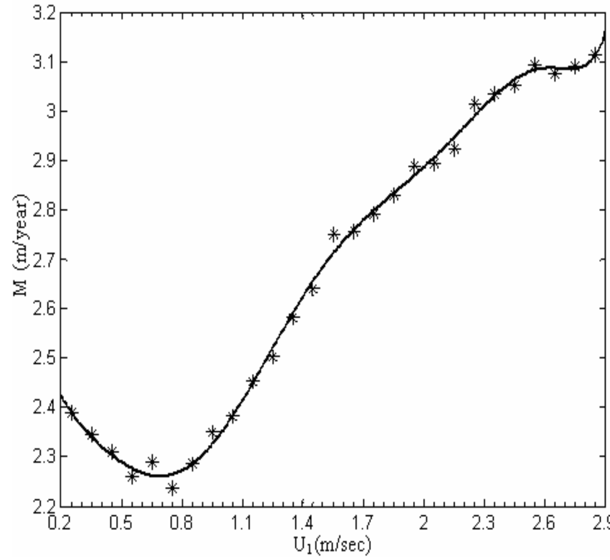


Figure (10) The Relationship between (U_1& M)

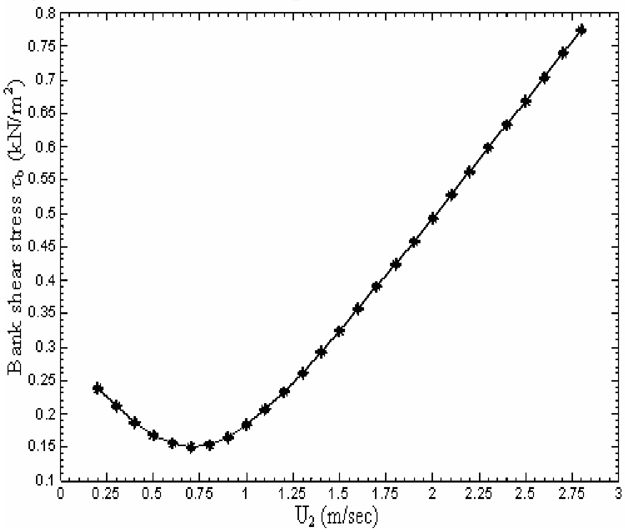


Figure (11) The relationship between (U_2 & τ_b)

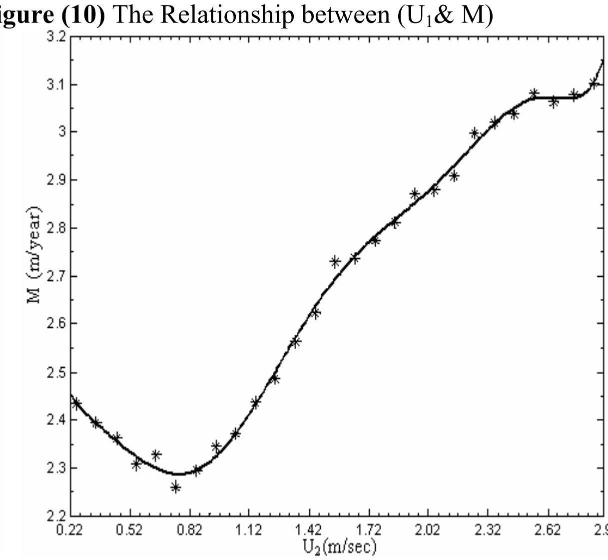


Figure (12) The relationship between (U_2 & M)

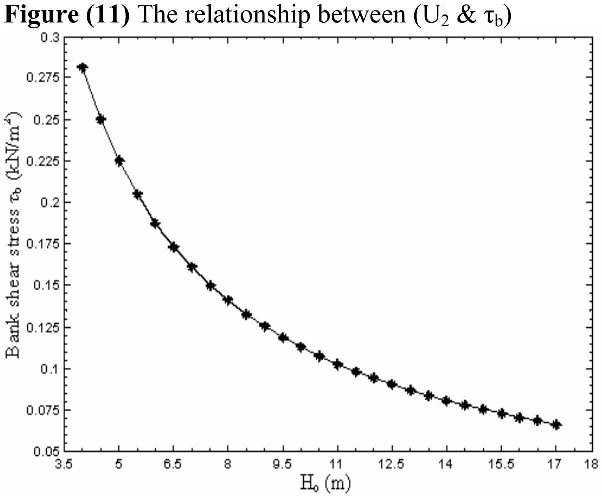


Figure (13) The Relationship between (H_o & τ_b)

