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Research article

MODELLING AND SIMULATION ON PRIMARY CONSOLIDATION AND POROSITY INFLUENCE ON VOID RATIO IN HOMOGENEOUS SILTY FORMATION

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Abstract

Soil consolidation in primary stage always deposit mostly in natural origin, these may be as a result of geological setting of the formation, geotechnical properties of soil are base on the natural condition investigated by experts, void ratio examination are normally carried out in most geotechnical activities in building and road construction, primary consolidation and porosity were investigated to predominantly pressure the deposition of void ratio in silty formation, such homogeneous deposit were monitored, this has express concern base on the parameters found in the study location, the cause of these condition were not known, the application of these concept generated the expressed values and other influences that pressure the deposition of void ratio in such silty formation, the generated values were compared with experimental values, both parameters express best fits validating the model.

Keywords: modelling, primary consolidation, porosity void ratio and silty formation

1. Introduction

The deposition of Shear strength, compressibility and permeability are considered to be the three most imperative properties of a soil mass applicable in areas such as in the development and examination of hydraulic structures like dams, retaining walls, soil foundation systems and in other applications pertaining to geotechnical engineering practice. Among these three, compressibility is the most important parameter while assessment the settlement of soil under the load of an infrastructure constructed on that soil mass (Tiwari and Ajmera, 2012; Amardeep and Shahid

2012). Compressibility of a soil mass is its vulnerability to diminish in volume under pressure and is indicated by soil characteristics like coefficient of compressibility, compression index and coefficient of consolidation. Although coefficient of volume compressibility is the most suitable, and most popular, of the compressibility coefficients for the direct calculation of settlement of structures, its variability with confining pressure makes it less useful when quoting typical compressibility's or when correlating compressibility with some other property. For this reason, the compression index of soils is generally preferred as its value does not change with the change in confining pressure for normally consolidated clays (Carter and Bentley, 1991; Gulhati and Datta, 2005). However, the determination of compression index in the labs is a cumbersome and time consuming process. Hence several attempts have been made in the past to correlate the value of compression index of soils with index properties of soil which are comparatively easier to determine and take lesser time. In numerous researchers correlations have been proposed whereby compressibility characteristics like compression index have been assessed using the following concepts liquid limit, natural moisture content, initial void ratio, plasticity index, specific gravity, void ratio at liquid limit, and several other properties of soil. Skempton (1944) and Terzaghi and Peck (1967) have given equations correlating compression index with the liquid limit of soils. Wroth and Wood (1978) used critical state soil mechanics concepts to deduce a relationship between compression index, plasticity index and specific gravity of remoulded clays. Nagaraj and Murthy (1983) proposed equations to evaluate the value of compression index with specific gravity and void ratio at liquid limit of soils. Di Maio et al. (2004) conducted one dimensional consolidation tests on the mixtures of Bentonite and kaolin as well as other natural clays and observed a good correlation between compression index and void ratio at liquid limit of soils. Tiwari and Ajmera (2012) prepared 55 different soil specimens in the laboratory by mixing various proportions of montmorillonite, illite, kaolinite, and quartz at initial moisture contents equal to the liquid limit and proposed two different equations to estimate the compression indices of remoulded clays with liquid limit, one for soils with activities less than one and the other for soils with activities greater than one. Based upon the past study, it can be concluded that compression index can be related with index properties (Liquid limit (LL) and Plasticity Index (PI)) of soil. The model proposed by Skempton (1944), Terzaghi and Peck (1967) and Wroth and Wood (1978).

2. Governing equation

$$K\phi \frac{\partial e_{(x)}}{\partial t} = Dv_{(x)} \frac{\partial e}{\partial x} + V_{(x)} \frac{\partial e}{\partial x} \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad (1)$$

Nomenclature

K = Permeability [LT^{-1}]
ϕ = Porosity [-]
D = Dispersion in number [-]
V(x) = Velocity [LT^{-1}]
e = Void Ratio [-]
T = Time [T]
X = Depth [L]

