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Effects of near-fault and far-fault ground motions on nonlinear dynamic response and seismic damage of concrete gravity dams

1. Introduction. Dams are important lifeline engineering which have contributed to the development of civilization for a...
2. Characteristics of near-fault ground motions. It ...

Effects of near-fault and far-fault ground motions on ...

Ground motions close to a fault can be significantly influenced by directivity effects. When the rupture and slip

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direction relative to a site coincide, and a significant portion of the fault ruptures towards the site, the ground motion can exhibit the effects of forward-directivity.

Effects of near-fault ground motions and equivalent pulses ...

Near-fault ground motion includes the characteristics of forward directivity and fling step. In addition to ground motion, the aspect ratio of the pier, as a representative factor of a structural system, influences the seismic behavior of bridges. Thus, this study assessed the seismic response of bridges with various aspect ratios under the near-fault and far-fault ground motion conditions. Nonlinear static analysis was first performed to evaluate the seismic capacity of the pier.

Special Issue "Effects of Near-Fault
Ground Motions on ...

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The latter is described with idealized pulses and near-fault seismic records strongly influenced by forward-directivity or fling-step effects (from Northridge, Kobe, Kocaeli, Chi-Chi, Aegion). In addition to the well known dependence of the resulting block slippage on variables such as the peak base velocity, the peak base acceleration, and the critical acceleration ratio, our study has consistently and repeatedly revealed a profound sensitivity of both maximum and residual slippage: (1) on ...

Effects of Near-Fault Ground Shaking on Sliding Systems ...

Near-fault ground motions have caused much damage in the vicinity of seismic sources during recent earthquakes. These ground motions come in large varieties and impose high demands on structures compared to "ordinary" ground motions.

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Recordings suggest that near-fault ground motions are characterized by a large high-energy pulse.

Effects of Near-Fault Ground Motions on
Frame Structures ...

Conclusions 1) The long-period pulse has a significant effect on the tunnel, which makes the near-fault ground motions more damaging... 2) For a given pulse period, the pulse with larger amplitude brings more energy and leads to higher strains in rock and... 3) The period of the pulse can ...

Effect of near-fault ground motions with
long-period ...

Effects of Near-Fault Ground Motion and
Fault-Rupture on the Seismic Response of
Reinforced Concrete Bridges

Effects of Near-Fault Ground Motion and

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Fault-Rupture on ... Structures

Closure to "Effect of Near-Fault Vertical Ground Motions on Seismic Response of Highway Overcrossings" by Sashi K. Kunnath, Emrah Erduran, Y. H. Chai, and Mark Yashinsky Discussion of "Effect of Near-Fault Vertical Ground Motions on Seismic Response of Highway Overcrossings" by Sashi K. Kunnath, Emrah Erduran, Y. H. Chai, and Mark Yashinsky

Effect of Near-Fault Vertical Ground Motions on Seismic ...

Abstract. Near-fault ground motions exhibiting forward directivity effects are critical for seismic design because they impose very large seismic demands on buildings due to their large-amplitude pulselike waveforms. The current challenge in seismic design codes is to recommend simple (easy-to-apply) yet

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proper rules to explain the near-fault forward directivity (NFFD) phenomenon for seismic demands.

Implementation of Near-Fault Forward Directivity Effects ...

On Topography: One of the main effects of the faults on topography is that they very often result in the development of distinct types of steep slopes which are aptly called fault scarps. Three types of fault associated scarps are often recognized- fault scarps, fault-line scarps and composite-fault scarps.

Faults: Meaning, Causes and Effects | Rocks | Geology

step effect is the outcome of the tectonic permanent deformation of the earth in the proximity of the fault. It manifests itself in the record with a static residual displacement, oriented parallel to the fault

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strike with strike-slip earthquakes and perpendicular to the fault with purely dip-slip normal or thrust earthquakes Abrahamson 2001 .

Effects of Near-Fault Ground Shaking on Sliding Systems

of severe, long-period pulses in near-fault ground motions may be a key factor in causing damages. Thus, it is necessary to investigate the effect of the long-period pulse on tunnels in order to interpret the observed damages. At present, there are two approaches to account for near-fault ground motions.

