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H 310 GENERAL REQUIREMENTS

All structures should be designed to sustain, within the allowable stresses, all applicable design loads and forces which are properly distributed. Allowable stresses are discussed in subsequent chapters, according to the type of material. Standards to be used in the selection of design loads and method of distribution are as follows:

a. The design standards in these Manuals.

b. State of California Department of Transportation (Caltrans), Bridge Planning and Design Manual (BPDM), Volume I, Sections 2 and 3.

c. The American Association of State Highway and Transportation Officials (AASHTO), Standard Specification for Highway Bridges (latest edition) and Specifications for the Design and Construction of Structural Supports for Highway Signs (latest edition).

d. The American Railway Engineering Association (AREA), Manual for Railway Engineering (latest edition as modified by the concerned railroad company) for railroad bridges.

e. Los Angeles City Building Code (LABC) for structures requiring a Los Angeles City Building Permit.

f. The governing code or specifications of the agency under whose jurisdiction the structure is to be constructed and maintained (e.g. LACFCD Structural Design Manual).

Structures are proportioned for the following loads and forces when they exist:

a. Dead Load of structure including superimposed loadings.

b. Live Load including applicable overloads.

c. Impact or dynamic effect of the live load.

d. Wind- Loads.

e. Seismic forces.

f. Earth pressures.

g. Thermal forces.

h. Other forces including longitudinal forces, centrifugal forces, buoyancy, shrinkage stresses, rib shortening, erection stresses, water pressure, construction loads, etc.

H 320 DEAD LOAD

Dead load consists of the vertical earth loads and the weight of the complete structure, including permanent building partitions, fixed service equipment, the roadways, sidewalks, railings, car tracks, ballast, and utilities. In addition, the dead load for vehicular bridge structures should also include an anticipated future wearing surface in addition to any surface or deck seal placed on the structure initially (35 psf (1.68 kPa) is recommended).

The unit weight of materials used in computing the dead load are listed in AASHTO-Section 2 and AREA-Chapters 8 and 15.

For earth covers less than the width of structures, the vertical earth load is computed ordinarily as the weight of earth directly above the structure with the minimum unit weight of earth taken as 120 pcf (1921 Kg/m) (shallow earth cover). For greater earth cover, the structure is designed as a subsurface structure. Effective earth pressures due to soil masses and surcharge loads used in the design of subsurface and retaining structures are discussed in Section H 370, Earth Pressures.

H 330 LIVE LOAD

Live load consists of the applied moving load of vehicles, cars, trains, pedestrians, etc. Distribution of surcharge live loads through earth as vertical and lateral forces is discussed in Subsection H 374.

H 331 HIGHWAY LIVE LOAD

The highway live loading and its application on the roadway of bridges or incidental structures is specified in BPDM, Volume I, Subsection 2-4 and Section 3. Alternate Military Loadings (AASHTO 1.2.5G) and Permit Design Loadings (BPDM 2-4.1) need not be used. The HS20-44 loading is the standard design loading for highway structures.

H 332 RAILROAD LIVE LOAD

Railroad live loads should be Cooper E-loading as recommended in the AREA Manual, Chapters 8 and 15, or as modified by the requirements of the affected railroad company. The requirements of some railroad companies are listed in Section H 270, Railroad Bridges. The recommended live load per track in the AREA Manual is Cooper E80 for concrete and steel bridges. The use of lesser live loading such as for branch or spur lines must be approved by the railroad company involved.

E-loadjngs are used in the design of all conduits or structures supporting railroad right-of-way or tracks.

H 333 MISCELLANEOUS LIVE LOADS

Following are design live loads to be used for frequently encountered miscellaneous structures or their elements. These minimum loadings should be increased if higher live loads are anticipated.

H 333.1 SIDEWALKS, CURBS AND RAILINGS

The design live loads for sidewalks, curbs, and railing (traffic and pedestrian) are specified in BPDM, Volume I, Subsection 2-13. The design uniform continuous live loading to be applied to the top rail is 50 plf (730 N/M). In addition, all balusters, pickets, intermediate rails and other railing elements should be designed to resist that uniform load or a 150 pound (667 N) concentrated load applied at any location. These loadings are not cumulative. Member deflections should be limited to 1/2% of the span.