Let $e = X\,T$ from equation (2), we have

$$K\phi\, T^1 Z = D_v\, TX^1 + V_{(x)}\, TX^1 \qquad \ldots\ldots\ldots\ldots \qquad (2)$$

$$K\phi \frac{T^1}{T} = D_v \frac{X^1}{X} + V_{(x)} \frac{X^1}{X} \qquad \ldots\ldots\ldots\ldots \qquad (3)$$

$$K\phi \frac{T^1}{T} = \tau^2 \qquad \ldots\ldots\ldots\ldots \qquad (4)$$

$$D_v \frac{X^1}{X} = \tau^2 \qquad \ldots\ldots\ldots\ldots \qquad (5)$$

$$V_{(x)} \frac{X^1}{X} = \tau^2 \qquad \ldots\ldots\ldots\ldots \qquad (6)$$

This implies that equations (4), (5), (6) and (7) can be written as:

$$\left[D_v + V_{(x)}\right]\frac{X^1}{X} = \tau^2 \qquad \ldots\ldots\ldots\ldots \qquad (8)$$

From (4) $K\phi \frac{T^1}{T} = \tau^2$

i.e. $K\phi \frac{\partial T}{dT} = \tau^2$ .... (9)

$$\int \frac{dT}{T} = \frac{\tau^2}{K\phi} \int dt \qquad \ldots\ldots\ldots\ldots \qquad (10)$$

$$Ln\,T = \frac{\tau^2}{K\phi} t + c_1 \qquad \ldots\ldots\ldots\ldots \qquad (11)$$

$$\frac{\tau^2}{K\phi} + c_1 \qquad \ldots\ldots\ldots\ldots \qquad (12)$$

$$\boxed{T = A\ell^{\frac{\tau^2}{K\phi}}} \qquad \ldots\ldots\ldots\ldots \qquad (13)$$

From (8)

$$\left[D_v + V_{(x)}\right]\frac{X^1}{X} = \tau^2\, dx \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \tag{14}$$

$$\int \frac{dx}{dx} = \frac{\tau^2}{D_v + V_{(x)} - K_d}\int dx \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \tag{15}$$

$$Ln\ x = \frac{\tau^2}{D_v + V_{(x)}} + c_1 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \tag{16}$$

$$Z = \exp\left[\frac{\tau^2}{D_v + V_{(x)} - K_d} + c_1\right] \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \tag{17}$$

$$X = B\exp\frac{\tau^2}{D_v + V_{(x)}}\, x \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \tag{18}$$

Combining (17) and (18), we have

$$C, TX = TX$$

$$A\ell^{K\phi} B\left[\exp\frac{\tau^2}{D_v + V_{(x)}}\right] \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \tag{19}$$

$$C\ X, T = AB\exp\left[\frac{t}{K\phi} + \frac{X}{D_v + V_{(x)}}\right]\tau^2 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \tag{20}$$

3. Materials and Method

Standard laboratory experiment where performed to predict degree of void ratio using the standard method for the experiment at different formation, the soil deposition of the strata were collected in sequences base on the structural deposition at different formation of the soil, this samples were collected at different location, it generated variations at different depths producing different degree of void ratio in various strata, the experimental results will be compared with the theoretical values for the validation of the model.

Table: 1 Theoretical values of void Ratio at Different Depth

Depth[m]	Theoretical Void Ratio
3	0.5
6	0.53
9	0.57
12	0.61
15	0.65
18	0.69
21	0.77
24	0.79
27	0.84
30	0.89
33	0.95
36	1.02

Table: 2 Theoretical values of void Ratio at Different Time

Time Per Day	Theoretical Void Ratio
10	0.5
20	0.53
30	0.57
40	0.61
50	0.65
60	0.69
70	0.77
80	0.79
90	0.84
100	0.89
110	0.95
120	1.02

Table: 3 Comparison of Predictive and Experimental of Void Ratio at Different Depth

Depth[m]	Theoretical values Void Ratio	Experimental Values Void Ratio
3	0.5	0.47
6	0.53	0.49
9	0.57	0.52
12	0.61	0.57
15	0.65	0.61
18	0.69	0.63
21	0.77	0.74
24	0.79	0.75
27	0.84	0.81
30	0.89	0.85
33	0.95	0.91
36	1.02	0.94

Table: 4 Comparison of Predictive and Experimental of Void Ratio at Different Time

