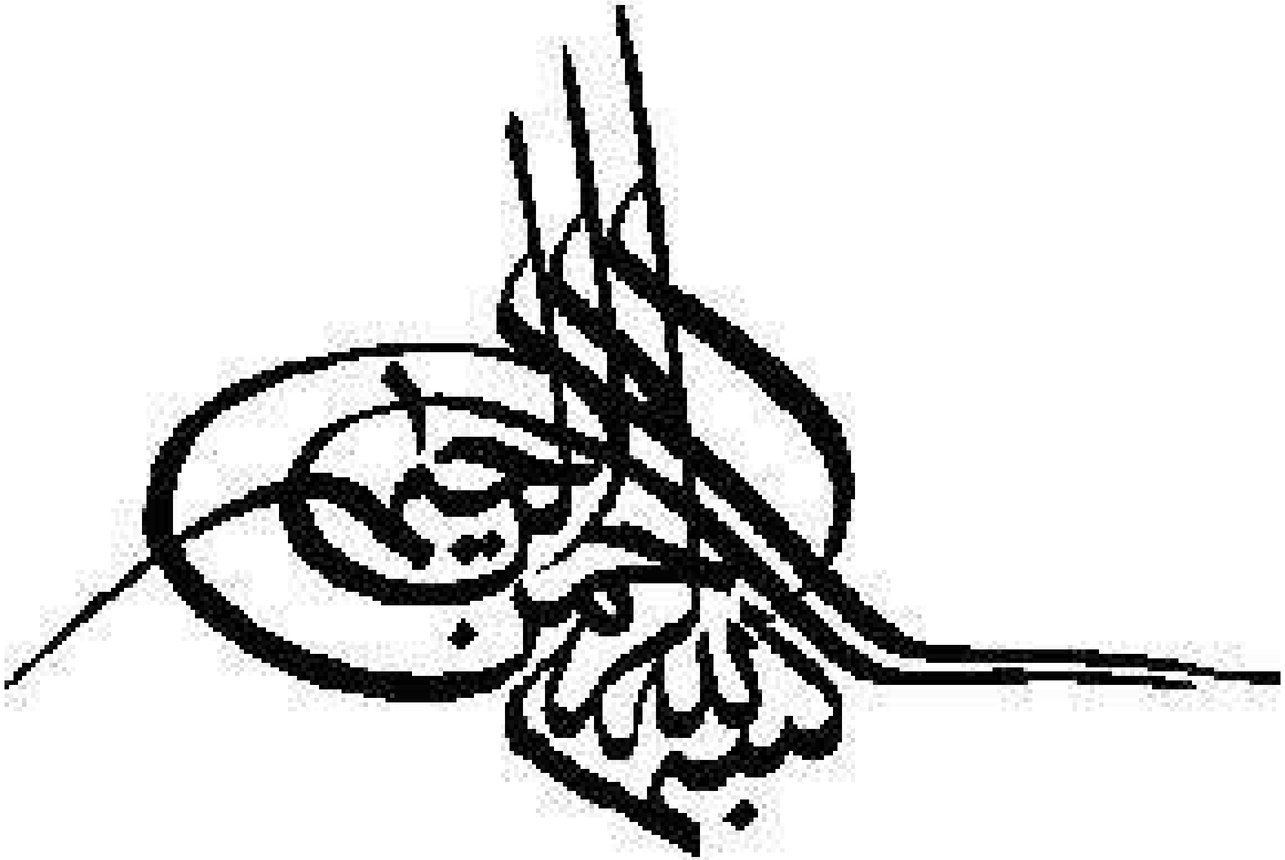

بسم الله الرحمن الرحيم

فنداسیون ماشینهاي ابزار

تهيه كنندگان:

مرتضي بشنيجي - حميد شايسته

استاد گرامي:

آقاي دكتر جهان پور

بهمن ۸۵

فهرست:

Chapter 1 :

Vibration absorption and isolation

مقدمه اي از ضربه گيرهاي ارتعاشي:

- دياگرام شماتيك ضربه گير فنداسيون(دياگرام آزاد سيستم جرم و فنر دوبل ضربه گير فنداسيون):

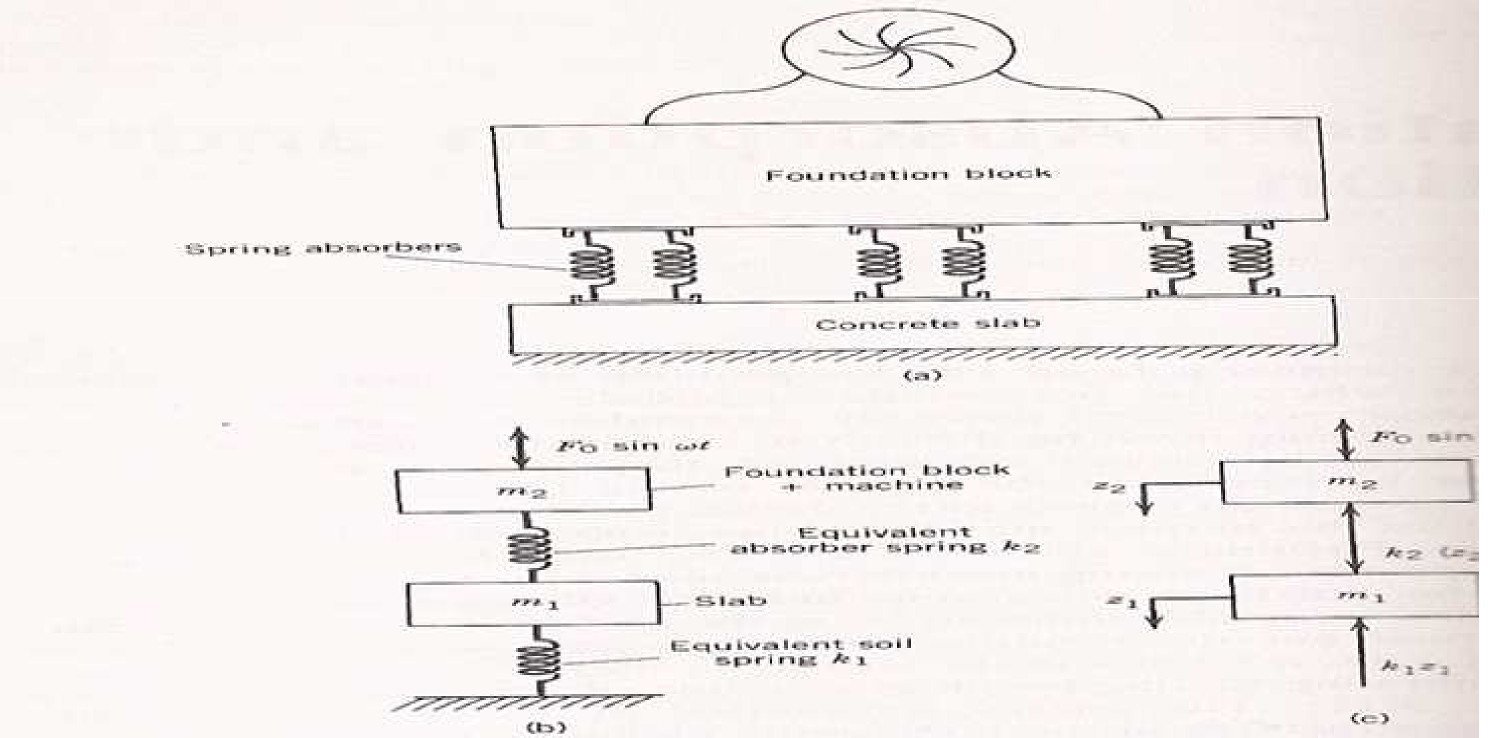


Figure 10.1. (a) Schematic diagram of a foundation on absorbers (support... valent two-spring—mass model of foundation absorber system. (c) Free-body...

$$m_1\ddot{z}_1+k_1z_1+k_2(z_1-z_2)=0$$

$$m_2\ddot{z}_2+k_2(z_2-z_1)=F_0\sin\omega t$$

$$k_1 = k_z = \frac{4Gr_0}{1-\nu}$$

and k_2 is the total equivalent stiffness of all springs in the

The frequency equation for the system is (Section 2.13

$$\omega_n^4 - (\omega_{nl1}^2 + \omega_{nl2}^2)(1+\mu)\omega_n^2 + (1+\mu)\omega_{nl1}^2\omega_{nl2}^2$$

in which $\omega_{n1,2}$ are the natural frequencies of the system, a

$$\mu = \frac{m_2}{m_1}$$

ω_{nl1} is the limiting natural frequency of the entire system (when no absorbers are used) and is given by

$$\omega_{nl1} = \sqrt{\frac{k_1}{m_1 + m_2}}$$

and ω_{nl2} is the limiting natural frequency of the mass m_2 rest and calculated on the assumption that the system below the rigidity. ω_{nl2} is given by

$$\omega_{nl2} = \sqrt{\frac{k_2}{m_2}}$$

The maximum amplitudes Z_1 and Z_2 are given by

$$Z_1 = \frac{\omega_{nl2}^2}{m_1\,\Delta(\omega^2)}F_0$$

$$Z_2 = \frac{(1+\mu)\omega_{nl1}^2 + \mu\omega_{nl2}^2 - \omega^2}{m_2\,\Delta(\omega^2)}F_0$$

in which

$$\Delta(\omega^2) = [\omega^4 - (1+\mu)(\omega_{nl1}^2 + \omega_{nl2}^2)\omega^2 + (1+\mu)\omega$$

$$Z_1 = \frac{S}{m_1}\,\frac{r_2^2}{[1-(1+\mu)(r_1^2 + r_2^2 - r_1^2 r_2^2)]} \quad (10.2)$$

$$r_1 = \frac{\omega_{nl1}}{\omega}, \qquad r_2 = \frac{\omega_{nl2}}{\omega} \quad (10.3)$$

o absorbers are used, the amplitude of vibration of the entire
n resting on soil is given by

$$Z = \frac{F_0}{(m_1 + m_2)(\omega_{nl1}^2 - \omega^2)} \quad (10.4a)$$

$$Z = \frac{S}{m_1(1+\mu)(r_1^2 - 1)} \quad (10.4b)$$

$$\eta = \frac{Z}{Z_1} = \frac{[1-(1+\mu)(r_1^2 + r_2^2 - r_1^2 r_2^2)]}{r_2^2[(1+\mu)(r_1^2 - 1)]}$$

10.2 ضربه گيرهاي نوساني معمولي:

- موادي كه تحت تغيير شكل الاستيك و ارتجاعي قرارمي گيرند را مي توان به عنوان جاذب وضربه گيربه كار برد و معمولا ضربه گيرهاي نوساني به كار رفته عبارتند از:
- ۱- فنرهاي فلزي يا فولادي
- ۲- چوب پنبه
- ۳-لايه هاي لاستيكي
- ۴-لايه هاي چوبي
- ۵- نئوپرين
- ۶- ضربه گيرهاي پنوماتيكي

10.2.1 فنرهاي فلزي يا فولادي:

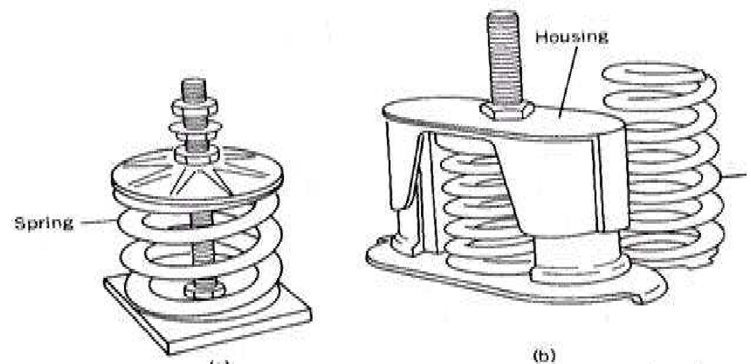
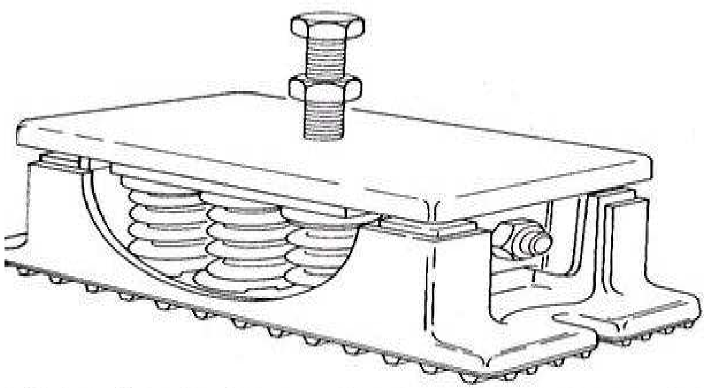


Figure 10.2. Spring absorber having only one spring: (a) without housing; (Courtesy Korfund, Inc. 1986.)