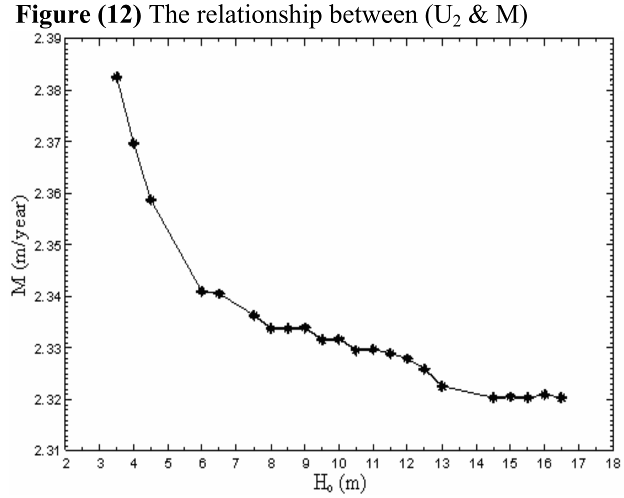


Figure (14) The Relationship between (H_o & M)

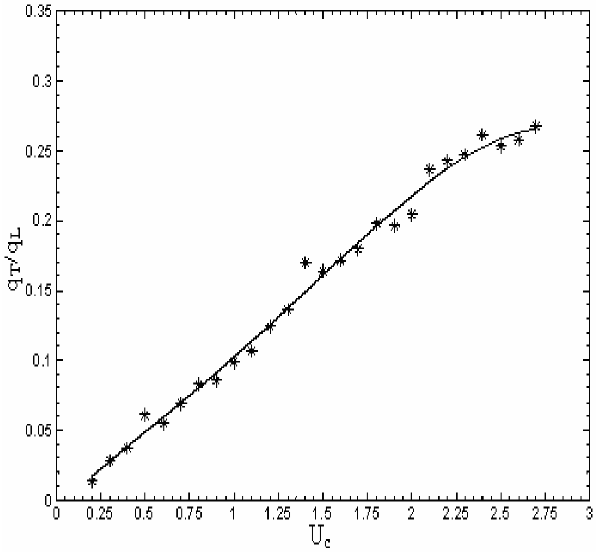


Figure (15) The Relationship between (U_c & q_T/q_L)

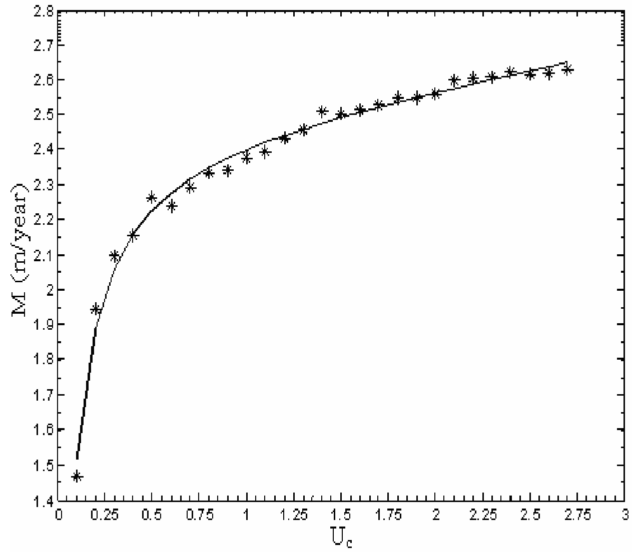


Figure (16) The Relationship between (U_c & M)