Time Per Day	Theoretical values Void Ratio	Experimental Values Void Ratio
10	0.5	0.45
20	0.53	0.47
30	0.57	0.51
40	0.61	0.55
50	0.65	0.58
60	0.69	0.61
70	0.77	0.71
80	0.79	0.72
90	0.84	0.78
100	0.89	0.84
110	0.95	0.91
120	1.02	0.93

Table: 2 Theoretical values of void Ratio at Different Depth

Depth[m]	Theoretical values Void Ratio
3	0.22
6	0.25
9	0.29
12	0.34
15	0.41
18	0.47
21	0.59
24	0.65
27	0.77
30	0.89
33	1.04
36	1.24

Table: 4 Comparison of Predictive and Experimental of Void Ratio at Different Time

Depth[m]	Theoretical values Void Ratio	Experimental Values Void Ratio
3	0.22	0.19
6	0.25	0.21
9	0.29	0.22
12	0.34	0.29
15	0.41	0.38
18	0.47	0.41
21	0.59	0.55
24	0.65	0.61
27	0.77	0.71
30	0.89	0.82
33	1.04	0.98
36	1.24	1.19

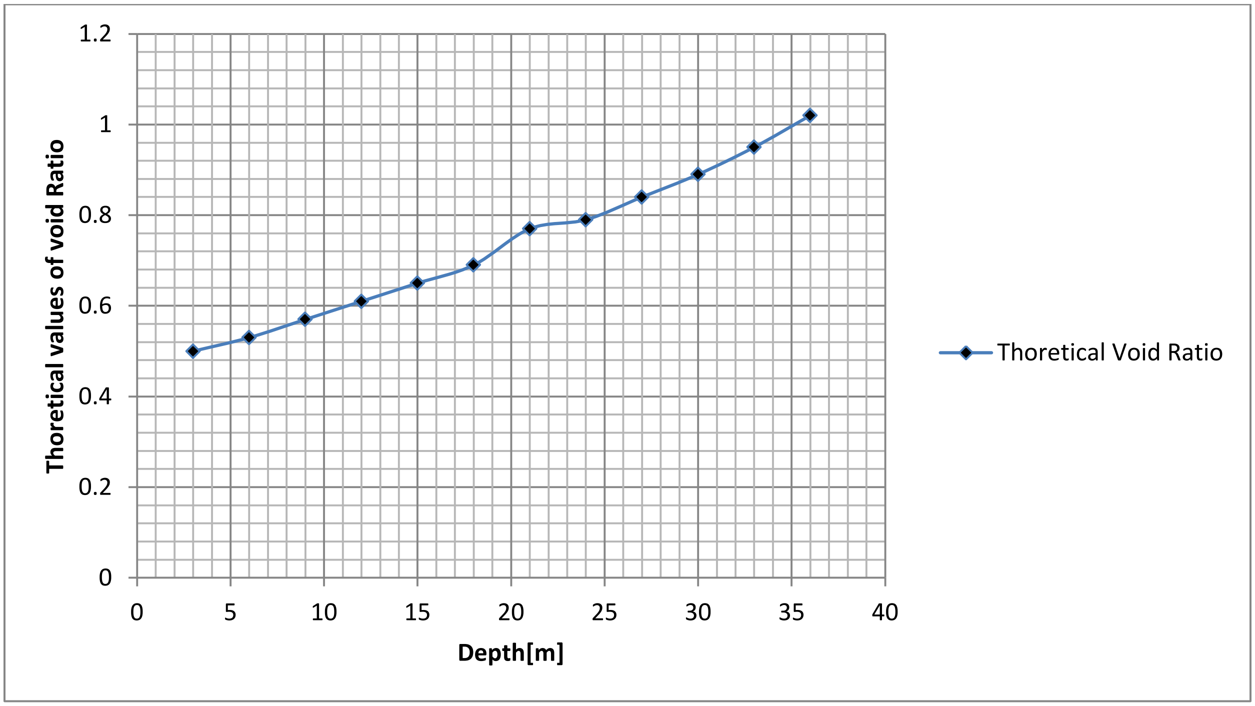

Figure: 1 Theoretical values of void Ratio at Different Depth

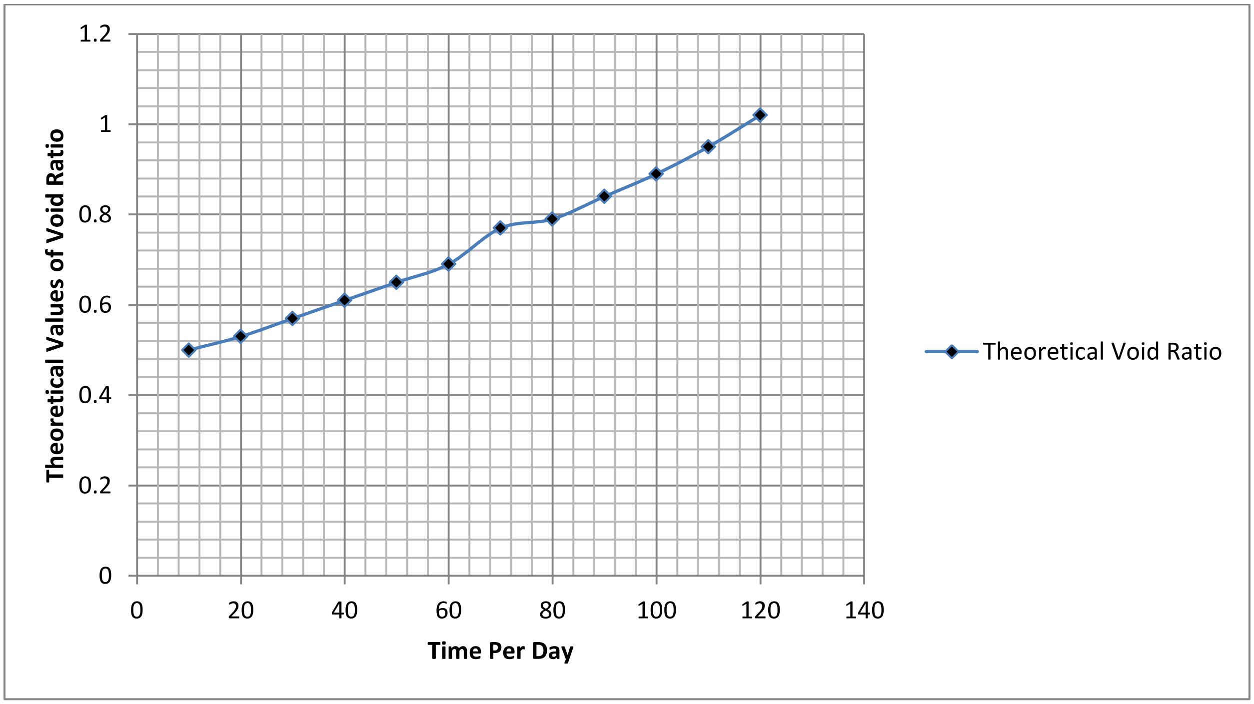

Figure: 2 Theoretical values of void Ratio at Different Time

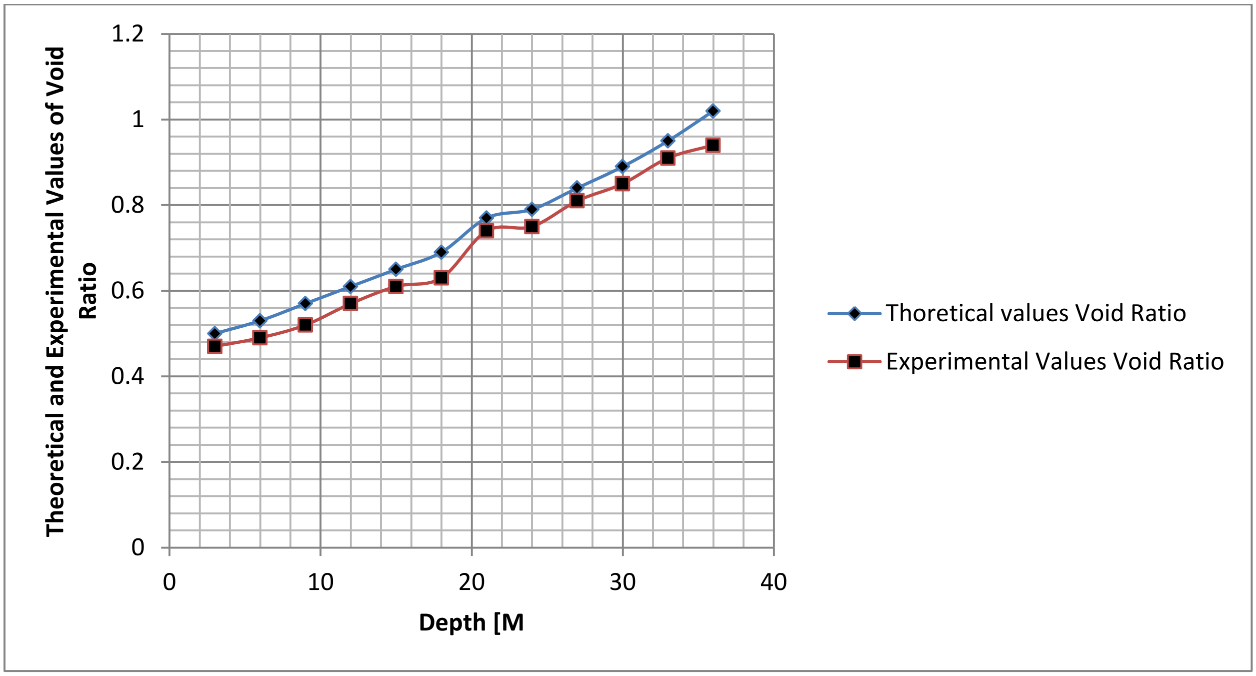

Figure: 3 Comparison of Predictive and Experimental of Void Ratio at Different Depth

