Fan Footing Soil Foundation to Safeguard High and Low Rise Buildings from Seismic Waves

B. Bikas Maiti[1], Dr. Ajayswarup[2]

[1]Research Scholar, Department of Civil Engineering, Sri SathyaSai University of Technology and Medical Sciences, Sehore, Bhopal. Madhya Pradesh, India
[2]Professor, Department of Civil Engineering, Sri SathyaSai University of Technology and Medical Sciences, Sehore, Bhopal. Madhya Pradesh, India

Abstract**—***Foundations may experience serious misery during an earthquake. Earthquake consequences for shallow and profound foundations are represented by planning them fundamentally to give important quality and ensure serviceability. Quality contemplations basically includes ensuring that the foundation loads stay well underneath that directed by the suitable bearing limit under seismic conditions and serviceability is ensured by outlining the substructure for the evaluated perpetual ground distortion. This paper talked about different aspects of earthquake ground motion influence on structures and furthermore how certain building qualities alter the manners by which the building reacts to the ground motion. The association of these attributes decide the general seismic response of the building: regardless of whether it is undamaged; endures minor harm; ends up unusable for quite a long time, weeks, or months; or crumples with extraordinary death toll. Clarifications of a few qualities of ground motion are trailed by portrayals of a few material, auxiliary, and building characteristics that, by communicating with ground motion, decide the building's seismic execution the degree and nature of its harm. The fundamental motivation behind the examination is to break down the seismic bearing limit of foundations and seismic weight and talk about the different issues and issue related into it. Fan Footing Soil Foundation (FPSF) technique was presented for reinforcing.*

Keywords—Seismic Waves, Shallow Foundation, Fan Footing (FF), Soil Foundation (SF), P and S Wave, Peak ground acceleration (PGA).

I. INTRODUCTION

Surface waves travel more gradually than body waves (P and S); and of the two surface waves, Love waves for the most part travel speedier than Rayleigh waves. Love waves (do not spread through water) can impact surface water just seeing that the sides of lakes and sea narrows pushing water sideways like the sides of a vibrating tank, though Rayleigh waves, because of vertical segment of their motion can influence the waterways, for example, lakes. P and S waves have trade mark which impacts shaking: when they travel through layers of shake in the hull, they are reflected or refracted at the interfaces between shake composes. At whatever point either wave is refracted or mirrored, a portion of the vitality of one kind is changed over to waves of the other sort. A typical illustration; a P wave ventures upwards and strikes the base of a layer of alluvium, some portion of its vitality will go upward through the alluvium as a P wave and part will pass upward as the changed over S-wave motion. Taking note of additionally that piece of the vitality will likewise be reflected back descending as P and S waves.

The realities talked about in this examination to the displayof seismic bearing limit of foundations and seismic pressure along these lines, finding out the validity of the algorithm will distinguish the restriction of the investigation. FPSF technique based algorithm was presented for additional reinforcing. There is no huge distinction amongst present and past common structure framework in India. There is huge distinction between seismic bearing limit of foundations and seismic pressure.

The information on seismic design of shallow foundations is presented below for four different cases:

1. Shallow Foundations on Soils Not Prone to Liquefaction
2. Settlement of Shallow Foundations on Soils Not Prone to Liquefaction
3. Shallow Foundation on Soil Prone to Liquefaction
4. Settlement of Shallow Foundations on Soil Prone to Liquefaction

The two most important variables affecting earthquake damage are,

1. The intensity of ground shaking caused by the quake coupled and
2. The quality of the engineering of structures in the region

The level of shaking, in turn, is controlled by the proximity of the earthquake source to the affected region and the types of rocks that seismic waves pass through en route (particularly those at or near the ground surface).

II. RELATED STUDY OF SHALLOW FOUNDATIONS

V K Puri et al., (2013) The seismic design of foundations for structures relies upon dynamic bearing limit, dynamic settlements and liquefaction vulnerability of soil. The dynamic bearing limit issue has been drawing attention scientists around fifty years.

Juan Carlos Tiznado A et al., (2014) With regards to engineering practice, the issue of the seismic bearing limit of shallow foundations has been unraveled in a roundabout way, either due an expansion of the static permissible soil weights identified with the likelihood of event of the plan earthquake or by embracing a proportional pseudo-static approach. In any case, amid a decades ago, a progression of diagnostic strategies that specifically address the issue from the seismic perspective has been created. This paper displays a parametric near investigation of various techniques for evaluating seismic bearing limit of shallow strip foundations. Expository techniques, created in the system of both cut off balance and breaking point examination speculations, and furthermore improved plan methods regularly utilized as a part of training were considered.

Strip footing: The strip footing is utilized if there should be an occurrence of a heap bearing divider. The strip footing is likewise utilized for a line of segments that are firmly held and divided with the end goal that their spread footing cover or has a tendency to about touch each other. In such cases it is more practical and successful to utilize a strip footing than to utilize various spread footings held in a solitary line. Along these lines, a strip footing is likewise called as continuous footing **(Alhassan, 2013)**.