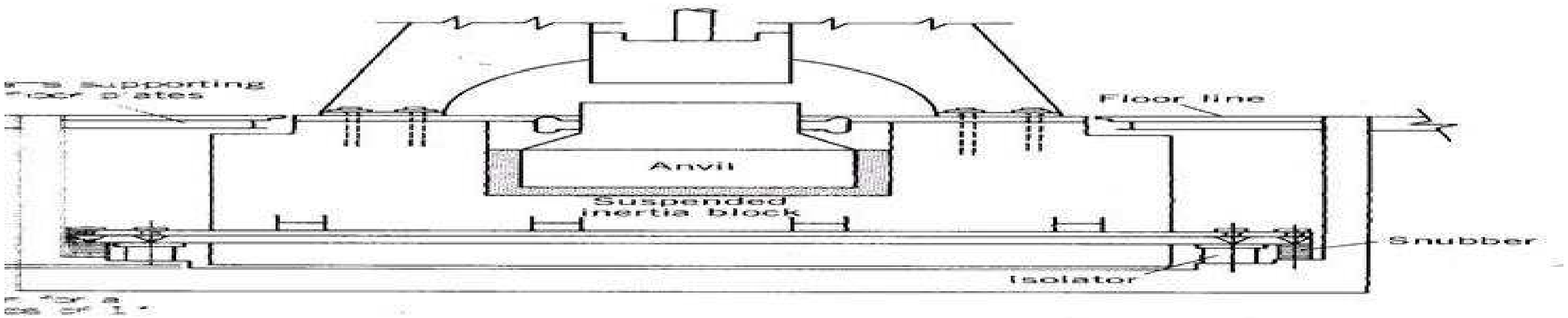
ultiple spring absorber assembly. (Courtesy Korfund, Inc. 1986).

- فنرهاي پيچشي ساخته شده از فولاد خاصيت الاستيکي زيادي دارند و ميزان نوسان در دستگاه را تا حد زيادي کاهش مي دهد اين نوع از جاذب ها در شکل نشان داده شده اند.
- اين نوع از ضربه گيرهاي فنري تنها براي دستگاه هاي با ظرفيت پايين به کار مي روند. براي دستگاه هايي با ظرفيت متوسط از ضربه گير هايي با چندين واحد فنري استفاده مي شود.
- که دو ترتيب و چيدمان در تعبيه ضربه گيرهاي فنري هستند.

نوع محافظي كه در اين طرح فنرها دقيقا در زير دستگاه و يا در پايه دستگاه قرار مي گيرند.

انتخاب هر نوع بستگي به بالانس و سرعت عملكردي آن دارد. براي دستگاههايي با سرعت بالا آنها در تعادل و توازن هستند نوع محافظتي در مورد جرم هاي زياد به كار مي رود. در دستگاه با جرم بالا از ضربه گيرهاي نوع تعليقي استفاده مي شود.

ضربه گيرهاي فنري از نظر صنعتي در ظرفيت هاي مختلفي در دستري هستند اطلاعاتي در مورد ويژگي انحراف و انحناي بار توسط سازندگان اين نوع ضربه گير در اختيار مصرف كننده قرار مي گيرد.



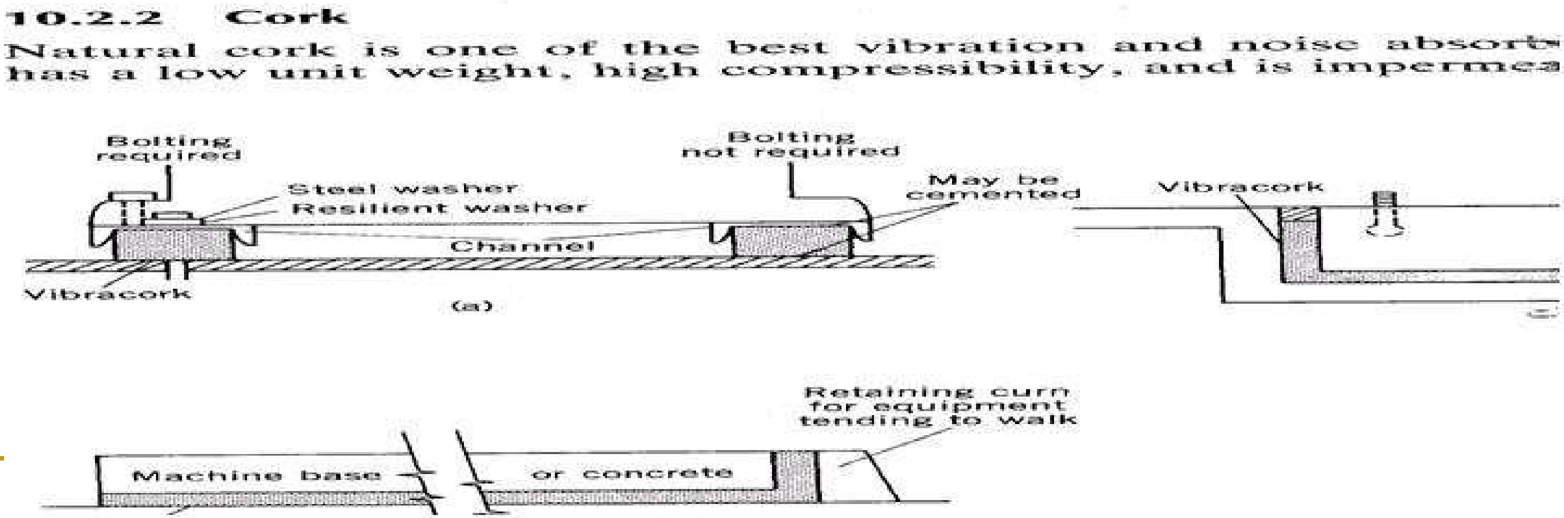
...cal isolated double-frame hammer foundation—suspended-type absorber ... Inc. 1986.)

10.2.2 چوب پنبه:

چوب پنبه طبيعي يكي از بهترين ضربه گيرهاي نوسان و نويز است كه داراي حداقل وزن و حداكثر تراكم پذيري است و قادر است تراكم و چگالي زيادي را تحمل كند.

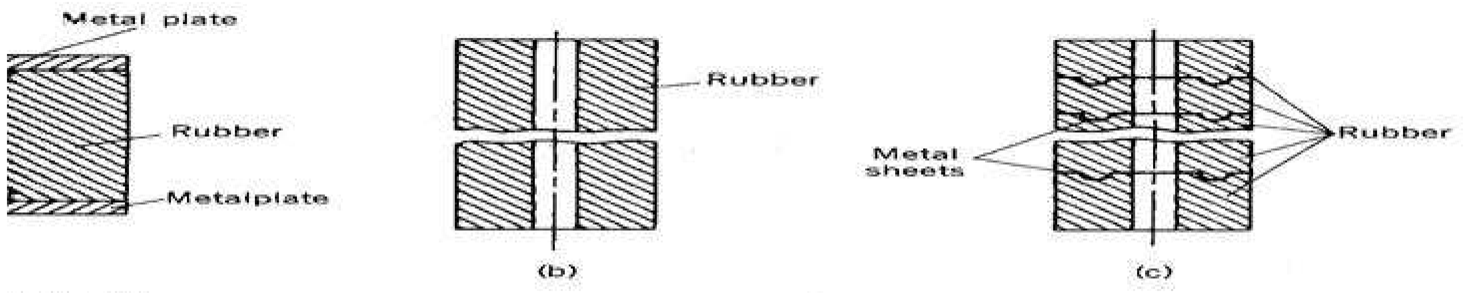
لايه هاي چوب پنبه اي در زير پايه و در فنداسيون دستگاه قرار مي گيرند.

روغن و آب باعث سريع خراب شدن چوب پنبه مي شود.



10.2.2 لايه هاي لاستيكي:

- مواد لاستيكي يك ضربه گير نوساني عالي را فراهم مي كنند به اين علت كه اين لايه هاي ارتجاعي و فنري از لاستيك ساخته شده اند براي اين هدف مي توانند استفاده شوند.



bonded rubber pads: (a) rubber spring bonded between two metal plates; (b) in the form of hollow cylinder; (c) rubber spring in the form of hollow cylinders

10.2.4 چوب :

- لايه ها و صفحه هاي چوبي معمولا در زير سطح اتكاي چكش استفاده مي شوند. لايه هاي تك و با چند لايه از چوب سخت (نظير چوب بلوط ، نارون) به اين منظور به كار مي روند.

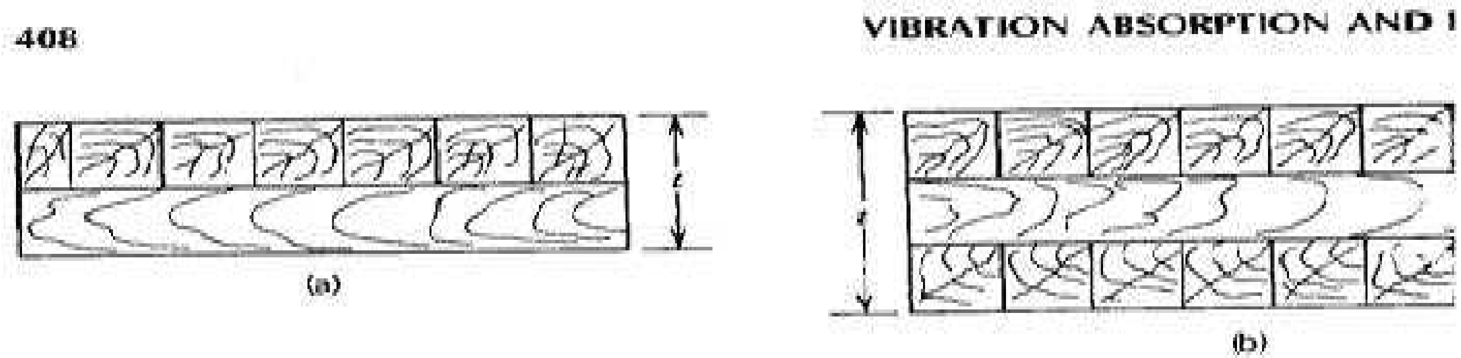


Figure 10.7. Timber pads with multiple layers: (a) two layers; (b) three la

۱۰.۲.۵ نئوپرين:

- لايه هاي نئوپرين و يا چوب پنبه هاي صنعتي بسيار مقاومند اين لايه ها در اندازه ها و وزنهاي مختلف در دسترس هستند.

۱۰.۲.۶ضربه گيرهاي پنوماتيكي :

ضربه گيرهاي پنوماتيكي از گاز يا هوا به عنوان يك ماده ارتجاعي استفاده مي كنند.

فنرهاي پنوماتيكي بر اساس قانون تراكم آدياباتيك كار مي كنند.

شمايي ازيك سيستم سيلندر پيستون به همراه روابط ترموديناميكي آن در صفحه بعد قابل مشاهده است.

