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Determination of Velocity And Acceleration of Structural Deformation Using Kalman Filter Technique

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Abstract

Objects and engineering structures are subject to displacements resulting from numerous internal and external factors. Determination of the magnitude of these displacements is possible on the basis of cyclic measurements of changes in position of points determining the geometrical shape of the studied object. Processing the measurement results as aimed at determining the characteristics of those changes and assessment of possible hazards. This paper outlines the procedure of geodetic monitoring system of circular oil storage tanks and presents the analysis of the resulted observations to determine the values of their deformation.

At the Forcados Tank Farm, there are eighteen tanks currently used for crude oil storage. In this study, only tank 6 was used as case study scenario for the determination of velocity and acceleration under loading. In order to monitor these tanks, studs were attached to the base of the tank at equal intervals. Measurement was carried out on the studs position from primary Geodetic controls located within the tank farm in 2000, 2003, 2004 and 2008 respectively.

In this study, deformation analysis by Kalman Filter technique of the measurement data obtained on Tank 6 with 22m high and 72m diameter using refletorless total Station at the Forcados Terminal is presented. The value of the velocity and the acceleration of the deformed structure are also presented. The measurement system consisted of 3 controls, 10 monitoring station and sixteen monitoring points carried. The data were collected during four measurement campaigns carried out between 2000 to 2008. The computation and least square adjustment of each epoch measurement were carried out using Carson 2011 software. Analysis of the result indicated that the tank ovality was expanding with years i.e. increased in diameter while the vertical components indicate settlement.

Keywords: Velocity, Acceleration, Deformation, Kalman Filter

1.0 Introduction

Nowadays, deformation surveys have become one of the most important application areas of Geodesy. In deformation monitoring studies, static deformation models are usually used. Static models are sufficient in studies where time is neglected. However, most of the current engineering applications require monitoring of movement behaviors. In such studies, kinematic deformation models determining displacements, velocities and acceleration as dependent on time are preferred.

During the last decade, the world of engineering surveying has seen enormous developments in both the techniques and instrumentation for spatial data acquisition. One of these developments has been the appearance of geodetic reflector less total station which not only carry out angular and linear measurement but has inbuilt software for real time processing of the data.

As a result of tanks age, geological formation of the soil around Forcados tanks, non uniform settlement of tanks foundations, loading and offloading of oil and temperature of the crude will cause stress and strain for tanks membrane and settlement of sediments. The tanks tend to undergo radial deformation or out of roundness, therefor monitoring the structural deformation of these circular oil storage tanks must be done by using accurate geodetic observations and analysis methods.

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To develop a reliable and cost effective monitoring system of any structure, deformation monitoring scheme consists of measurements made to the monitored object from several monitoring stations that are referred to several reference control points (assumed to be stable). To obtain correct object point displacements (and thus deformation), the stability of the monitoring stations must be ensured. This is accomplished by creating a reference network of monitoring stations surrounding a particular structure [1].

The method involves dividing the tank into circular cross section. These monitoring points are suited at the outer surface of the tank and placed at the same level 2.0 m from the tank base [2].

The monitoring stations are connected to the existing control networks at Forcados terminal. However, it is important to state that the monitoring stations, surrounding the studied tank, were first established in 1999 by Geodetic Positioning Services Limited. All recent control established were referred to the control established in 1999 after confirming their integrity [3].

The surveillance of an object involved in a deformation process requires the object as well as modeling process. Geodetic modeling of object and its surrounding means dissecting the continuum by discrete points in such a way that the points characterize the object, and that the movements of the points represent the movements and distortions of the object. This means that only the geometry of the object is modeled. Furthermore, modeling the deformation process means conventionally to observe (by geodetic method) the characteristic points in certain time intervals in order to monitor properly the temporal course of the movements. This means that only the temporal aspect of the process is modeled [4].

2.0 Structural Deformation Modeling

Nowadays, different models have been developed for analysis and the interpretation of structural deformations. These models include static, kinematic and dynamic models. Static model is not time dependent but provides the deformation characteristic on points, area or the structure being monitored [5].

However, most of the current engineering applications require monitoring of movement behaviors. A kinematic deformation model determines displacements, velocities and acceleration and is time dependent [6].

In dynamic model, in addition to the kinematic model, the relationship between deformations and the influencing factors are also taken into consideration. Different deformation analysis algorithms are shown in (Fig. 1.0).