H 333.2 BIKEWAY AND PEDESTRIAN BRIDGES

The design live loading is as specified for pedestrian bridges in BPDM, Volume I, Subsection 2-13.1, except that the bridge should be designed using one of the following live loads, which- ever produces higher stress in the members:

a. Live load of 85 psf (4.07 kPa), except for bridges on private property requiring a Department of Building and Safety permit which may be designed for lOO psf (4.79 kPa) if required.

b. A light sidewalk sweeper. Design for the actual weight of the sweeper if available, but not less than a total weight of 4,000 pounds (1814 kg) distributed as three concentrated loads (Figure H 333.2).

H 333.3 EQUESTRIAN BRIDGES

The design live load to be applied to equestrian bridges, unless other live loads govern, shall consist of the 10-ton H-load group, containing an H-10 truck and corresponding lane load, as illustrated in Figures 1.2.5A, B of AASHTO.

H 333.4 SPECIAL STRUCTURES

The live loads to be used in design of special structures, either publicly or privately owned which are within the public way, are as follows:

a. Sidewalks, elevator doors, driveways, utility vaults and other sidewalk area structures300 psf (14.36 kpa)

b. Driveway bridges:

1.	Commercial, industrial areas	H 15-44
2.	Residential areas	H 10-44
3.	Raised median	H 15-44

c. Structures in City Easement (Slope 5:1 or less) H 15-44

Structures in City Easement (Slope more than 5:1)...2' earth surcharge

d. Structures in City traveled way H 20-44

H 333.5 PUMPING AND TREATMENT PLANT STRUCTURES

The design live loading shall be as follows:

a. Roof slabs, tank covers and galleries - Design for anticipated loads. 100 psf (4.79 kpa) L.L. or for

b. Floor slabs and stairways 100 psf (4.79 kpa) (min.)
c. Heavy equipment rooms 300 psf (14.36 kpa)

(use actual weights of equipment for the design of floor beams).

d. Electrical equipment rooms 250 psf (11.97 kpa)

H 340 IMPACT AND VIBRATION

Due to the dynamic nature of moving loads, the live load stresses produced by vehicular or railroad loadings are increased to include the effects of dynamic, vibratory, and impact forces.

The distribution of impact load through earth fill to underground conduits and structures, is discussed in Subsection H 374.

Impact is applied to items in Group A and not to those in Group B.

H 341 GROUP A

a. Superstructure, including steel or concrete supporting columns, steel towers, legs of rigid frames, and generally those portions of the structure which extend to the main foundation.

b. The portion above the ground line of concrete or steel piles which are rigidly connected to the superstructure as in rigid frames or continuous designs.

H 342 GROUP B

a. Abutments, retaining walls, piers, piles, except Group A, Item b above.

b. Foundation pressures and footings.

c. Timber structures.

d. Culverts and other structures having earth cover of 3 feet (0.91 m) or more.

H 343 IMPACT FORMULA, VEHICULAR

Impact is expressed as a fraction of the live load stress, and the formula is discussed in AASHTO l.2.l2, Impact.

H 344 IMPACT FORMULA, RAILROAD

The impact formulas which pertain to railroad loadings are specified in Chapters 8 and 15 of the AREA Manual as modified by the railroad company.

H 345 VIBRATION

Allowances should be made for the effects of vibratory forces as explained in the General Features of Design, Subsections H 257 and H 281.

H 350 OVERLOAD

When vehicular bridges are designed for lighter than HS 20 or H 20 loadings, the Overload Provisions of AASHTO, latest edition, shall apply.

H 360 SEISMIC FORCES

Generally, all structures except underground structures should be designed to resist earthquake (seismic) forces. All bridges should be designed to conform to the seismic design requirements included in the current AASHTO LRFD Bridge Design Specifications and respective Caltran amendments. Building structures should be designed to conform to the current City of Los Angeles Building Code.