Spread/isolated footing: The spread/confined/cushion footing is for the most part built to help an individual segment. The spread footing might be roundabout, square or rectangular chunk of uniform thickness. Here and there it might be outlined as ventured or haunched to spread/circulate the heap over a bigger region**(M. T. Adams et al, 1997)**.

Combined footing: The joined footing is intended to help two parallel sections. It is essentially utilized when the two sections are close to the point that to each other that their individual footing would cover. The joined footing may likewise be built when the property line is so near section that a spread footing gets erratically stacked if kept inside the property lines. Accordingly, by consolidating it with that of an inside segment, the heap gets equally/consistently disseminated. The consolidated footing might be rectangular or trapezoidal **(M. TolgaYilmaz, 2009).**

Strap or cantilever footing: The lash (or cantilever) footing includes two isolated/singular footing associated with a basic tie or a lever. The tie is included to associate the two footing all together that they works and winds up like a solitary unit. Be that as it may, the tie essentially fills in as an association pillar and does not avoid any soil response. Consequently, the tie is composed as an unbending member. The individual footings are planned with the end goal that their joined line of activity goes through the resultant of the aggregate load. The tie footing turns out to be more efficient than a consolidate footing when the allowable soil weight is relatively more prominent and furthermore the separation between the columns is more noteworthy **(Vikram Singh Rathore, 2017)**.

Mat or raft foundations: The mat/raft foundation is a major chunk supporting various columns and walls of whole structure or in an expansive piece of the structure. The tangle is proficient when the passable soil weight littler or where the sections and dividers are close to the end goal that individual footing gets cover or almost touched each other. The tangle foundations are effective in wiping out the differential settlement on the non-homogeneous soils or where there is an extensive variety in loads on the individual sections **(Saad Eldin, 2014)**.

III. DIFFERENT IMPACTS ON B/W HIGH AND LOW RISE BUILDINGS

During an earthquake buildings oscillate, however not all buildings react to an earthquake similarly. In the event that the recurrence of swaying of the ground is near the characteristic resonance of the building, reverberation (high sufficiency proceeded with wavering) may cause extreme harm. Low ascent buildings are more influenced or shaken by high recurrence waves (short and incessant). For instance, a little vessel cruising in the sea will not be incredibly influenced by a low-recurrence swell where the waves are far separated. Then again a few little waves with hardly a pause in between can upset, or invert, the watercraft. Similarly, a little building encounters all the more shaking by high recurrence earthquake waves. Tall structures are more influenced by low-recurrence, or moderate shaking. For example, a sea liner will encounter little aggravation by short waves with hardly a pause in between. Be that as it may, a low-recurrence swell will fundamentally influence the ship. Also, a high rise will maintain more prominent shaking by long stretch earthquake waves than by the shorter waves.

Table.1: Properties of Wave

Braces or Bracing	Structural components incorporated with a wall to include strength. These might be made of different materials and associated with the building and each other in different ways. Their capacity to withstand pressure relies upon the attributes of the materials and how they are connected.
Lead	The sum of vertical forces (gravity) and horizontal forces (shear forces) following up on the mass of a structure. The general load is additionally separated into the loads of the different parts of the building. Various parts of a building are outlined and built to convey distinctive loads.
Lead path	The path a load or force takes through the structural elements of a building.
Rigid connections	Connections that do not permit any motion of the structural elements relative to each other.
Shear force	Force that demonstration horizontally (along the side) on a wall. These forces can be caused by seismic tremors and by wind, in addition to other things. Various parts of a wall encounter diverse shear forces.
Shear walls	Walls added to a structure to carry horizontal (shear) forces. These are usually solid elements and are not necessarily designed to carry the structure's vertical load.
Structural elements or structural features	A general term for all the basic, non-enriching parts of a building that contribute basic quality. These incorporate the walls, vertical section underpins, horizontal beams, connectors, and braces.

IV. SEISMIC WAVE

Seismic waves will be waves of vitality that movement through the Earth's layers, and are a consequence of earthquakes, volcanic emissions, magma movement, huge avalanches and extensive man-made blasts that give out low-recurrence acoustic vitality. Numerous other normal and anthropogenic sources make low-amplitude waves ordinarily alluded to as encompassing vibrations. Seismic waves are considered by geophysicists called seismologists. Seismic wave fields are recorded by a seismometer, hydrophone (in water), or accelerometer. Earthquakes make particular sorts of waves with various speeds; when achieving seismic observatories, their diverse travel times help researchers to find the wellspring of the hypocenter. In geophysics the refraction or impression of seismic waves is utilized for examine into the structure of the Earth's inside, and man-made vibrations are regularly created to explore shallow, subsurface structures.

