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To Investigate Effect of Density in Sea Water by the Motion of Spherical Shock Wave

Anil Kumar

Department of Physics, Bareilly College, Bareilly, India

ABSTRACT: The propagation of shock wave in deep sea, have been investigating the effect of density of sea under water Earthquake to analyze 'Tsunami' for two cases i.e. diverging and conversing spherical shock wave and summarize shock strength different shock parameters and depend on direction.

I. INTRODUCTION

The shock wave propagation in sea water has been studied by Bhatnagar at., al; Rao Ranga & Ramana (1973) Singh at., al (1980) without taking the effect of earth gravitating atmosphere and all direction since Yadav & Kumar (1970) in the troposphere. Investigation in this paper the propagation of spherical shock wave under sea water medium depends on the density of water. Thus the water medium is non-uniform although the change in presence of density in all direction. Propagation spherical shock wave in under sea water diverging and conversing the shock strength and density change in all direction. Using different techniques many authors have been study the propagation of shock waves in uniform and non-uniform medium .Yadav and Singh(2004) have studied of strong spherical and cylindrical shock wave in the non- uniform medium father effect of overtaking disturbances Yadav (1992).the variation of shock velocity, particle velocity, pressure and density in all direction.

II. BASIC EQUATION

The basic equations for the flow behind the shock front in sea water-

$$\frac{\partial \rho}{\partial t}+\frac{\partial}{\partial r}(\rho u)+\frac{1}{r}\frac{\partial}{\partial \theta}(\rho \mathrm{v})+\frac{\alpha \rho u}{r}+\rho \mathrm{v}\frac{\cot\theta}{r}=0 \qquad (1)$$

$$\frac{\partial u}{\partial t}+u\frac{\partial u}{\partial r}+\frac{\mathrm{v}}{r}\frac{\partial u}{\partial \theta}+\frac{1}{\rho}\frac{\partial p}{\partial r}=0 \qquad (2)$$

$$\frac{\partial \mathrm{v}}{\partial t}+u\frac{\partial \mathrm{v}}{\partial r}+\frac{\mathrm{v}}{r}\frac{\partial \mathrm{v}}{\partial \theta}+\frac{1}{\rho r}\frac{\partial p}{\partial \theta}=0 \qquad (3)$$

Where, r is propagation distance u, v, p U and are respectively the particle velocity in redial direction, velocity in transverse direction, the pressure, the shock velocity and $\alpha = 1$ or 2 respectively for the cylindrical or spherical flow.

III. BOUNDRY CONDITIONS

If p_0 and ρ_0 denoted the undisturbed value of pressure and density in front of shock wave the jump condition are

$$u=\frac{2a_0 M}{(n+1)}, \quad p=\frac{2a_0^2 M^2 \rho_0}{(n+1)}, \quad \rho=\rho_0\frac{(n+1)}{(n-1)}$$

$$s=\sqrt{\frac{2n}{n+1}}$$

$$\rho = \mathrm{SMa}_0\left(\frac{n-1}{n+1}\right) \qquad (4)$$

THEORY FOR DIVERGING SHOCK WAVES

In the freely propagation description, the characterstics form of system of equation (1)-(3) i.e. the form in which each equation contains derivatives in only direction in the (r, t) plane.

$$dp + \rho a du + \frac{\rho a^2}{(u+a)}\left(\frac{\alpha u}{r} + \frac{v}{r}\cot\theta\right) dr = 0 \quad (5)$$

Equations (5) represent the characteristic form of diverging shock wave.
Now using jump conditions in equation (5), we get –

$$M^2 \frac{d\rho_0}{\rho_0} + (1+\frac{s}{2})dM^2 + \frac{s^2 M^2 (n-1)(\alpha + \cot\theta)}{[2+s(n-1)]}\frac{dr}{r} = 0$$

Where , $\rho_0 = \rho^1(1+xr)$

x = Arbitrary constt.

$$\frac{dM^2}{M^2} + \frac{2}{(2+s)}\frac{xdr}{(1+xr)} + \frac{2}{(2+s)}\frac{s^2(n-1)(\alpha+\cot\theta)}{[2+s(n-1)]}\frac{dr}{r} = 0$$

Let $Q = \frac{2}{(2+s)}\frac{s^2(n-1)(\alpha+\cot\theta)}{[2+s(n-1)]}$, $\mu = \frac{2}{(2+s)}$

on integrating equation.