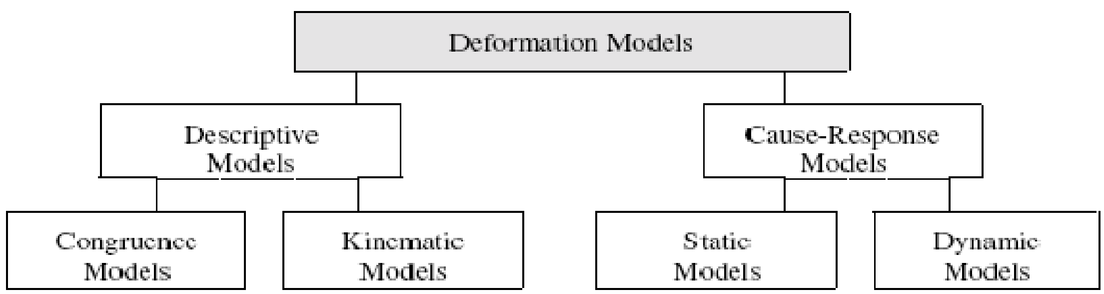

Figure 1.0 - Hierarchy of models in geodetic deformation analysis

In the following table (fig. 2.0), the four categories of deformation models are characterized by their capacity of taking the factors ‘time’ and ‘load’ into account.

Table 1 - Characterization and classification of deformation models

Deformation Model	Congruence Model	Kinematic Model	Static Model	Dynamic Model
Time	no modeling	movements as a function of time	no modeling	movements as a function of time and loads
Acting Forces	no modeling	no modeling	displacements as a function of loads	
State of the Object	sufficiently in equilibrium	permanently in motion	sufficiently in equilib-rium under loads	permanently in motion

3.0 Kinematic Deformation Model

Using kinematical deformation model, the motion of network stations (control points) and even their accelerations can be computed. This procedure is carried out for every point. These kinds of deformation models are called as "single point deformation models. The objective of kinematical single point deformation model is to find a proper definition for the point displacements by means of time dependent functions without taking into account the external forces causing deformations. The unknown parameters of a single point deformation model are the velocity and the acceleration of control points. Therefore, a time-dependent function is required to estimate these parameters. The most common approach for this type of model is a quadratic polynomial function [7].

$$X_j^{(k+1)} = X_j^{(k)} + v_j(t_{k+1} - t_k) + \frac{1}{2} a_j(t_{k+1} - t_k)^2 + \qquad (1)$$

Where:

$X_j^{(k+1)}$: is a coordinate vector at time t_{k+1}.

$X_j^{(k)}$: Coordinate vector at time t_k

v_j : Velocity vector at time t_k

a_j : Acceleration vector at time t_k.

In order to compute the adjusted motion parameters for each point from the kinematical single point deformation model given above, measurements carried

out in many periods are needed. Kalman filtering technique enables us to compute the motion parameters using measurements collected in less number of periods. In the 3 dimensional models the motion model consisting of position, motion and acceleration can be formed up as follows [6]:

$$\begin{cases} x_j^{(k+1)} = x_j^{(k)} + v_{xj}(t_{k+1} - t_k) + \frac{1}{2}(t_{k+1} - t_k)^2 a_{xj} \\ y_j^{(k+1)} = y_j^{(k)} + v_{yj}(t_{k+1} - t_k) + \frac{1}{2}(t_{k+1} - t_k)^2 a_{yj} \\ z_j^{(k+1)} = z_j^{(k)} + v_{zj}(t_{k+1} - t_k) + \frac{1}{2}(t_{k+1} - t_k)^2 a_{zj} \end{cases} \qquad (2)$$

Where $X_J^{K+1}, Y_J^{K+1}, Z_J^{K+1}$ - Coordinates of point J at time t_{k+1} (predicted values), $v_{X_J}^K, v_{Y_J}^K, v_{Z_J}^K$ – velocities of X, Y,Z coordinates of point J at time t_k; $a_{X_J}^K, a_{Y_J}^K, a_{Z_J}^K$ – accelerations of X, Y,Z coordinates of point J at time t_k. k=1, 2, . . . , m (m: measurement period number(number of epochs)). j =1, 2, n (n: number of points