Table.3: List of Different types of Waves

c	the wave reflects off the outer core
d	a wave that has been reflected off a discontinuity at depth d
g	a wave that only travels through the crust
i	a wave that reflects off the inner core
I	a P-wave in the inner core
h	a reflection off a discontinuity in the inner core
J	an S wave in the inner core
K	a P-wave in the outer core
L	a Love wave sometimes called LT-Wave (Both caps, while an Lt is different)
n	a wave that travels along the boundary between the crust and mantle
P	a P wave in the mantle
p	a P wave ascending to the surface from the focus
R	a Rayleigh wave
S	an S wave in the mantle
s	an S wave ascending to the surface from the focus
w	the wave reflects off the bottom of the ocean
	No letter is used when the wave reflects off of the surfaces

Table.2: Types of Wave

Body waves	Body waves go through the inside of the Earth along ways controlled by the material properties regarding density and modulus (firmness). The density and modulus, thus, differ as per temperature, structure, and material stage. This impact takes after the refraction of light waves. Two kinds of molecule movement result in two sorts of body waves: Primary and Secondary waves.
Primary waves	Primary waves (P-waves) are compressional waves that are longitudinal in nature. P waves are pressure waves that is moving quicker than different waves through the earth to land at seismograph stations first, subsequently the name "Primary". These waves can go through a material, including liquids, and can go at about 1.7 times quicker than the S waves. In air, they appear as sound waves, henceforth they go at the speed of sound. Run of the mill speeds are 330 m/s in air, 1450 m/s in water and around 5000 m/s in granite.
Secondary waves	Secondary waves (S-waves) are shear waves that are transverse in nature. Following a tremor event, S-waves land at seismograph stations after the quicker moving P-waves and dislodge the ground opposite to the course of engendering. Contingent upon the propagational course, the wave can go up against various surface attributes; for instance, on account of horizontally energized S waves, the ground moves on the other hand to the other side and afterward the other. S-waves can travel just through solids, as liquids (fluids and gases) don't bolster shear stresses. S-waves are slower than P-waves, and speeds are normally around 60% of that of P-waves in any given material.
Surface waves	Seismic surface waves go along the Earth's surface. They can be named a type of mechanical surface waves. They are called surface waves, as they reduce as they get further down from the surface. They travel more gradually than seismic body waves (P and S). In vast seismic tremors, surface waves can have an amplitude of a few centimetres.
Rayleigh waves	Rayleigh waves, additionally called ground roll, are surface waves that travel as swells with motions that are like those of waves on the surface of water (note, in any case, that the related molecule motion at shallow profundities is retrograde, and that the re-establishing power in Rayleigh and in other seismic waves is versatile, not gravitational concerning water waves). The presence of these waves was anticipated by John William Strutt, Lord Rayleigh, in 1885. They are slower than body waves, around 90% of the speed of S waves for run of the mill homogeneous flexible media. In the layered medium (like the outside and upper mantle) the speed of the Rayleigh waves relies upon their recurrence and wavelength.
Love waves	Love waves are horizontally polarized shear waves (SH waves), existing just within the sight of a semi-endless medium overlain by an upper layer of limited thickness. They are named after A.E.H. Love, a British mathematician who made a scientific model of the waves in 1911. They generally travel marginally speedier than Rayleigh waves, around 90% of the S wave speed, and have the biggest amplitude.
Stoneley waves	A Stoneley wave is a type of boundary wave (or interface wave) that engenders along a strong liquid limit or, under particular conditions, additionally along a strong limit. Amplitudes of Stoneley waves have their most extreme esteems at the limit between the two reaching media and rot exponentially towards the profundity of every one of them. These waves can be created along the walls of a liquid filled borehole, being a vital wellspring of reasonable commotion in VSPs and making up the low recurrence part of the source in sonic logging. The equation for Stoneley waves was first given byDr. Robert Stoneley (1894–1976), Emeritus Professor of Seismology, Cambridge.

V. SOUND AND LIGHT WAVES

Since seismic waves are like sound waves in a considerable lot of their properties, it is valuable to think about the attributes of sound waves. At the point when a tuning fork is struck, the vibrations of its prongs create substitute compressions (pushes) and expansions (pulls) of the contiguous air, setting up the sound waves. Such stable waves are transmitted by longitudinal vibrations of the air; which implies the relocations of the air are dependably toward the path in which the wave is voyaging. In a uniform gas, the wave front will spread out at an equivalent speed every which way, shaping a roundly extending surface.Unpredictable sound waves by and large constitute clamor; normal waves, for example, those created by the tuning fork, offer ascent to melodic notes of unequivocal pitch. Pitch is controlled by the recurrence of the sound waves, and uproar by their amplitude or wave vitality. A large number of the ideas and phrasing utilized as a part of the investigation of music persist to seismological examinations.

An unadulterated melodic tone comprises of a solitary pitch or recurrence. In any case, most melodic tones are mind boggling summations of different unadulterated frequencies - one trademark recurrence, called the major, and a progression of suggestions or music. Any perplexing tone from a melodic instrument can be recognized by the prepared ear or electronic hardware from a comparative tone from another instrument since music tones are created in various mixes of amplitudes by various instruments. The show of the part tones as far as individual frequencies an amplitudes is known as the wave range. Photos of the spectra of complex wave structures can be extremely helpful in acoustical examinations as well as in seismology. Sound waves have similar variations of other wave frames. As they go out from their source they reduce in uproar because of the procedure of geometrical spreading and frictional lessening. When they go from a medium of one thickness into a medium of another thickness, they are refracted. When they experience impediments, they are reflected as echoes. The retrogressive diffusing that happens when they strike little hindrances is a noteworthy reason for weakening. A wide range of waves endure constriction by diffusing as they proliferate through issue conditions containing hindrances, limits, cavaties and layers of various materials. The blueness of the day sky is a consequence of the diffusing of daylight via air atoms. Light waves rather than sound waves (which just have longitudinal charactersistics) vibrate in a plane opposite to the course in which the light is voyaging. The wave properties of sound and light can be firmly identified with the attributes of ground vibrations caused by earthquakes.