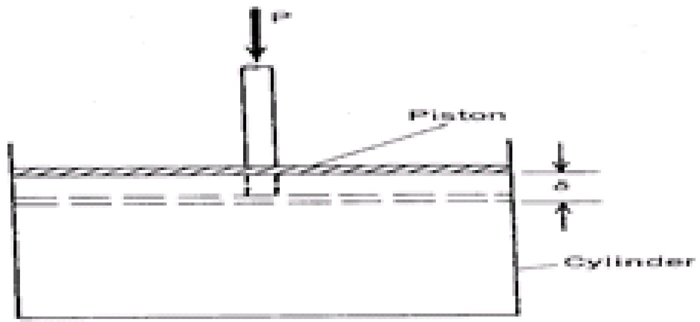


Figure 10.8. Principle of a pneumatic ab

.. and let δ be the downward movement of the piston. If the area
. is A, then the new pressure p_2 is given by P/A. According to

$$p_2 V_2^n = p_1 V_1^n \tag{10.6}$$

an index. Also,

$$V_2 = V_1 - \delta A$$

$$\frac{P}{A}(V_1 - \delta A)^n = p_1 V_1^n \tag{10.7a}$$

$$P = p_1 A \left(\frac{1}{1 - \left(\frac{A}{V_1}\right)\delta} \right)^n \tag{10.7b}$$

g Eq. (10.7b) with respect to δ, we get

$$k = \frac{dP}{d\delta} = \frac{n p_1 A^2}{V_1} \left(\frac{1}{1 - \left(\frac{A}{V_1}\delta\right)} \right)^{n+1}$$

in volume is small, then the above expression becomes:

$$k = \frac{n p_1 A^2}{V_1} \tag{10.8}$$

and let δ be the downward movement of the piston. If the area is A, then the new pressure p_2 is given by P/A. According to

$$p_2 V_2^n = p_1 V_1^n \tag{10.6}$$

an index. Also,

$$V_2 = V_1 - \delta A$$

$$\frac{P}{A}(V_1 - \delta A)^n = p_1 V_1^n \tag{10.7a}$$

$$P = p_1 A \left(\frac{1}{1 - \left(\frac{A}{V_1}\right)\delta} \right)^n \tag{10.7b}$$

g Eq. (10.7b) with respect to δ, we get

$$k = \frac{dP}{d\delta} = \frac{n p_1 A^2}{V_1} \left(\frac{1}{1 - \left(\frac{A}{V_1}\delta\right)} \right)^{n+1}$$

in volume is small, then the above expression becomes:

$$k = \frac{n p_1 A^2}{V_1} \tag{10.8}$$

c springs may be the single- or double-acting type (Harris and Pneumatic springs can be made to provide damping as well. porting area may vary with deflection. Pneumatic springs are available in different shapes and capacities. A typical convo- g known as "Airmount" manufactured by Firestone, Inc., is . 10.9. The performance characteristics of the pneumatic pplied by the manufacturers and must be ascertained before of such systems.

loads are heavy and the required natural frequency of the v. the static deflection in the usual (spring or pad) type of be large. However, in pneumatic absorbers, the static deflec- ntrolled by adjusting the air or gas pressure to support the intaining the low stiffness necessary. Baxa and Ebisch (1982)

محاسبه ميزان ضريب جذب η:

- Z_1 ميزان دامنه نوسانات ضربه گير فنداسيون است

$$\eta = \frac{Z}{Z_1}$$

تعيين نسبت فركانس r_2:

كه $\omega_{n/2}$ فركانس طبيعي ضربه گير فنداسيون است.

$$\eta = \frac{Z}{Z_1} = \frac{[1-(1+\mu)(r_1^2+r_2^2-r_1^2 r_2^2)]}{r_2^2[(1+\mu)(r_1^2-1)]}$$

$$\omega_{n/2} = \sqrt{\frac{k_2}{m_2}}$$

تعيين $\omega_{n/2}$:

$$r_2^2 = \frac{\omega_{n/2}^2}{\omega^2} \qquad \omega_{n/2}^2 = r_2^2\omega^2$$

تعيين سختي عمودي كل ضربه گير:

$$k_2 = m_2 \omega_{nl2}^2$$

انتخاب نوع ضربه گير:

يك ضربه گير مي تواند براحتي توسط كاتالوگهاي داده شده شركت سازنده كه درباره بارگذاري و تغييرشكل ضربه گير است، به طور اقتصادي انتخاب شود.

پيدا كردن دامنه نوسان سيستم بالا (Z2):

$$Z_2 = \frac{(1+\mu)\omega_{nl1}^2 + \mu\omega_{nl2}^2 - \omega^2}{m_2\,\Delta(\omega^2)} F_0$$

$$\Delta(\omega^2) = \omega^4 - (1+\mu)(\omega_{nl1}^2 + \omega_{nl2}^2)\omega^2 + (1+\mu)\omega^{2}$$

بار موثر بر روي هر فنر:

$$P_a = kZ_2$$

10-6 روشهاي كاهش ميزان نوسان و ارتعاش موجود در فنداسيون دستگاه:

- ارتعاش و نوسانات اضافي در پايه دستگاه گاهي اوقات پس از نصب دستگاه و پس از عدم تعادل بارها كه در نتيجه فرسايش وپارگي قطعات دستگاه مي باشد اتفاق مي افتد.
- اين ارتعاش و نواسانات را مي توان از طريق انتخاب مناسب در اندازه گيريهاي مورد نظر كاهش داد.
- تاكيد مي شود كه قبل از انجام هر كاري بايد علت اين ارتعاشات و نوسانات اضافي را بررسي كرد.
- انتخاب نادرست در اندازه هاي ابعاد بار بجاي بهتر كردن وضعيت باعث بدتر شدن آن مي شود.

متدهاي به كار رفته عبارتند از:

- ۱- متوازن كردن بارهاي نامتعادل
- ۲- تثبيت شيميايي خاك
- ۳- ابعاد ساختاري
- ۴- تامين دمپرهاي ارتعاشي

some optimum value of damping. Dampers for foundations under-
:king or sliding vibrations can be designed similarly.

AMPLES

LE 10.7.1

he foundation for a reciprocating machine operating at a speed of The weight of the machine is 2.0 t and it produces a sinusoidally inbalanced force of 0.5 t in the vertical direction. Due to limited space, the area of the foundation should not exceed 3 m × 2 m. presence of precision machines in the vicinity, the vibration amp- ould be less than 0.025 mm. Assume the dynamic shear modulus of $G = 1950\ t/m^2$ and $\nu = 0.305$. Unit weight of concrete γ_c may be $2.4\ t/m^3$.

on

esign Data

ight of the machine = 2.0 t
erating speed = 750 rpm = 78.53 rad/sec
tical unbalanced force $P_Z = 0.5$ t
namic shear modulus $G = 1950\ t/m^2$
sson's ratio for the soil = 0.305
missible amplitude of vibration = 0.025 mm

rst Trial

miting amplitude of foundation vibrations is only 0.025 mm. Con- the limitation of 3 m × 2 m on the foundation area, it will not be to design a simple block foundation satisfying the criteria for design. The amplitude of vertical vibrations is 0.2024 mm as d subsequently. A foundation resting on absorbers must be de-

econd Trial

: a foundation area of 3 m × 2 m. Let the size of the foundation e absorber (Fig. 10.1a) be 3 m × 2 m × 0.3 m and the size of the on block above the absorber be 3 m × 2 m × 1 m.

ight of foundation block below the absorber = W_1
$3 \times 2 \times 0.3 \times 2.4 = 4.32$ t

ss $m_1 = \dfrac{4.32}{9.81} = 0.4403\ t\ sec^2/m$

ight of foundation block above the absorber $W_2 = 3 \times 2 \times 1 \times 2.4 =$
4 t

Total weight above the absorber = 14.4 + 2 = 16.4 t

Mass $m_2 = \frac{16.4}{9.81} = 1.6177 \text{ t sec}^2/\text{m}$

Ratio of masses $\mu = \frac{m_2}{m_1} = \frac{1.6717}{0.4403} = 3.796$

4. *Stiffness of Soil Spring below the Base k_1*

Equivalent radius r_0

$$r_0 = \sqrt{\frac{6}{\pi}} = 1.382 \text{ m}$$

$$k_1 = k_z = \frac{4 \times 1950 \times 1.382}{(1 - 0.305)} = 15510 \text{ t/m}$$

5. *Limiting Natural Frequency of the Whole System Res*

$$\omega_{nl1} = \sqrt{\frac{k_1}{m_1 + m_2}}$$

$$\omega_{nl1} = \sqrt{\frac{15510}{0.443 + 1.6717}} = 85.69 \text{ rad/sec}$$

6. *Frequency Ratio r_1*

$$r_1 = \frac{\omega_{nl1}}{\omega} = \frac{85.69}{78.53} = 1.0911$$

7. *Amplitude of the System Resting on Soil (No Abso*

$$Z = \frac{F_0}{(m_1 + m_2)(\omega_{nl1}^2 - \omega^2)}$$

$$= \frac{0.5}{(0.4407 + 1.6716)(85.69^2 - 78.53^2)}$$

$$= 0.0002024 \text{ m} = 0.2024 \text{ mm}$$

8. *Degree of Absorption*

$$\eta = \frac{Z}{Z_1}$$

$$\eta = \frac{0.2024}{0.025} = 8.096$$

Adopt $\eta = -10$ for the design

9. *Frequency Ratio r_2*, i.e., ω_{nl2}/ω

$$\eta = \frac{[1 - (1 + \mu)(r_1^2 + r_2^2 - r_1^2 r_2^2)]}{r_2^2[(1 + \mu)(r_1^2 - 1)]}$$

$$r_2^2 = \frac{1 - (1 + \mu)r_1^2}{(1 + \mu)(\eta - 1)(r_1^2 - 1)}$$

$$\frac{\cdot}{\cdot} = \frac{1 - (1 + 3.796)(1.0906)^2}{(1 + 3.796)(-10 - 1)(1.0906^2 - 1)} = 0.4706$$

ination of ω_{nl2}^2

$$r_2^2 = \frac{\omega_{nl2}^2}{\omega^2}$$

$$\omega_{nl2}^2 = (0.4706)(78.53)^2/\text{sec}^2$$

$$\omega_{nl2} = 53.87 \text{ rad/sec}$$

s of the Absorber k_2

$$k_2 = m_2\omega_{nl2}^2 \quad (2.98b)$$

$$= (1.6717)(0.4706)(78.53)^2 = 4851 \text{ t/m}$$

is the total stiffness of the absorber system. Use eight
, each having a stiffness of 600 t/m. The actual value of
00) / 1.6717 = 53.58 rad/sec.
mitted since pertinent data is not supplied.

ude of Vibration of the System above the Absorber Z_2

$$Z_2 = \frac{(1 + \mu)\omega_{nl1}^2 + \mu\omega_{nl2}^2 - \omega^2}{m_2\Delta(\omega^2)} F_0 \quad (2.109)$$

$$^2) = \omega^4 - (1 + \mu)(\omega_{nl1}^2 + \omega_{nl2}^2)\omega^2 + (1 + \mu)\omega_{nl1}^2\omega_{nl2}^2 \quad (2.104)$$

$$\Delta(\omega^2) = 2.200 \times 10^8$$

$$= \frac{(1 + 3.796)(85.65)^2 + 3.796(53.58)^2 - 78.53^2}{(1.6717)(2.20 \times 10^8)} (0.5)$$

$$= 0.000053 \text{ m} = 0.054 \text{ mm}$$

mic load on each absorber = 0.000053 × 600 = 0.0324 t

the amplitude Z_2 is calculated to check the stresses in the
rial. The amplitude Z_1 has been restricted to a value less than
value of 0.025 mm. The value of Z_1 may be calculated using

$$Z_1 = \frac{\omega_{nl2}^2}{m_1 \Delta(\omega^2)} F_0$$

$$= \frac{(53.58)^2}{(0.4403)(2.20 \times 10^8)} (0.5) = 0.0000148 \text{ m}$$

$$= 0.0148 \text{ mm}$$

$$< 0.025 \text{ mm}$$

EXAMPLE 10.7.2

A compressor having an operating speed of 1200 rpm was industrial unit. Two precision machines were added to the p was felt necessary to protect these precision machines fro vibrations due to operation of the compressor. The locatio pressor (C_1) and precision machines (P_1 and P_2) are show

Design an open trench barrier to provide effective vibrati the cases of (a) active and (b) passive isolation. The velocity was determined at the site by cross bore hole method and found to be 150 m/sec.