The dynamic pressure on fluid containers due to the effect of seismic forces should be included in the structural design (see Reference 1).

H 370 EARTH PRESSURES

Vertical and lateral earth pressures due to soil mass and surcharge loadings (dead and live) for design of subsurface and retaining structures are discussed in this subsection.

H 371 EARTH LOADS - UNDERGROUND CONDUITS AND STRUCTURES

Earth loads or rigid underground conduits and structures (except tunnel supports and jacked pipe conduits, Subsection H 372) are determined by means of "Marston's Theory of Loads on Underground Conduits" (see Reference 2). The theory states that the load on a buried conduit is equal to the weight of the prism of earth directly over the conduit plus or minus the friction forces on the prism due to differential settlement of earth.

Earth load computations, based on the construction methods that influence the loads, are classified into three conditions:
trench condition, projection conditions, and imperfect trench condition. The essential features of these conditions are illustrated in Figure H 371 and discussed in the following subsections. For loads on flexible underground conduit, see Subsection 211.4.

H 371.1 NOTATIONS

We = Earth load on full width of conduit along the center line, plf (N/m).

w = The design unit weight of the backfill material (usually taken as 120 pcf (1922 Kg/m3) but not less than actual weight as determined by soil investigation).

H = Height of fill above top of conduit, Ft. (m).

Bd = Horizontal width of trench at top of conduit, Ft. (m).

Bc = Outside width of the conduit, Ft. (m).

Cd = Load coefficient for trench condition.

Cc = Load coefficient for positive projecting condition.

Cn = Load coefficient for negative projecting condition and imperfect trench.

h = The vertical distance between the top of the conduit and the adjacent existing ground.

h' = The vertical distance between the top of the conduit and the surface of the first tage of compacted fill, Ft. (m).

p = The positive projection ratio, h/Bc.

p' = Projection ratio for negative projection (h/Bd) or projection ratio for imperfect trench condition (h /Bc).

rsd = The settlement ratio.

K = Ratio of active lateral unit pressure to vertical unit pressure.

u = Coefficient of internal friction of fill material.

Ku = Soil friction coefficient (usual assumed value = 0.15 in the absence of soil test data).

u' = Coefficient of friction (sliding) between fill material and sides of trench.

H 371.2 EARTH LOAD - TRENCH CONDITION

A trench condition is created when a conduit is installed in relatively narrow trench excavated in undisturbed soil. The trench is backfilled with earth which extends to the original ground line (see Figure H 371).

The earth-load on conduits and structures constructed in trench condition is equal to the weight of the backfill material less the frictional resistance of the trench walls and is expressed by the Marston Formula:

$$We = Cd\ w\ Bd^2$$

The coefficient Cd is dimensionless and its value depends upon the soil properties, width of trench, and height of backfill. Figure 371.2A can be used to obtain this value. It should be noted that an increase in the trench width (Bd) reduces the term (H/Bd and also the value of Cd, but since the earth load varies directly with Bd^2, a marked increase in earth load will result. Therefore, the value of Bd should be held to a minimum (see Standard Plan S-251).

A trench width due to over excavation or sloughing may approach a positive projection condition. This width of trench is called the transition width (Figure H 371.2B). Width of trench is measured at the top of conduit.

The earth load is usually calculated as a trench condition if the breadth is less than the transition width, and as positive projection condition if the breadth is equal to or greater than the transition width. However, for h/Bd = 2 or less (approx.), the trench width influences earth loads disproportionately and the positive projection condition may give lesser loads. The least value of earth loading based on trench condition or positive projection condition should always be used in design.

H 371.3 EARTH LOAD - PROJECTION CONDITIONS

The projection condition is subdivided into positive projection and negative projection conditions.

H 371.31 POSITIVE PROJECTION CONDITION

Positive projection condition results when a conduit is installed in shallow bedding with the top of the conduit projecting above the surface of the natural ground and then covered with earth fill (Figure H 371) or where a conduit is installed in a trench wider than permitted for trench condition. The transition width (Figure H 371.2B) is that trench width where trench condition earth loads equal those of positive projection.