SHOCK STRENGTH

$$M_+ = \xi r^{-Q/2}(1+xr)^{-\mu/2} \quad (6)$$

where ξ is constant of integration

Shock velocity, Particle Velocity and Density expression

$$U = \left[\frac{n\xi}{\rho'(1+xr)}\right]^{1/2} \xi\, r^{-Q/2}\, (1+xr)^{-\mu/2} \quad (7)$$

$$u = \frac{2}{(n+1)}\left[\frac{n\xi}{\rho'(1+xr)}\right]^{1/2} \xi\, r^{-Q/2}\, (1+xr)^{-\mu/2} \quad (8)$$

$$P = \frac{2\rho_0}{(n+1)}\left(\frac{n\xi}{\rho'(1+xr)}\right) \xi^2\, r^{-Q}\, (1+xr)^{-\mu} \quad (9)$$

$$\rho = \rho'\left(\frac{\xi}{M}\right)^{2/\mu} r^{-Q/\mu}\left(\frac{n+1}{n-1}\right) \quad (10)$$

THEORY FOR CONVERGING SHOCK WAVE

In the freely propagation description, the characteristic form of system of equations (1) - (3) i.e. the form in which each equation contains derivatives in only direction in the (r, t) plane is-

$$dp - \rho a du + \frac{\rho a^2}{(u-a)}\left(\frac{au}{r} + \frac{v}{r}\cot\theta\right) dr = 0 \quad (11)$$

Equations (11) represent the characteristics for using boundary condition in this equation we get –

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$$\frac{dM^2}{M^2} + \frac{2}{(2-s)}\frac{xdr}{(1+x\,r)} + \frac{2}{(2-s)}\frac{s^2(n-1)(\alpha+\cot\theta)}{[2-s(n-1)]}\frac{dr}{r} = 0$$

Let $K = \frac{2}{(2-s)}\frac{s^2(n-1)(\alpha+\cot\theta)}{[2-s(n-1)]}$

Let $K = \frac{2}{(2-s)}\frac{s^2(n-1)(\alpha+\cot\theta)}{[2-s(n-1)]}$, $L = \frac{2}{(2-s)}$

SHOCK STRENGTH

$$M_{-} = cr^{-k/2}(1+x\,r)^{-L/2} \qquad (12)$$

Shock velocity, Particle Velocity and Density expression

$$U = \left[\frac{n\xi}{\rho'(1+xr)}\right]^{1/2} \xi\ r^{-K/2}\ (1+xr)^{-L/2} \qquad (13)$$

$$u = \frac{2}{(n+1)}\left[\frac{n\xi}{\rho'(1+xr)}\right]^{1/2} \xi\ r^{-K/2}\ (1+xr)^{-L/2} \qquad (14)$$

$$P = \frac{2\rho_0}{(n+1)}\left(\frac{n\xi}{\rho'(1+xr)}\right)\xi^2\ r^{-K}\ (1+xr)^{-L} \qquad (15)$$

$$\rho = \rho'\left(\frac{\xi}{M}\right)^{2/\mu} r^{-K/L}\left(\frac{n+1}{n-1}\right) \qquad (16)$$

IV. RESULT AND DISCUSSION

a. The variation of shock strength for diverging spherical shock wave

Initially ,taking M=7 at r=9 and n=7.5, the variation of shock strength with propagation distance r, parameter n and angle $\cot\theta$ are given in tables and figures (1, 2 &3).

r	M
8.2	7.8612157
8.4	7.6287594
8.6	7.4083067
8.8	7.1989843
9.0	7.0000002
9.2	6.8106343
9.4	6.6302309
9.6	6.4581911
9.8	6.2939677
10.0	6.137059

Table-1

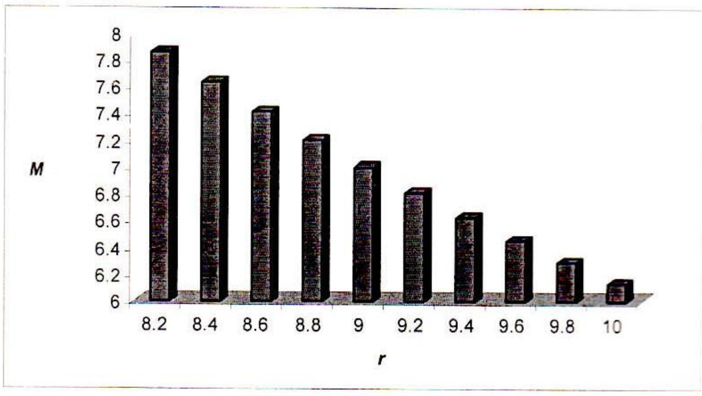

Fig.-1 : Variation with shock strength *(M)* with propagation distance *(r)* for shperical shock wave.

n	M
7.5	7.0000002
7.6	6.949929
7.7	6.9014244
7.8	6.8544156
7.9	6.8088359
8.0	6.7646224
8.1	6.721716
8.2	6.6800605
8.3	6.6396032
8.4	6.6002941