1558. Effect of near-fault ground motions with long-period ...

Characteristics of Near-Fault Ground Motions. \square F d Di ti it Eff tForward

Directivity Effect: \square Fault rupture propagates toward a site with $V_r \square \square$ (and slip

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On Frame Structures vector points toward the site). □ Appears in the form of two-sided velocity pulse. □ Observed in the strike-normal direction for strike-slip and dip-slip faults.

NEAR-FAULT GROUND MOTIONS: FAULT GROUND MOTIONS ...

To investigate the effects of earthquake characteristics, two categories of strong ground motions are assumed through IDA method, i.e. near and far-field sets. To study the extent of modification for various heights of structures, 4 □ 6 and 10 stories moment-resisting concrete frames are considered as case studies.

Effects of Near-fault Strong Ground Motions on ...

The analyses results revealed that the seismic performance of the CBFs without FVDs is very poor and sensitive to the

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velocity pulse period and the intensity of the NF ground motion due to brace buckling effects. Installing FVDs into the CBFs significantly improved their seismic performance by maintaining their elastic behaviour.

Effect of near-fault ground motion and damper ...

near-fault phenomenon requires consideration in the design process for structures that are located in the near-fault region, which is usually assumed to extend about 10 to 15 km from the seismic source (1996 SEAOC Blue Book). Aside from directivity effects, near-fault ground motions are more severe than ordinary

**EFFECTS OF NEAR-FAULT GROUND
MOTIONS ON FRAME STRUCTURES**

Effects of Near Fault and Far Fault

Ground Motions on Nonlinear Dynamic

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Response and Seismic Improvement of Bridges. Mohammad Hajali, Abdolrahim Jalali, Ahmad Maleki. Abstract. In this study, the dynamic response of bridges to earthquakes near and far from the fault has been investigated. With respect to available data and showing the effects ...

Effects of Near Fault and Far Fault
Ground Motions on ...

Ground motions with velocity pulses caused by near-fault directivity have received a great deal of attention from engineers and seismologists because of their potential to cause severe damage to structures.

Growth of major population centers near

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Seismically active faults has significantly increased the probability of a large earthquake striking close to a big city in the near future. This, coupled with the fact that near-fault ground motions are known to impose larger demands on structures than ground motions far from the fault, makes the quantitative study of near-fault seismic hazard and risk important.

Directivity effects cause pulse-like ground motions that are known to increase the seismic hazard and risk in near-fault region. These effects depend on the source-to-site geometry parameters, which are not included in most ground-motion models used for probabilistic seismic hazard assessment computation. In this study, we develop a comprehensive framework to study near-fault ground motions, and account for their effects in seismic hazard assessment. The proposed framework is designed to be modular, with separate

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models to predict the probability of observing a pulse at a site, the probability distribution of the period of the observed pulse, and a narrow band amplification of the spectral ordinate conditioned on the period of the pulse. The framework also allows deaggregation of hazard with respect to probability of observing the pulse at the site and the period of the pulse. This deaggregation information can be used to aid in ground-motion selection at near fault sites. A database of recorded ground motions with each record classified as pulse-like or non-pulse-like is needed for an empirical study of directivity effects. Early studies of directivity effects used manually classified pulses. Manual classification of ground motions as pulse-like is labor intensive, slow, and has the possibility to introduce subjectivity into the classifications. To address these problems we propose an efficient

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algorithm to classify multi-component ground motions as pulse-like and non-pulse-like. The proposed algorithm uses the continuous wavelet transform of two orthogonal components of the ground motion to identify pulses in arbitrary orientations. The proposed algorithm was used to classify each record in the NGA-West2 database, which created the largest set of pulse-like motions ever used to study directivity effects. The framework to include directivity effects in seismic hazard assessment, as proposed in this study, requires a ground-motion model that accounts for directivity effects in its prediction. Most of the current directivity models were developed as a correction for already existing ground-motion models, and were fitted using ground-motion model residuals. Directivity effects are dependent on magnitude, distance, and the spectral acceleration period. This

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On-Fault Structures interaction of directivity effects with magnitude and distance makes separation of distance and magnitude scaling from directivity effects challenging. To properly account for directivity effects in a ground-motion model they need to be fitted as a part of the original model and not as a correction. We propose a method to include the effects of directivity in a ground-motion model and also develop models to make unbiased prediction of ground-motion intensity, even when the directivity parameters are not available. Finally, following the approach used to model directivity effects, we developed a modular framework to characterize ground-motion directionality, which causes the ground-motion intensity to vary with orientation. Using the expanded NGA-West2 database we developed new models to predict the ratio between maximum and median ground-motion intensity over all

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On Frame Structures orientations. Other models to predict distribution of orientations of the maximum intensity relative to the fault and the relationship between this orientation at different periods are also presented. The models developed in this dissertation allow us to compute response spectra that are expected to be observed in a single orientation (e.g., fault normal, orientation of maximum intensity at a period). It is expected that the proposed spectra can be a more realistic representation of single orientation ground motion compared to the median or maximum spectra over all orientations that is currently used.