Equation (2) can then be written in matrix form as follows

$$\hat{x}_{k+1}^{-} = \begin{bmatrix} x \\ y \\ z \\ v_x \\ v_y \\ v_z \\ a_x \\ a_y \\ a_z \end{bmatrix}_{k+1} = \begin{bmatrix} I & I(t_{k+1} - t_k) & \frac{I\,(t_{k+1} - t_k)^2}{2} \\ 0 & I & I(t_{k+1} - t_k) \\ 0 & 0 & I \end{bmatrix}_{k+1,k} \begin{bmatrix} x \\ y \\ z \\ v_x \\ v_y \\ v_z \\ a_x \\ a_y \\ a_z \end{bmatrix}_k \qquad (3)$$

$\Phi_{k+1/k}$: Transition matrix from time t_k to t_{k+1}

$$\Phi_{k+1/k} = \begin{bmatrix} I & I(t_{k+1} - t_k) & \frac{I\,(t_{k+1} - t_k)^2}{2} \\ 0 & I & I(t_{k+1} - t_k) \\ 0 & 0 & I \end{bmatrix}_{k+1,k} \qquad (4)$$

$\hat{X}_{K+1}$: State vector at time t_{k+1}

$\hat{X}_{K}$: State vector at time t_k

Equation (3) is the prediction equation that is the basic equation of the Kalman filtering. The system noise in the prediction equation is considered as the noise matrix **S** that consists of the terms of the last column of the matrix given in Equation (4) [6].

Actually, the filtering phase is based on classical least squares adjustment. The most important difference with the classical adjustment procedure is that, contrary to the classical approach, in the filtering the number of observations can be less than the number of unknowns. Through the filtering, adjusted values of state unknowns are computed using weighted combination of measurements and a priori estimations [6].

