MODELLING OF BURIED FAULTS USING APPLIED ELEMENT METHOD

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ABSTRACT

Recent ground-motion observations suggest that there is a considerable difference in surface-rupturing earthquakes and earthquakes due to buried faults. Near fault records for buried as well as surface fault earthquakes, in the distance range of less than 100 m from the faults are not available except for few cases. Therefore numerical simulation of ground motions for such near-fault situations for buried and surface fault earthquakes is necessary. In this paper the difference in ground motion due to buried faults and surface faults has been studied using 3D Applied Element Method. For the surface fault when the fault intersects the surface, a remarkable concentration of large ground acceleration in a very narrow region around the fault trace has been seen. The presence of the low velocity layer tends to reduce the particle velocity and rupture speed leading to the reduction in ground motion. The ground motion due to buried fault contains low frequency content thereby giving greater response to long period structures. It has been seen that there is increase in peak ground acceleration value on the surface with the increase in the stiffness of the bedrock layer where the rupture takes place and increase in the strong ground motion with the decrease in the rise time of the slip applied at the base of the fault plane. This study explains some of the features of the buried fault earthquakes.

KEYWORDS: Applied Element Method, Buried Faults, Surface Faults, Fault Motion

INTRODUCTION

Large earthquakes usually break the surface, but small earthquakes usually do not (Wells and Coppersmith, 1994). Over one-half of the earthquakes in the magnitude range of 6.0 to 6.5 do not break the surface; this fraction decreases to about one-third for the magnitude range of 6.5 to 7, and about one-fifth of earthquakes in the magnitude range of 7.0 to 7.5 (Lettis et al., 1997). Recent ground-motion observations suggest that there is a considerable difference in surface-rupturing earthquakes and earthquakes due to buried faults. Surface-rupturing earthquakes generate weaker near-fault ground motion than buried earthquakes. This difference is significant in the period range of 0.3–3 sec. Fig. 1 shows the response spectra of near-fault recordings of recent large earthquakes. The left panel shows recordings from four shallow earthquakes in the Mw range of 7.4 to 7.9, and the right panel shows recordings from two deep earthquakes of magnitude Mw 6.7 and 7.0. The response spectra of the deep earthquakes are much stronger than those of the larger shallow earthquakes for periods less than 1.5 sec. As shown in Fig. 1 at short and intermediate periods (0.3–3.0 sec), the near-fault ground motions that produce large surface rupture are systematically weaker than the near-fault ground motions from earthquakes whose ruptures are confined to the subsurface (Somerville, 2003). Contributing factors to this phenomenon may include the effect of fault zone weakness at shallow depth on rupture dynamics for surface rupture earthquakes. Whereas the blind faults which reside in rock layers deeper than the surface rupture earthquakes are perfectly suited to violent rupture. And when they strike, they focus explosions of energy toward the surface, jarring the nearby vicinity with heavy ground motion on the surface. When analyzing the kinematic rupture models of several earthquakes, Kagawa et al. (2004) found that surface-rupturing earthquakes have larger rupture area and hence lower stress drop than buried-rupture earthquakes.
show that, compared with shallow asperities, deep asperities have on average three times larger stress drop as well as two times larger peak slip velocity. Although limited to long periods, these kinematic rupture models of past earthquakes suggest that the cause of the observed differences in ground-motion amplitude and frequency content produced by surface and buried rupture is mainly due to differences in fault rupture dynamics in the shallow regions of the crust, compared with rupture at greater depths.

**Figure 1: Near-Fault Response Spectra of Surface and Buried Faulting**

Left: Four earthquakes, Mw 7.2 to 7.9, with shallow asperities and surface faulting. Right: Two earthquakes, Mw 6.7 and 7.0, with deep asperities and no surface faulting. (Abrahamson, 2000)