VI. WAVE PROPERTIES AND MOTION

The pure musical tone delivered by striking a tuning fork is said to have a specific unadulterated pitch or recurrence. That recurrence is the circumstances that the sound waves pack and widen in a moment, or, for water waves and different sorts of vibration, the circumstances the wave rises or falls in a moment. Frequencies are given in hertz, truncated Hz, a unit of estimation named to pay tribute to Heinrich Hertz, a German physicist who in 1887 first created electromagnetic waves. One hertz is equivalent to one cycle of rise and fall every second. The time between the peaks is the wave time frame; it is equivalent to the corresponding of the wave recurrence. Individuals can identify sounds having frequencies in the vicinity of 20 and 10,000 Hz. A seismic P wave can refract out of the stone surface into the climate, and if the frequencies are in the capable of being hearing range, the wave can be heard as a thunder as it goes by the ear. Most earthquake waves have frequencies lower than 20 Hz, and are generally felt by individuals as opposed to felt.

Table.4: Damage during an earthquake results from several factors

Strength of shaking	The strong shaking created by an magnitude 7 earthquake turns out to be half as strong at a distance of 8 miles, a quarter as strong at a separation of 17 miles, an eighth as solid at a separation of 30 miles, and a sixteenth as solid at a distance of 50 miles.
Length of shaking	Length relies upon how the blame breaks amid the seismic tremor. The most extreme shaking amid the Loma Prieta tremor kept going just 10 to 15 seconds. During other magnitude 7 seismic tremors in the Bay Area, the shaking may last 30 to 40 seconds. The more drawn out structures shake, the more noteworthy the damage.
Type of soil	Shaking is expanded in soft, thick, wet soils. In certain soils the ground surface may settle or slide.
Type of building	Certain types of buildings, discussed in the reducing seismic tremor damage section, are not sufficiently safe to the side-to-side shaking common during earthquakes.

Waves can be described by a few parameters. Consider the simple harmonic wave drawn as a solid line below with wave height y at a particular position x and time t. Suppose that the maximum amplitude of the wave is A and that the wave length λ is the distance between the crests. The time for a complete wave (crest to crest_ to travel one wavelength is called the period T. Thus the wave velocity v is the wave length divided by the period:

$$v = \frac{\lambda}{T}$$

The frequency of the wave, f, is the number of complete waves that pass every second, so that

$$f = \frac{I}{T}$$

The actual position of a wave depends on its position relative to the origin time and distance.

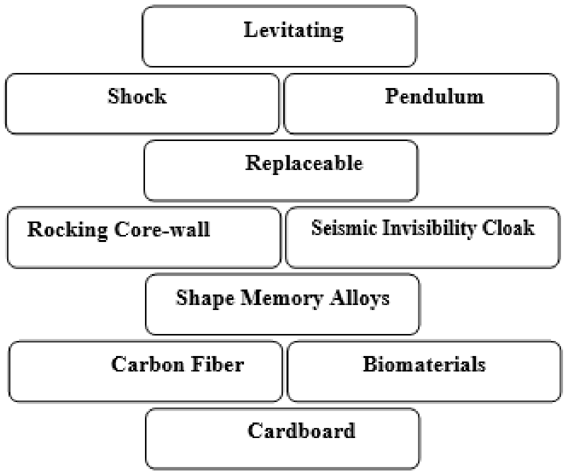

Fig.1: Protection Technologies for Buildings from Earthquake

Table.5: Presumptive bearing capacity values as per IS1904-1978

Type of soil/rock	Safe/allowable bearing capacity (KN/ m^2)
Rock	**3240**
Soft rock	**440**
Coarse sand	**440**
Medium sand	**245**
Fine sand	**440**
Soft shell / stiff clay	**100**
Soft clay	**100**
Very soft clay	**50**

Table.6: Bearing Capacity Based on Presumptive Analysis

Type of soil/rock	Safe/allowable bearing capacity (KN/ m^2)
Rock	**3240**
Soft rock	**440**
Coarse sand	**440**
Medium sand	**245**
Fine sand	**100**
Soft shell / stiff clay	**440**
Soft clay	**100**
Very soft clay	**50**

