The Effect of Near Fault and Far Fault Earthquake on Dynamic Analysis of Concrete Face Rockfill Dam with Case Study on the Neka, Gelevard CFRD

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ABSTRACT: Comparing of time histories and frequency containing of various accelerogram from near and far fault that show reached vibrations to various points depend on distance from causative fault position, the direction of the advancing rupture and the characteristics of the source parameters. The accelerogram crop of near fault and far fault general containing less effect's time to regard of accelerogram from near fault and far fault and usually from high frequency compilation type. In this state that accelerogram from near fault and far fault records general are containing low frequency compilations. The studies histories seismic of various structures that show in using effect earthquake of near fault and far fault that are containing various frequency and that show difference act. Considering that such studies on Rockfill dams with concrete face rockfill dams (CFRD) is rare and due to its importance in the present paper will be discussedFor example from CFRD to various earthquake earned from near fault and far fault and will compared together, in continue from base of earned results in this studies difference seismic CFRD to will became manifest in near fault and far fault earthquake.
[Hasan Houshmandan, Reza Rasouli, Mohammad Hajiamiri. **The Effect of Near Fault and Far Fault Earthquake on Dynamic Analysis of Concrete Face Rockfill Dam with Case Study on the Neka, Gelevard CFRD.** *J Am Sci* 2014;10(1s):42-51]. (ISSN: 1545-1003). http://www.jofamericanscience.org. 9

Keywords: concrete face rockfill dam, CFRD, near fault & far fault

1. Introduction

Soil and rockfill dams are geotechnical constructions that rupture in them can be resulted to irrecoverable damages. Therefore, in their designing it is necessary to apply all controls and sensitivities. One of these cases is to control dam's stability at the time of earthquake and after it [1]. Accurate investigation of stability in concrete face rockfill dam against earthquake is one of the most complicated problems in domain of soil constructions [2]. The cause of this is that the collection of knowledge and relationships among them in analyzing this problem is very different and varied. By regarding to the extent of these dams' application and also talent for earthquake in Iran, estimation of vibration's safety of these dams have valuable role. The second project to establish concrete face rockfill dam (CFRD) in this country is Gelevard CFR Dam in Neka whose height reaches to 113 meters and is unique in this case in Iran. This dam has been located in Mazandaran province and its location is in 28 km distance of eastern south of Neka city and in geographical coordination of 53 degree in eastern length and 36 degree from northern wide.

Table 1: Characteristics Gelevard CFRD

concrete face rocfill	type of dam
111 m	Height of dam from
12 m	Wide of crest
739 m from sea level	crest's amounts
1v 1.5H	Upper slope
1v 1.4H	Below slope

In this research, dynamic responses of concrete face rockfill dam are analyzed by case study on the gravel dam of Neka and by regarding that until now such studies haven't been performed on concrete face rockfill dam (CFRD), the present study will investigate it. The main software used for dynamic analysis in this studies is PLAXIS 8.2 which application widely in mechanic of soil problems at now.

2. Theory concepts of earthquakes (near fault & far fault) and their effect

The near fault earthquakes have less distance from the center of releasing energy. Some of researchers know this distance 50km and others such as Eki knows this distance 1km [3]. in this study, the limitation of near fault earthquakes is considered in 10km radius of the surface center of earthquake and more than this distance is considered far domain of earthquake. The resulted records from near fault generally have severe pulses. These characteristics aren't observed in far faults. In addition to these, performed studies show that recorded acceleration measurements in near domain generally include high frequency components, while recorded acceleration measurements in far domain generally include low frequency components. It is worth to mention that these specifications Because for Directivity Effect are seen in the front areas of Rupture front because in the mode of propagation, disconnection toward site with the speed near to the speed of shear waves' propagation, causes most vibration energy resulted from disconnection reaches to the site like a strong pulse, while in area behind the front, this disconnection isn't seen in record. Another point which is important in the study of near domain is that the component perpendicular to the protraction of fault has more energy than parallel component of fault which causes earthquake and there is high difference of pulsation range in low frequencies among these two components, but in high frequencies this distance is minimum (fig.2). Also as it is seen from (fig.2), the replacement's response spectrum of component perpendicular to on the fault in smaller than 1 Hz frequencies is greater from parallel component along the fault [4].

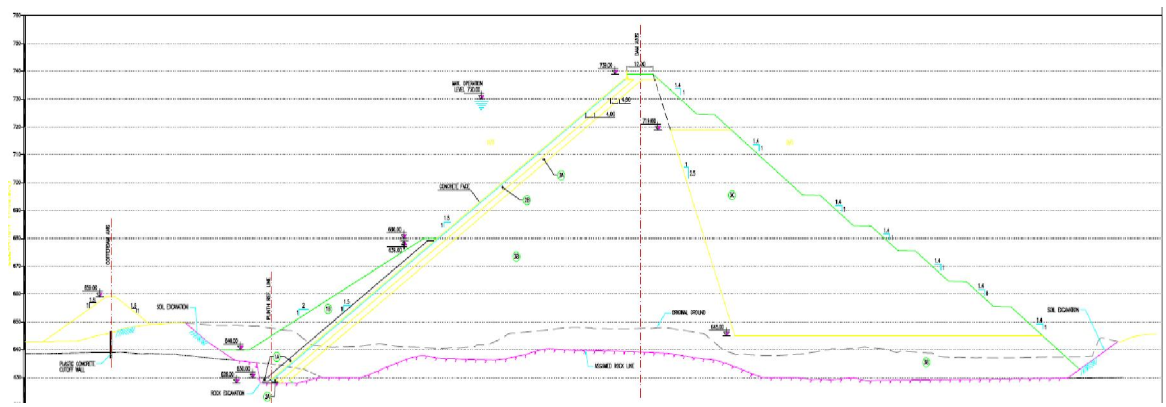

Figure1: cross-section of Gelevard CFRD

Table 2: information related to the selected records for dynamic analysis of Gelevard dam's model among records of Kalkan.