Qifang et al. (2007) have studied the difference in the near fault ground motions for surface rupture fault (SRF) and buried rupture fault (BRF). The comparison results show that the final dislocation of the SRF is larger than the BF for the same stress drop and initial conditions on the fault plane. The maximum final dislocation occurs on the fault upper line for the SRF. However, for the BRF, the maximum final dislocation is located on the fault central part. Meanwhile, the PGA, PGV and PGD of long period ground motions generated by the SRF are much higher than those of the BF in the near-fault region. The peak value of the velocity pulse generated by the SRF is also higher than the BF. Furthermore, it is found that in a very narrow region along the fault trace, ground motions caused by the SRF are much higher than by the BRF. These results may explain why SRF’s almost always cause heavy damage in near-fault regions compared to buried faults. Pitarka et al. (2009) presented results from numerical experiments of spontaneous dynamic rupture and near-source ground-motion simulations of surface rupturing and buried earthquakes and discussed the mechanisms for the observed ground-motion differences. The surface rupturing earthquake was modelled with a shallow zone of 5 km thickness containing areas of negative stress drop (within the framework of the slip-weakening friction model) and lower rigidity. Surface-rupturing models with this weak zone generate lower amplitude ground velocity than do models without this modification. Observed ground-motion differences between surface and buried events were qualitatively reproduced by imposing higher stress drop in the buried earthquakes than in the surface earthquakes, combined with introducing a deeper rupture initiation for buried rupture.

The slip velocity is a much more important aspect of strong ground motion levels than fault slip alone (Dan and Sato, 1999). The effective slip velocity is defined by Ishii et al. (2000) as the slip velocity averaged over the time in which the slip grows from 10% to 70% of its final value, and represents the dynamic stress drop. Somerville and Pitarka et al. (2006) used the results from the numerical simulations of rupture dynamics to suggest that the shallow events have large near-surface displacements, but they do not have correspondingly large slip velocities. They showed that the slip velocities of the deep events are larger than those of the shallow events, causing larger ground motion levels.
Numerical modelling allow us to investigate a number of aspects of the fault rupture propagation, which are difficult to study from the examination of case histories or the conduct of physical model tests. Numerical simulations of earthquake fault rupture have the advantage of being much more flexible to investigate a number of aspects of the fault rupture propagation phenomenon than analytical solutions. Since our problem is related to the fault rupture propagation we need a method which can handle the discontinuities. The Applied Element Method which was used to study fault rupture phenomenon by Pradeep et al. (2001) has many advantages with respect to the above problems. Using AEM the crack initiation and propagation can be modeled in reasonable time by using the available parallel computing power. The main advantage of this method of modeling is that it has the ability of crack initiation based on the material failure and propagation of crack till the collapse. In this paper we try to investigate the near fault ground motion due to dip-slip faults and study the difference in ground motion due to buried faults and surface faults using Applied Element Method. In the coming section the numerical method will be described briefly and numerical results will be discussed.

**NUMERICAL METHOD: 3D APPLIED ELEMENT METHOD**

Applied Element Method is an efficient numerical tool based on discrete modeling (Hatem, 1998). The two elements shown in Fig. 2 are assumed to be connected by the set of one normal and two shear springs. Each set is representing the volume of elements connected. These springs totally represents stress and deformation of that volume of the studied elements. Six degrees of freedom are assumed for each element. These degrees of freedom represent the rigid body motion of the element. Although the element motion is as a rigid body, its internal deformations are represented by spring deformation around each element. This means that the element shape doesn’t

![Figure 2: Element Formulations in 3D AEM](image)

**Figure 2: Element Formulations in 3D AEM**

$$
\begin{array}{cccccc}
K_{NN} & K_{NS} & K_{SN} & K_{SS} & K_{NR} & K_{SR} \\
K_{SN}^T & K_{SS} & K_{SN} & K_{SR} & K_{NR} & K_{SR} \\
K_{SN}^T & K_{SN} & K_{NN} & K_{SR} & K_{NR} & K_{SR} \\
K_{SR} & K_{SR} & K_{SR} & K_{NN} & K_{NR} & K_{SR} \\
K_{NR} & K_{NR} & K_{NR} & K_{NR} & K_{NN} & K_{SR} \\
K_{SR} & K_{SR} & K_{SR} & K_{SR} & K_{SR} & K_{NN} \\
\end{array}
$$

**Figure 3: One Quarter of Stiffness Matrix**

- $K_{NN}$: Stiffness of normal spring
- $K_{SS}$: Stiffness of shear springs
- $N$: Normal spring vector
- $S_1$, $S_2$: Shear springs Vector
- $R$: Vector connecting the center of the element
change during analysis, which means that the element is rigid, but the behaviour of element collections is deformable. To have a general stiffness matrix, the element and contact spring’s locations are assumed in a general position. The stiffness matrix components corresponding to each degree of freedom are determined by assuming a unit displacement in the studied degree of freedom direction and by determining forces at the centroid of each element. The element stiffness matrix size is (12 X 12). Fig. 3 shows the components of the upper left quarter of the stiffness matrix. It is clear that the stiffness matrix depends on the contact spring stiffness and the spring location. The stiffness matrix given is for only one pair of contact springs. However, the global stiffness matrix is determined by summing up the stiffness matrices of individual pair of springs around each element.