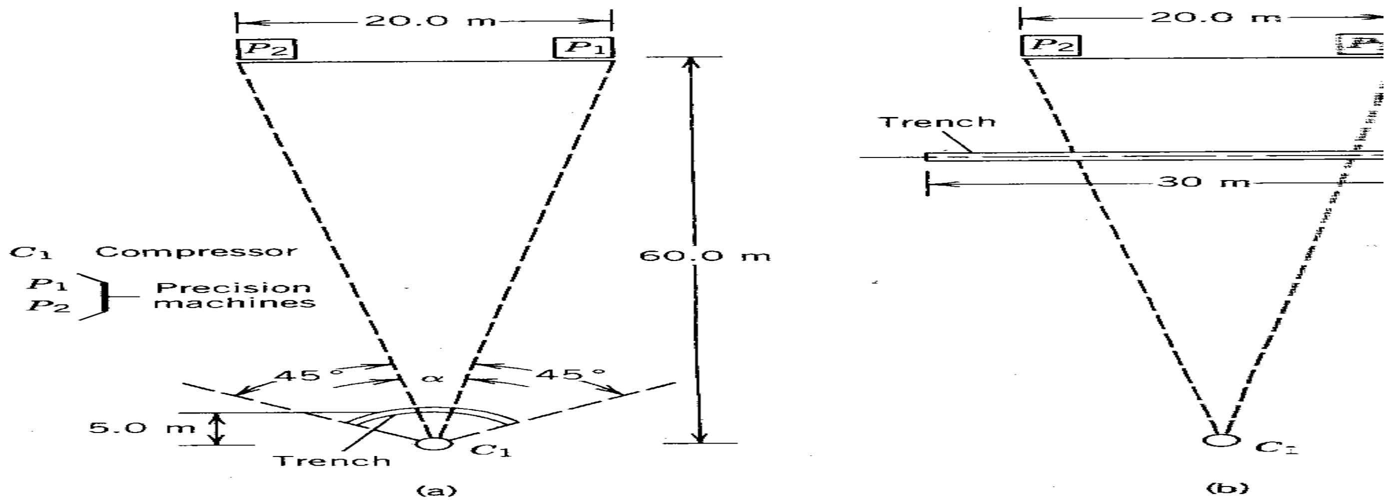


Figure 10.20. Layout of compressor and precision machines in the industri 10.7.2). (a) Active isolation; (b) passive isolation.

Chapter 2 :

Construction of machine foundations

…ONSTRUCTION ASPECTS OF BLOCK FOUNDATIONS

…ing

…he selection of the aggregates and proportioning of concrete mix …be made according to specifications laid down in ACI 301 (American …e Institute, 1975) or similar prevalent codes dealing with use of …e for general building construction.

…he ultimate compressive strength of concrete should be in accord …e criteria set forth in ACI 318-83 (American Concrete Institute, … If no information is available, the ultimate strength of concrete …not be less than 150 kg/cm^2 or 2.2 ksi.

…he concreting should be done in horizontal lifts. The first pour should … in a 300-mm (12-in) layer and subsequent pours in 400-mm (16-in)

…he height of the pour should be as low as possible, and one must …re that the concrete does not segregate.

…he foundation should be concreted in a single pour to avoid cold … If it is necessary to have a time gap between two successive pours, …e should be short and should not exceed 30 min.

…ecause of practical difficulties, sometimes a single pour may not be …, and a cold joint becomes unavoidable. In this case, it should be …red as a construction joint and its location chosen with care. The …hicity of the structure at this construction joint should be ensured by …ng a suitable number of dowels and shear keys through the joint, and …control and supervision during the operation. The dowels should be …ough to assure a full capacity bond. Their length beyond the joint …be 4.0 diameters or 12 in, whichever is more. The dowels may be …sing #5 or #6 bars.

…tain an adequate joint in mass concrete construction, such as in … a block, one must provide shear connectors (U-bars) at the level of …t. A strong bond between old and new concrete can be made by …ning or honeycombing the upper surface of the old concrete. The …surface should be cleaned with a hard wire brush and then covered …thin layer of cement grout before the new concrete is poured. For … guidelines for forming a proper joint, one should follow those given … building codes or ACI: 318–83 (American Concrete Institute, 1983).

…are should be taken to avoid bulging of the concrete at offsets by …itably designed form work.

…he areas around openings and pockets should be concreted with care.

…he foundation should be properly cured. Improper curing may lead …inkage cracks, which may widen after the machine is in operation.

Reinforcement

Reinforcement for a Foundation Block. Massive block foun not have the same structural requirements as beams or columns. they are provided with only minimal reinforcement to take ca perature and shrinkage effects. According to ACI 318 (America Institute, 1983), the minimum steel reinforcement† should be ap 0.0018 times the gross concrete area in each direction. The steel be spaced no farther than 18 in center to center. The minimu concrete for protection of reinforcement should be 75 mm (3 bottom and 50 mm (2 in) on the sides and tops. Details for a ty foundation, which was provided to support a compressor unit capacity, are shown in Figure 14.1a, and b.

The reinforcement details for the foundation block of an imp are similar to those discussed above except for the top portion below the anvil where additional reinforcing bars are required of stresses occasioned by impact. The spacing of the bars in thi block is usually kept on 100-mm (4-in) centers. Typical reinforce for a hammer foundation are shown in Figure 14.2a and b.

Reinforcement around Openings and Cavities. A steel re equal to 0.5 to 0.75 percent of a cross-sectional area of an open should be installed around all such features. This must be pro form of a cage. In the case of circular openings, the reinforce overlap for a length equal to 40 times the bar diameter or sh 300 mm (12 in) beyond the point of intersection. Typical re details around a circular opening are shown in Figure 14.3.

14.2 CONSTRUCTION ASPECTS OF FRAME FOUNDATIONS

Concreting

The construction of a frame foundation involves the conc base slab, columns, and deck slab. The concrete mix should b ensure the strength required by the design. This can be done the recommendations of ACI 301 (American Concrete Institu other relevant building codes. In contrast to the constructi foundations, flexural strength is a very important factor in t frame foundations and should receive the utmost consideratio

Concreting the Base Slab. The base slab is usually concret continuous pour in the same manner as for a block foundatic

† For grade 60 steel bars.

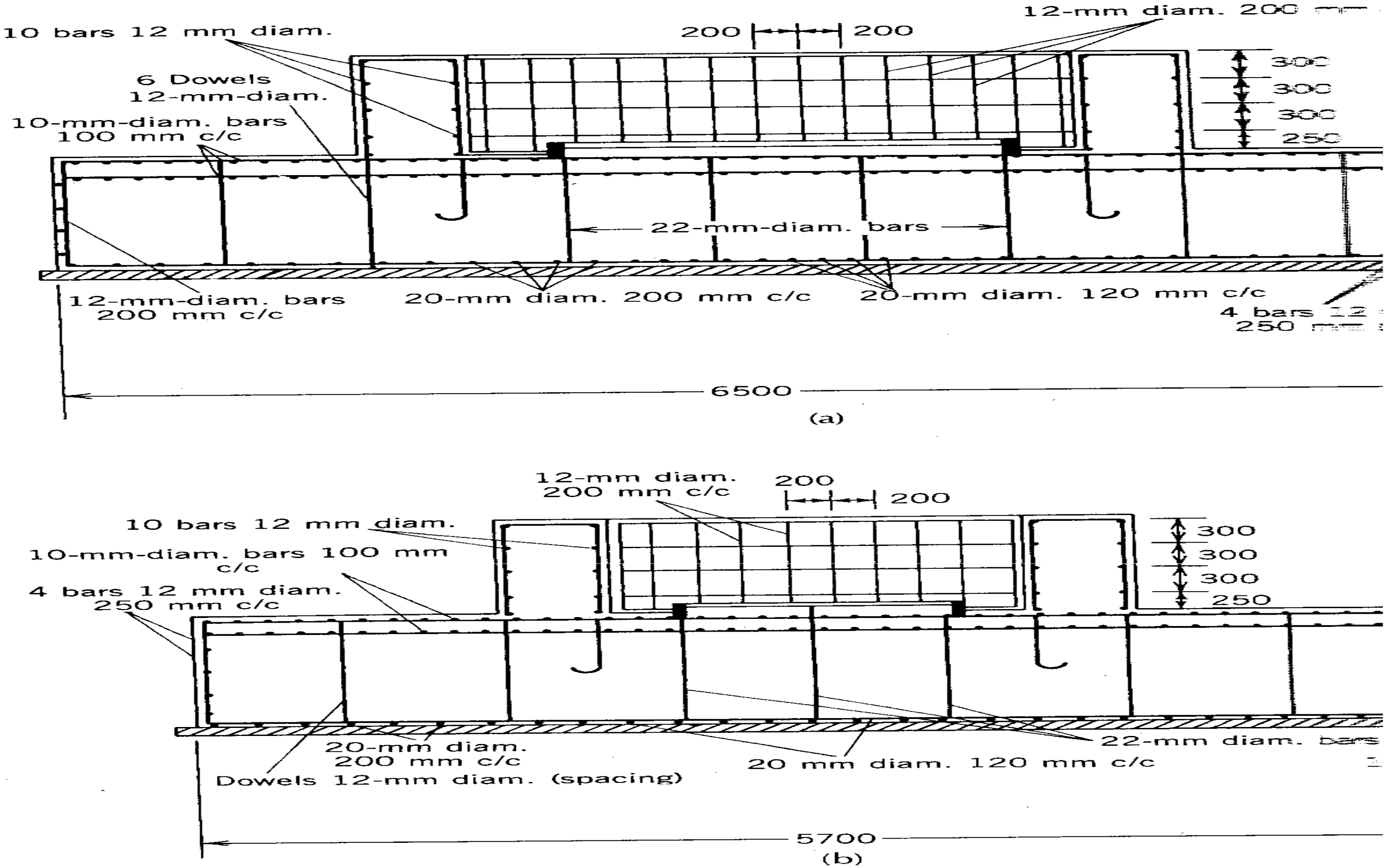
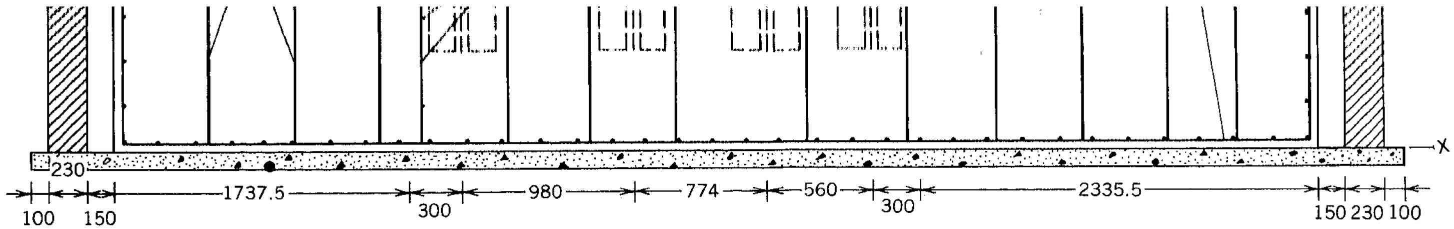


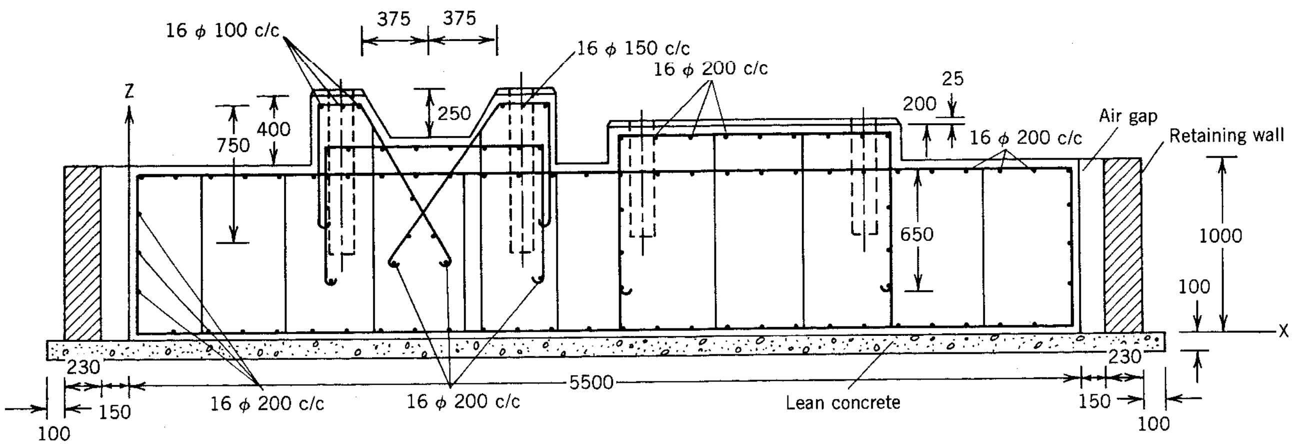
Figure 14.2. (a) Reinforcement details for a hammer foundation: (a) longitud cross section. (After Prakash and Gupta, 1970.)