PGD (cm)	PGV (cm/s)	PGA (g)	Comp.	Site Class[3]	Dist.[2] (km)	Station	Mech.[1]	M_W	Earthquake	Record No	GM Characteristics
5.48	20.97	0.29	180	D	26.4	Moorpark (Ventura Fire Stn.)	0.02	6.7	Northridge	4	Far-Fault(1)
43.25	106.30	0.42	022	D	6.2	Jensen Filt. Plant	0.02	6.7	Northridge	13	Forward-Dir.
205.93	82.05	0.41	EW	C	3.2	Sakarya	0.01	7.4	Kocaeli	11	Fling
		0.43		D	26.9	Saturn Street School		6.7	Northridge	6	Far-Fault(2)

Table 3: damping parameters of model

f1=0.296	w1=1.256	0.085 = α
f2=0.169	w2=2.637	0.0256 = β

Table 4: parameters of materials to build model

Material	υ	E (MPa)	γ (KN / m3)	Φ(degree)
Concrete Face	0.2	5000	25	-
2A Zone	0.3	59	22.9	42
2B Zone	0.3	45	22.2	45
3A Zone	0.3	45	22.2	45
3B Zone	0.3	45	22.2	45
3C Zone	0.3	30	21.8	40
Alluvium	0.35	16	20.9	28
Safe bedrock	0.25	2000	26	-

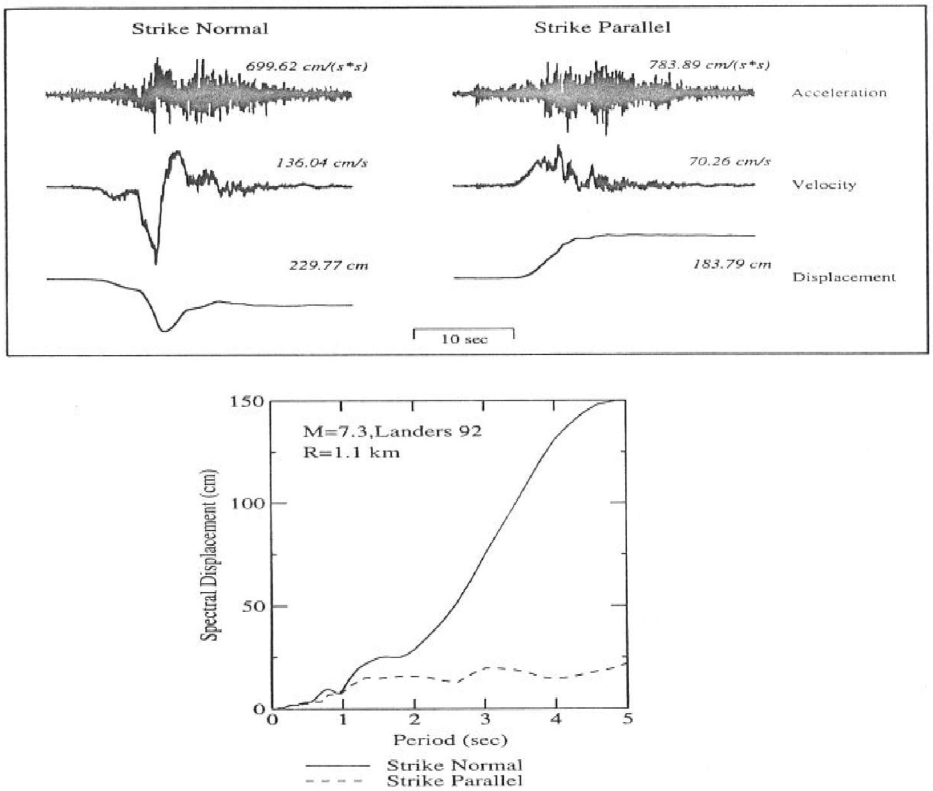

Figure 2: top picture: time history of acceleration, velocity and displacement of components perpendicular and parallel with recorded horizontal movement during 1992 earthquake. Below picture: transformation response spectrum vertical and parallel. [Somerville et. al., 1997]

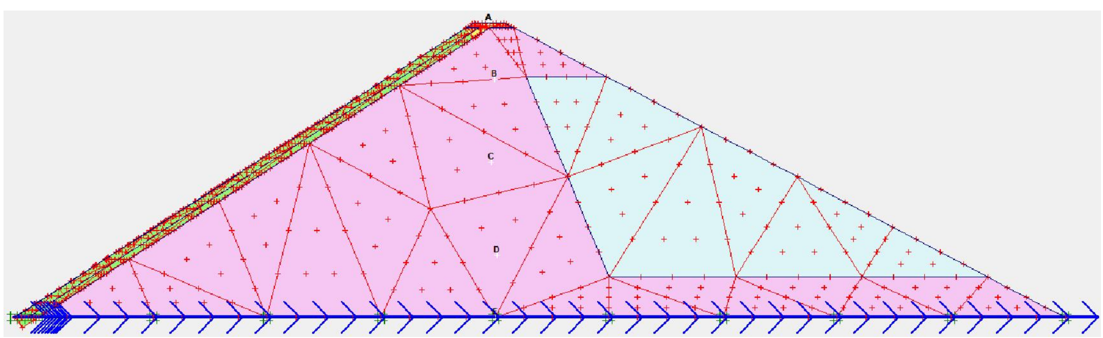

Figure3: selected points on dam's body

3. Modeling details

The main software used for the dynamic analysis of this Research, is finite element software PLAXIS 8.2.Plaxis is advanced finite element software that applied to the analysis deformations and stability in geotechnical engineering projects.