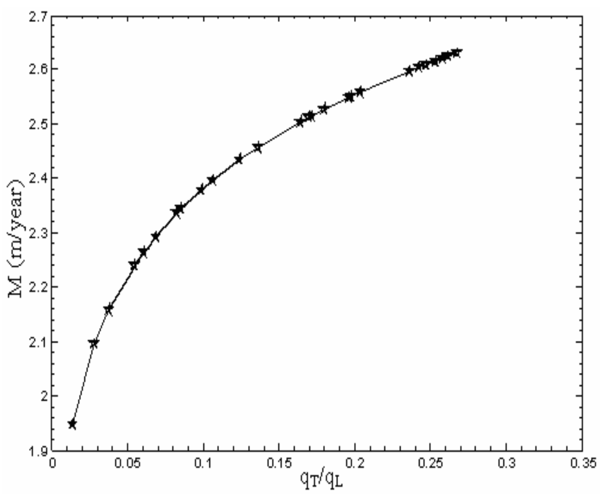


Figure (17) The Relationship between (q_T/q_L & M)

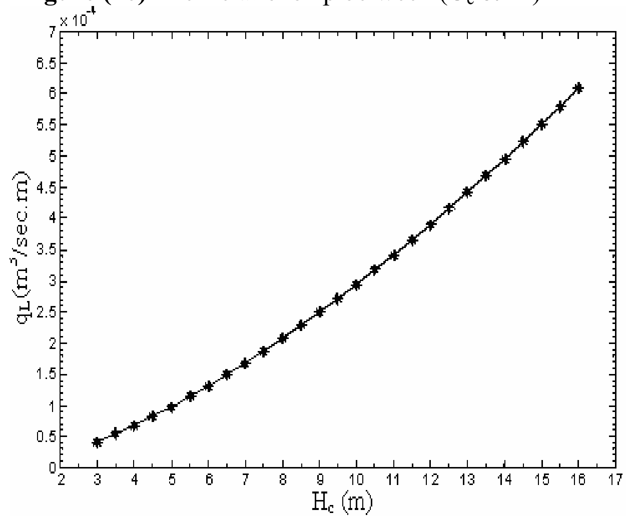


Figure (18) The Relationship between (H_c & q_L)

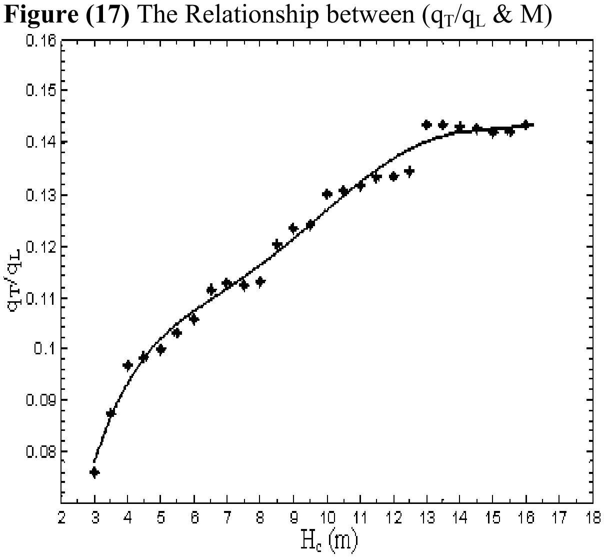
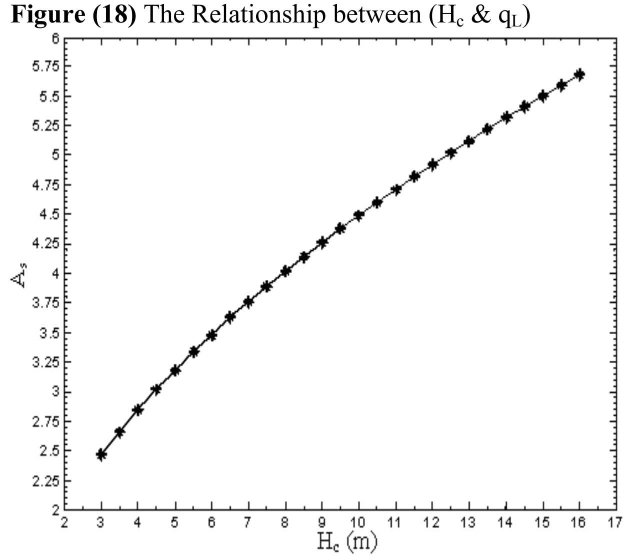


