1.3. Loads and Load Designation

There is a wide range of loads and forces act on bridge structures. Depending on the bridge type, location and function, the designation loads can be determined. Generally, the design loads are classified into two main groups; they are permanent and transient loads as explained below:

1.3.1. Permanent Loads (Time Invariant)

- CR: force effects due to creep.
- DD: downdrag force.
- DC: dead load of structural components and nonstructural attachments.
- DW: dead load of wearing surfaces and utilities.
- EH: horizontal earth pressure load.
- EL: miscellaneous locked-in force effects resulting from the construction process including jacking apart of cantilevers in segmental construction.
- ES: earth surcharge load.
- EV: vertical pressure from dead load of earth fill.
- PS: secondary forces from post-tensioning for strength limit states; total prestress forces for service limit states.
- SH: force effects due to shrinkage.

1.3.2. Transient Loads (Time Variant)

- BL: blast loading.
- BR: vehicular braking force.
- CE: vehicular centrifugal force.
- CT: vehicular collision force.
- CV: vessel collision force.
- EQ: earthquake load.
- FR: friction load.
- IC: ice load.
- IM: vehicular dynamic load allowance.
- LL: vehicular live load.
- LS: live load surcharge.
- PL: pedestrian live load.
- SE: force effects due to settlement.
- TG: force effect due to temperature gradient.
- TU: force effect due to uniform temperature.
- WA: water load and stream pressure.
- WL: wind on live load.
- WS: wind load on structure.

1.4. Load Combinations and Load Factors

The total factored load (Q) effect shall be taken as:

$$Q = \sum \eta_i \gamma_i Q_i$$

The values of load factor (γ_i), which defined before, depend on the case of design or analysis and taken according the intended load combination. ASSHTO specifications adopted these values as tabulated herein.

Table 1.1: Load Combinations and Load Factors [AASHTO LRFD Table 3.4.1-1]

Load Combination Limit State	DC DD DW EH EV ES EL PS CR SH	LL IM CE BR PL LS	WA	WS	WL	FR	TU CR SH	TG	SE	Use One of These at a Time				
										EQ	BL	IC	CT	CV
Strength I (unless noted)	γ_p	1.75	1.00	–	–	1.00	0.50/1.20	γ_{TG}	γ_{SE}	–	–	–	–	–
Strength II	γ_p	1.35	1.00	–	–	1.00	0.50/1.20	γ_{TG}	γ_{SE}	–	–	–	–	–
Strength III	γ_p	–	1.00	1.00	–	1.00	0.50/1.20	γ_{TG}	γ_{SE}	–	–	–	–	–
Strength IV	γ_p	–	1.00	–	–	1.00	0.50/1.20	–	–	–	–	–	–	–
Strength V	γ_p	1.35	1.00	1.00	1.00	1.00	0.50/1.20	γ_{TG}	γ_{SE}	–	–	–	–	–
Extreme Event I	1.00	γ_{EQ}	1.00	–	–	1.00	–	–	–	1.00	–	–	–	–
Extreme Event II	1.00	0.50	1.00	–	–	1.00	–	–	–	–	1.00	1.00	1.00	1.00
Service I	1.00	1.00	1.00	1.00	1.00	1.00	1.00/1.20	γ_{TG}	γ_{SE}	–	–	–	–	–
Service II	1.00	1.30	1.00	–	–	1.00	1.00/1.20	–	–	–	–	–	–	–
Service III	1.00	γ_{LL}	1.00	–	–	1.00	1.00/1.20	γ_{TG}	γ_{SE}	–	–	–	–	–
Service IV	1.00	–	1.00	1.00	–	1.00	1.00/1.20	–	1.00	–	–	–	–	–
Fatigue I LL, IM & CE only	–	1.75	–	–	–	–	–	–	–	–	–	–	–	–
Fatigue II LL, IM & CE only	–	0.80	–	–	–	–	–	–	–	–	–	–	–	–

Table 1.2: Load Factors for Permanent Loads [AASHTO LRFD Table 3.4.1-2]