\[ [M] \ddot{U} + [C] \dot{U} + [K] U = P(t) \]  

(1)

We compute the displacement time histories by the three-dimensional dynamic elasticity equation given by Eq. (1), Where \([M]\), \([C]\) and \([K]\) are the mass, damping and global stiffness, respectively; \(U\) the displacement vector and \([P(t)]\) the applied load vector. Here mass proportional damping matrix is used with 10% damping coefficient. The above differential equation is solved numerically by Newmark’s method. The material model adopted in AEM is the two-parameter model called hyperbolic model. It is logical to assume that any stress-strain curve of soils is bounded by two straight lines that are tangential to it at small strains and at large strains as shown in Fig. 4. The tangent at small strains denoted by \(G_o\), represents the elastic modulus at small strains and the horizontal asymptotic at large strain indicates the upper limit of the stress \(\tau\), namely the strength of soils. The stress-strain curve for the hyperbolic model can be obtained directly from Eq. (2)

\[ \tau = \frac{G_o \times \gamma}{1 + \frac{\gamma}{\gamma_f}} \]  

(2)

The above equation has been extensively used for representing the stress-strain relations of a variety of soils. Since the target of this study is to show the application of AEM, we adopted the material model which is based on only two parameters, namely, initial modulus, \(G_o\) and reference strain, \(\gamma_f = \frac{\tau}{G_o}\), where \(\tau\) is the upper limit of the stress.

Figure 4: Non-Linear Behavior of Soil - Skeleton Curve
However, any type of material model can be adopted in AEM. For further details on material modelling please refer Hardin (1972). To define the failure criteria we need to find the three-dimensional state of stress at each point where the spring is defined. The three-dimensional state of stress is defined at each spring location point. After obtaining all the components of stress tensor we shall define the failure criteria. A Mohr Coulomb failure criterion has been adopted here. Mohr Coulomb invariants $I_1$, $J_2$ and $\theta$ (Smith et al. 2004) has been calculated using three dimensional stress components. After defining the Mohr Coulomb invariants soil's internal friction angle $\phi$ and cohesion $c$ is calculated using uni-axial tension capacity $y_t$ and uni-axial compression capacity $y_c$ and from Eq. 3 & Eq. 4. (Boresi et al. 2002).

$$\phi = \frac{\pi}{2} - 2 \tan^{-1}\left(\frac{y_t}{y_c}\right)$$  \hspace{1cm} (3)

$$c = \frac{y_t}{2} - \left(\frac{y_c}{y_t}\right)$$  \hspace{1cm} (4)

Using the above invariants the Mohr-Coulomb failure envelops is defined by Eq. 5. (Smith et al. 2004) In principal stress space, this criterion takes the form of an irregular hexagonal cone, as shown in Fig 5.

$$F = \frac{1}{3} I_1 \sin \phi + \sqrt{J_2} \left(\cos \theta - \frac{\sin \theta \sin \phi}{\sqrt{3}}\right) - c \cos \phi$$  \hspace{1cm} (5)

Failure if $F \geq 0$

![Figure 5: Mohr Coulomb Failure Envelop in Three Dimension](image)

The failure envelop $F$ depends on the invariants discussed above and the cohesion $c$ and the friction angle $\phi$, which depends on the soil uniaxial tension ($y_t$) and uniaxial compression ($y_c$). If the $F$ value is greater or equal to zero the spring is said to be failed. The normal and shear forces in the failed springs are redistributed in the next increment by applying the forces in the reverse direction. These redistributed forces are transferred to the element centre as a force and moment, and then these redistributed forces are applied to the structure in the next increment. The redistribution of spring forces at the crack location is very important for following the proper crack propagation. For the normal spring, the whole force value is redistributed to have zero tension stress at the crack faces. Although shear springs at the location of tension cracking might have some resistance after cracking due to the effect of friction and interlocking between the crack faces, the shear stiffness is assumed zero after crack occurrence. Having zero value of shear stress indicates that the crack direction is coincident with the element edge direction. In shear dominant zones, the crack direction is mainly dominant by...
shear stress value. This technique is simple and has the advantage that no special treatment is required for representing the cracking.