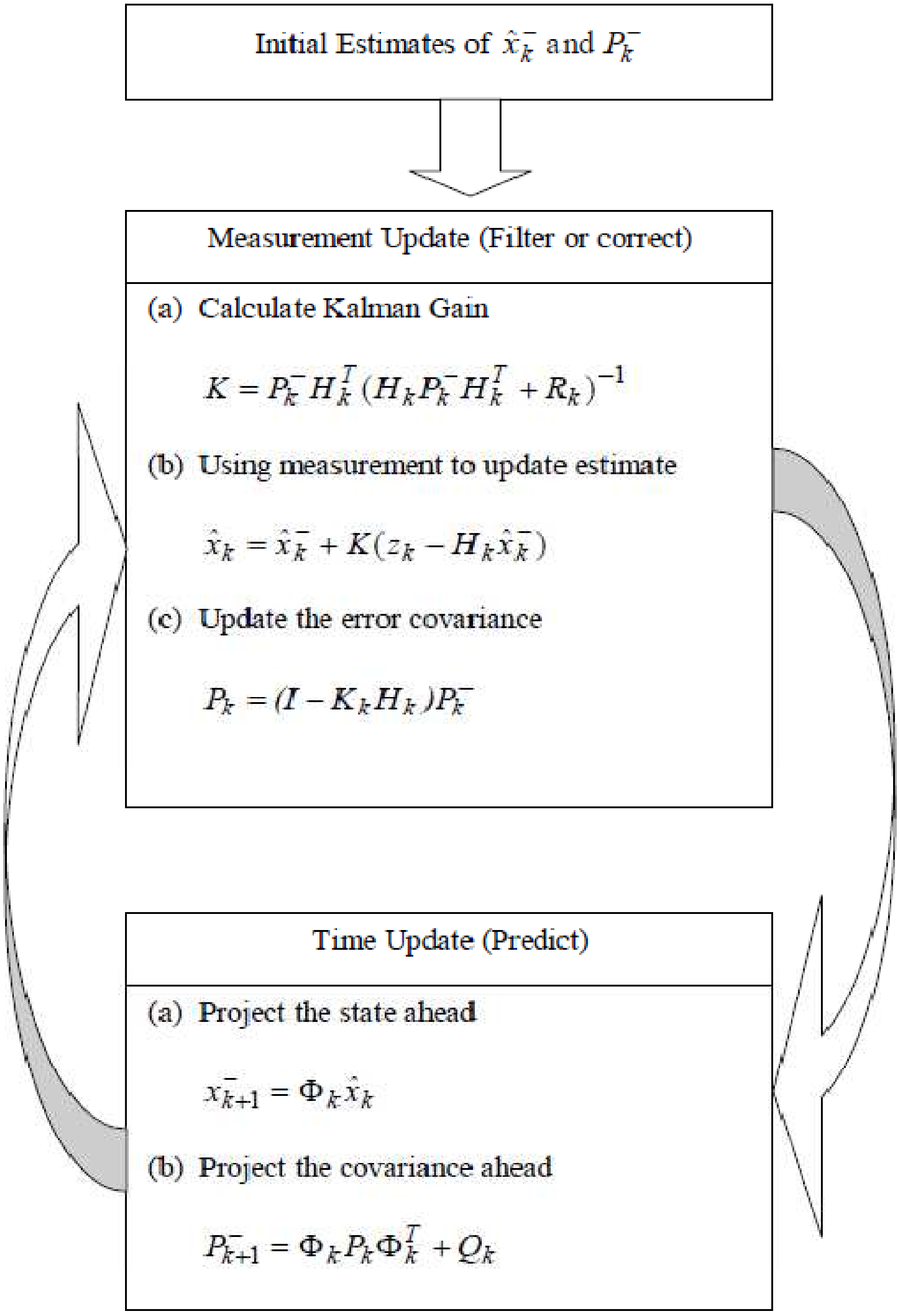

Figure 2.0 – Kalman Filter flow chart

4.0 Velocity and Acceleration using Kalman Filter

Kalman filtering is an important tool for deformation analysis combining information on object behavior and measurement quantities. The intention of kinematic models is to find a suitable description of point movements by time functions without regarding the potential relationship to causative forces.

Kalman filtering technique is employed for the prediction of present state vector using state vector information of known motion parameters at period t_k and the measurements collected at period t_{k+1}. The state vector of motion parameters consists of position, motion and acceleration variables. The motion and acceleration parameters are the first and the second derivations of the position with respect to time. The matrix form of the motion model used for the prediction of motion parameters by Kalman filtering technique in 3-D networks can be given as follows [7]:

$$\begin{bmatrix} X_J^{K+1} \\ Y_J^{K+1} \\ Z_J^{K+1} \end{bmatrix} = \begin{bmatrix} X_J^{K} \\ Y_J^{K} \\ Z_J^{K} \end{bmatrix} + (t_{K+1} - t_K) \begin{bmatrix} v_{X_J}^{K} \\ v_{Y_J}^{K} \\ v_{Z_J}^{K} \end{bmatrix} + \frac{1}{2}(t_{K+1} - t_K)^2 \begin{bmatrix} a_{X_J}^{K} \\ a_{Y_J}^{K} \\ a_{Z_J}^{K} \end{bmatrix}, \tag{5.0}$$

By analysis of equation (5.0) it is shown that the unknown displacement parameters consist of position, velocity (first derivative of position) and acceleration (second derivative of position). These unknown parameters can be calculated using the method of Kalman filter with four cycles of measurements at different times.

Kalman Filter is designed for recursive estimation to the state vector of a priori known dynamical system. To determine the current state of the system, the current measurement must be known, as well as the previous state of the filter. Thus, the Kalman filter is implemented in the time representation, rather than in frequency. Using the Kalman filter, the kinematic model of movement of any observable point J on the surface of circular oil storage tanks can be written in matrix form as following [8]:

$$\bar{Y}_{K+1} = \begin{bmatrix} X \\ Y \\ Z \\ v_X \\ v_Y \\ v_Z \\ a_X \\ a_Y \\ a_Z \end{bmatrix}_{K+1} = \begin{bmatrix} I & I(t_{K+1}-t_K) & I\dfrac{(t_{K+1}-t_K)^2}{2} \\ 0 & I & I(t_{K+1}-t_K) \\ 0 & 0 & I \end{bmatrix} \begin{bmatrix} X \\ Y \\ Z \\ v_X \\ v_Y \\ v_Z \\ a_X \\ a_Y \\ a_Z \end{bmatrix}_{K} + \begin{bmatrix} I\dfrac{(t_{K+1}-t_K)^2}{2} \\ I(t_{K+1}-t_K) \\ I \end{bmatrix} \xi_K, \tag{6.0}$$

Then,

$$\bar{Y}_{K+1} = R_{K+1,K}\,\hat{Y}_K + S_{K+1,K}\,\xi_K, \tag{6.1}$$

Where $R_{K+1,K}$ – transition matrix from time t_K to t_{K+1} (matrix of prediction);

$\bar{Y}_{K+1}$ – state vector at time t_{K+1} containing prediction values and its noise;

$\hat{Y}_K$ – state vector at time t_K;

$S_{K+1,K}$ – noise (error) matrix;

ξ_K – vector of stochastic effects (the vector of noise) during t_K;

I – unit matrix.