Figure (19) The Relationship between (H_c & q_T/q_L)



Figure(20) The Relationship between(H_c & A_s)

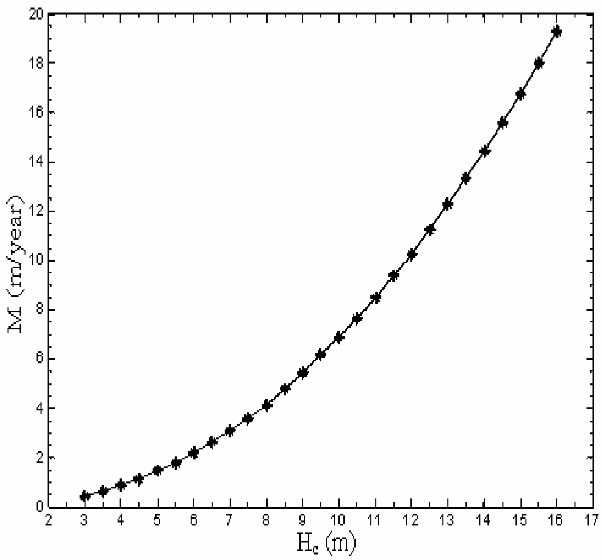


Figure (21) The Relationship between (H_c & M)

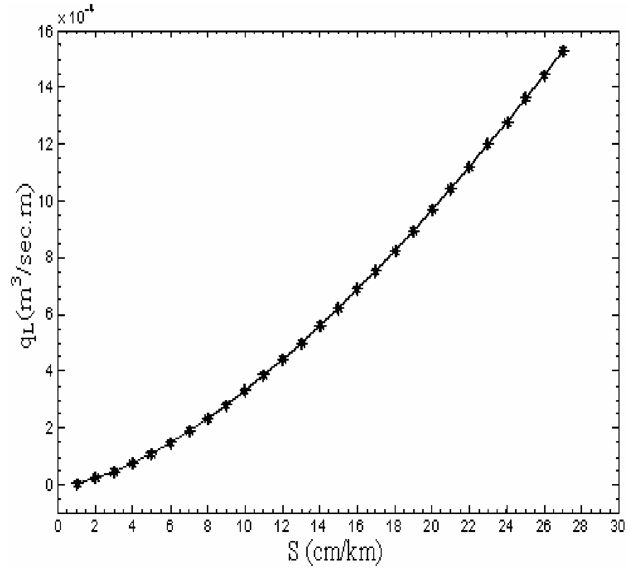


Figure (22) The Relationship between (S & q_L)

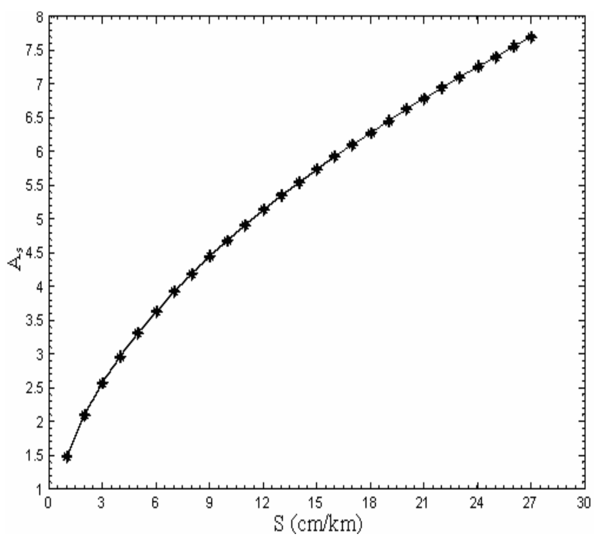


Figure (23) The Relationship between (S & q_T/q_L)