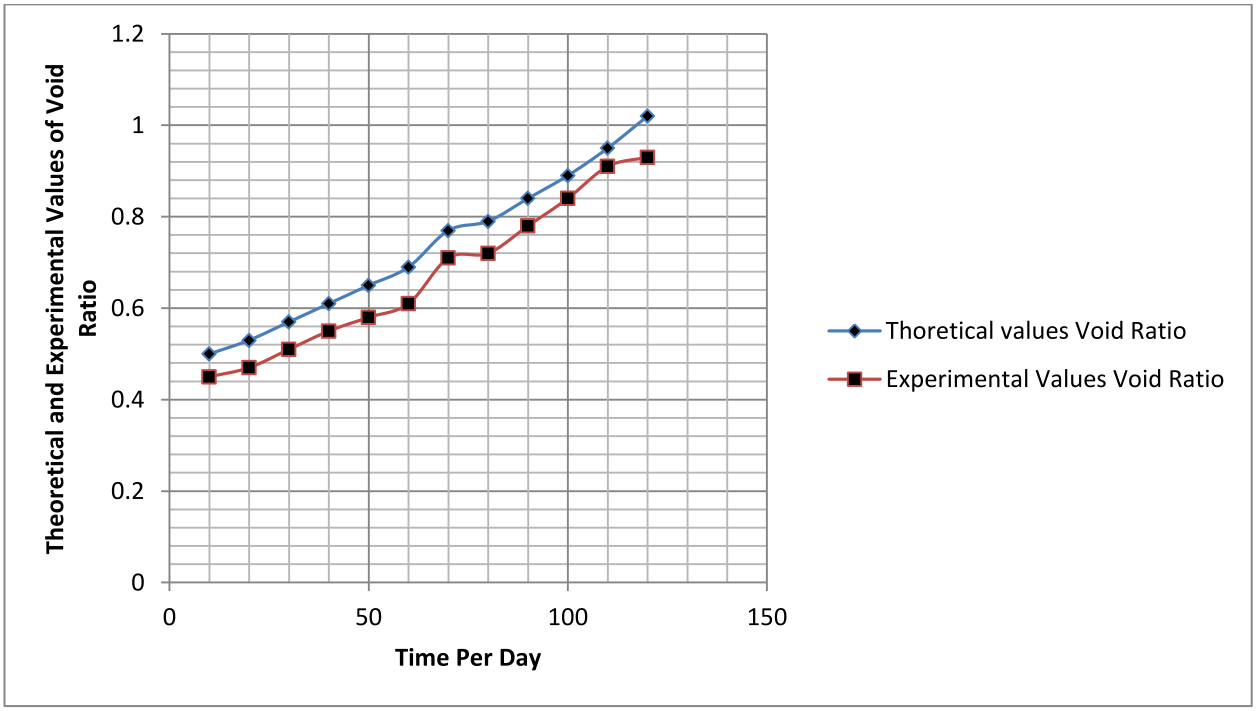

Figure: 4 Comparison of Predictive and Experimental of Void Ratio at Different Time