VII. FAN FOOTING WITH SFIN SEISMIC ENVIRONMENT

Not like geothermal and water well boring and fan footing operators, a foundation boring contractor is a little cog in a vast wheel, at that point fan footing utilizing with 2 wings, 3 wings and with single layer, twofold layer, multi-layer. Regardless of whether it is respectful development or bridge construction, foundation drillers work with the prime contractual workers and perform inside the bounds of the outline parameters of the bigger project. The exercises the foundation drillers perform, for example, anchored earth retention, pile construction and bored shaft foundations, are altogether controlled by the elements that administer the building venture they are a piece of soil foundations. This requires a nearer association between foundation drillers and prime contractual workers. A great deal of issues decide the gainfulness of foundation with fan footing tasks and the contractual workers must stay cautious of poor offering rehearses, delays, change-orders, spending overwhelms, doubt, question, and specialized difficulties to ensure that the fan footing work is finished securely, soundly and productively. This white paper examines a portion of the key advances foundation fan footing temporary workers need to take to keep their employments productive. A cautious examination of these reports will furnish the fan footing temporary worker with a great deal of data basic to understanding the extent of the work, for example, the sort, size, amount and the auxiliary subtle elements of the heaps that should be built; site particular data about the basic idea of the overburden and shake layers (dirts, chilly till, shale shake and so on.) will be point by point in the drag sign on these reports.

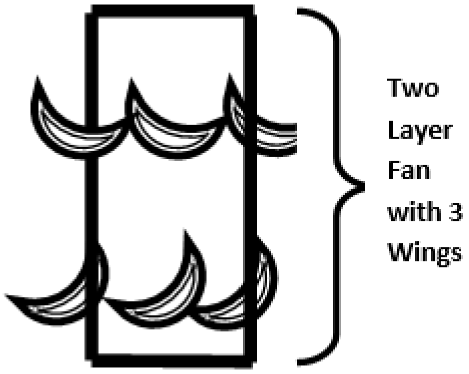

Fig.2: Fan Footing for Soil Foundation

Earthquake motion spreads in soil layers by diffraction and refraction and rise to the top with even and vertical parts that are called P and S waves. P wave compresses and relaxes the earth volumetrically and as it spreads slopes to vertical course while going through the layers of the earth. It ways to deal with the plumb (has a tendency to be vertical) till achieving the surface. S waves are otherwise called float waves. They frame float motions which keep running in opposite to the undulation course. Amplitudes of P waves are little and of S waves are huge that can cause obliteration. The P waves rise to the surface in plumb line that causes vertical motions in the surface while S wave causes even motion. As the ground is extremely unpredictable with numerous stone layers, it may not be conceivable that the p waves rise to the top totally vertical. By introducing some foundation layers without sticky materials this can be obtained. Because of the limit conditions, amplitudes of the earthquake wave pairs in free surface because of increasing speed of gravity going with vertical P wave. It becomes {g+2a.sin(ωt)} in the structure on the surface of the ground by oscillations with 2a accelerations due to earthquake:

$$W(t) = m.\{g + 2a.\sin(\omega t)\} = m.g + 2a.\sin(\omega t)$$

The weight of the structure on the surface, W goes through the harmonic change dependent on time. The effect of (mg) which is the modulus of the vertical load is accompanied by harmonic 2am.sin (ωt) load. Vertical load vector remains with the same sign in each period and it changes its direction in the event of rare case of (a) value **(Fig.3)**.

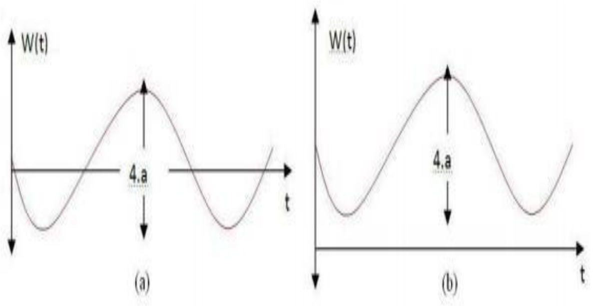

Fig.3: a) Weight of a structure during an earthquake with acceleration a, and b) Changing signs of acceleration in drift motion of the ground

S wave dependably rehashes the full harmonic 2a.sin(ωt) motion. Load vector which constitutes float pressures swings to one (+) and one (-) vector by changing sign in every period (Fig. 3b). It is effectively observed that the increasing speed of gravity's up and down in the layer from where the P wave rises to the surface. Float stresses which are shaped by the heaviness of the structure up and downs in each time of the earthquake in flat planes. The float focuses on that up and downs in the basic even planes can be utilized to diminish the impact of S wave vitality. One might say that S wave with the level wavering does not pass on especially to the structure when vertical speeding up esteem is at greatest. In the meantime when vertical speeding up is least, the float pressures lessening to a critical extent in the even layer. This demonstrates the coefficient of rubbing in the energetic surface abatements with the vertical vibration time frame and adequacy of the plane. The numerical detailing for discovering change parameters can be determined for structure with expanded foundation in period interim. We can make the capacity of the two motions that will be framed the base for the count by taking out the time in theW(t)=m.{g+2a.sin(ωt)} function to a period interval **(Fig.4)**.