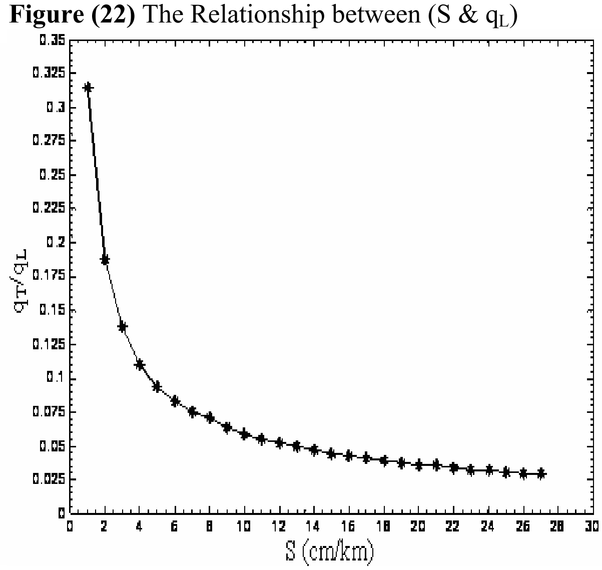


Figure (24) The Relationship between (S & A_s)

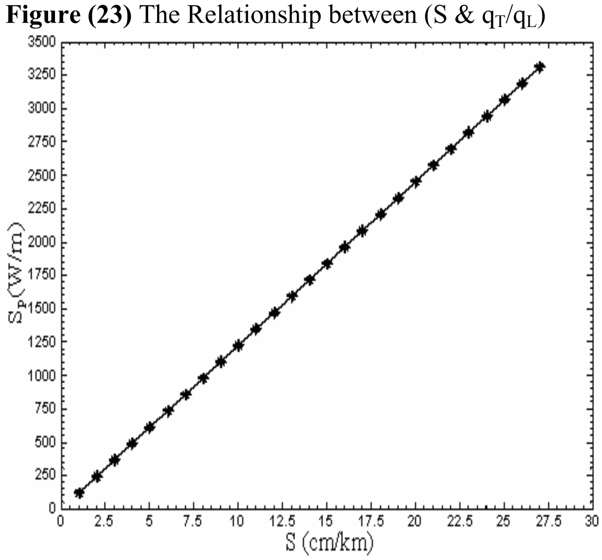


Figure (25) The Relationship between (S & s_p)

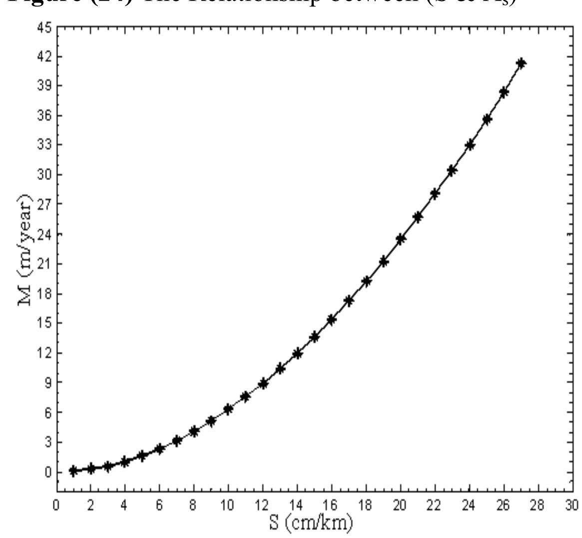


Figure (26) The Relationship between(S & M)

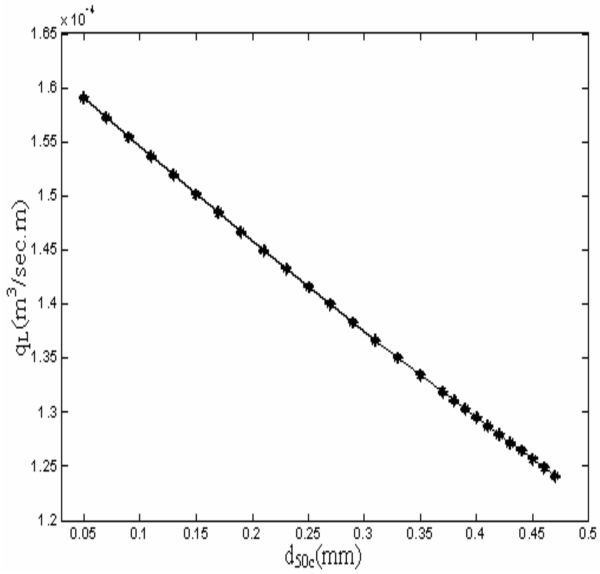


Figure (27) The Relationship between (d_{50c} & q_L)