Usually in important problems of geotechnical, it is necessary an advanced behavioral model for modeling of non-linear behavior and depended to the time of soils by regarding to the intended purpose. To use earthquakes' records by PLAXIS software it should be modified and final correction of input records also was performed completely to eliminate additional frequencies of accelerogram at the time of earthquake recording.

The selective records are for analysis which cases 1 and 2 related to the earthquake near fault and cases 3 and 4 are related to the records of far fault which are from record collection of below:

1- Fling
2- Forward directivity
3- Far fault (1)
4- Far fault (2)

From this record collection a record sample whose PGA is more similar to the PGA of Gelevard dam are was selected and model of Gelevard dam with their prepared and corrected records was modeled and then analyzed[5] [6]. In the area of Gelevard dam with the performed investigation: PGA= 0.41g, MDL: 0.31g

Also damping parameters of model are shown in table 3.

It is worth to mention that the foundation of this model are considered quite Rigid.

For this case, 5 points in the height of dam were selected for analysis of parameters which are apparent in the picture.

And on this bases, the results of analysis and outputs of Plaxis software for 4 records are represented in the present analysis and all obtained results from analysis will be represented by that record after representing software's outputs in graphic view form on the body of dam represented by graphs and diagrams.

4. Results and Conclusions

4.1 Results of analysis with fling selective records

In this model, non-linear response of Gelevard dam is obtained by Mohr-Coulomb behavioral model. This model could consider two type of hardening: shear hardening and pressure hardening and able to make viscous damping in cyclic loading for soil element. It has been tried that parameters of MC model and Rayleigh damping parameters be computed correctly. The outputs results of the dynamic analysis with fling records in figures below(fig.4 to fig.7).