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Urban areas have experienced tremendously growth in seismically active zone since last century. Only in recent decades it has been realised that the shaking closely adjacent to a fault (e.g. within 20 km) produced a different effect on the seismic loading from far-source induced shaking. The immense cost of damage due to the near-fault earthquakes emphasized the importance of studying near-fault ground motions and their effects on structures. In conventional seismic design, footing uplift is not permitted, thus the energy can only dissipate through the damping of the structure and plastic hinge development at a specific location. Plastic hinge development, within limits, helps to improve the safety of people. However, recent research indicates that plastic hinging due to near-fault earthquakes is more significant than that caused by far-

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On Frame Structures field excitations, which has a substantial impact on economics and functionality. Therefore, the research reported in this PhD thesis considers an innovative low-damage seismic design philosophy: mitigate the damage resulting from near-fault excitations by incorporating footing uplift. Previous research on footing uplift focused on the structural response. The footing response, including the contact forces at the interface of the footing and support, is investigated in this study for the first time. The outcomes of this research provide the basis of holistic low-damage seismic design. This research starts with a simple experimental system to provide a rational interpretation of the structure and footing response including the effect of uplift. The effects of the supporting soil, the characteristics of the earthquake excitations and the structural plastic hinge development were then

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incorporated to enhance the understanding of this topic. To achieve this objective, a series of shake table experiments were conducted on physical models with different scales. The series of testing consisted of three groups of experiments with consideration of varying support and loading conditions: (1) a bridge pier with footing uplift on a rigid base under free-vibration induced by an initial vertical footing displacement, harmonic and strong earthquake base excitations, (2) a bridge pier with soil-foundation structure interaction under near-fault and far-field excitations, (3) a single bridge span with footing uplift on a rigid base and with strong vertical excitations included for the first time. The correct similitude of an uplifting structure on a rigid base, within the scaling laws, were addressed and applied to the experiments. Sensors were attached at the interface of the footing and

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support, i.e. load cells, a pressure mapping sensor and strain gauges, to reveal the contact forces due to footing uplift. The results shown in this thesis provide an experimental verification for existing theoretical models of structures with uplift. This research showed that near-fault horizontal excitation with strong pulses dominated the footing response. However, under horizontal ground motion without a pulse, the vertical component had the main effect on uplift. Uplift sometimes caused a lower contact force compared with the fixed base case. Moreover, a system designed with multiple energy dissipating mechanisms, i.e. foundation soil yielding, footing uplift and structural plastic hinge development, were likely to avoid the excessive rotation sometimes observed in structures with a single nonlinear mechanism.

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A comprehensive parameterized stochastic model of near-fault ground motions in two orthogonal horizontal directions is developed. The proposed model uniquely combines several existing and new sub-models to represent major characteristics of recorded near-fault ground motions. These characteristics include near-fault effects of directivity and fling step; temporal and spectral non-stationarity; intensity, duration and frequency content characteristics; directionality of components, as well as the natural variability of motions for a given earthquake and site scenario. By fitting the model to a database of recorded near-fault ground motions with known earthquake source and site characteristics, empirical

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"observations" of the model parameters are obtained. These observations are used to develop predictive equations for the model parameters in terms of a small number of earthquake source and site characteristics. Functional forms for the predictive equations that are consistent with seismological theory are employed. A site-based simulation procedure that employs the proposed stochastic model and predictive equations is developed to generate synthetic near-fault ground motions at a site. The procedure is formulated in terms of information about the earthquake design scenario that is normally available to a design engineer. Not all near-fault ground motions contain a forward directivity pulse, even when the conditions for such a pulse are favorable. The proposed procedure produces pulseline and non-pulseline motions in the same proportions as they naturally occur