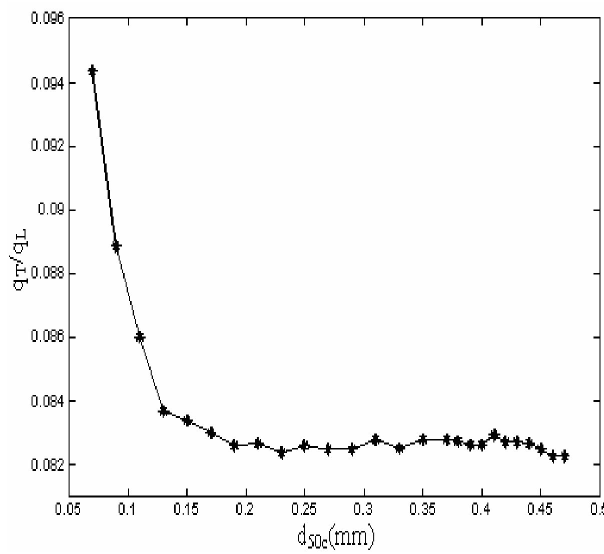


Figure (28) The Relationship between (d_{50c} &q_T/q_L)

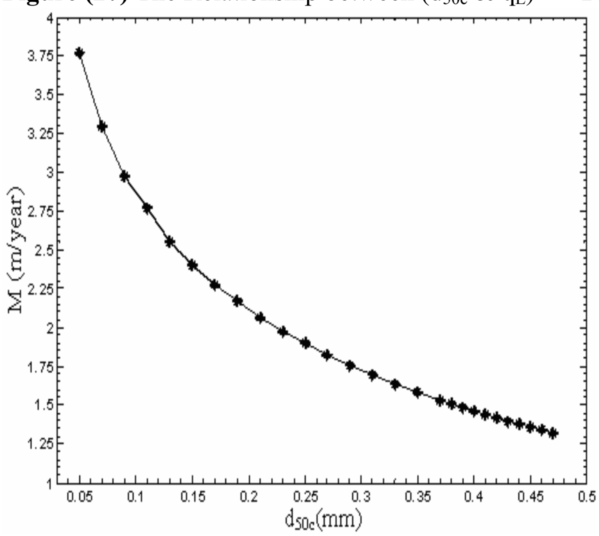


Figure (29) The Relationship between (d_{50c} & M)

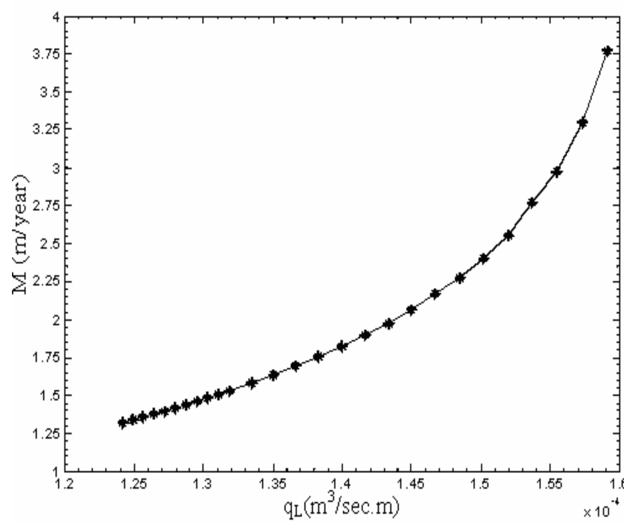


Figure (30) The Relationship between (q_L & M)