Table-2

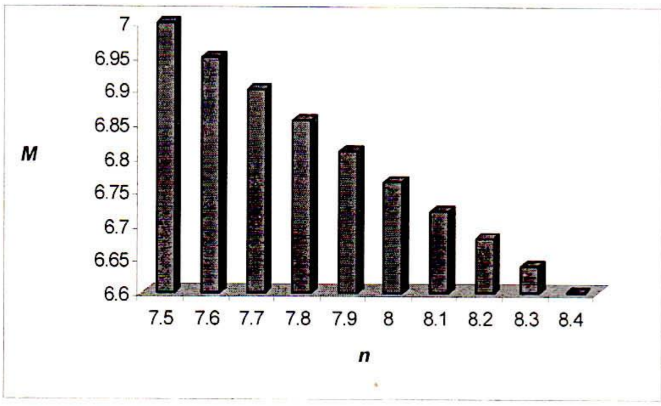

Fig.-2 : Variation with shock strength *(M)* with shock parameter (n) for shperical shock wave.

θ	cot θ	M
20^0	1.1920	7.8612157
25^0	1.1500	7.6287594
30^0	1.1100	7.4083067
35^0	1.0720	7.1989843
40^0	1.0360	7.0000002
45^0	1.0000	6.8106343
50^0	0.9325	6.6302309
55^0	0.9004	6.4581911
60^0	0.8693	6.2939677

Table-3

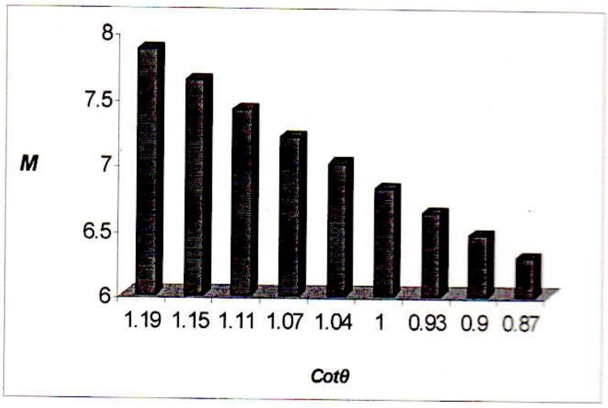

Fig.-3 : Variation with shock strength *(M)* with angle *(θ)* for shperical shock wave.

The shock strength decrease with propagation distance (r) as shown in table (1). Shock strength decreases with parameter (n) as shown in table (2). Shock strength also decreases with shock front angle (θ) as shown in table (3). The corresponding variation is also given with the figs. (1) to (3)

b. The variation of shock strength for converging spherical shock wave

Agains taking *M*=7 at *r*=9 and *n*=7.5, the variation of shock strength with propagation distance r, parameter n and angle *cot* θ are given in tables and figures (1, 2 &3).

r	M
8.20	3.870987
8.40	4.512984
8.60	5.242135
8.80	6.067780
9.00	7.000000
9.20	8.049666
9.40	9.228475
9.60	10.54899
9.80	12.02470
10.0	13.67004
10.2	15.50045

Table-4

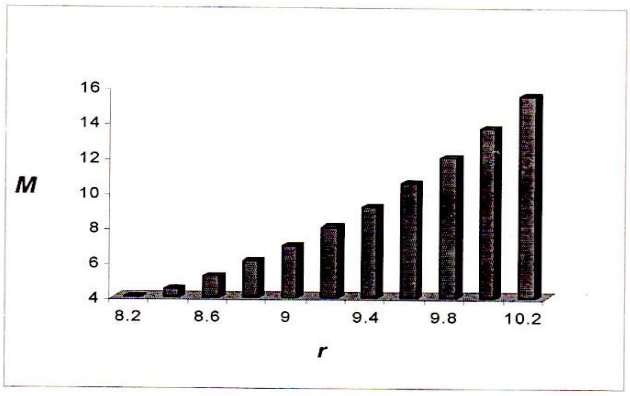

Fig.-4 : Variation with shock strength *(M)* with propagation distance *(r)* for shperical shock wave.

n	M
7.5	7.000000
7.6	6.674206
7.7	6.377597
7.8	6.106755
7.9	5.858749
8.0	5.631049
8.1	5.421468
8.2	5.228105
8.3	5.049300
8.4	4.883602
8.5	4.729736

Table-5

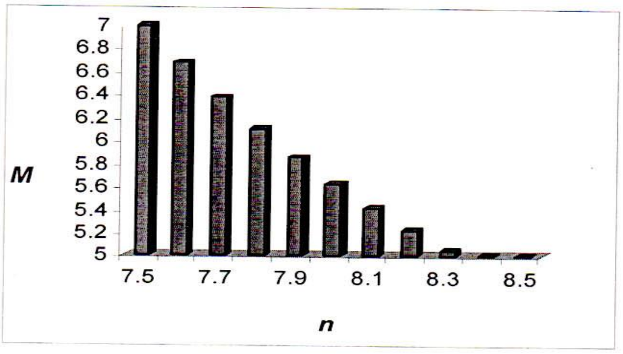

Fig-5: Variation with shock strength *(M)* with parameter *(n)* for shperical shock wave.