MODEL PARAMETERS FOR BURIED FAULTING AND SURFACE FAULTING

The primary aim of this paper is to study the difference in ground motion due to buried faults and surface faults. For this purpose a 3D numerical model of length 26 km, width 10 km and depth 2.5 km was constructed as shown in the Fig. 6. The element size has been taken as 100 m X 100 m. The model shown in Fig. 6 the fault reaches the surface and Fig. 7 shows the cross section of the same model and the location of the stations where the ground motion is studied. Station's S1, S2 and S3 are 3.5 km, 2 km and 0.3 km respectively from the fault trace located on the footwall. Station's S4, S5 and S6 are 0.3 km, 2 km and 3 km respectively from the fault trace located on the hanging wall. Fig. 8 shows the buried fault model where the fault does not reach the surface, but instead the rupture is stopped 1 km below the ground surface. The cross section of the buried fault model is seen in Fig. 9. For applying the bedrock displacement value in the form of Pulse-like displacement time history that represents the base motion is considered referring to Malden (2000) and Pradeep (2001). As an approximation, the corresponding displacement pulse can be assumed as Gaussian-type function (Eq. 6) where \( V_p \) is the amplitude of static velocity pulse, \( T_p \) - velocity pulse duration, \( t_c \) - time instant, at which the pulse is centered, \( n \) - constant equal to 6 and \( t \) is the time. The term \( T_p/n \) has the meaning of standard deviation and controls the actual spread of the pulse with respect to the given pulse duration and \( \Phi \) is the normal probability function.

![Figure 6: 3D Model with Fault Reaching Surface with 40° Dip-Angle](image1)

![Figure 7: Cross-Section for the Surface Fault Numerical Model Showing Selected Station Points where the Ground Motion is Referred](image2)

![Figure 8: 3D Numerical Model with Buried Fault with 40° Fault Dip-Angle](image3)
Modelling of Buried Faults Using Applied Element Method

The boundary at the left side and the bottom side of the footwall is kept fixed in all the direction. The displacement is applied at the bottom side and right side of the hanging wall. The location of the base fault is assumed to lie exactly at the centre of the model. Generally, soil strata and bedrock extend upto longer distances in horizontal direction. The numerical modelling of such a large media is a difficult task and moreover, for studying the surface behaviour near active fault region, it is necessary to model the small portion of the region that includes all the effects when the bedrock moves. Before starting the analysis, the stability analysis must be carried out in order to bring the model to initial condition. For stability analysis, bottom of the model is considered as fixed boundary and two side boundaries are fixed in horizontal direction and free in vertical direction. In static way, the self-weight is applied in increments without considering inertia forces. In this method it is important to decide the number increments in which the gravity load is applied. This number of increments will depend on the material properties. It is important to check the failure of the material, i.e. the connecting springs of the material should not fail during the application of self-weight. Hence, while performing the dynamic analysis, the model is brought into equilibrium in the static way and then the dynamic analysis is performed. The uni-axial tension capacity ($y_t$) is taken as 40000 kN/m$^2$ and uniaxial compression capacity ($y_c$) as 400000 kN/m$^2$.

$$d_{sp}(t) = \frac{\sqrt{2\pi}}{n} V_{sp} T \rho \Phi \left[ \frac{t - t_c}{T} \right]$$

(6)

The seismic bed rock motion in the form of displacement is applied at the base of the fault plane with the slip rate as shown in Fig.10. The dip angle of the numerical models considered in this paper for the buried and surface faults is 40°. The shear wave and the p-wave velocity of the material of the model has been taken as 2 km/sec and 2.8 km/sec respectively. Initially as the slip is applied at the base of the fault plane after the self-weight is applied in a static way as stated above, the stress resultants in the material of the fault plane build’s up, and the two blocks undergo a small deformation to store strain energy. When the stress resultant of the elements at the base along the fault plane reaches the failure strength the local element connection springs of the elements of the fault plane are considered to be failed. The normal and shear forces in the failed springs are redistributed in the next increment by applying the forces in the reverse direction. This allows the rupture to propagate along the fault. In general the rupture initiated at the deepest part of the fault.
and propagated to the free surface. The rupture propagates only on the fault plane shown in the numerical model for buried and surface fault. Fig. 11 shows the acceleration time histories at stations s1- s6 for the fault reaching the surface and the Fig.12 shows the acceleration time histories at stations s1- s6 for the buried fault. From these figures we can see more ground motion on the hanging wall than the foot wall and also near the fault trace reaching the surface. The recording station S3 and S4 are among the stations where the rupture reaches the surface and it shows the maximum ground motion compared to other stations. The reason for this is as the fault rupture propagates to the surface the ground motion is amplified as there is no overburden pressure at the updip location of the fault trace reaching the surface, whereas the buried fault is constrained not to move at both its edges. Infact, simply pinning the updip edge of the fault that intercepts the free surface will be enough to reduce the resultant ground motion for the surface faults.