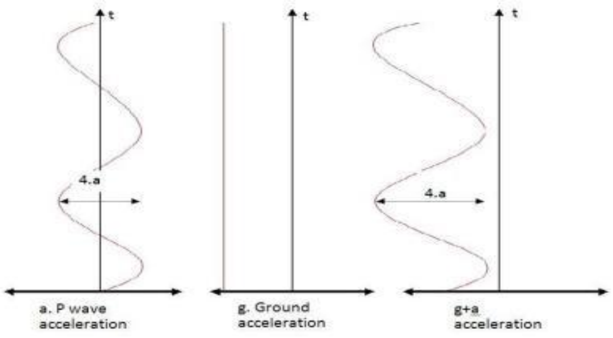

Fig.4: Increasing and decreasing of acceleration on the ground surface due to earthquake.

Some assumption can be made to continue the calculation with the value of the vertical loads W=m.{g±2a) in the structure. We accept the vertical acceleration of gravity as positive. The acceleration of the P wave, m is the mass of the structure, A is the S wave acceleration on the ground and μ is the coefficient of friction of the horizontal plane made between the foundation and block. $N = \frac{a}{A} = P$is the proportion of the P wave acceleration to the S wave acceleration. This value is in the position of $N = 2/3$.

The force that the S wave can form in the horizontal direction on the structure‟s ground is as much as F=m.ASin(ωt). It becomes F=m.A, if we degrade it to the half period interval. This force passes to the structure as it is and shakes it in the horizontal direction, if there is no drift on the ground. W=m.(g+2a) vertical load originates in the structure base in the (g+2a) state of P wave acceleration. The weight of the structure is W=m.(g-2a) in the (g-2a) state. If the structure is separated from the upper structure with dilatation on the plane from where it emerges to the surface if static friction force is f= μ.m.(g±2a). The shifting force magnitude which the earthquake will form in the horizontal direction is as much as F=m.A under the dilatation plane in the structure. The drift is formed if the friction force F in the dilatation is equal to or smaller than the shifting force magnitude.

$$\mu.m(g \pm 2g) \leq m.A \rightarrow \mu = \frac{A}{(g \pm 2a)} \quad N = \frac{a}{A} \rightarrow\rightarrow a = NA$$

If we take as $A = a.g; a \rightarrow$ is the earthquake acceleration parameter according to the acceleration of gravity.

$$\mu \leq \frac{A}{g \pm 2.N.A} = \frac{a}{1 \pm 2N.a}$$

$\mu \leq \frac{a}{1 \pm 2N.a}$ Two separate equation are formed in a period interval.

We can make the graphic of the change of the coefficient of friction with the earthquake acceleration parameter and make interpretations **(Fig.5).** We can determine the limits of the coefficient of friction for the formation of drift in the structure‟s foundations according to the change of the ground acceleration parameter of the earthquake. In the graphic, there is asymptote of the coefficient of friction in $a = 1/2N$ value for the $\mu \leq \frac{a}{1-2N.a}$ case. In the upper accelerations of the α value, the structure and stratum are separated. The vertical earthquake acceleration is bigger than the acceleration of gravity and between the structure and foundation is widened. There is asymptote of $\mu \leq \frac{a}{1+2N.a}$ equality for the coefficient of friction $\mu = 1/2N$ value. Coefficients of friction above this value do not let the drift in the structure’s foundation. For every value within these borders, drift occurs in the structure‟s foundation.

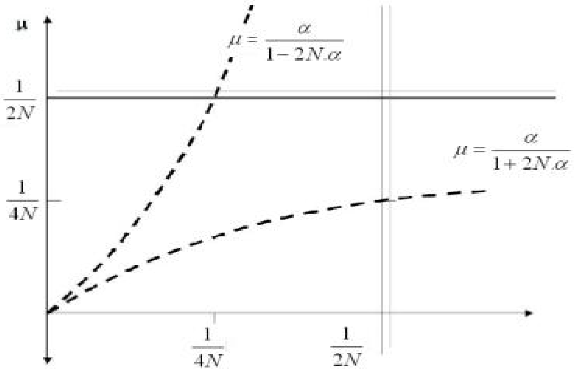

Fig.5: Diagram showing the structure’s motion depending on the acceleration ratio to that of the coefficient of friction

When N=a/A≤ $1\ or\ N \geq 1$, we evaluate $1/2N$. In the N≤ 1 environment, P wave of the earthquake is bigger than the S wave acceleration. It makes it easy that friction can occur in the structure’s foundation for the high values of the coefficient of friction. When $N \geq 1$, it is necessary to form planes with low coefficient of friction for the formation of drift in the structure’s ground as the P wave acceleration is big.

Inertial forces and acceleration with Fan Footing

The seismic body and surface waves make inertial forces inside the building. Inertial forces are made inside a question when an outside power tries to influence it to move on the off chance that it is very still or alters its rate or course of motion on the off chance that it is moving. Inertial power takes us back to secondary school material science and to Newton's Second Law of Motion, for when a building shakes it is liable to inertial powers and should comply with this law similarly as though it were a plane, a ship, or a competitor. Newton's Second Law of Motion expresses that an inertial power, F, rises to mass, M, increased by the acceleration, A.

$$\boldsymbol{F = MA}$$

Figure: Newton’s Second Low of Motion

Mass can be expected as proportionate (at ground level) to the heaviness of the building, thus this piece of the law clarifies why light buildings, for example, wood outline houses, have a tendency to perform preferred in earthquakes over substantial overwhelming ones the powers on the building are less. The speeding up or the rate of progress of the speed of the waves getting the building under way, decides the level of the building mass or weight that must be managed as a horizontal force.