Expression (6.1) is the basic equation of the Kalman filter model when performing kinematic analysis of measurement results. Therefore, the covariance matrix of the state vector during t_{K+1} has the form

$$C_{\bar{Y}_{K+1}} = R_{K+1,K}\, C_{\overset{\frown}{Y}_K}\, R^T_{K+1,K} + S_{K+1,K}\, C_{\xi_K}\, S_{K+1,K}, \tag{6.2}$$

where $C_{\overset{\frown}{Y}_K}$ – variance-covariance matrix of vector $\overset{\frown}{Y}_K$; C_{ξ_K} – variance–covariance matrix of vector ξ_K .

The variance-covariance matrix C_{ξ_K} can be determined as following:

$$C_{\xi_K} = 4(t_{K+1} - t_K)^{-4} C_{\overset{\frown}{Y}_K}, \tag{6.3}$$

Using the method of least squares, the corrected state vector at the time t_{K+1} is formed as follows:

$$l_{K+1} + V_{l,K+1} = A_{K+1} \overset{\frown}{Y}_{K+1}, \tag{6.4}$$

Where l_{K+1} – observations at time t_{K+1};
$V_{l,K+1}$ – vector of corrections to measurements results;
A_{K+1} – matrix of coefficients.

Equations (6.1) and (6.4) can be combined together to create a functional and probabilistic model of the Kalman filter and stored in a matrix form as follows [6]:

$$\begin{bmatrix} \bar{Y}_{K+1} \\ l_{K+1} \end{bmatrix} = \begin{bmatrix} I \\ A_{K+1} \end{bmatrix} \overset{\frown}{Y}_{K+1} - \begin{bmatrix} V_{\bar{Y},K+1} \\ V_{l,K+1} \end{bmatrix}. \tag{6.5}$$

By this model, motion parameters and cofactor matrix are computed. The first step in solving the equation (6.5) using the Kalman filter is the computation of the Kalman gain matrix G as follows

$$\left.\begin{aligned} G_{K+1} &= C_{\bar{Y},K+1} A^T_{K+1} (C_{l,K+1} + A_{K+1}\, C_{\bar{Y},K+1}\, A^T_{K+1})^{-1}, \\ G_{K+1} &= C_{\bar{Y},K+1} A^T_{K+1} D^{-1}_{K+1}. \end{aligned}\right\} \tag{6.6}$$

Therefore, the adjusted state vector for the monitoring point in the surface of the tank at time t_{K+1} can be calculated by the formula:

$$\overset{\frown}{Y}_{K+1} = \bar{Y}_{K+1} + G_{K+1}(l_{K+1} - A_{K+1}\, \bar{Y}_{K+1}). \tag{7.7}$$

In solving the system of equations (6.6) and (6.7) using the software MATLAB, the observed movements of points on the surface of the Tank and its velocity were determined using four cycles of measurements, as a minimum. It should be noted that the advantages of using the Kalman filter in comparison with the classical least squares method is that in this model of filtration; the number of observations can be less than the number of unknown parameters [7].

It is important to note that the velocity of deformation of any point J between two periods of time can be determined by:

$$\left.\begin{aligned} v^{K+1}_{X_J} &= \frac{X^{K+1}_J - X^K_J}{\Delta t_{k+1,k}}; \\ v^{K+1}_{Y_J} &= \frac{Y^{K+1}_J - Y^K_J}{\Delta t_{k+1,k}}; \\ v^{K+1}_{Z_J} &= \frac{Z^{K+1}_J - Z^K_J}{\Delta t_{k+1,k}}. \end{aligned}\right\} \tag{7.0}$$

And the acceleration by the form:

$$\left.\begin{aligned} a_{X_J}^{K+1} &= \frac{X_J^{K+1} - X_J^K}{\Delta t_{k+1,k}^2}; \\ a_{Y_J}^{K+1} &= \frac{Y_J^{K+1} - Y_J^K}{\Delta t_{k+1,k}^2}; \\ a_{Z_J}^{K+1} &= \frac{Z_J^{K+1} - Z_J^K}{\Delta t_{k+1,k}^2}. \end{aligned}\right\} \tag{8.0}$$

The calculated values of velocities for horizontal and vertical deformation values for tank № 6 are presented in the following tables 1.