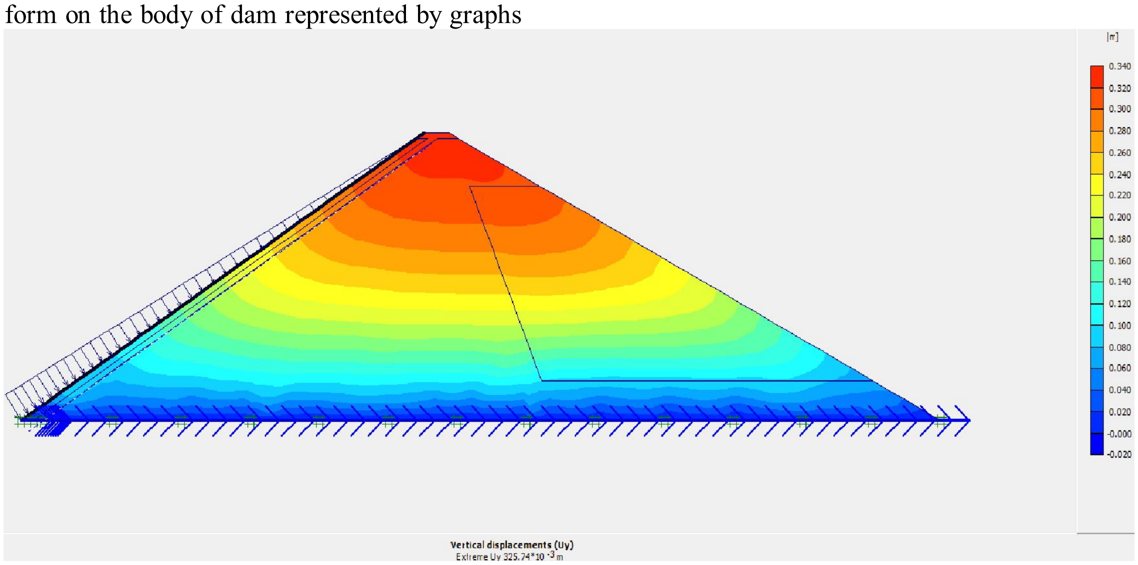

Figure 4: distribution of vertical displacements

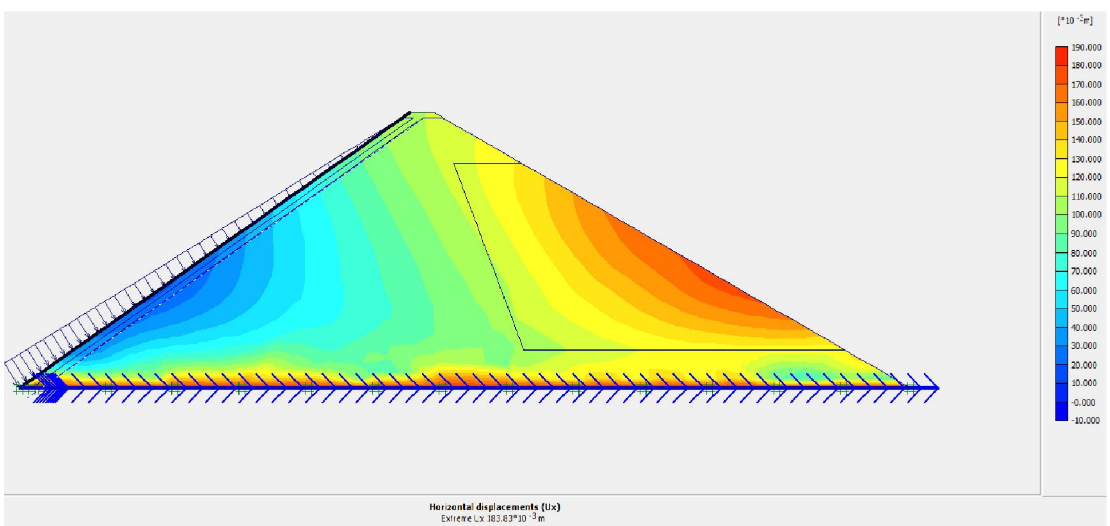

Figure 5: distribution of vertical displacements

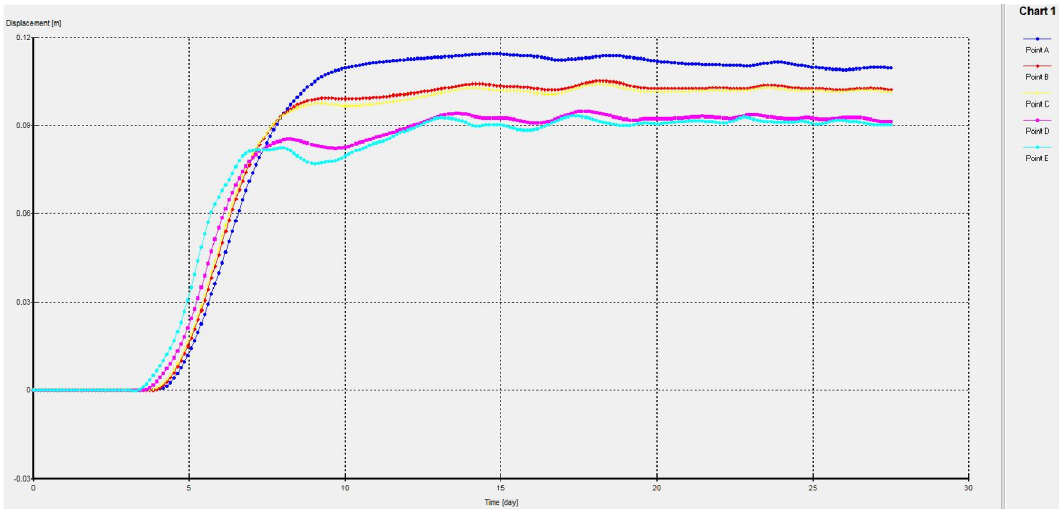

Figure 6 : Horizontal displacement versus time Curve (Ux-t)

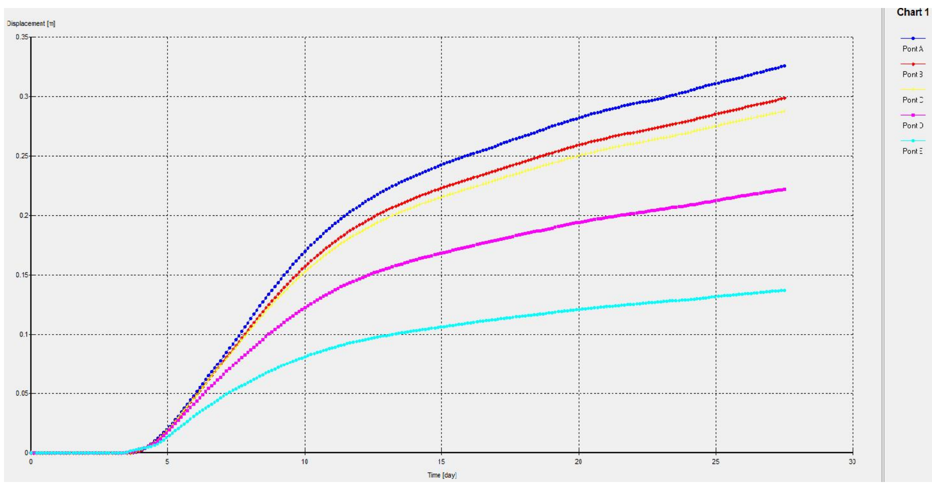

Figure 7 : Vertical displacement versus time Curve (Uy-t)

4.2 Results of analysis with forward directivity selective records

The outputs results of the dynamic analysis with forward directivity records in figures below (fig.8 to fig.11).

