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SEISMIC RESPONSE OF CONCRETE BUILDINGS AFFECTED BY EARTHQUAKE OF NEAR-FIELD (CONTAINING THE DIRECTED FORWARD EFFECT) WITH DISTANT ZONE

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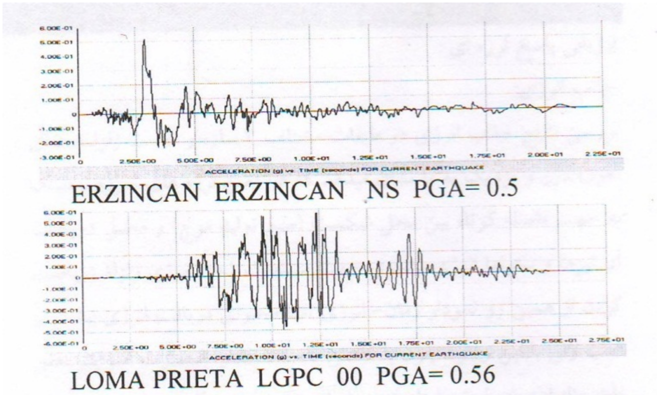
ABSTRACT

The ground motions close to an active fault are essentially affected by fault mechanism, the direction of fault propagation relative to the origin and static deformation of land surface in relation with launch effects. These results which are derived from nearness to earthquake source causes the earthquake energy reaches to the structure as a long period pulse. This type of ground motions produces many seismic needs so that makes the structure waste the input energy with relatively large dislocations. In contrast with post-earthquake observations, current earthquake regulations which are based on response spectrum do not have a certain stand on ground motions in near fields. Although some regulations have introduced parameters to magnify elastic design spectrum, but effectiveness of these magnification factors in proper elasticity of structures and structural components located near faults is not conclusive.

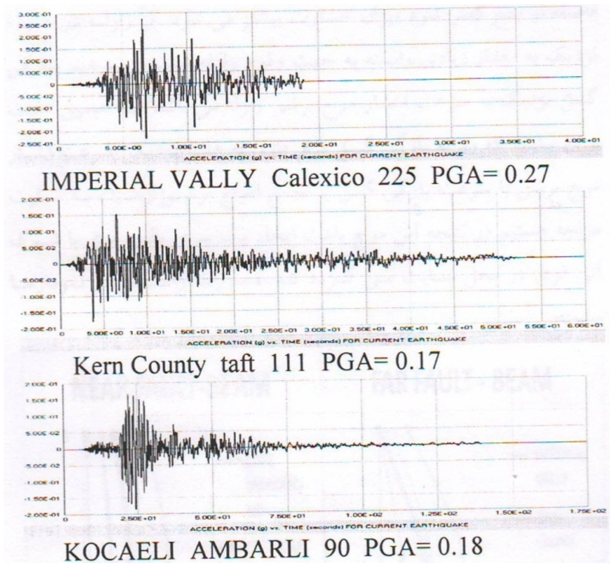
INTRODUCTION

Ground motions far from faults are significantly different from near fault records recorded within a few kilometers from fault rupture. In terms of historical patterns of relocation, structure responses to ground motions near faults are divided into two different categories which depend on process of the rupture and its corresponding directing effect. When the rupture moves forward in the direction of source and the direction of slide is the same with source, the ground motions produce long period pulses with short time period and large magnitude.

Forward directed movement occurs when the fault is distributed almost as rapid as shear wave is dispersed. Relative dislocation with such shear wave velocity is perpendicular to larger fault slides. Some records may show forward movement, but these records do not hold clear pulse velocity.