θ	cot θ	M
20°	1.1920	20.7374
25°	1.1500	16.3523
30°	1.1100	13.0412
35°	1.0720	10.5189
40°	1.0360	8.58091
45°	1.0000	7.00000
50°	0.9325	4.77839
55°	0.9004	3.98498
60°	0.8693	3.34217

Table-6

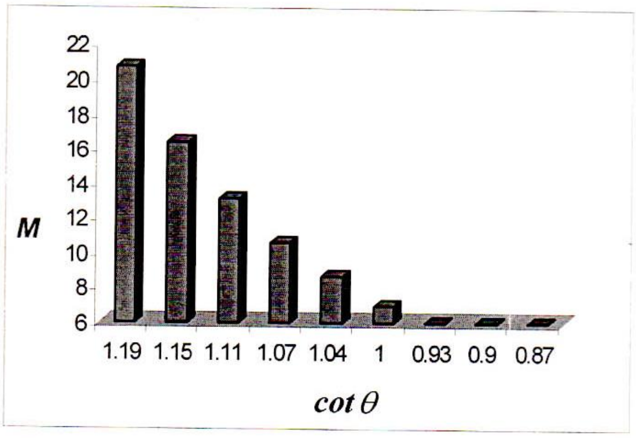

Fig.-6 : Variation with shock strength *(M)* with angle *(cot θ)* for shperical shock wave.

The shock strength increases with propagation distance (r) as shown in table (4). Shock strength decreases with parameter (n) as shown in table (5). Shock strength also decreases with shock front angle (θ) as shown in table (6). The corresponding variation are also given with the figs. (4) to (6).

The variation Shock Velocity, Particle Velocity pressure and density with different parameters shown in table below.
The diverging Spherical Shock wave in table-1-3 and converging Spherical Shock wave in table-4-6 .

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r	U	u	P	ρ
8.2	240.6682	56.62781	149968.2	14.38985
8.4	233.5516	54.95332	144361.8	14.70892
8.6	226.8026	53.36531	139092.1	15.028
8.8	220.3942	51.85746	134131.7	15.34708
9.0	214.3024	50.42409	129455.9	15.66615

Table No. -1

n	U	u	P	ρ
7.5	214.3024	50.4241	129455.9	15.66615385
8.5	213.8699	45.02525	115362	15.17466667
9.5	214.7193	40.89892	105205.8	14.79882353
10.5	216.4059	37.63581	97572.46	14.50210526
11.5	218.656	34.98496	91643.08	14.26190476

Table No. -2

r	U	u	P	ρ
8.2	240.6682	56.62781	149968.2	14.38985
8.4	233.5516	54.95332	144361.8	14.70892
8.6	226.8026	53.36531	139092.1	15.028
8.8	220.3942	51.85746	134131.7	15.34708
9.0	214.3024	50.42409	129455.9	15.66615

Table No. -3

r	U	u	P	ρ
8.2	0.036814	0.008662	0.003509	14.38985
8.4	0.04292	0.010099	0.004875	14.70892
8.6	0.049855	0.01173	0.006721	15.028
8.8	0.057707	0.013578	0.009196	15.34708
9	0.066572	0.015664	0.012493	15.66615

Table No. -4

n	U	u	P	ρ
7.4	0.069519	0.016552	0.012634	15.72375
7.6	0.063896	0.01486	0.011375	15.6103
7.8	0.059228	0.013461	0.009551	15.50353
8	0.05531	0.012291	0.008144	15.40286
8.2	0.05199	0.011302	0.007039	15.30778

Table No. 5

cotθ	U	u	P	ρ
1.192	0.197221	0.046405	0.109641	15.66615
1.15	0.139616	0.032851	0.059074	16.84308
1.11	0.100692	0.023692	0.032874	18.02
1.072	0.073915	0.017392	0.018871	19.19692
1.036	0.055185	0.012985	0.011164	20.37385

Table No. -6

V. CONCLUSION

From this analysis it is concluded that the variation of strength of Tsunami depends on parameters and angle θ therefore damage due to Tsunami is different in different directions. Futher this analysis need to improve with the consideration of the effect of overtaking disturbances.

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