The earth load on conduits and structures under a positive projection condition is equal to the weight of the backfill material plus the frictional load transfer from adjacent soil, and is expressed by the Marston Formula:

$$We = Cc\ w\ Bc^2$$

The coefficient Cc (see Figure H 371.3B) is dependent upon several physical factors:

a. The ratio of height of fill to breadth of conduit, H/Bc.
b. The coefficient of internal friction of the soil, u.

c. The projection ratio, p = h/Bc.

d. The settlement ratio, rsd. Its value may be obtained from Figure H 371.3A and is usually taken as 0.7 in the absence of test data.

H 371.32 NEGATIVE PROJECTION CONDITION

A negative projection condition results when a conduit is installed in a shallow trench of such depth that the top of the conduit is below the natural ground surface, but is then covered with earth fill to a higher ground level as shown in Figure H 371.

The earth load on conduits and structures under a negative projection condition is equal to the weight of the backfill material less the frictional resistance of the trench walls, and is expressed by the Marston Formula:

$We = Cn\ w\ Bd^2$

The coefficient Cn (see Figure H 371.3A) is dependent upon several physical factors:

a. The ratio of the height of fill to the horizontal breadth of the trench at top of conduit (H/Bd).

b. The projection ratio p' = h/Bd.

c. The settlement ratio rsd. Its value, which is negative can be obtained from Figure H 371.3A and is usually taken as -0.5 in the absence of soil test data.

H 371.4 EARTH LOAD - IMPERFECT TRENCH CONDITION

The imperfect trench condition (see Figure H 371) is sometimes used to achieve the load reducing characteristic of the negative projection condition in situations where a positive projection condition with high embankment would induce excessive earth loads.

The earth load is calculated using the Marston Formula:

$We = Cn\ w\ Bc^2$ (Surface load is not included)

The value of Cn can be obtained from Figure H 371.3B using procedures similar to that for the negative projection condition, except the value of Bc is used rather than Bd.

The conduit is first insta11ed as a positive projecting conduit. Compacted fill is then placed over the pipe about 1 to 1-1/2 times the width of conduit, then a trench (same width as conduit) is dug to the top of the pipe, Next, the trench is filled with material placed in the loosest possible manner. The remainder of the embankment is then placed in the usual manner. This method of installation is not usually permitted for City projects and should only be used where feasible alternatives are not available and only under rigid control of construction.

H 372 EARTH LOADS - TUNNEL SUPPORTS AND JACKED PIPE CONDUITS

Earth loads used in the design of tunnel supports and jacked pipe conduits differ from those for loads on conduits in open cut.

H 372.1 TUNNEL SUPPORTS

The minimum vertical and lateral earth loads used for design of tunnel supports are as follows: (refer also to Subsection H 213.3, Tunnel Supports and Shaft Shoring):

(Refer to Figure H 372.1 for loading diagram)

$C = K(B + Z)$

$p = 0.3w(0.5Z + C)$

$C' = Cw$

C = Equivalent height of earth loading, Ft. (m).

K = Coefficient which depends on soil type and water table location (see below).

B = Maximum width of tunnel, Ft. (m).

Z = Maximum height of tunnel, Ft. (m).

p = Average unit horizontal earth pressure acting on tunnel supports, psf (pa).

w = Unit weight of soil usually taken as 110 pcf (1762 Kg/m), in the absence of test data.

C' = Average unit vertical earth pressure acting on tunnel supports, psf (pa).

The value of **coefficient K** may be furnished by the Geology and Soils Engineering Section, from field test, or may be recommended by another agency when using their design criteria.

Proctor and White, Reference 3, recommends various values of K depending upon the density of the sand being mined and the care with which the tunnel is excavated, supported, and backpacked. These values range from 0.27 for dense sand with slight settlement of the tunnel crown to 0.60 for loose sand with higher settlement of tunnel crown.