Table.7: Site Response without FF (Test-1)

S.No	Depth in meter	Velocity m/sec	Spectral Acceleration	Peak ground acceleration	Vertical force	Lateral force	Zone
1	0	0	0.00	0.01	20	10	Iv
2	5	0	0..012	0.012	30	15	IV
3	10	50	0.016	0.018	40	20	IV
4	15	100	0.02	0.0215	60	40	III
5	20	150	0.025	0.0266	70	50	III
6	25	200	0.03	0.0357	90	60	III
7	30	250	0.032	0.0384	100	70	II
8	35	300	0.034	0.0451	120	80	II
9	40	350	0.05	0.0499	160	120	I
10	45	400	0.07	0.0687	180	130	I

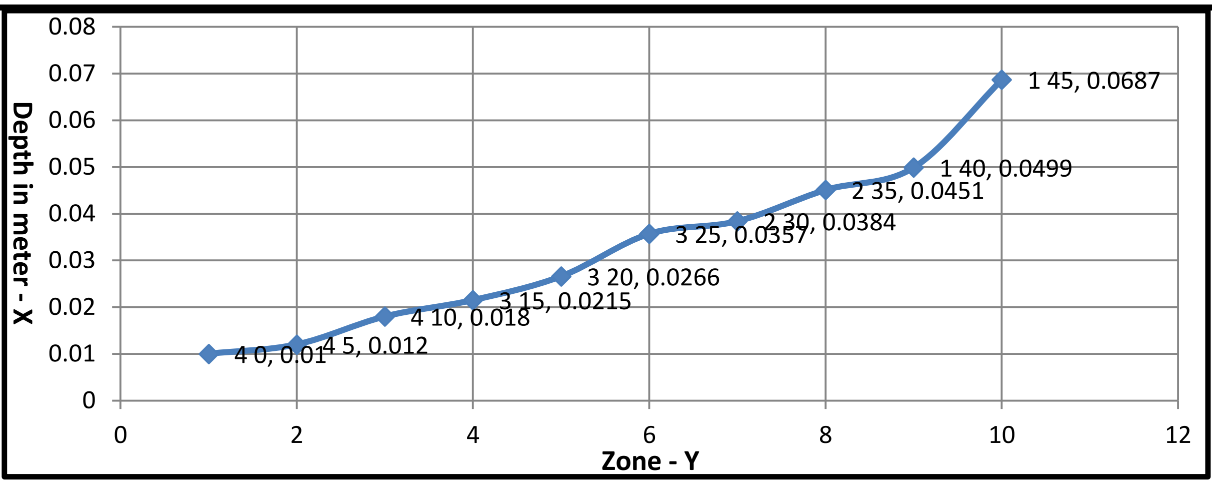

Fig.6: Result of without FF

Table.8: Typical values of elastic constants, density, Poisson's ratio and seismic wave velocities

Material or Geologic Formation	Bulk Modulus in 10^9 Pa	Shear Modulus in 10^9 Pa	Density in kg m^{-3}	Poisson Ratio	V_D inkms^{-1}	V_D inkms^{-1}	V_p/V_S
Air	0.0001	0	1.0	0.5	0.32	0	∞
Water	2.2	0	1000	0.5	1.5	0	∞
Ice	3.0	4.9	920	-0.034	3.2	2.3	1.39
Clastic sedimentary rocks	-	-	-		(1.4-5.3)	-	-
Sand stone	24	17	2500	0.21	4.3	2.6	1.65
Salt	24	18	2200	0.17	4.6 (3.8-3.7)	2.9	1.59
Limestone	38	22	2700	0.19	4.7 (2.9-5.6)	3.6 (3.4-3.7)	1.62
Granite	56 (47-69)	34 (30-37)	2610 (2340-2670)	0.25 (0.20-0.31)	6.2 (5.8-6.4)	3.6 (3.4-3.7)	1.73 (1.65-1.91)
Basalt	71 (64-80)	38 (33-41)	2940 (2850-3050)	0.28(0.26-0.29)	6.4 (6.1-6.7)	4.4 (4.0-4.7)	1.80 (1.76-1.82)
Peridotite, Dunit, Pyroxenite	128 (113-141)	63 (52-72)	3300(3190-3365)	0.29 (0.26-0.29)	8.0 (7.5-8.4)	-	1.8 (1.76-1.91)
Metamorphic & igneous rocks	-	-	-	-	(3.8-6.4)	-	-
Ultramafic rocks	-	-	-	-	(7.2-8.7)	-	-
Cenozoic	-	-	1500-2100	0.38-<0.5	(0.2-1.9)	0.34	2.3-8
Cenozoic water saturated	-	-	1950	0.48	1.7	0.34	5
Cretaceous & Jurassic	-	-	2400-2500	0.28-0.43	-	-	1.8-2.8
Triassic	-	-	2500-2700	0.28-0.40	-	-	1.8-2.5
Upper Permian	-	-	2000-2900	0.23-0.31	-	-	1.7-1.9
Carboniferous	-	-	-	0.31-0.35	-	-	1.9-2.1