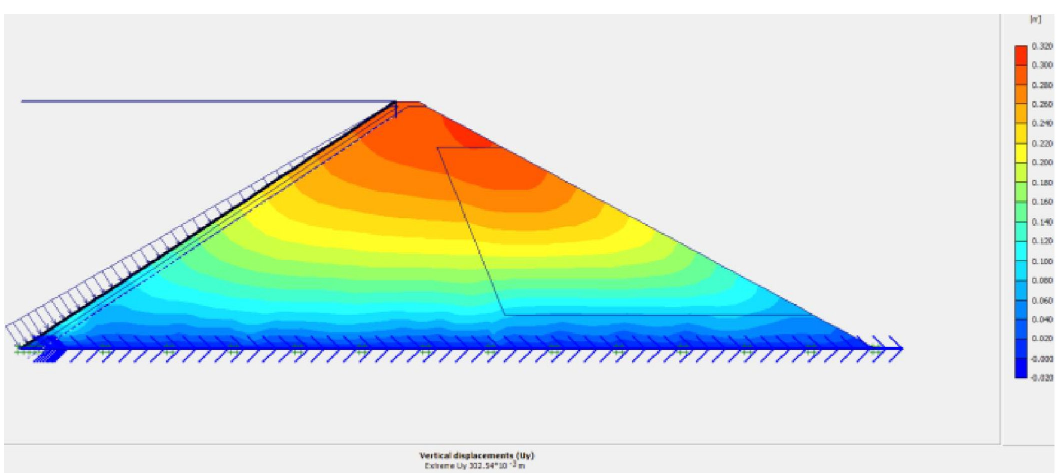

Figure 8: distribution of vertical displacements

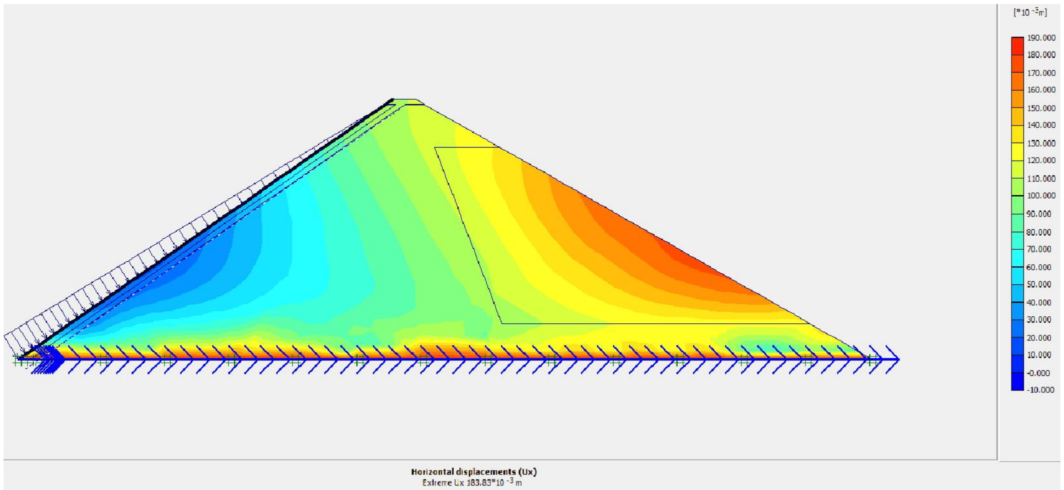

Figure 9: distribution of horizontal displacements

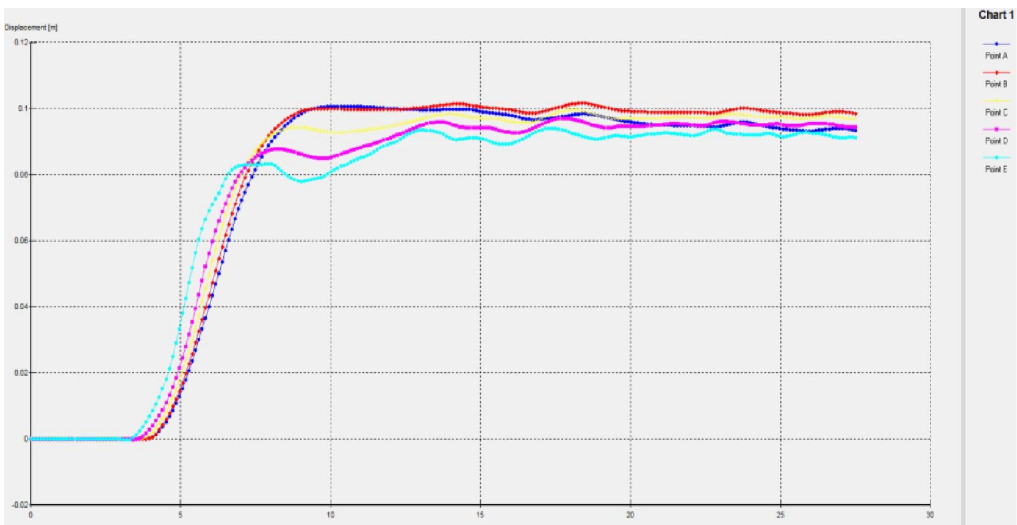

Figure 10 : Horizontal displacement versus time Curve (Ux-t)

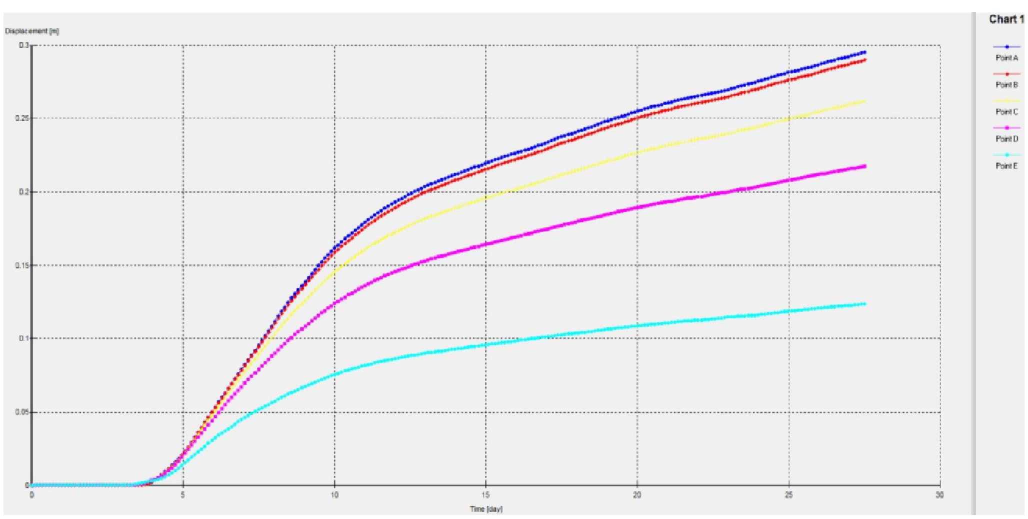

Figure 11 : Vertical displacement versus time Curve (Uy-t)