The value of **equivalent height C**, is determined as follows:

a. When the tunnel is constructed below the water table, the value of C should be doubled.

b. When the earth cover over the tunnel is less than 8 feet (2.44 m) or twice C, as determined from the above equation, the full height of cover is used.

c. For tunnels under railroad tracks, the value of C, as determined above, is tripled, but need not exceed the actualearth cover.

H 372.2 JACKED PIPE CONDUITS

The earth load We on pipe conduits jacked through undisturbed soil is calculated as follows:

We = Ct Bt (wBt - 2c)

We = earth load on full width of conduit, plf (N/m).

w = unit weight of soil, pcf (kg/m3)

Bt = OD of pipe, Ft. (m)

c = cohesion, psf (Pa)

Ct = a load coefficient which is identical to that of Cd in Marstons equation (see Subsection H 371.2)

Recommended safe values of cohesion c, for various soils (if it is not practical to determine c from laboratory test) are:

Material	Value of c
Clay, very soft	40
Clay, medium	250
Clay, hard	1,000
Sand, loose dry	0
Sand, silty	100
Sand, dense	300
Top soil, saturated	100

If the soil is not considered homogeneous, contains voids or utility backfill, will undergo substantial vibrations due to live loads, or if the depth of cover is 15 feet (4.51 m) or less, the effect of cohesion should be neglected.

H 373 LATERAL EARTH PRESSURES

Following are recommended lateral earth pressures to be used in the design of retaining structures. The additional effects of surcharge live or dead loads are discussed in Subsection H 374.2.

The type of retaining structure chosen determines the shape of pressure loading diagram to be used in the design, triangular (EFP) or trapezoidal (arching effect).

H 373.1 EQUIVALENT FLUID PRESSURE, EFP

Unbraced (free to overturn) structures which retain drained fills are designed to withstand horizontal equivalent fluid pressures, EFP. For structures supporting the public way, earth weight is assumed as 120 pcf (1922 kg/m3). For structures supporting private property the LABC may be used and earth weight is assumed to be 100 pcf (1601 kg/m2). Equivalent fluid pressures used are as follows:

Slope of Backfill	EFP (Public Way)	EFP (LABC)
Level	36 pcf (577 kg/m3)	30 pcf (481 kgXm3)
5:1	38 pcf (615 kg/m3)	32 pcf (513 kg/m3)
4:1	42 pcf (673 kg/m3)	35 pcf (561 kg/m3)
3:1	46 pcf (737 kg/m3)	38 pcf (609 kg/m3)
2:1	52 pcf (833 kg/m3)	43 pcf (689 kg/m3)
1-1/2:1	66 pcf (1057 kg/m3)	55 pcf (881 kg/m3)
1:1	96 pcf (1538 kg/m3)	80 pcf (1282 kg/m3)

These values should be used in the absence of test data and analysis in a soils report.

A vertical component, Ev, of lateral earth pressure (wall friction) may be assumed to resist overturning in granular soils. This force is applied in a vertical plane at the heel of the footing.

Ev / Eh = O for level backfill

Ev / Eh = 0.33 for backfill steeper than 3:1

Eh = horizontal component of the active earth pressure

Ev = may be assumed to vary linearly for intermediate values of backfill slope.

H 373.2 ARCHING EFFECT

Braced retaining structures (restrained against overturning) such as tieback shorings, tunnel shafts, jacking pits, special manholes, and pumping plant walls should be designed using lateral loads based on arching effects of soil. The trapezoidal pressure loading diagrams to be used are as follows -(refer to Figure H 373.2 A and B):

P = KD

P = unit horizontal pressure, psf

D = depth of excavation, ft.

K = coefficient, depending on the type of soil. In the absence of soil test data, assume for level backfill:

Soil Type	K(Supporting) Public Way	K(LABC)
Saturated Sand	92	92
Saturated or Plastic Clay	46	46
Unsaturated Soil	26	22

For sloped embankment, these K-values should be increased in the same proportion as for sloped embankment EFP tabulated in Subsection 373.1.