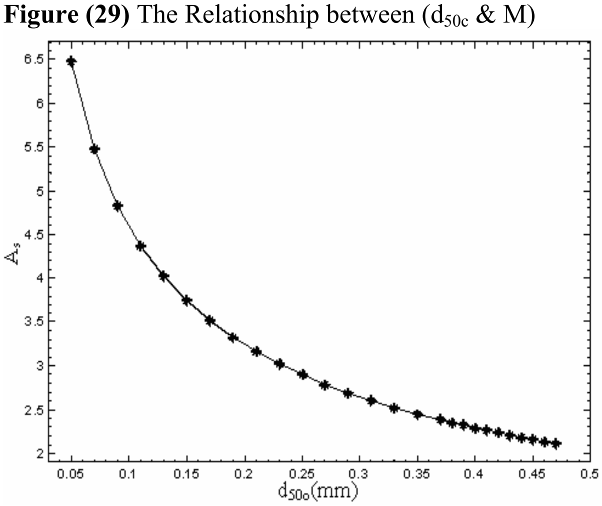


Figure (31) The Relationship between (d_{50o} & A_s)

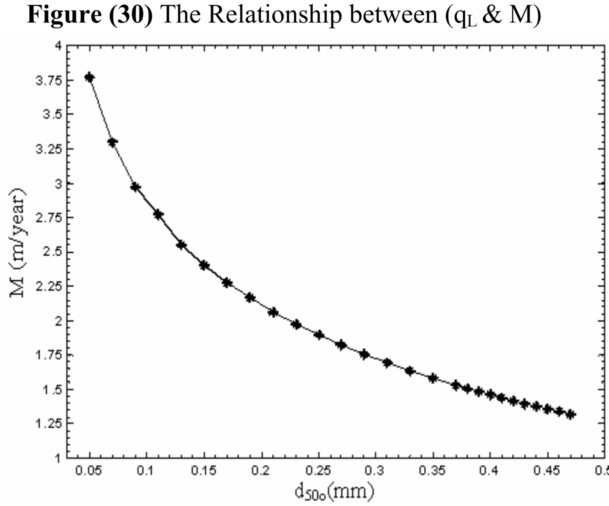


Figure (32) The Relationship between (d_{50o} & M)

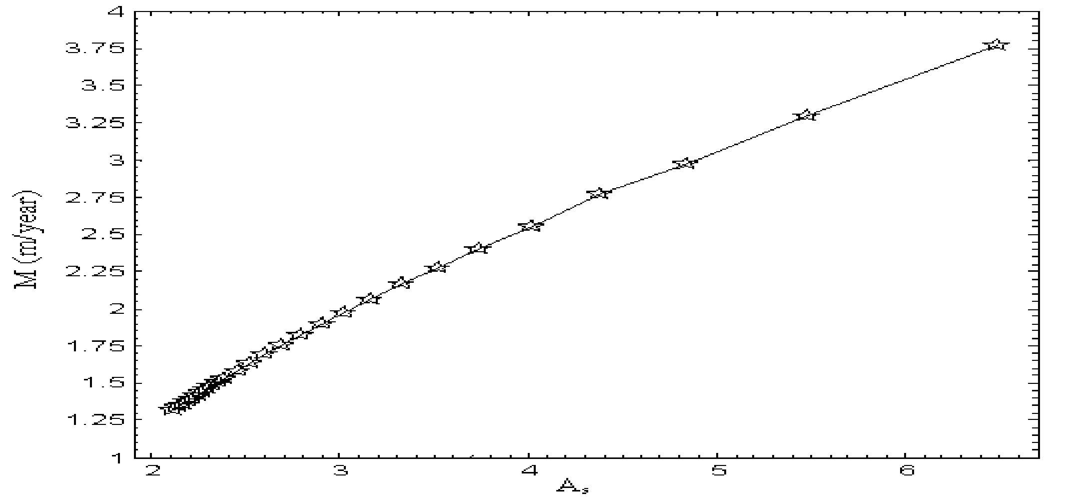


Figure (33) The Relationship between (A_s & M)