Table 2 – Velocity of Tank 6

Monitoring point	Velocity, mm/year					
	Horizontal values, mm / year			Vertical values, mm/year		
	t= 3 years from 5/2000 to May-03	t= 4.25 year from 5/2000 to Aug -04	t= 8 years from 5/2000 to May-08	t= 3 years from 5/2000 to 5/2003	t= 4.25 year from 5/2000 to 8/2004	t= 8 years from 5/2000 to May-08
STUD1	*21.58*	*17.26*	*19.39*	*3.84*	*3.68*	*2.87*
STUD9	*26.90*	*19.11*	*14.87*	*5.82*	*7.08*	*4.43*
STUD16	*33.19*	*24.94*	*20.88*	*4.67*	*4.75*	*3.69*
STUD8	*32.62*	*17.44*	*14.82*	*4.14*	*4.60*	*3.52*
STUD2	*25.91*	*16.35*	*17.92*	*3.69*	*3.99*	*3.18*
STUD10	*0.00*	*5.60*	*6.13*	*5.60*	*6.97*	*4.46*
STUD4	*32.92*	*12.36*	*19.94*	*0.00*	*0.64*	*1.24*
STUD12	*43.29*	*30.85*	*23.11*	*5.44*	*7.14*	*4.41*
STUD3	*13.79*	*9.52*	*16.08*	*0.00*	*0.76*	*1.32*
STUD11	*0.00*	*1.40*	*4.75*	*5.60*	*7.07*	*4.47*
STUD5	*22.31*	*5.12*	*14.25*	*1.33*	*2.35*	*2.07*
STUD13	*0.00*	*-2.15*	*9.03*	*4.97*	*6.60*	*4.26*
STUD7	*44.14*	*17.96*	*21.78*	*1.30*	*2.35*	*2.20*
STUD15	*28.60*	*17.69*	*20.05*	*3.46*	*5.84*	*3.88*
STUD6	*20.40*	*9.53*	*11.36*	*1.07*	*2.19*	*2.04*
STUD14	*27.78*	*22.35*	*17.40*	*4.10*	*6.42*	*4.15*

Table 3 – Acceleration of Tank 6

Monitoring point	Acceleration, mm/year^2					
	Horizontal values, mm/year^2			Vertical values, mm/year^2		
	t= 3 years from 5/2000 to May-03	t= 4.25 year from 5/2000 to 8/2004	t= 8 years from 5/2000 to May-08	t= 3 years from 5/2000 to 5/2003	t= 4.25 year from 5/2000 to 8/2004	t= 8 years from 5/2000 to May-08
STUD1	*7.19*	*4.06*	*2.42*	*1.28*	*0.87*	*0.36*
STUD9	*8.97*	*4.50*	*1.86*	*1.94*	*1.66*	*0.55*
STUD16	*11.06*	*5.87*	*2.61*	*1.56*	*1.12*	*0.46*
STUD8	*10.87*	*4.10*	*1.85*	*1.38*	*1.08*	*0.44*
STUD2	*8.64*	*3.85*	*2.24*	*1.23*	*0.94*	*0.40*
STUD10	*0.00*	*1.32*	*0.77*	*1.87*	*1.64*	*0.56*
STUD4	*10.97*	*2.91*	*2.49*	*0.00*	*0.15*	*0.16*
STUD12	*14.43*	*7.26*	*2.89*	*1.81*	*1.68*	*0.55*
STUD3	*4.60*	*2.24*	*2.01*	*0.00*	*0.18*	*0.17*
STUD11	*0.00*	*0.33*	*0.59*	*1.87*	*1.66*	*0.56*
STUD5	*7.44*	*1.21*	*1.78*	*0.44*	*0.55*	*0.26*
STUD13	*0.00*	*-0.51*	*1.13*	*1.66*	*1.55*	*0.53*
STUD7	*14.71*	*4.23*	*2.72*	*0.43*	*0.55*	*0.27*
STUD15	*9.53*	*4.16*	*2.51*	*1.15*	*1.37*	*0.49*
STUD6	*6.80*	*2.24*	*1.42*	*0.36*	*0.52*	*0.26*
STUD14	*9.26*	*5.26*	*2.18*	*1.37*	*1.51*	*0.52*