H 374 DISTRIBUTION OF SURCHARGE LOADS THROUGH EARTH

The distribution of dead and live load surcharge on underground and retaining structures supporting earth is discussed in this subsection. These loads produce pressures acting both vertically and laterally resulting from pedestrian, vehicular, railroad, and other live load surcharges as well as dead loads from earth, buildings and other adjacent structures.

H 374.1 SURCHARGE LOADS, VERTICAL LOADING

The distribution of vertical surcharge loads on underground structures and conduits is as follows:

H 374.11 HIGHWAY LIVE LOADING

The design highway live load surcharge in the public way is the HS 20-44 truck loading. A lesser loading may be used depending upon the location of the structure (refer to Subsection H 333.4, Special Structures).

Impact loading should not be added to: Vertical load when earth cover is 3 feet (0.91 m) or greater, lateral loads, and invert loads.

Design vertical live loads for circular conduits, RC boxes, and arched conduits are as follows:

Circular Conduits:

Lateral live load surcharge may be neglected. For covers less than 3 feet (0.91 m) and pipe diameters of 36 inches (914 mm) or less, the average live load and impact applied to the conduit is calculated using a modified Marston Formula:

W1 = Ic Ct P/A, pif (N/m)
A = 3 feet (0.91 m), length of conduit
Ic = Impact factor
Ct = Concentrated surface load coefficient, Figure H 374.1A

P = 16,000 lb (72 Kn), HS20 truck load

Depth of Cover	**Impact of Factor (Ic)**
0' to 1'	1.3
1.1' to 2'	1.2
2.1' to 2'-11"	1.1

For depths of cover less than 3'-0" (().91 m) and pipe diameters greater than 36" (914 mm), use a 16 kip (72 Kn) wheel load distributed over an area equal to the Bc of the pipe times 3'-0" (0.91 m) length of pipe. Multiply loads by impact factors indicated above.

For earth covers 3 feet (0.91 m) or greater, the live load is distributed according to AASHTO, Article 1.3.3, and the charts in Figures H 374.1B, C, D, E, F can be used.

For vertical depths of cover greater than 8 feet (2.44 m), the effects of truck loads may be neglected.

RC Box Culverts and Arched Conduits:

For RC box culverts and for arched conduits, design live loadings are as follows:

a. When earth cover is 2'-11" (0.89 m) or less, wheel loads and impact are distributed on the top slab in accordance with AASHTO, Articles 1.3.2 and 1.2.12(c).

b. When the cover is over 2 '-11" (0.89 m) but less than 8 feet (2.44 m), the wheel loads are distributed on the top slab in accordance with Figure H 374.1B and H 374.1D.

c. When the cover is over 8 feet (2.44 m), truck live loading may be neglected if depth of cover exceeds length of structure (see AASHTO, Article 1.3.3).

d. The effect of truck live loads on the invert slabs can be determined using the charts in Figures H 374.1C, H 374.1E, and H 374.1F.

e. The charts in Figures H 374.1B , H 374.1C , H 374.1D , H 374.1E , and H 374.1F include conditions of traffic parallel and perpendicular to the main reinforcement. In general, the maximum value of the two conditions is used. However, where location of the conduit is such that traffic is possible in one direction only, the applicable condition should be used.

H 374.12 RAILROAD LIVE LOADING

The design railroad live loading is the Cooper E-loading (see Subsection H 332, Railroad Live Load).

Impact is applied to the vertical loading on conduits and culvert structures. The AREA recommends 40 percent at 0 cover to 0 percent at 10 feet (3.05 m) cover. Railroad vertical live loads at various depths of cover for E-80 loading are shown in Figure H 374.1G.

H 374.13 OTHER EXTERNAL LOADS

Surcharge loads due to existing or proposed adjacent structures (such as buildings or bridges) should be considered in the design of underground structures and conduits. Uniform surcharge loads may be converted to equivalent additional depth of earthfill. Concentrated loads or line loads may be analyzed as shown in AASHTO 1.3.3.