582



Longitudinal section

(a)



Transverse section

(b)

Figure 14.1. Typical reinforcement details of a concrete block: (a) Longitudinal section; (b) Transverse section. (All dimensions are in mm.)

581

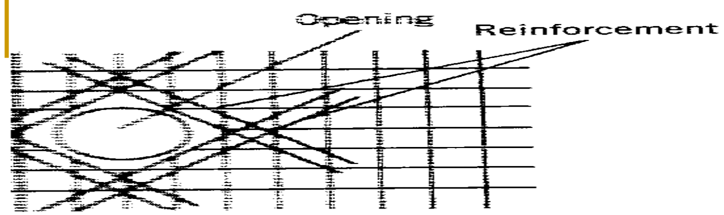
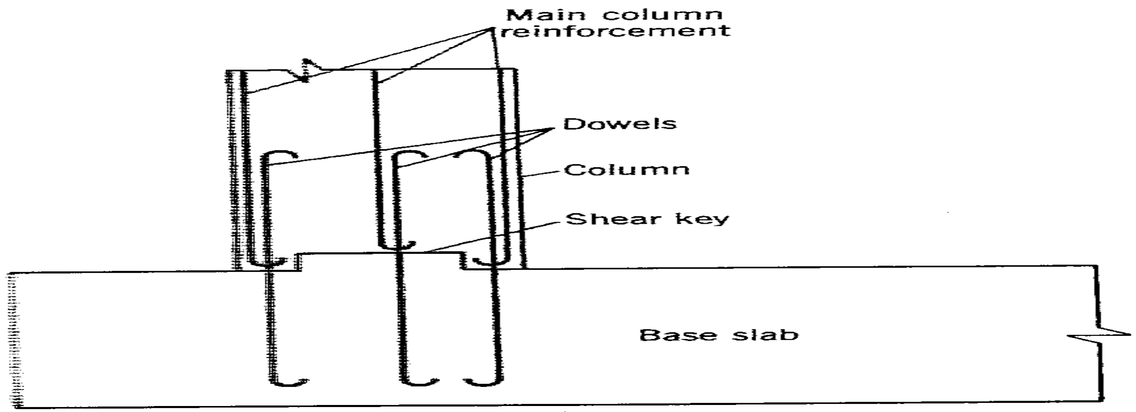


Figure 14.3. Typical reinforcement details around a circular opening.

...ing the Columns and Deck Slab. Although the concreting of the ..., columns, and deck slab in a single continuous pour is desirable, it ... not possible from a practical standpoint. As a result, a construc- ... is formed between the columns and the base slab. Details of a construction joint formed between the columns and the base slab are ... Fig. 14.4. The concreting of the columns and the deck slab is then ... in one pour with the necessary precautions being taken to ensure ... of the structure. When the column heights are more than ... concreting of the superstructure in one pour may not be feasible, ... be necessary to provide a second construction joint, but generally ... joint is not recommended.

... provision of a construction joint in the top part of a column near the ... and in the construction and reduce the height of the pour, thereby ... the chances of the concrete becoming segregated. A construction ... a weak plane from the standpoint of shear strength, and in



...4. Typical details of a base slab-column joint (other reinforcement details not shown ...

…should be insulated to a length of at least 150 mm (6 in) from the …ion point to avoid any stray currents occasioned by induction.

…AP AROUND THE FOUNDATION

…mize the transmission of vibrations to adjoining structures, a gap …e provided around the foundation as shown in Fig. 14.1. For frame …ons, a clear gap should be provided around the base as well as the deck slab. The gap around the foundation should be kept free …bris. If contact of the machine foundation with an adjoining …al unit is unavoidable, two layers of a resilient material such as felt …used at the interface.

…ONDING OF FRESH TO OLD CONCRETE

…be necessary to bond fresh to old concrete to repair a defective …e surface brought about through an unforeseen interruption in the …ing or as a result of a defective casting or improper curing. Also, if …e reason the surface after concreting is loose, it would be necessary …ide a hard surface for proper machine performance. In such cases, …cted area should be chipped off up to 100 mm (4 in) and cleaned. …keys should then be cut into the surface. The number and size of keys depend upon the extent of the surface being repaired. A …m of four shear keys should be provided. The size of the shear keys …be 75 × 75 × 600 mm (3 × 3 × 24 in). They should be thoroughly …. The surface so exposed, including the grooves for the shear keys, …e treated with epoxy. This would consist of Araldite (100 parts), …er (40 parts), and filler silica (4 parts) and be applied in three thin … When the last coat is sticky, rich concrete mix should be poured and …d. Additional steel bars 10 mm (0.375 in) in diameter may be placed … grooves for the shear keys.
…e process of bonding fresh concrete to old concrete is quite expensive …feasible for small areas only.

…INSTALLATION OF SPRING ABSORBERS

…ethods of installing spring absorbers for a machine foundation depend …e type of the absorber system. There are two types of spring absorber …s: the supported and the suspended type. These have been described …apter 10 (Section 10.1).

ضربه گيرهاي نوع محافظ:

- جرم سنگين روي فنرها مستقيما قرار نمي گيرد. براي فنرهاي قسمت پايه دستگاه ، جرم زياد مستقيما روي چهارچوب فلزي قابل نصب است.
- اين نظم وترتيب براي تعادل بهتر بكار مي رود چرا كه وجود نيروهاي نامتعادل خارجي باعث از بين رفتن هارمونيك و هماهنگي دستگاه مي شود.

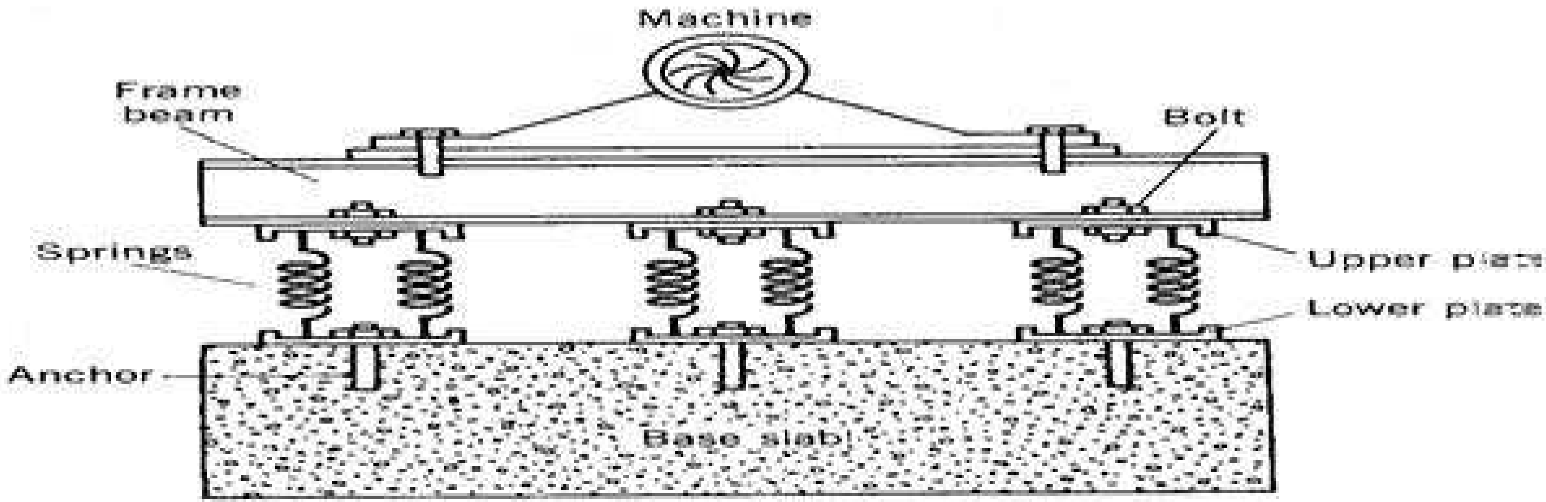


Figure 14.12. Supported-type spring absorber system with machine attached

Chapter 3 :