5.0 Analysis Of Results

Table 2 presents the velocity in terms of horizontal and vertical deformation values for tank № 6. The first epoch of observation was year 2000. This serves as the reference observation. From table2, in term of horizontal component for year 2000 and 2003, the minimum velocity was at studs 10, 11 and 13 with value zero. By this we mean that no displacement at theses monitoring point for the year under study. The maximum velocity occurred at stud 7 with numerical value of 44.14mm/yr. For year 2000 and 2004, the minimum velocity was found to be -2.15mm/yr at stud 13 and maximum at stud 12 with a numerical value of 30.85mm/yr. For 200 and 2008, the minimum displacement was at stud 5 with value of 4.75mm/yr and maximum at stud 12 with value 23.11mm/yr.

In term of settlement, the vertical displacement for year 2000 and 2003 was minimum at studs 3 and 4 with a zero value which is an indication that there was no displacement at these monitoring points for that year. The maximum displacement occurred at stud 9 with a numerical value of 5.53mm/yr. For year 2000 and 2004, the minimum value occurred at stud 4 with value of 0.64mm/yr and maximum at stud 12 with value of 7.1mm/yr. From the table, maximum displacement of 4.47mm/yr occurred at stud 1 and minimum at stud 4 with value of 1.24mm/yr between year 2000 and 2008.

Table 3 present the Acceleration component of the Tank under consideration. The deformation also follows that of the velocity trend as can be seen above. The maximum acceleration occurred at stud 7 in year 2003 with a numerical value of $14.71mm/yr^2$ and minimum in year 2004 with a numerical of $-0.51mm/yr^2$.

It is important to note that no observation was carried out in year 2001, 2002, 2005, 2006 and 2007 because of the unrest in the Niger delta of Nigeria.

6.0 Conclusion

Based on the presented analysis, the value of movement of 14.71mm/sec. square horizontal at stud 7 for year 2003 appears high and it is now left for the structural Engineer to decide whether to put off the Tank for further investigation and this depends on the Tank elastic parameter.

Further observations need to be carried out to investigate the behavior of this point and other points where movement appears to be abnormal and before final conclusion can be drawn about the behavior of the structure as a rigid body.

References

[1] Ehigiator – Irughe, R. and Ehigiator M. O.(2010) "Estimation of the centre coordinates and radius of Forcados Oil Tank from Total Station data using least square Analysis", International Journal of pure and applied sciences. A pan – African Journal Series 2010

[2] Calson Survey 2011software with IntelliCAD 6.6

[3] Ehigiator-Irughe, R. Environmental safety and monitoring of crude oil storage tanks at the Forcados terminal. M. Eng. Thesis. - Department of civil engineering, University of Benin, Benin City. Nigeria. – 2005.

[4] Gairns, C. Development of semi-automated system for structural deformation monitoring using a reflector less total station. M.Sc. Thesis. – Department of Geodesy and Geomatics Engineering – University of New Brunswick, 2008.

[5] Ehigiator – Irughe, R. Ashraf A. A. Beshr, and Ehigiator M. O.(2010) "Structural deformation analysis of cylindrical oil storage tank using geodetic observations" (Paper Presented at Geo –Siberia 2010, International Exhibition and scientific conference VI page 34 - 37, Novosibirsk Russia Federation)

[6] Radia MIR, Salem Kahlouche and Said Touam (2011) "Investigation of Deformation in North of Algeria with GPS data and Kinematic model", Paper Presented at FIG working week , Marrakeck, Morocco.

[7] Temel Bayrak and Mualla (2003) "A kinematic analysis program for deformation Monitoring", Paper Presented at proceeding, 11th FIG symposium on Deformation Measurement Santorini, Greece.

[8] Ashraf A. Beshr (2010), Development and Innovation of Technologies for Deformation Monitoring of Engineering Structures Using Highly Accurate Modern Surveying Techniques and Instruments, Ph.D. thesis, Siberian State Academy of geodesy SSGA, Novosibirsk, Russia, 205 p. [Russian language].