Earthquakes mapping velocity (nearfield):



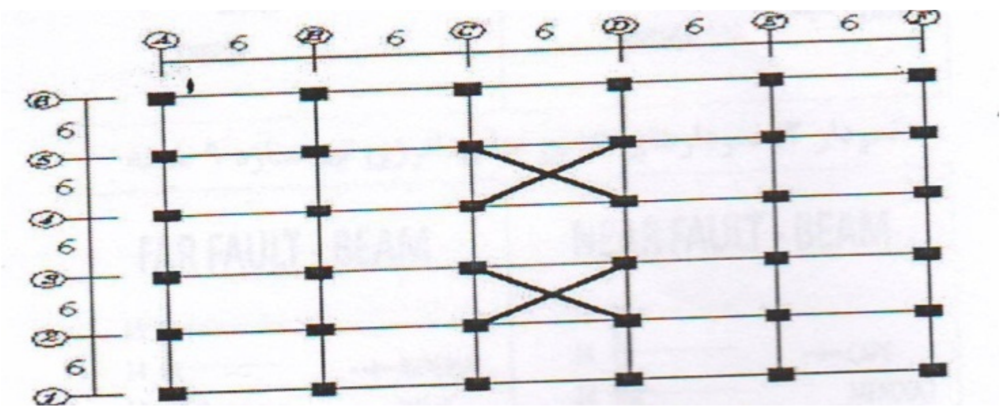
Earthquake mapping velocity (far field)

The important point in the figures above is the depiction of gradual formation of input energy for far-field records which leads to increase of non-elastic cycles. In contrast, near-field earthquakes are recognized by their fewer non-elastic cycles and more frequent elastic cycles.

Despite post-earthquake observations, the existing seismic design regulations which determine the design earthquake based on theories of response spectrumdo not have a clear position toward ground motions on the near field. Although seismic design regulations such as (IBC, UBC, FEMA-356, ATC40) introduced site parameters and dependent near source and field in NV and NA distance to magnify the elastic design spectrum of shear increase of design base, but the effectiveness of these fixed magnification factors in determining the proper levels of elasticity for these structures and the components of structures located near fault areas are not certain and is in question. The problem is arisen by long-time development of current design spectrum based on random procedures which determines the far-field earthquakes.

Studied buildings

The plan of studied building stories is depicted in the figure below. Five opening in east to west direction with five meters long each and five openings in north-south direction with six meters long each have formed a plan with 30*30. The height of stories is considered 3 meters. The dimensions of structure components including beams, columns, shear walls and used amount of steel in these components are determined so that the regulation requirements would be met. The resistant system against lateral load in buildings with 3, 9 and 15 stories are flexural. The connection of all columns and shear walls to foundation is in the form of fixed joints.



The plan of stories in the studied building

Ec = 2.18e5	B (3 ST) = 2.68
v = 0.2	B (9 ST) = 1.54
M (CONCRET) = 240	B (15 ST) = 1.19
M (STEEL)= 795	C (3 ST) = 0.117
Fc = 210	C (9 ST) = 0.067
Fy = 3000	C (15 ST) 0.052
F yc = 3000	t (3 ST) = 20
A = 0.35	t (9 ST) = 25
I = 1	t (15 ST) = 35
T0 = 0.5	DEAD (STORY) = 300
T (3 ST) = 0.363	DEAD (B) = 262
T (9 ST) = 0.829	DEAD (S) = 700
T (15 ST)=1.21	RL (STORY) =200
H = 3 m	L (B) = 150
R = 8	L (S) = 350

Considered parameters for linear analysis

NAME	DATE	STATION	Mw	KM	PGA	PGV	PGD
CAPE	1992	Petrolia	7.1	9.5	0.7	89.67	28.99
ERZ	1992	Erzincan	6.9	2	0.5	83.95	27.66
LOMA	1989	LGPC	7	1.3	0.6	94.71	41.13
NORTH	1994	Rinaldi	6.7	7.1	0.8	166	28.15
NORTH	1994	Sylmar	6.7	6.4	0.8	129.3	31.92
TABAS	1978	Tabas	7.4	3	0.9	121.2	95.06