foundations for impact machines

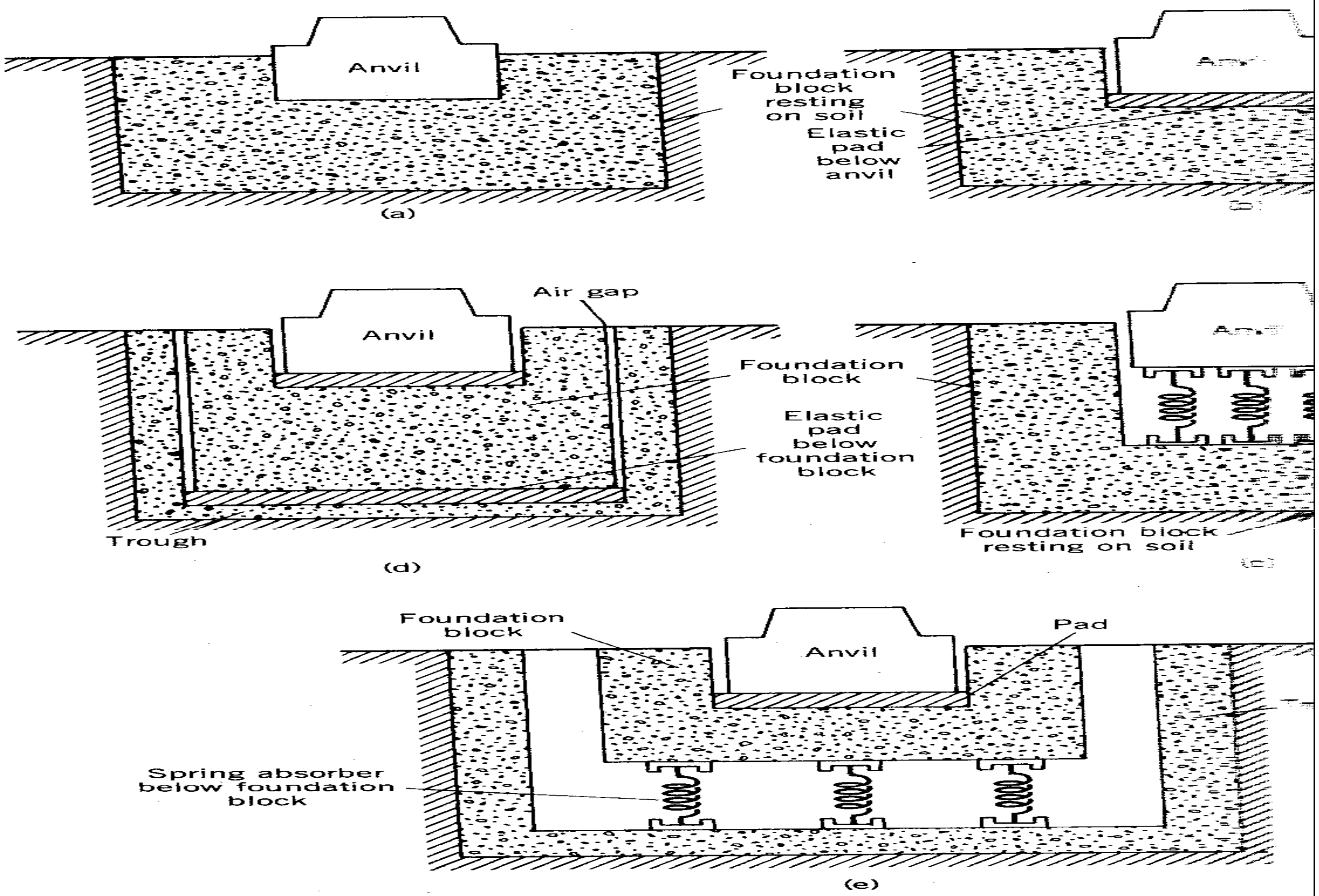
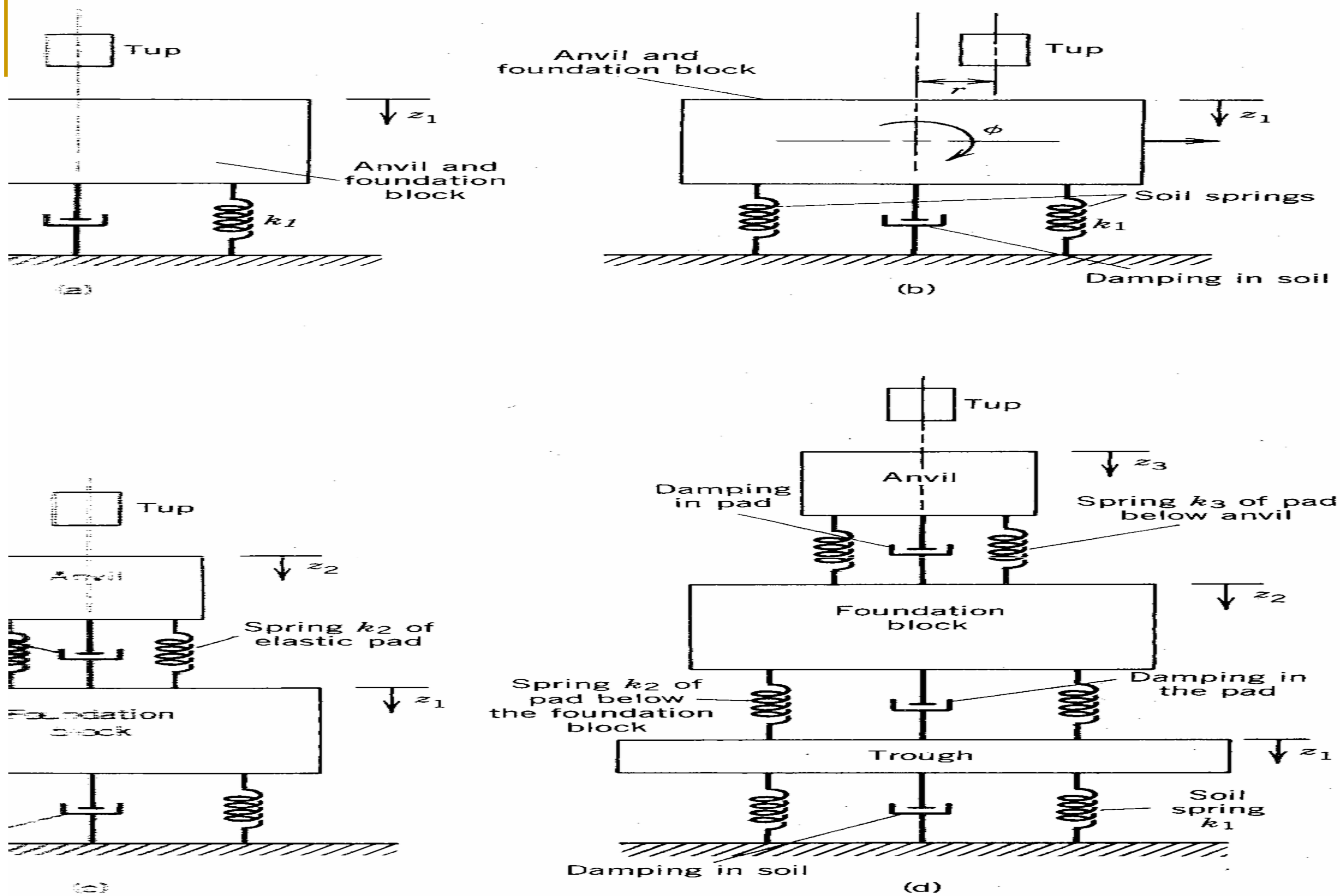


Figure 7.2. Schematic diagram showing different arrangements for s foundation block: (a) anvil resting directly on the foundation block; (b) an (c) anvil on spring absorbers; (d) foundation block on elastic pad; (e) springs.

308



models for representing hammer—foundation—soil systems: (a) single-degree-
central impact); (b) three-degree-of-freedom model (eccentric impact); (c)
dom system (central impact); (d) three-degree-of-freedom system (central

309

will undergo only vertical vibrations and may be modeled as a of-freedom system, as shown in Fig. 7.3a.

When the impact is at an eccentricity, the same system c undergo not only vertical vibrations, but also rocking (rotatic plane and sliding (horizontal translation) and may thus be mo in Fig. 7.3b. For cases when the anvil rests on an elasti foundation block rests directly on soil (Fig. 7.2b, c). the system may be modelled as shown in Fig. 7.3c. If the impac system of Fig. 7.3c can be analyzed as a two degree f undergoing vertical translation. If the impact is at an eccen the masses m_1 and m_2 (Fig. 7.3c) will have three degre consisting of vertical translation and coupled rocking and slid an overall system with six degrees of freedom. When the fo rests on absorber (Fig. 7.2d), the system can be modeled a 7.3d and will have three degrees of freedom for central impa nine degrees of freedom when the impact is at an eccen stiffness of trough (Fig. 7.2d) is usually very high compare pad below the foundation block, the trough may be assum supported on the soil (Novak, 1983) and a two-mass model for all practical purposes. The eccentricity of impact is gene suitably controlling the geometrical layout of the foundat alignment of the tup and frequent maintenance, and most pr thus be analyzed by using a two-degree-of-freedom model 7.3c). The computations can be further simplified by maki assumptions:

1. The anvil, foundation block, frame, and tup are rigid
2. The pad and the soil can be simulated by equivalent w springs.
3. The damping of the elastic pad and soil is neglected.
4. The time of impact is short compared to the pe vibrations of the system.
5. Embedment effects are neglected.

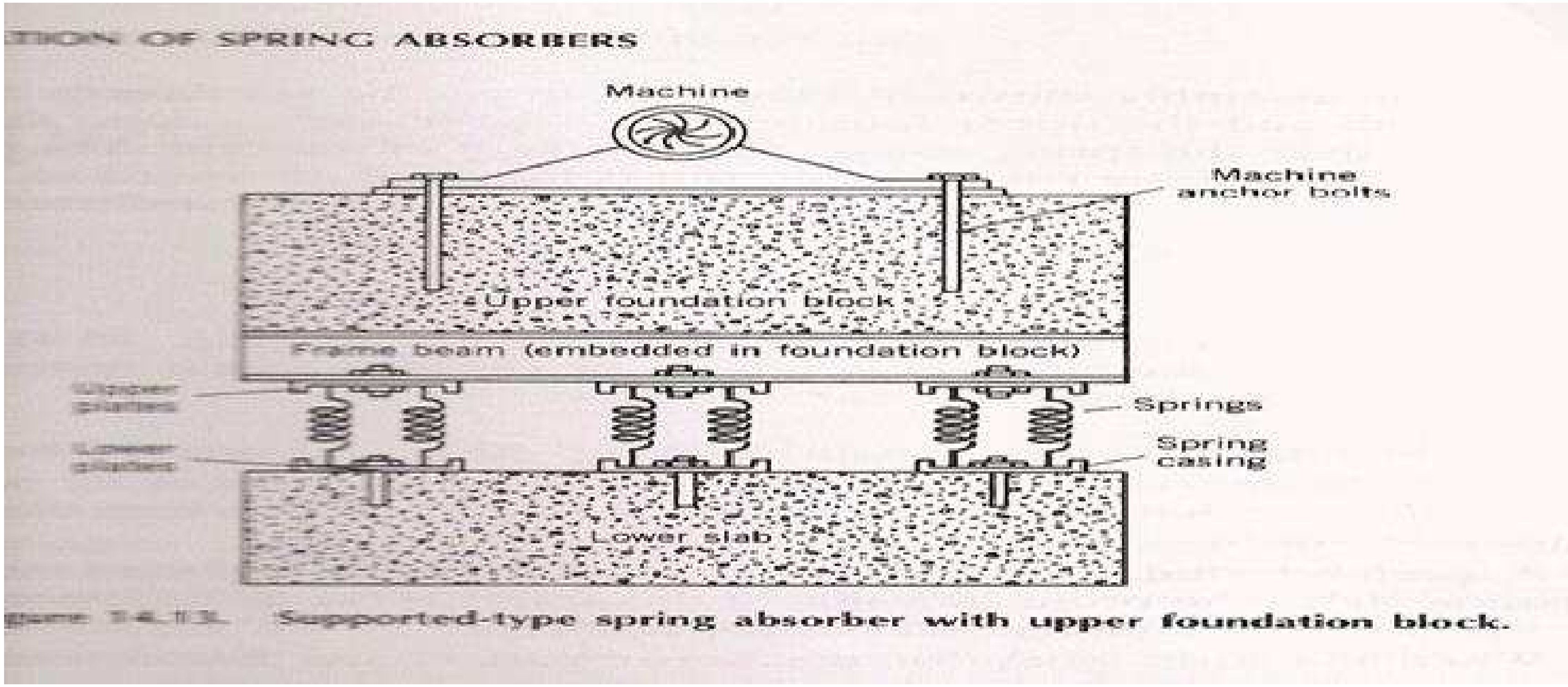
Validity of the Assumptions

Assumption 1 about the rigidity of the anvil, foundation frame is practically correct. The pad material and soil can behave elastically (assumption 2) for small amplitudes of pad between the anvil and the foundation block becomes c losing its elasticity and should be replaced after regular ration. Assumption 3 about neglecting the damping in the p not correct. The foundation block supporting the anvil u vibrations and a significant amount of geometrical as

اصول ايجاد چنين فنداسيوني عبارتست از:

- ۱- ساختار صفحه اصلي كه مشابه با بلوك و قالب پايه است كه ضخامت آن بستگي به طراحي پايه دستگاه دارد كه در حدود 0.3 تا 1.2 متر است.
- ۲- قبل از نصب صفحه و قالب پايه ، پيچ هاي محور در موقعيت مناسب براي اتصال صفحات تحتاني ضربه گيرهاي فنري تنظيم مي شوند. و سپس صفحات تحتاني ضربه گيرها در موقعيت خود ثابت مي شوند.
- ۳- چارچوب فلزي پيش ساخته(شامل غلتك هاي فولادي نصب شده بالاي صفحات تحتاني ضربه گير)

- ۴- فنرها در صفحات تحتاني قرار مي گيرند و توسط يك كاور پوشانده مي شوند كه به چارچوب متاليك فوقاني پيچ شده اند.
- ۵-قسمت فوقاني فونداسيون (چارچوب فلزي) به وسيله ي پيچ تنظيم كننده متعادل و متوازن مي شود. جرمي سنگين وزن در بالاي فنرها مورد نياز است.

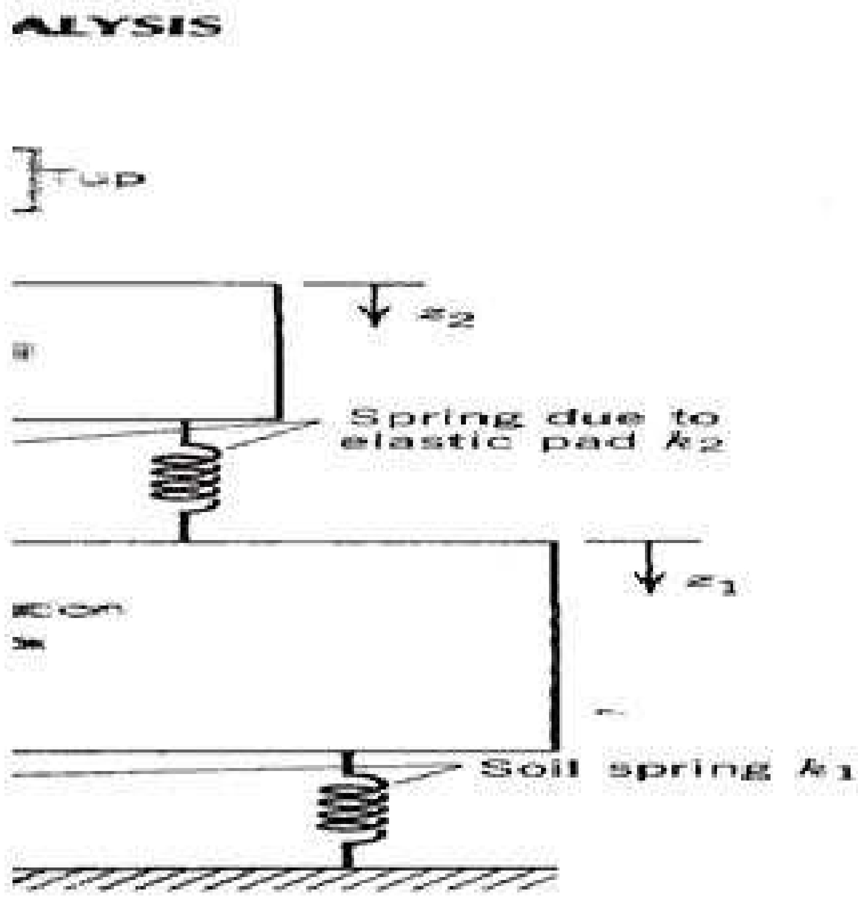


Supported-type spring absorber with upper foundation block.