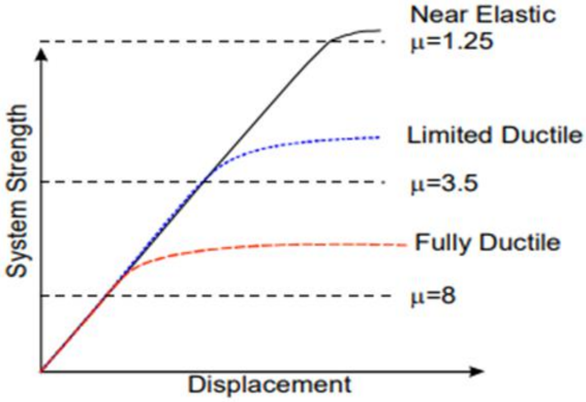

Fig.7: Performance of test result

Table.9: Inertial forces and acceleration with Fan Footing (Test-2)

S.No	Depth in meter	Velocity m/sec	Spectral Acceleration	Peak ground acceleration	Vertical force	Lateral force	Zone
1	0	0	0.00	0.00	10	0	**Iv**
2	5	0	0.00	0.011	20	5	**IV**
3	10	40	0.011	0.0112	30	15	**IV**
4	15	80	0.015	0.016	40	20	**III**
5	20	110	0.019	0.0172	45	25	**III**
6	25	150	0.021	0.0211	50	30	**III**
7	30	190	0.024	0.0264	55	35	**II**
8	35	210	0.037	0.0287	70	50	**II**
9	40	250	0.039	0.0299	85	55	**I**
10	45	290	0.041	0.0312	110	70	**I**

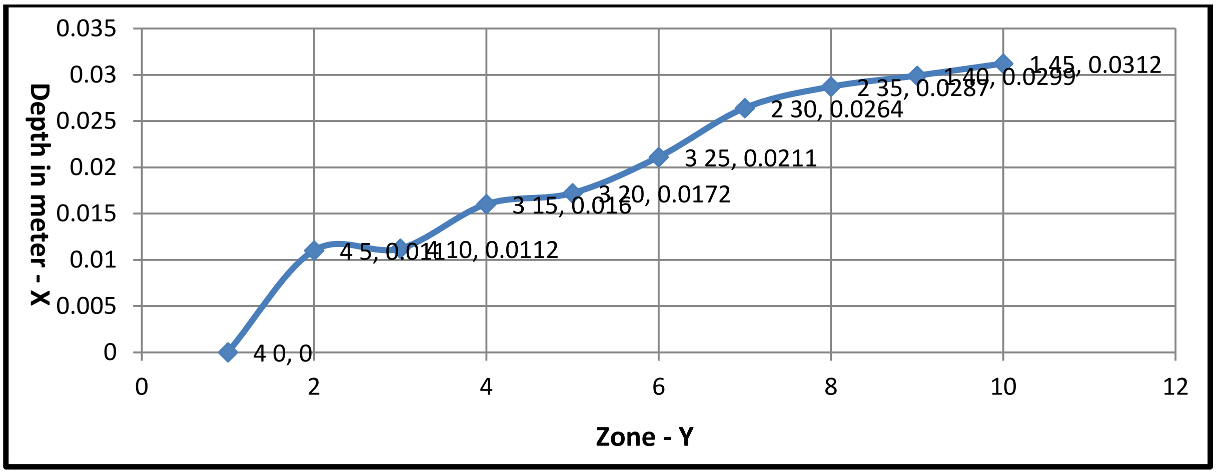

Fig.8: Performance result with FF

VIII. CONCLUSION

The calculations are about the static coefficient of friction. Moreover, there is likewise dynamic coefficient of friction. The dynamic coefficient of friction is greater than the static coefficient of friction. On the off chance that the calculations are made by the static coefficient of friction, it will be a more secure region than the active one. The float of the foundation to the structure's ground causes critical releases in the earthquake vitality which will go to the structure. The vitality got in the earthquake waves loses quality with moment releases is vital for its consequences for the structure. For this situation the structure's foundation proceeds with its motions without shaking. If the structure is tied down to the foundation whatever is left of the structure turns into the last layer that implies over the foundation up to the rooftop. For this situation the increasing speed in the structure ends up multiplied. We can shield the structure from the S wave by utilizing the way that P waves reach to the structure first and shape vibrations vertical way. In other words that we can isolate the upper piece from the foundation by influencing dilatation on the ground to surface. Vertical vibrations that the P waves shape in the structure diminish the coefficient of grinding in the even dilatation on the foundation. S waves of the earthquake which reach to the structure's ground later resemble achieving the free layer and release its vitality in this way cause level vibrations not to achieve the upper structure which then it stops S waves horizontal and destructive impacts.

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