NAME	DATE	STATION	Mw	KM	PGA	PGV	PGD
IMPER	1979	Calexico	6.5	90.6	0.3	21.23	8.98
Kern	1952	Taft	7.4	81	0.2	17.47	8.83
KOCA	1999	Ambarli	7.4	78.9	0.2	33.22	25.84
LOMA	1989	cliff house	6.9	83.1	0.1	19.78	5.06
LOMA	1989	Presidio	6.9	84.4	0.1	12.91	4.32
MAN	1990	Abbar	7.37	74	0.5	42.46	14.92
TABAS	1978	Deyhook	7.4	107	0.4	26.17	9.1

Earthquakes and predicted stations

Evaluating seismic response:

Energy absorption:

Studying the results of energy absorption in different stories of three structures under far and near-field earthquakes demonstrate that in near-field earthquakes, beams and columns receive higher amount of energy to consumption of earthquake energy because of short distance between rupture location (source of wave production), thus the time-energy diagram contains more received energy. However, the loss increases with distance reduction. So the loss amount has a negative relationship with the distance from the source and the lesser the distance from the source, the larger the loss amount will be. The earthquake effect in nearfields highly depends on the direction of earthquake occurrence and the fault rupture velocity is close to the propagation velocity of earthquake shear wave. Therefore, we will face the accumulation of shear waves on a site with the probability of fault rupture, because the propagation velocity of shear waste is close to the fault rupture velocity. So, this wave causes a series of strong pulses with instantaneous shockin situ which is apparent in diagrams.