بوسيله فرضهاي زير مي توان محاسبات را ساده نمود:

- ۱- سندان ، بلوك فنداسيون ، چارچوب و tub صلب هستند.
- ۲- لايه ها و خاك مي توانند به وسيله فنر شبيه سازي شوند.
- ۳- دمپينگ لايه و خاك قابل صرف نظر كردن است.
- ۴- زمان برخورد در مقايسه با ارتعاش سيستم كوتاه است.
- ۵- اثر فرو رفتن قابل اغماض است.

- m1 = جرم فونداسيون و شامل جرم چارچوب (درصورت نصب)
- m2= جرم سندان (شامل جرم نصب شده روي سندان است)
- k1= فنر معادل لايه زيرين فونداسيون
- k2= فنر معادل لايه زيرين سندان
- z1= جابجايي فونداسيون
- z2= جابجايي سندان



$$m_1\ddot{z}_1 + k_1 z_1 + k_2(z_1 - z_2) = 0 \qquad (2.95c)$$

$$m_2\ddot{z}_2 + k_2(z_2 - z_1) = 0 \qquad (2.95b)$$

- مقادير فنرهاي معادل k1 از روش الاستيك بدست مي آيد.(ريچارد ويتمن ۱۹۶۷) ويا از روش فنري خطي كه متد الالستيك معادله عبارتست از:

$$k_1 = k_z = \frac{4Gr_0}{(1-\nu)}$$

- مقادير از روش فنري خطي از معادله فوق به دست مي آيد:

$$k_1 = C_u A_1$$

- A_1 مساحت بلوك پايه در تماس با k_2 است.

- كه k_2 از معادله زير بدست مي آيد:

$$k_2 = \frac{E}{b} A_2$$

- كه E مدول يانگ براي لايه است. و b ضخامت لايه و A_2 مساحت بستر سندان در تماس با لايه است.

فركانس هاي طبيعي:

- دو فركانس ω_{n1} و ω_{n2} از ارتعاشات از معادله زير تعيين مي شوند:

$$\omega_n^4 - (1+\mu)(\omega_{nl_1}^2 + \omega_{nl_2}^2)\omega_n^2 + (1+\mu)\omega_{nl_1}^2 \omega_{nl_2}^2$$

- كه نهايتا با توجه به روابط صفحه بعد به فرمول هاي زير مي رسيم:

$$z_2 = \frac{V_a}{(\omega_{n1}^2 - \omega_{n2}^2)} \left\{ \frac{(\omega_{nl_2}^2 - \omega_{n2}^2)\sin \omega_{n1} t}{\omega_{n1}} - \frac{(\omega_{nl_2}^2 - \omega_{n1}^2) \ldots}{\omega_{n2}} \right.$$

$$Z_1 = \frac{(\omega_{nl_2}^2 - \omega_{n1}^2)(\omega_{nl_2}^2 - \omega_{n2}^2)}{\omega_{nl_2}^2(\omega_{n1}^2 - \omega_{n2}^2)\omega_{n2}} V_a$$

$$Z_2 = \frac{(\omega_{nl_2}^2 - \omega_{n1}^2)V_a}{(\omega_{n1}^2 - \omega_{n2}^2)\omega_{n2}}$$

niting natural frequency of the anvil and foundation resting
l (assuming the anvil is rigidly attached to the foundation

niting natural frequency of the anvil vibrating on the elastic
r springs, and

$$\mu = \frac{m_2}{m_1}$$

of ω_{nl_1} and ω_{nl_2} may be calculated as

$$\omega_{nl1} = \sqrt{\frac{k_1}{m_1 + m_2}} \tag{2.99a}$$

$$\omega_{nl2} = \sqrt{\frac{k_2}{m_2}} \tag{2.99b}$$

Anvil and Foundation Motion

s of anvil and foundation vibration may be computed by
free vibrations of the anvil–foundation soil system as being
initial velocity imparted to the anvil by the impact of the ram
iece being forged.
ar solutions for amplitudes of vibration may be obtained by
nd z_2 as follows:

$$z_1 = C_1 \sin \omega_{n1} t + C_2 \sin \omega_{n2} t \tag{7.2a}$$

$$z_2 = D_1 \sin \omega_{n1} t + D_2 \sin \omega_{n2} t \tag{7.2b}$$

litions of vibration may be expressed by using Eq. (7.3). At

$$z_1 = z_2 = 0 \tag{7.3a}$$

$$\dot{z}_1 = 0 \quad \text{and} \quad \dot{z}_2 = V_a \tag{7.3b}$$

he initial velocity of anvil motion. By substituting z_1 and z_2
into Eqs. (2.95b and c) and using the initial conditions given
he expressions for z_1 and z_2 are obtained Eq. (7.4):

$$\frac{(\omega_{nl_2}^2 - \omega_{n1}^2)(\omega_{nl_2}^2 - \omega_{n2}^2)}{\omega_{nl_2}^2(\omega_{n1}^2 - \omega_{n2}^2)} \left(\frac{\sin \omega_{n1} t}{\omega_{n1}} - \frac{\sin \omega_{n2} t}{\omega_{n2}}\right) V_a \tag{7.4a}$$

سرعت وشتاب اوليه سندان در زمان اصابت ضربه:

- براي يك چكش تك كاره ، سرعت اوليه در زمان اصابت ضربه پس از رها شدن سندان عبارتست از :

$$V_{Ti} = \eta\sqrt{2gh}$$

- كه h افتادن tup در مقياس متر است و g شتاب جاذبه زمين و η بازده و راندمان با توجه به ازدست رفتن انرژي در جذب نيروي اصطكاك و مقاومت فشار هوا و يا بخار است

$$V_{Ti} = \eta\sqrt{2g\,\frac{(W_o + pA_p)h}{W_o}}$$

- ω0 وزن ناخالص بخشهاي در حال سقوط است.
- P فشار هوا و يا گاز
- Ap مساحت پيستون شبكه است.

of Anvil Motion V_a

ocity of the anvil just after the tup's impact can be determined aw of conservation of momentum. The impact of the tup on be central or eccentric (Fig. 7.5). In cases of central impact, ocity V_a may be computed by assuming that the impact takes ertical plane through the centroid of the foundation. The act will result only in translational vibrations in the vertical only linear momentum need be considered. The momentum of e impact is $(W_o/g)V_{Ti}$. The anvil is initially at rest, and its fore impact is zero. The momentum of the tup and anvil after n by

$$\frac{W_o}{g} V_1 + \frac{W_2}{g} V_a$$

the velocity of the anvil after impact, W_2 the weight of the g the frame if it is mounted on the anvil), and V_1 the velocity l of the tup after impact. According to the principal of impact es, the momentum before and after the impact in a conser- is constant. Therefore,

$$\frac{W_o}{g} V_{Ti} = \frac{W_o}{g} V_1 + \frac{W_2}{g} V_a \tag{7.8}$$

) has two unknowns, V_1 and V_a. A second equation may be

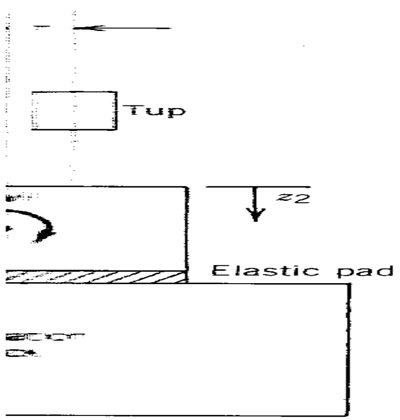


Figure 7.5. Model for calculating initial velocity of anvil for the case of eccentric impact.

با استفاده از قانون نیوتن ضریب ارتجاع e از معادله زیر تعریف مي شود:

$$e = \frac{\text{relative velocity after impact}}{\text{relative velocity before impact}}$$

- ضریب ارتجاع الاستیك بستگي به سرعت اجسام در هنگام اصابت دارد. ضریب ارتجاع میان دو جسم هم اندازه يك است.
- وقتي يك جسم صلب به يك جسم پلاستیكي برخورد مي كند e صفر است. در این صورت دامنه e بين يك و صفر مي باشد.
- ضریب ارتجاع با معادله زیر افزایش مي یابد:

$$e = \frac{V_a - V_1}{V_{Ti}}$$

- از معادله زیر va بدست مي آید:

$$V_a = \frac{1 + e}{1 + s} V_{Ti}$$

- که :

$$s = \frac{W_2}{W_o} = \frac{m_2}{m_o}$$

- mo = جرم قطعات در حال رها شدن است.

- اگر ضربه چكش روي مركز سندان نباشد در حركت طولي و در مسير عمودي ، سندان داراي دوران خواهد شد كه از طريق مركز ثقل سندان عبور مي كند. به علاوه نيروي حركت آني چكش و سندان نيز در شرايط گريز از مركز از اين معادله بدست مي آيد:

$$\frac{W_e}{g} V_{Ti} r = \frac{W_e}{g} V_1 r + M_{m2} \dot{\phi}_a$$

- كه r گريز از مركز و M_{m2} گشتاور جرم چكش در اطراف محور چرخش Φ_a سرعت اوليه سندان است.
- كه خواهيم داشت:

$$e = \frac{(Va + r\dot{\phi}_a - V_1)}{V_{Ti}}$$

: impact, it is $V_a + r\dot{\phi}_a - V_1$. By applying Eq. (7.9), we obtain

$$e = \frac{(Va + r\dot{\phi}_a - V_1)}{V_{Ti}} \tag{7.13}$$

.8), (7.12), and (7.13), the values of V_a and $\dot{\phi}_a$ are obtained as

$$V_a = \frac{(1 + e)k^2}{(1 + s)(r^2 + k^2) - r^2} V_{Ti} \tag{7.14a}$$

$$\dot{\phi}_a = \frac{s(1 + e)r}{(1 + s)(r^2 + k^2) - r^2} V_{Ti} \tag{7.14b}$$

equal to $M_{m2}g/W_o$. When r is zero, i.e., for central impact, nd (7.14b) yield

$$V_a = \frac{(1 + e)}{1 + s} V_{Ti}$$

n for V_a is the same as in Eq. (7.11a).