4.3 Results of analysis with far fault (1) selective records

The outputs results of the dynamic analysis with far fault (1) records in figures below (fig.12 to fig.15).

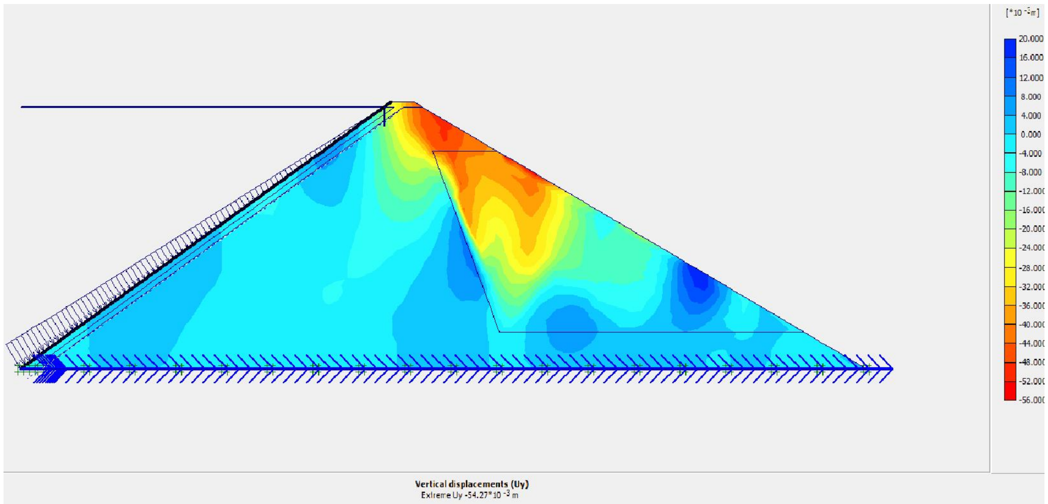

Figure 12 : distribution of vertical displacements

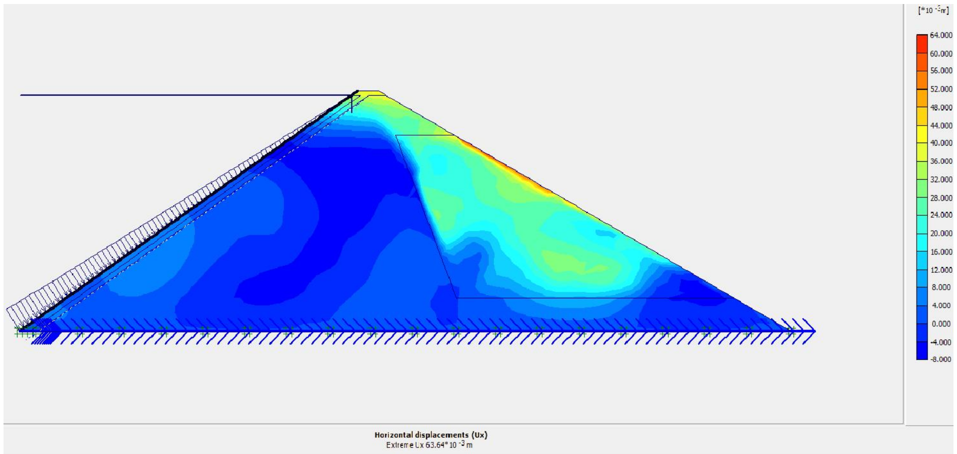

Figure 13: distribution of horizontal displacements

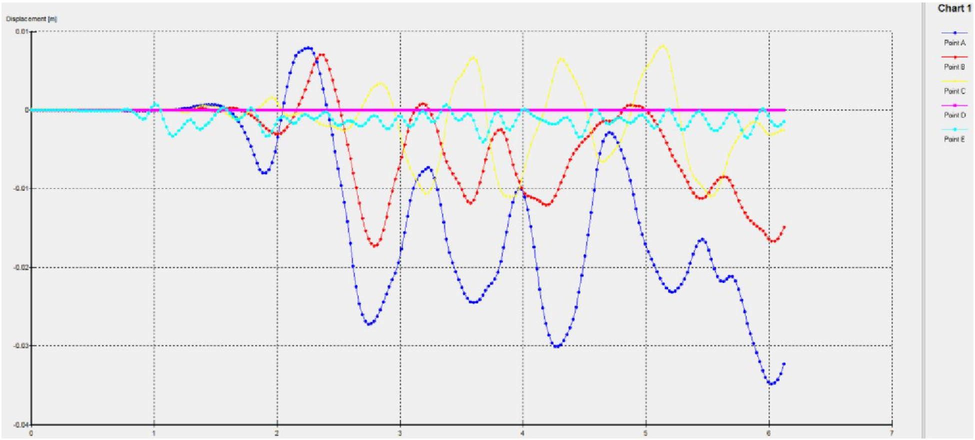

Figure 14 : Horizontal displacement versus time Curve (Ux-t)