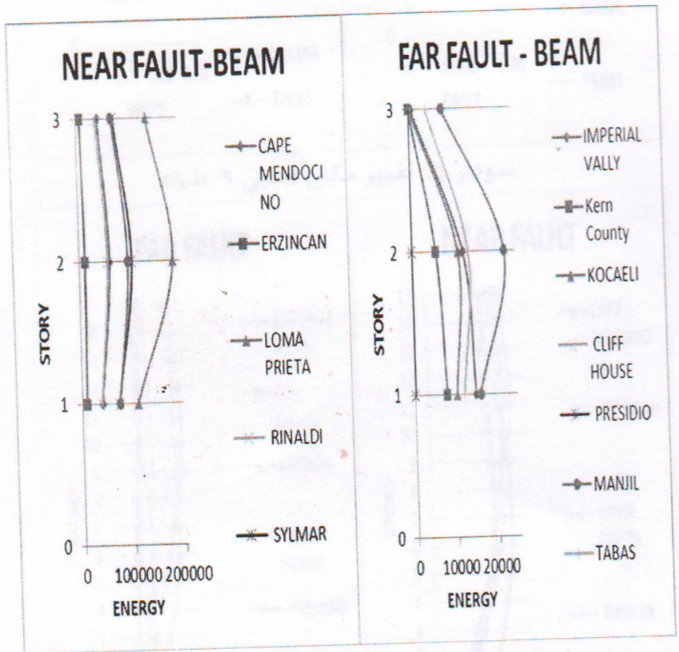


Diagram1. The diagrams of beam energy absorption results in 3-story structure

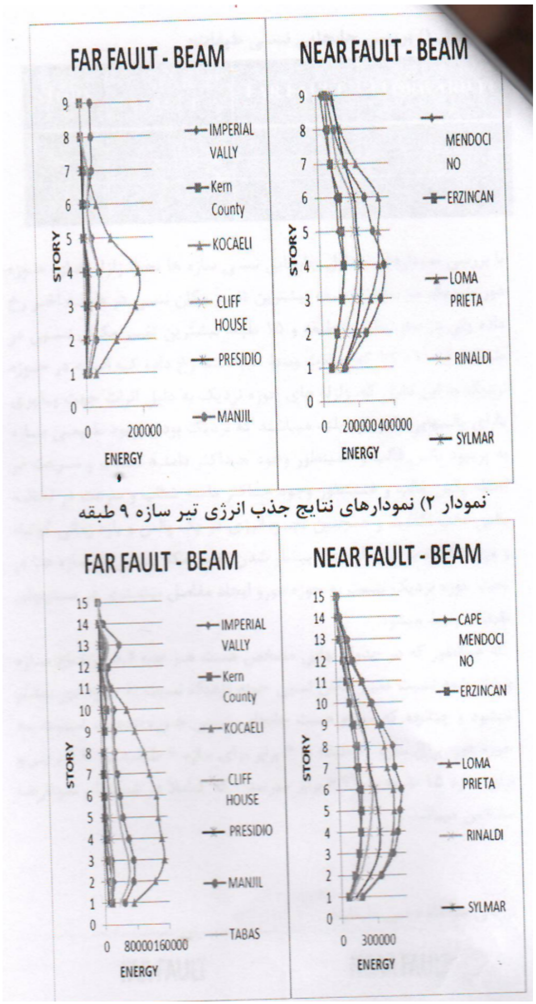


Diagram2. The diagrams of beam energy absorption results in 9-story structure

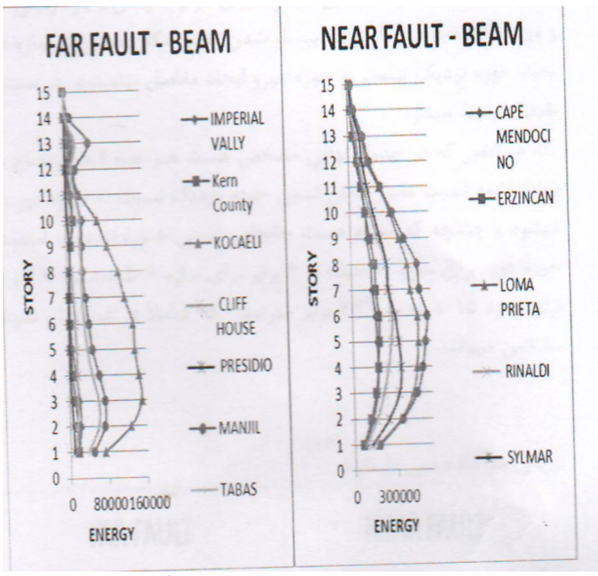


Diagram3. The diagrams of beam energy absorption results in 15-story structure

Studying the relative relocation rate

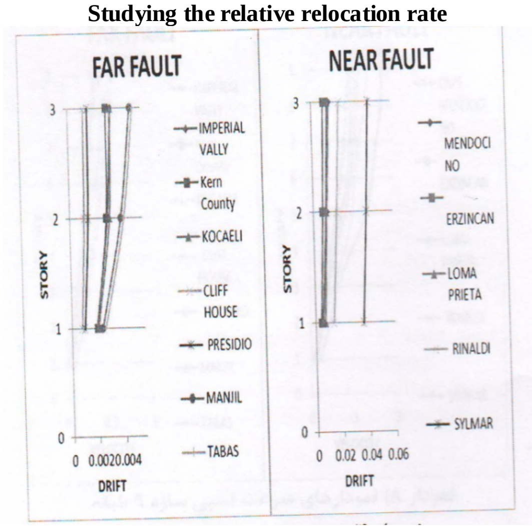


Diagram4. Relative relocation of 3-story structure

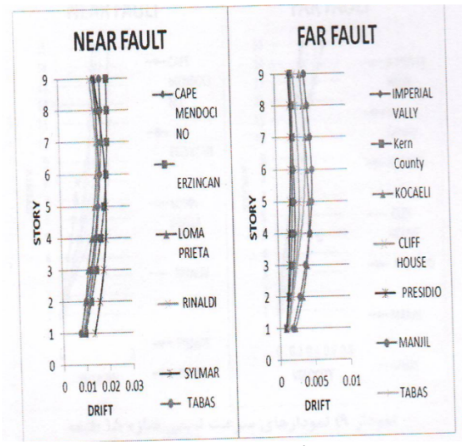


Diagram5. Relative relocation of 9-story structure

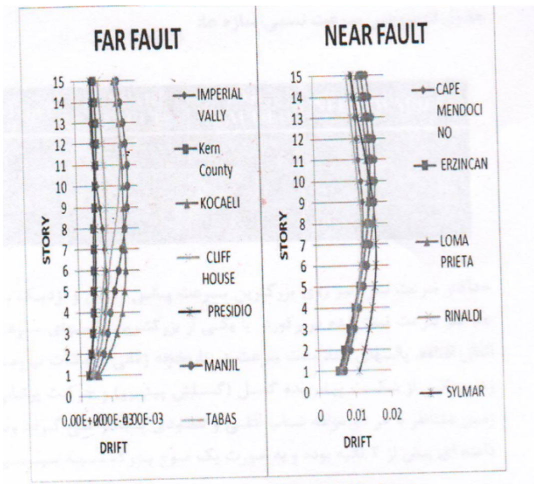


Diagram6. Relative relocation of 15-story structure

Table1. Studying the relative relocation of stories

STORY	NEAR FAULT	FAR FAULT	FFORW[illegible]
3 ST	0.018	0.003	6
9 ST	0.016	0.0026	6.07
15 ST	0.011	0.0018	6.11

Examining the diagrams and tables of relative relocation under near-field and far-field earthquakes in three-story structure shows that the highest relocation rate has occurred in the last story, but in 9-story and 15-story structures the highest relative relocation is seen in 9th, 10th and 11th stories (the middle ones). Since near-field earthquakes have long-period pulse due to the direction effects. The nearness of structure natural period to prevalent pulse period and the existence of maximum velocity amplitude, velocity of the moment of prevalence pulse moment, the accumulation of energy in one pulse, the short time interval and sudden entrance to structure causes the increase of relative relocation in near-field structures compared to far-field ones, producing more joints in columns of middle stories.

As it is obvious in final table, the higher the structure, the higher the relative relocation rate of near-field will be. The relative relocation of near field compared to far field for 3-story structure will be six times more. This amount is 6.7 times for 9-story structure and 6.11 times for 15-story structure.

Studying the relative velocity of the stories:

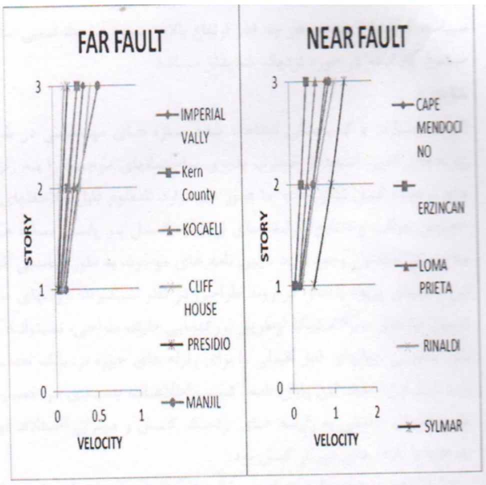


Diagram7. The diagrams of structure relative velocity in 3-story structure

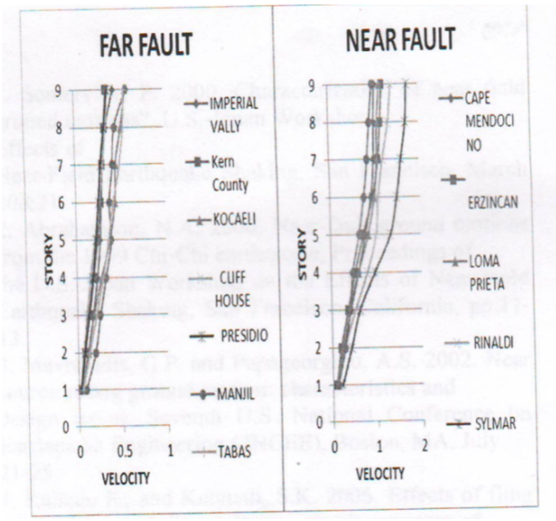


Diagram8. The diagrams of structure relative velocity in 9-story structure

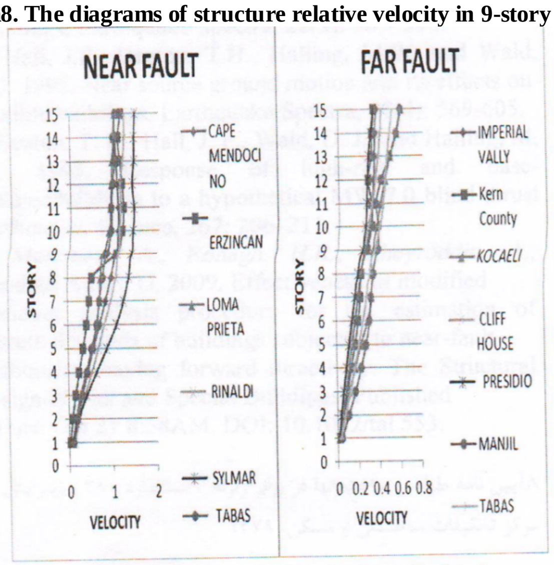


Diagram9. The diagrams of structure relative velocity in 15-story structure

Table2. The relative velocity of structures

STORY	NEAR FAULT	FAR FAULT	NFFORWARD/FF
3 ST	0.88	0.32	2.75
9 ST	1.25	0.44	2.78
15 ST	1.14	0.40	2.81

Maximum structure velocity recorded has occurred in a velocity close to the maximum recorded velocity pulses. Long-term velocity pulses in time history ofearth strong vibration due to the fault progressive break and launch of earth corresponding to both horizontal and vertical velocity components within amplitude higher than 2 second. It appears like a large sinus wave and can be a significant factor on structure response and relative velocity of structure.

The important point observed in the studies was that the velocity over 0.8m/s caused non-linear (elastic) joints in aforementioned model. This velocity is not related to the farness or nearness of the field but the records of near fields experienced more growth than far-field records in equal velocity.

In near-fault earthquakes, the ground motionoccurs with pulse due to near faults such as Silmar and Rinaldi, and happens without any pulse due to the effect of faults such as Loma Prieta. Because of short distance of location to the fault, the record resulted by velocity has a pulse shape with high period because of its higher. In near-field earthquakes, there is no time for amortization of high frequencies due to the short distance between breaking point (source of wave) and the location of receiving it. Thus, time history of their velocity and acceleration contains high frequency. Near-field earthquakes contain critical energy pulses. Although these earthquakes may have high Richter degree or small amplitude, but have a very high destructive potential. Velocity pulses are usually derived by rapid fault sliding which are more severe in near-field earthquakes.

As it is observed in the diagrams, the relative velocity distribution in 3-story structure is uniform and its maximum rate is in the highest story and it is stronger in Selimar near-field earthquake. In 9- story and 15-story structures, the relative velocity distribution in far field is completely uniform, but it has some oscillations which are more critical and severe in the highest story. According to the table above, the ratio of relative velocity of far-field earthquakes compared to near-field earthquakes are 2.75 bigger in 3-story structures, 2.78 times bigger in 9-story structures and 2.81 times bigger in 15-story structures. It demonstrates that the higher the structure is, the higher the relative velocity will become, which is stronger in near fields.

RESULTS

Although the observed loss and rupture of engineering structures in the recent earthquakes has proved the susceptibility of current building to near fault earthquakes, but there are some considerable unknown items regarding consequences and results of near fault earthquakes and their effect on common seismic response of structures. The existing regulations do not consider the effects of these high period pulses in the procedure of design properly. The simple methods for determining non-elastic needs by magnifying design spectrum cannot correctly estimate the acceptable responses for near field earthquakes. So, this dissertation aimed at gaining new data about responses of flexural frames to near fault earthquakes and the discrepancy between these responses with the ones of far fault earthquakes.

Numerical modeling showed that concrete buildings in the presence of velocity pulse in time history of velocity is under the effect of magnitude change needs and so the structure is required to waste considerable energy in one or more limited plastic cycles.

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