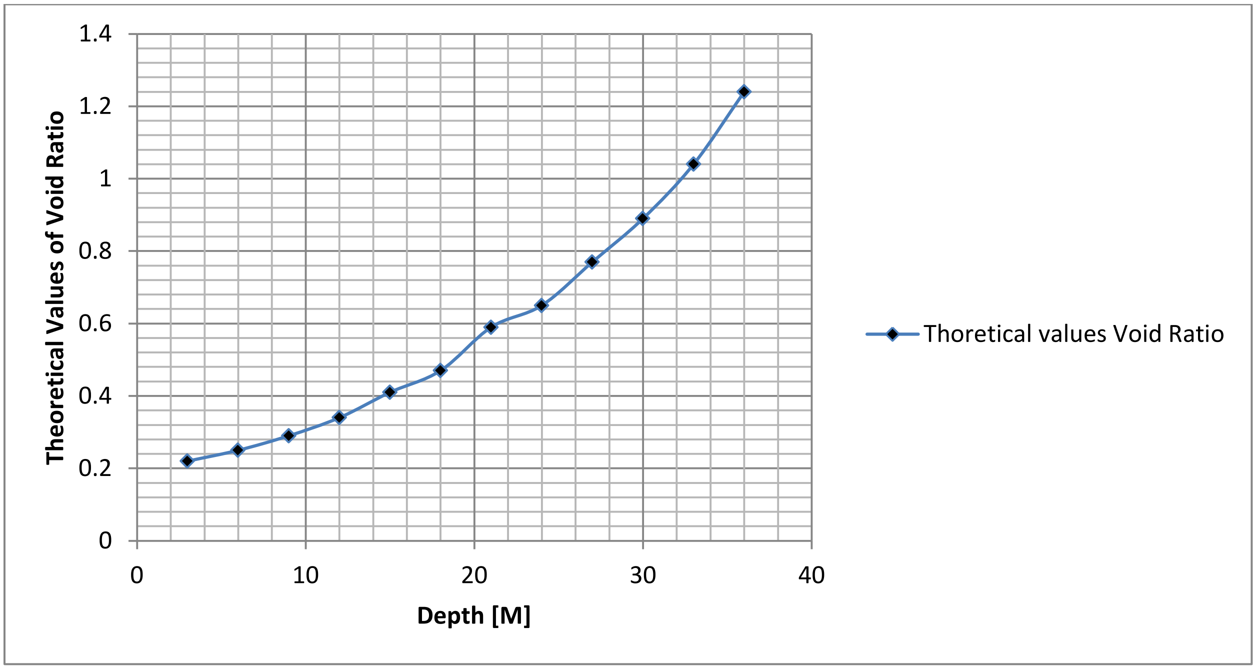

Figure: 5 Theoretical values of void Ratio at Different Time

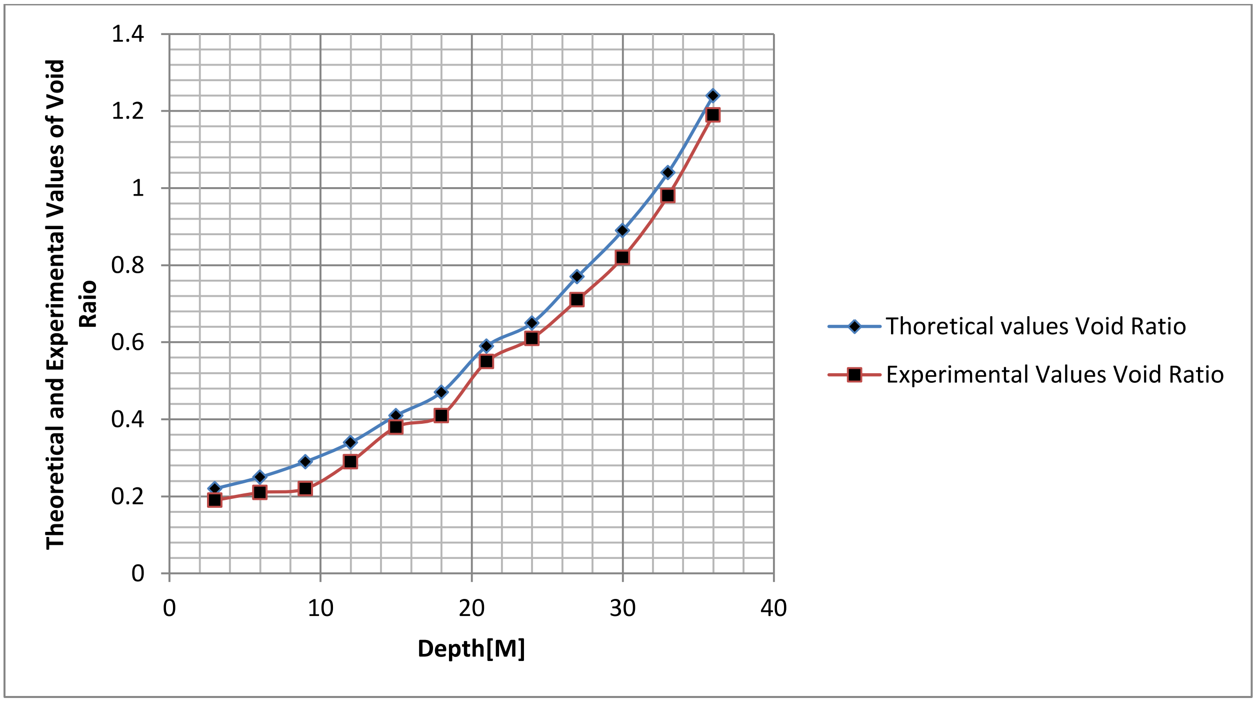

Figure: 6 Comparison of Predictive and Experimental of Void Ratio at Different Time

The study express the deposition of void between the intercedes of the formation, the figures shows how the void ratio deposit in various strata of the formation, figure one express linear increase in deposition, the void in the formation predominantly increase in gradual process with slights fluctuation which may be as a results from the rate disintegration of the porous rock as sediments in the formation, various disintegration to grain size determined the void percentage deposition in various formation, the study establish mathematical model through the influences from primary consolidation on void ratio deposition in silty formation, the derived model were developed base on the variables influences that pressure various void percentage deposition in silty formation, pore distribution are from sedimentary disintegration at various sediments depositing in various soil structures, the express void ratio varies due to consolidation in primary state, such pressures has in ages of porous rocks generates these primary consolidation to influences through the rates of void ratio deposition in silty formation, derived solution from the developed governing generated model will determine void ratio for shallow and deep foundations, the express model predict void ratio at any influences that the soil may have been subjected to developed coefficient volume of compressibility. The developed model were simulated to generated predictive values, these were compared with experimental values for validation, both parameters express best fit, the study is imperative because it will definitely assist soil engineers to determined void ratio for any design of foundation in the deltaic environments.

5. Conclusion

The deposition of void ratio under the influences of primary consolidation of silty formation were to monitor the rate of void percentage under such situation in silty deposition, the silty are known to deposit lower void ratio in the soil, but in most instance there are some other geotechnical properties that may pressure the void ratio deposition more than expectation from man assumption, therefore the investigation of void ratio for any construction activities is imperative, in line with conceptualized engineering trend thus better way of thorough efficiency, it is of serious concern to investigate parameters in any construction activities were void ratio determination is essential, the deposition of void percentage in silty formation were determined through development of mathematical model, these were another concept applied to predict void ratio influenced by primary consolidation, the study express various parameters that were pressured by primary consolidation in silty formation, experimental values were compared with the predictive results, both parameters developed best fit validating the developed model for the study.

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