ad

mpressive stress in the elastic pad below the anvil depends tive displacements of anvil and the foundation block. The compression in the pad develops when the anvil moves d at the same instant of time, the foundation block moves maximum compressive stress in the pad is thus expressed by

$$\sigma_p = k_2 \frac{Z_1 + Z_2}{A_2} \tag{7.15}$$

e Transmitted by the Foundation

orce F_{dyn} transmitted to the soil is given by

$$F_{dyn} = k_1 Z_1 \tag{7.16}$$

Soil

itted to the soil σ through the combined static and dynamic ssed by

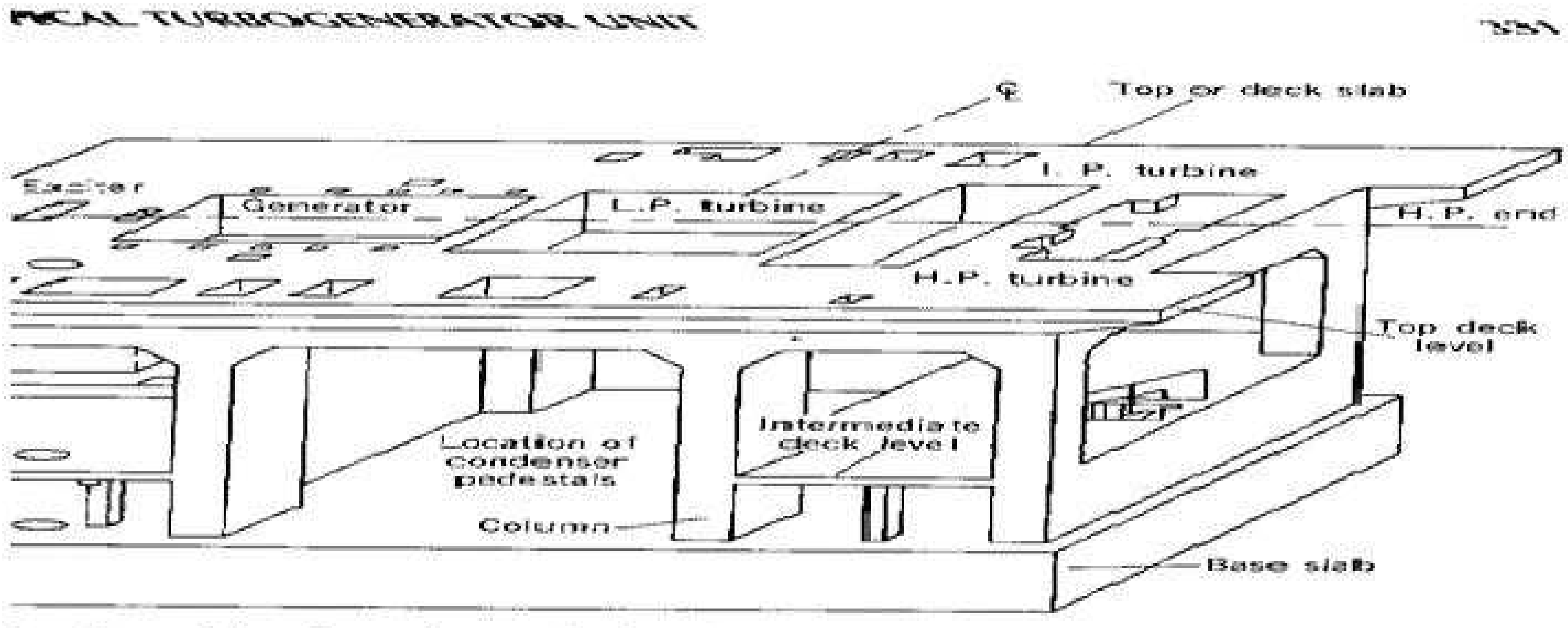
$$\sigma = \frac{W_1 + W_2 + Z_1 K_1 A}{A_1} \tag{7.17}$$

Chapter 4 :

foundations for high-speed rotary machins

8.2 بارهاي روي توربوژنراتورها:

- در طي سرويس هاي دستگاههاي برقي ، فونداسيون T.G (توربو ژنراتور) داراي انواع مختلفي از نيروها و بارها است.

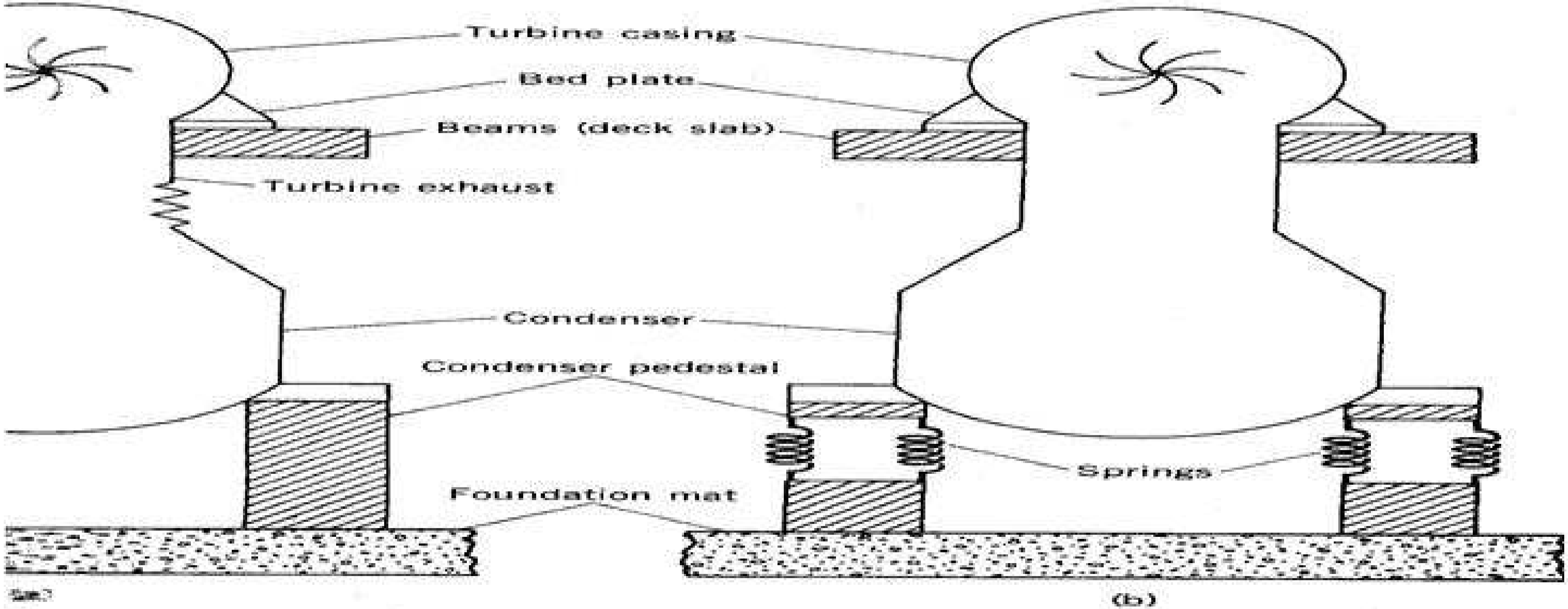


1. Isometric view of a typical turbo-generator frame foundation.

- طراحي توربوژنراتور از نقطه نظر ماهيت بارهاي تحت تاثير فونداسيون را مي توان اين گونه تقسيم بندي كرد:

۱- بارهاي ناشي از عملكرد طبيعي و نرمال دستگاه

۲- بارهاي ناشي از شرايط اضطراري و فوري



...ic arrangement of supporting condensers: (a) condenser on rigid supports; ...ring supports.

8.2 بارهاي ناشي از عملكرد نرمال دستگاه:

- ۱- بار ساكن
- ۲- بار پويا
- ۳- بارهاي متراكم
- ۴- بارهاي حرارتي
- ۵- بارهاي لوله(pipe)
- ۶- بارهاي نامتعادل ناشي از دستگاه
- ۷- بارهاي گشتاور

When the condenser rests directly on the rigid supports, t
weight of the condenser unit is transferred to the foundation
springs are provided between the condenser and the base m
transferred partly to the base mat and partly to the deck sl
stiffness determines the proportion in which the load is shar
base slab and the deck. The stiffness of the springs may be
manufacturer of the turbine or condenser.

Loads Due to Vacuum in Condenser. The pressure on th
is atmospheric and the pressure in the condenser is below
pressure. The differential pressure between the turbine
condenser results in a suction or a vacuum load transferred
through turbine base plates. The magnitude of the vacu
nificantly large and may be several times the weight of the c
considered as a distributed load along edges of supporting
results in localized stress concentration and torsion. The a
this vacuum load acts is the area of the opening (joint) th
condenser to the turbine outlet. The condenser vacuum
calculated using Eq. (8.1):

$$P_v = A(p_a - p_c)$$

in which

P_v = condenser vacuum load
A = area of joint opening between the turbine and con
p_a = atmospheric pressure
p_c = vacuum pressure

The pressure in the condenser is below the atmospheric
amount $(p_a - p_c)$, which represents depression in the conc
The information on condenser vacuum load is furnished
turer of the turbine.

Thermal Loads

The heat emitted by pipes carrying superheated steam, cir
or hot gases through the turbines and operation of the m
rise to temperature changes that result in temperature g
foundation components causing additional stresses on them
heats up, the shaft expands. The shaft is supported on a sin
permitting its free sliding in the longitudinal direction and
are induced due to expansion of the shaft. The therma
concrete is low compared to that of steel and therefor
temperatures of turbine and generator result in local dis

crete. Heat buildup in turbine casing and bed plates induces ng on the foundation. The expansion of the casing and bed achine relative to the concrete deck results in frictional loads at are internally balanced (resulting in local effects but no net t.

to estimate precisely the magnitude and direction of thermal ey depend on a number of factors, such as the distance points where bed plates are held down with anchor bolts, n the bed plates and concrete, and the load on the bed plate. te estimate of the thermal load may be made by using Eq.

$$F_T = \mu P \tag{8.2}$$

l load
ent of friction between material of bed plate and material of

loads due to machine, condenser, pipes, and normal torque

o temperature changes are generally taken into account by ential temperatures between the upper and the lower slabs e inner and the outer faces of the deck slab as specified by er. The deck slab is considered as a horizontal frame and nts due to differential temperature are accounted for. Con-ld also be given to change in direction of thermal loads l shut down.

load includes self weight of pipe, dynamic effect of fluids in al effects. The magnitude of pipe load and its distribution on depend upon pipe material, size, insulation, and layout gnitude of pipe load is specified by the manufacturer.

ads Due to Machine

l generator rotors are well-balanced equipment. The unbal-s checked and corrected or minimized during test runs by rototype on specially designed test or balancing beds. The ce is ascertained by monitoring the vibration amplitudes at The unbalance is specified as the distance between the axis of ass center of gravity of the rotor, and is known as effective e operation of the machine causes unbalanced forces that

depend upon speed of rotation. The magnitude of unbalanc
moments can be calculated using Eqs. (5.38) and (5.39). Th
pulsating loads are transferred to the foundation through the s
The T.G. manufacturers provide information about unbalan
should be used in the design of the foundation under nor
conditions. In designing a T.G. foundation, most unfavorabl
of unbalanced dynamic loads should be used.

Torque Loads

The torque considered here is different from that due to un
(moments due to machine operation). Forces due to steam i
section impose a torque on the stationary turbine casing
opposite to the direction of rotation of the rotor. The norma
generator stator acts in the direction of rotor rotation. The m
torque depends upon the operational speed and power out
the turbines. The turbine manufacturers provide the inform
magnitude of this torque. This torque is applied to the f
couple acting through the machine bed plates.

For a T.G. unit having a multistage turbine Fig. 8.3, the
calculated as follows:

$$T_A = \frac{10.48 P_A}{N} \text{ t m}$$

$$T_B = \frac{10.48(P_B - P_A)}{N} \text{ t m}$$

$$T_C = \frac{10.48(P_c - P_B)}{N} \text{ t m}$$

$$T_g = \frac{10.48(P_c)}{N} \text{ t m}$$

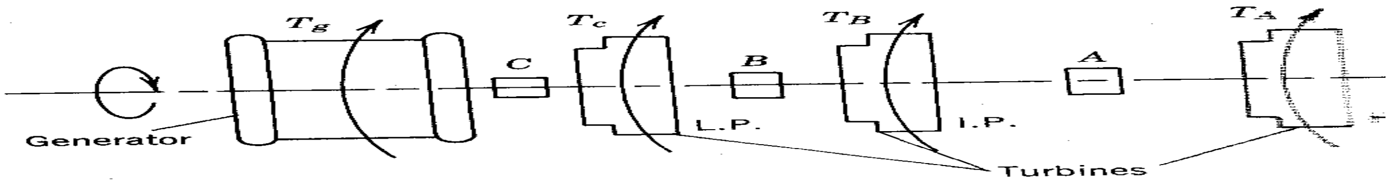


Figure 8.3. Torque due to normal operation of a multistage turb

با تشکر از حسن توجه شما