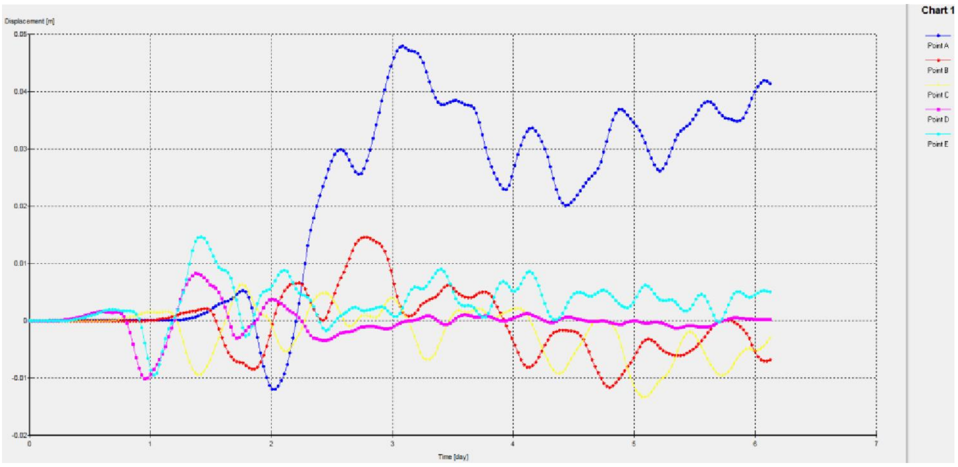

Figure 15 : Vertical displacement versus time Curve for far fault(1) records (Uy-t)

4.4 Results of analysis with far fault(2) selective records:

In this model because of high effects of displacements in ranges, two other points were considered to investigate the effect of replacements in ramps of two sides of dam which are F and G points. The outputs results of the dynamic analysis with far fault(1) records in figures below(fig.16 to fig.19).