H 374.2 SURCHARGE LOADS, LATERAL LOADING

Lateral earth pressure due to pedestrian, highway, and railroad live load, dead load and other surcharge loads, are applied as equivalent fluid pressures in the design of subsurface and retaining structures as follows.

H 374.21 PEDESTRIAN LIVE LOADING

Retaining walls and other structures providing lateral support to sidwalks should be designed with a uniform live load equivalent to one foot of earth surcharge. The lateral pressure need only be applied to the upper 10 feet (3.05 m) of the retaining structure and may be ignored where highway live load is used or when the sidewalk falls outside a distance from the wall equal to half the height.

H 374.22 HIGHWAY LIVE LOADING

Lateral earth pressures due to highway live load surcharge are as follows:

RC Boxes:

Lateral pressure for design of substructures such as RC boxes and arch conduits is shown in Figure H 374.2A. Impact need not be applied.

Bridges:

For bridge abutments refer to AASHTO l.2.l9, Earth Pressures.

Retaining Walls and Shoring:

a. Live load surcharge need be applied only to the upper 10 feet (3.05 m) of the wall.

b. Walls with level backfill which support public roadways should be designed with a live load surcharge equivalent to 2' (-0.61 m) surcharge.

c. Live load may be neglected if vehicles do not come within 10' and a distance from the wall equal to half the wall height.

Rectangular Open Channels:

Channels walls supporting a public street easement are designed for HS 20-44 truck live load surcharge. HS15-44 truck loading is used for private or maintenance roads or drainage easements. (See Figure H 374.2B).

H 374.23 RAILROAD LIVE LOADING

The lateral earth pressure due to railroad live loading applied to substructures and retaining structures should be in accordance with the AREA Manual, Chapter 8, Parts 5 and 16. Cooper E-80 loading pressures are shown in Figures H 374.2C and H 374.2D.

H 374.24 OTHER EXTERNAL SURCHARGE LOADINGS

Other surcharge loads due to existing or proposed adjacent structures (such as buildings or bridges) should be distributed as shown in LABC, Section 91.2309. Uniform vertical surcharge loadings may be converted to equivalent additional depth of earth fill.

H 380 OTHER LOADS AND FORCES

Longitudinal forces, wind loads, thermal forces, uplift, forces of stream current, buoyancy and centrifugal forces which may affect highway structures are covered in AASHTO 1.2.13-1.2.18 and 1.2.21. Some of the other loads and forces are discussed here.

H 381 INTERNAL WATER PRESSURES

Internal water pressure is calculated for the conduit flowing just full in combination with other service loading conditions. An additional structural analysis should be made if the maximum hydraulic gradient is more than 5' (1.52 m) above the top of conduit. This analysis includes the following loads: pressure due to hydraulic head above the soffit of the conduit, internal water pressure assuming the conduit flowing just full, dead weight of the structure, vertical and horizontal earth loadings. For this loading condition, the allowable stresses may be increased by one-third.

H 382 CONSTRUCTION LOADS

Structures should be checked for loads sustained during construction. Allowable stresses for temporary construction loads may be increased by one-third.

H 383 SHRINKAGE

Provisions should be made in concrete structures for stresses and movements resulting from shrinkage, such as for arches using a shrinkage coefficient of 0.0002. For other types of structures, refer to the appropriate subsections of Section H 400.

H 384 FRICTION FORCES

For bridge structures, forces due to friction at **expansion bearings** may be neglected when loads on the bearings are such that rolling friction results.

When **rockers** which rotate on pins are used as bearings, a longitudinal force due to friction shall be applied. Its magnitude shall equal the vertical load on bearing, times the coefficient of friction, times the radius of the pin, divided by the radius of the rocker.

When **sliding plates** are used, the longitudinal force due to friction shall be the vertical load times the coefficient of friction.

Logitudinal forces due to friction in bearings shall be applied at the elevation of the plate surface on which the rocker rests or the contact surface of the sliding plates.

Friction in expansion bearings is a consequence of other loads.

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