Figure 11: Time Histories of the Horizontal Ground Motion for the Surface Fault at the Selected Stations as Shown in Figure 3

Figure 12: Time Histories of the Horizontal Ground Motion for the Buried Fault at the Selected Stations as Shown in Figure 5

Figure 13: Fourier Spectrum for the Time Histories of the Horizontal Ground Motion for the Surface Fault at the Selected Stations as Shown in figure 3
Fig. 14: Fourier Spectrum for the Time Histories of the Horizontal Ground Motion for the Buried Fault at the Selected Stations as Shown in Figure 5

Fig. 15: Comparison of the Acceleration Response Spectrum for the Time Histories of the Horizontal Ground Motion for the Buried Fault and Surface Fault at the Selected Stations

Fig.13 and Fig.14 represent the Fourier spectrum for the acceleration time histories at stations s1-s6 for surface and buried faults. Fig.15 shows the comparison of acceleration response spectra at all the stations for the buried fault and the surface plot. In this plot we can see that the response is greater for the surface fault at the station near to the fault. At station S3 and s4 there is huge response for the short period structures. This is because of high frequency content present in the ground motion which can be seen in Fig.13 where the amplitude of the high frequency (~3Hz - 6Hz) content in the ground motion signal is more compared to the amplitude of the buried fault ground motion. In response spectrum plot it
can also be seen that except near the fault (station S3 and s4) the response is approximately little bit more for the buried fault ground motion for the large period structures.

This is because the buried fault ground motion contains higher amplitude of lower frequency content. Fig.16 shows the variation of the horizontal and vertical Peak ground acceleration on the surface for buried fault and surface fault and the vertical line in the figures shows the fault trace. For the surface fault when the fault intersects the surface, a remarkable concentration of large ground acceleration in a very narrow region around the fault trace can be seen. Although there is slight difference in the variation for the horizontal and vertical accelerations, the fundamental features are common to both. The amplitude of vertical direction is more than the horizontal direction and appears in a very narrow region along the fault trace as shown on the right side of Fig.16. This large amplitude in the direction of rupture propagation is because of rupture directivity which is in the updip direction.

![Figure 16: Horizontal and Vertical Peak Ground Acceleration on the Surface for Buried Fault and Surface Fault](image)

![Figure 17: 3D Numerical Model for Surface Fault with Shallow Low Velocity Layer of Shear Wave Velocity of 1 km/sec](image)

**EFFECT OF SHALLOW LOW VELOCITY LAYER**

From the literature discussed in introduction section it has also been observed that the earthquakes with surface faults have produced weaker ground motion than buried faults. Contributing factors to this phenomenon may include the effect of fault zone weakness at shallow depth on rupture dynamics for surface rupture earthquakes (Pitarka et al., 2009). Therefore the numerical model for this purpose with shallow low velocity layer on the surface has been tested. Fig.17 shows the 3D numerical model for surface fault with shallow low velocity layer with shear wave velocity of 1 km/sec on top. This model has been given the same input as in the previous section. Fig.18 represents the horizontal and vertical peak ground acceleration on the surface for buried fault and surface fault with shallow low velocity layer. It can be seen that the
there is a reduction in the peak values of acceleration for the surface fault with low velocity layer compared to the buried fault earthquake.

Figure 18: Horizontal and Vertical Peak Ground Acceleration on the Surface for Buried Fault and Surface Fault with Shallow Low Velocity Layer

Figure 19: Time Histories of the Horizontal Ground Motion for the Surface Fault with Shallow Low Velocity Layer at the Selected Stations

Fig. 19 shows the acceleration time histories and its corresponding Fourier spectrum at stations S1-S6 can be seen in Fig. 20 for surface fault with shallow low velocity layer. From the plot of Fourier spectrum the reduction in the high frequency content can be seen when compared to the spectral amplitude values for the surface fault without the low velocity layer. The presence of the low velocity layer tends to reduce the particle velocity and rupture speed and wave propagation and absorption effects in such deposits might reinforce the dynamic effects, that is, by preferentially absorbing high-frequency waves and amplifying lower frequency waves. Fig. 21 shows the comparison