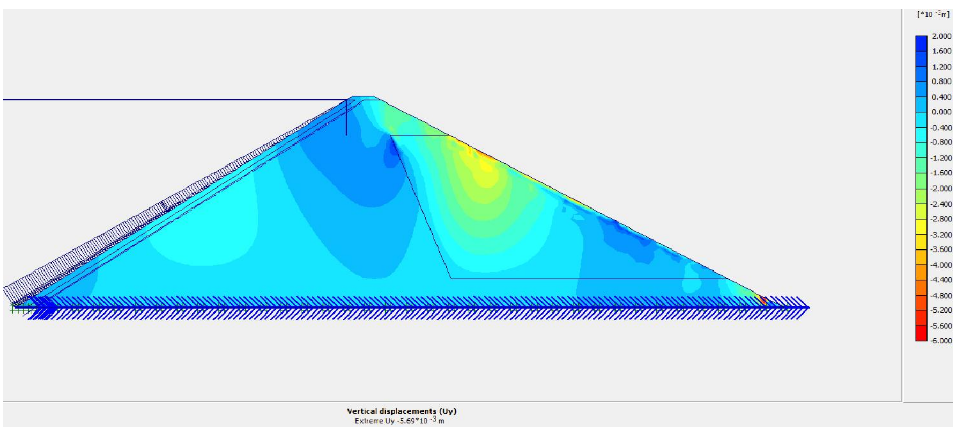

Figure 16- distribution of vertical replacement

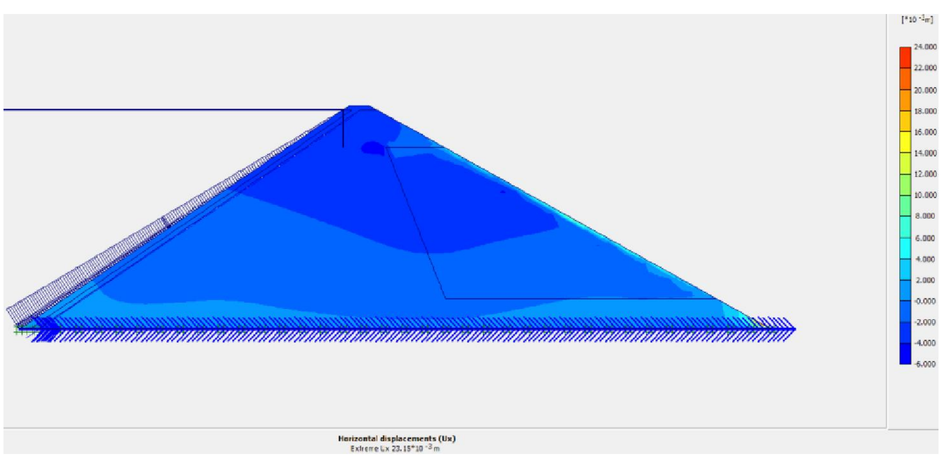

Figure 17: distribution of horizontal replacement

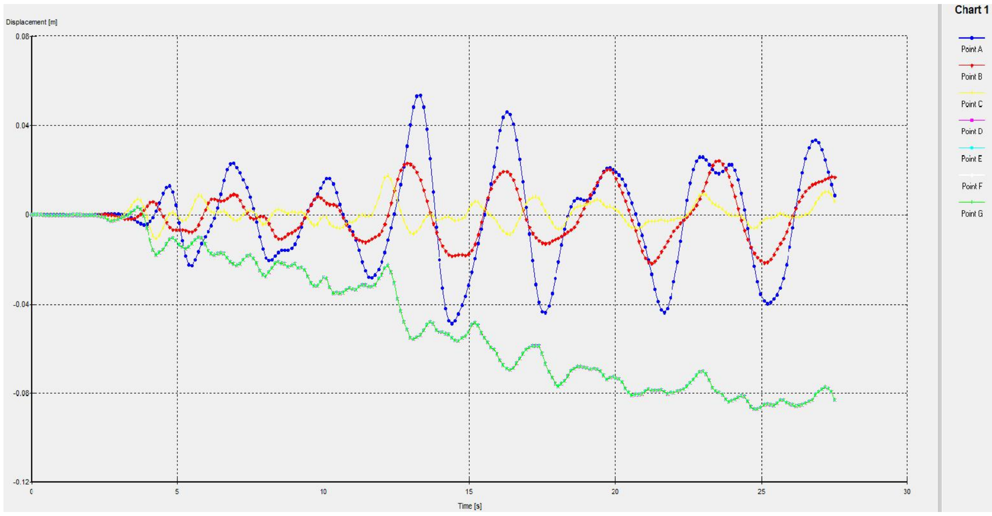

Figure 18 : Horizontal displacement versus time Curve (Ux-t)

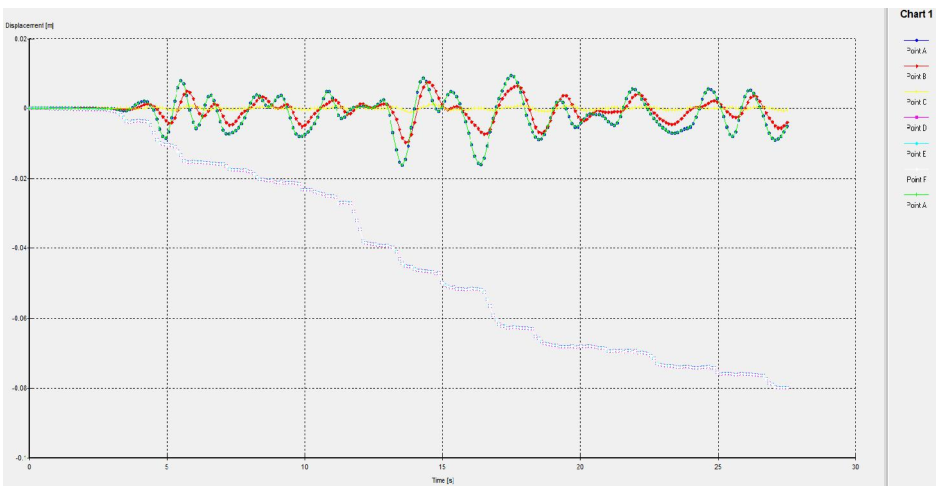

Figure 19 : Vertical displacement versus time Curve for far fault (1) records (Uy-t)

5. Conclusion

In this section we will investigate results obtained from the research which are as the following:

5.1 The results obtained from dynamical analysis on Neka Gelevard concrete face rockfill dam by means of two records of near fault earthquake which include Fling record and Forward directivity showed that the model of dam in analysis is by means of behavioral model of Mohr-coulomb after analysis showed stable changes so that in case of displacement parameter this amount reaches to about 32 cm about subsidence and vertical displacement and about 18cm in case of about horizontal displacement which about first parameter means subsidence was significant amount and it needs higher accuracy in relation to the kind of designing and operation with caution in this case. This is while this parameter in the results of analysis with two records of far fault (1 and 2) show that earthquakes far from fault haven't significant changes on the model, so that about displacement parameter this amount reaches to about 5cm about subsidence and vertical displacement and about 6cm and 23 cm about horizontal displacement and these amounts aren't significant and effective amounts on the parameters of materials and general condition of dam after earthquake with the condition of far fault.

5.2 With the review on technical literature in the world in this field and similar research works and the present research this reality will be highlighted that the more height of dam and specially on rockfill dam cause more effectiveness of obtained from near fault records which generally have a sever pulse and their velocity and displacement of them is in small frequencies proportional to the records far from fault and dam will have long term changes

[7]. It is worth to mention that these

characteristic is seen because of Directivity Effect which are forward of rupture zone because in terms of seismology, in the mode of dissipation of rupture is toward site with a velocity near to the velocity of shear waves dissipation, the most seismic energy resulted from rupture reaches to the site as a sever pulse. But while in back of rupture zone this pulls isn't seen on the record.

5.3 In dynamical analysis about analysis of model with the far fault record or with the near fault records it can be concluded that high vertical displacements occur in crest of dam(point A)

5.4 About horizontal displacements in each group of the results after analysis in body of dam, generally and approximate it can be said that in the part of reservoir, Horizontal displacement is less than Upstream also according to dispersion of displacement in the body of dam can conclude that Instability of dam at the time of earthquake, is in subsidence mode and heaving of lower parts is toward reservoir of sea which is naturally acceptable [8]. It is worth to mention that indexes of displacement output curves show that these curves are concentrated in the area of filler and as it is observed the crest of dam in fillers sides and drainages sides has more displacement and the amount of height so that due to earthquake in stable seepage Not occur Overflow water danger from crest dam (Overtopping) and structure of dam against MCL earthquake show Appropriate behavior.

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1/8/2014