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among recorded near-fault ground motions for a given design scenario. The proposed models and simulation procedure are validated by several means. Synthetic ground motion time series with fitted parameter values are compared with the corresponding recorded motions. The proposed empirical predictive relations are compared to similar relations available in the literature. The overall simulation procedure is validated by comparing suites of synthetic ground motions generated for given earthquake source and site characteristics to the ground motion prediction equations (GMPEs) developed as part of phase 2 of the Next Generation Attenuation (NGA) program, (NGA-West2, see, e.g., Campbell and Bozorgnia, 2014). Comparison is made in terms of the estimated median level and variability of elastic ground motion response spectra. The use of synthetic motions in addition to

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or in place of recorded motions is desirable in performance-based earthquake engineering (PBEE) applications, particularly when recorded motions are scarce or when they are unavailable for a specified design scenario. As a demonstrative application, synthetic motions from the proposed simulation procedure are used to perform probabilistic seismic hazard analysis (PSHA) for a near-fault site. The analysis shows that the hazard at a near-fault site is underestimated when the ground motion model used does not properly account for the possibility of pulselike motions due to the directivity effect.

Rotational components of ground motions, torsion about the vertical axis and rocking about the horizontal axes, have caused significant damage to engineering structures and failures to bridges. Several

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analytical and experimental studies have been conducted to investigate the effect of these components on structures. Rotational components of ground motions cannot be measured directly and have been measured by rotational sensors only for explosions and by strong motion arrays only for far-field seismic events. Therefore, in the absence of near-fault records of differential ground motions, the characterization, parameterization, modeling and simulation of strain, rocking, and torsional ground motions in the vicinity of the fault, as well as the systematic investigation of their effects on the dynamic response of engineering structures becomes an important issue. In this study, the dynamic ground deformations generated by Mavroeidis and Papageorgiou (2010a) for two well-documented seismic events (i.e. 1979 Imperial Valley and 1999 Izmit

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earthquakes) based on the discrete wavenumber representation method (Bouchon and Aki, 1977; Bouchon, 1979a) are utilized to obtain torsional and rocking ground motions and their associated distributions on the gridded region in the vicinity of each earthquake. These synthetic ground deformations are used in this study to investigate the effect of the biaxial action of recorded translational ground motions and synthetic torsional ground motions on the response of symmetric and asymmetric structures. In the current seismic design codes and standards, this torsional ground motion accounts by the shifting of the center of mass to produce the desired results. In order to investigate the effects of torsional motions on the structural responses, a software has been developed to study the linear and nonlinear response of buildings under biaxial and torsional seismic ground

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excitation. The program is able to perform nonlinear time history analysis based on the force- and displacement-based formulation methods developed by Spacone (1992). The biaxial and uniaxial Smooth Hysteresis Models developed Simeonov et al. (2000) are employed to model the hysteresis behavior of elements in the context of the moment-curvature relationship. The uniaxial and biaxial smooth hysteresis behaviors of the material, similar to the widely used Bouc-Wen model are employed in this research. Various numerical approaches such as the implicit Runge-Kutta, Newton-Raphson and Newmark methods are used to solve the differential equations that govern the dynamic response of the system. Finally, parametric linear and nonlinear analyses are performed for a series of symmetric and asymmetric single-story buildings to investigate the influence of the natural and

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accidental torsional eccentricity on the response of structures. The structural models are subjected to bidirectional recorded translational motions and synthetic low-frequency angular accelerations from the 1979 Imperial Valley and 1999 Izmit earthquakes. In order to examine the response of structures subjected to synthetic torsional motions containing high-frequency components, the bidirectional translational records from the 1986 Taiwan earthquake at FAT-1 station and the associated synthetic torsional motion, generated by the Surface Distribution Method, are also used to conduct parametric nonlinear analysis. The equivalent accidental eccentricity is developed through the mathematical formula for structures subjected to the combination of the bidirectional translational motions and torsional ground motions. The torsional amplifications

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On Frame Structures developed in structures either by accidental torsion or by synthetic ground differential deformations are not significant for the lower periods. The nonlinear behavior of the structure imposed by strength eccentricity is also explored, while the results are displayed in the biaxial Base Shear and Torque (BST) Surface, inferred for the possible collapse mechanisms regardless of the analysis results.

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