Figure 20: Fourier Spectrum for the Time Histories of the Horizontal Ground Motion for the Surface Fault with Low Velocity Layer at the Selected Stations
Figure 21: Comparison of the Acceleration Response Spectrum for the Time Histories of the Horizontal Ground Motion for the Buried Fault and Surface Fault with Shallow Low Velocity Layer at the Selected Stations

of the acceleration response spectrum for the time histories of the horizontal ground motion for the buried fault and surface fault with shallow low velocity layer at the selected stations. In this plot the increase in the response from the buried fault time histories can be seen compared to the surface fault, particularly for the long period structures. Primary reason is due to weak zone effect which has reduced the response in very short period and also for long period structure in the response spectrum due to surface faults. Therefore the results may explain why the ground motion from small buried earthquakes is larger than that from large surface-rupturing earthquakes which is generally accompanied by a low velocity layer.

EFFECT OF STIFFNESS OF BEDROCK

Blind faults reside in rock layers perfectly suited to violent rupture. And when they strike, they focus explosions of energy toward the surface, jarring the nearby vicinity with heavy ground motion. In order to see the effect of the stiffness of rock layer on the ground motion, where the rupture takes place for buried fault earthquakes, we have constructed the models with different bedrock property. The shear wave velocity of the bedrock is taken as 2.2 km/sec and 2.5 km/sec and it is compared with the homogeneous model of 2 km/sec. One such model is seen in Fig. 22. All the three models were given the same input motion as in the previous section. Fig. 23 shows the variation of horizontal and vertical Peak ground acceleration on the surface for buried fault with different bedrock shear wave velocity. From the figure we can see the increase in peak ground acceleration value on the surface with the increase in the stiffness of the bedrock layer where the rupture takes place. The reason here is that when the stiffer material is ruptured more energy is released. This released energy is applied in the form of impulsive forces at the failure area, which is turn is transferred to the surface. Fig. 24 and Fig. 25 shows the time histories of the horizontal and vertical ground motion for different shear wave velocity at the
base fault and their corresponding response spectrum in the right panel of the figure. The response spectrum plot shows the increase in the response with the increase in the stiffness of the bedrock layer where the rupture takes place.

**Figure 22:** 3D Numerical Model for Buried Fault having More Shear Wave Velocity (2.2 km/sec) than the Overburden

**Figure 23:** Horizontal and Vertical Peak Ground Acceleration on the Surface for Buried Fault with Different Shear Wave Velocity

**Figure 24:** Time Histories of the Horizontal Ground Motion for Different Shear Wave Velocity at the Base Fault and their Corresponding Response Spectrum in the Right Panel of the Figure

**Figure 25:** Time Histories of the Vertical Ground Motion for Different Shear Wave Velocity at the Base Fault and their Corresponding Response Spectrum in the Right Panel of the Figure
EFFECT OF SLIP VELOCITY

When analyzing the kinematic rupture models of several earthquakes, Kagawa et al. (2004) found that buried faults contain 2 times higher slip velocities than shallow earthquakes with surface rupture, therefore causing larger ground motion. In order to analyze the effect of slip velocity in this section we try to investigate the effect of slip velocity i.e. rise time for the slip to occur at the fault plane. Fig. 26 shows the three different slip velocities with rise time 4, 3 and 2 sec respectively. Fig. 27 and Fig. 28 shows the variation of peak ground acceleration and peak ground velocity on the surface.
for different velocities applied at the bottom of the fault plane. From the figures we can see the increase in the strong ground motion with the decrease in the rise time of the slip.

CONCLUSIONS

In this paper the difference in ground motion due to buried faults and surface faults has been studied using 3D numerical model. For the surface fault when the fault intersects the surface, a remarkable concentration of large ground acceleration in a very narrow region around the fault trace has been seen. The presence of the low velocity layer tends to reduce the particle velocity and rupture speed leading to the reduction in ground motion. The ground motion due to buried fault contains low frequency content there by giving greater response to long period structures. It has been seen that there is increase in peak ground acceleration value on the surface with the increase in the stiffness of the bedrock layer where the rupture takes place and increase in the strong ground motion with the decrease in the rise time of the slip applied at the base of the fault plane. This study explains some of the features of the buried fault earthquakes.

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