Type of Load, Foundation Type and Method Used to Calculate Downdrag				Load Factor (γ_P)	
				Maximum	**Minimum**
DC	Component and Attachments	Strength Limit States		1.50	0.90
		Strength IV only		1.50	0.90
DD	Downdrag	Piles, α Tomlinson Method		1.40	0.25
		Piles, λ Method		1.05	0.30
		Drilled shafts, O'Neill and Reese (2010) Method		1.25	0.35
DW	Wearing Surfaces and Utilities			1.50	0.65
EH	Horizontal Earth Pressure	Active		1.50	0.90
		At-Rest		1.35	0.90
		AEP for anchored walls		1.35	N/A
EL	Locked-in Construction Stresses			1.00	1.00
EV	Vertical Earth Pressure	Overall Stability		1.00	N/A
		Retaining Walls and Abutments		1.35	1.00
		Rigid Buried Structure		1.30	0.90
		Rigid Frames		1.35	0.90
		Flexible Buried Structures	Metal Box and Structural Plate Culverts with Deep Corrugations	1.50	0.90
			Thermoplastic Culverts	1.30	0.90
			All others	1.95	0.90
ES	Earth Surcharge			1.50	0.75

Table 1.3: Load Factors for Service III Load Combination [AASHTO LRFD Table 3.4.1-4]

Bridge Component	Load Factor (γ_{LL})
Prestressed concrete components designed using the refined estimates of time-dependent losses in conjunction with taking advantage of the elastic gain	1.00
All other prestressed concrete components	0.80

In current academic course (506064032) only gravity loads are considered to design the deck slabs and girders; therefore, load combinations used which normally have only (DC), (DW) and $(LL + IM)$ as:

- $Q = 1.25DC + 1.50DW + 1.75(LL + IM)$ [Strength I]
- $Q = 1.50DC + 1.50DW$ [Strength IV]
- $Q = 1.00DC + 1.00DW + 1.00(LL + IM)$ [Service I]
- $Q = 1.00DC + 1.00DW + 0.80(LL + IM)$ [Service III/ Prestressed]
- $Q = 1.75(LL + IM)$ [Fatigue I]

By the same way, moment and shear for Strength I limit state shall be:

$$M_u = 1.25M_{DC} + 1.50M_{DW} + 1.75M_{LL+IM}$$

$$V_u = 1.25V_{DC} + 1.50V_{DW} + 1.75V_{LL+IM}$$

1.5. Resistance Factors

Factored resistance shall be the product of nominal resistance determined according to AASHTO specifications.

$$R_r = \phi R_n$$

where:

R_r: factored resistance

R_n: nominal resistance

ϕ: resistance factor

The values of resistance factor (ϕ) shall be taken as:

- For the strength limit state:
  - $\phi = 0.90$ [tension-controlled reinforced concrete sections]
    $= 1.00$ [tension-controlled prestressed concrete sections with bonded strands]
    $= 0.90$ [tension-controlled prestressed concrete sections with unbonded strands]
    $= 0.90$ [shear and torsion reinforced concrete sections]
    $= 0.85$ [shear and torsion monolithic and CIP prestressed concrete sections]
    $= 0.75$ [compression-controlled concrete sections with spirals or ties]
    $= 0.70$ [bearing on concrete]
- For all other limit states:
  - $\phi = 1.00$

Also, for strength limit state, in transition zone (in between compression- and tension-controlled) the resistance factor (ϕ) value shall be obtained by linear interpolation from:

$$0.75 \le \phi = 0.75 + 0.15(\varepsilon_t - \varepsilon_{cl})/(\varepsilon_{tl} - \varepsilon_{cl}) \le 0.9 \text{ [nonprestressed members]}$$

$$0.75 \le \phi = 0.75 + 0.25(\varepsilon_t - \varepsilon_{cl})/(\varepsilon_{tl} - \varepsilon_{cl}) \le 1.0 \text{ [prestressed members]}$$

where:

ε_t: net tensile strain in the extreme tension steel at nominal resistance.

ε_{cl}: compression-controlled strain limit in the extreme tension steel.

ε_{tl}: tension-controlled strain limit in the extreme tension steel.

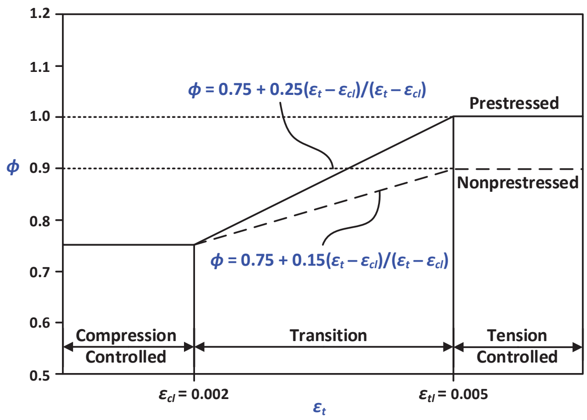

Figure 1.1: Variation of resistance factor with net tensile strain at extreme fibers for reinforced and prestressed concrete [AASHTO LRFD Figure C5.5.4.2-1]