

# Construcción de Espectros CMS

**Miguel Francisco Cruz Azofeifa, Dr. Sc.**

Colegio Federado de Ingenieros y de Arquitectos de Costa Rica

Cochabamba, Bolivia  
19 de julio de 2024

UNIVERSIDAD  
CATÓLICA  
BOLIVIANA  
COCHABAMBA

Espacio opcional para logotipo de  
institución a la que pertenece el  
presentador



Construcción de espectro de diseño para la ciudad de San José, Costa Rica, usando el mapa del CMS y comparándolo con mapa de Código Sísmico de Costa Rica.

Se adiciona otro ejemplo para Ciudad de Guatemala.

# Datos de la amenaza, el suelo y del diseño

Suelo tipo  $S_3$  equivalente  
a suelo D

$$S_3 = D$$

Aceleración pico máximo  
sismo creíble

$$PGA_M = 0.90 g$$

Velocidad de onda de  
corte

$$v_s = 180 - 350 m/s$$

Valores del SPT

$$N = 15 - 35$$

Pseudo aceleración  
períodos largos para  
máximo sismo creíble

$$S_{M1} = 0.65$$

Amplificación períodos  
cortos

$$F_a = 1.12$$

Amplificación períodos  
largos

$$F_v = 1.7$$

Factor de reducción a  
usar

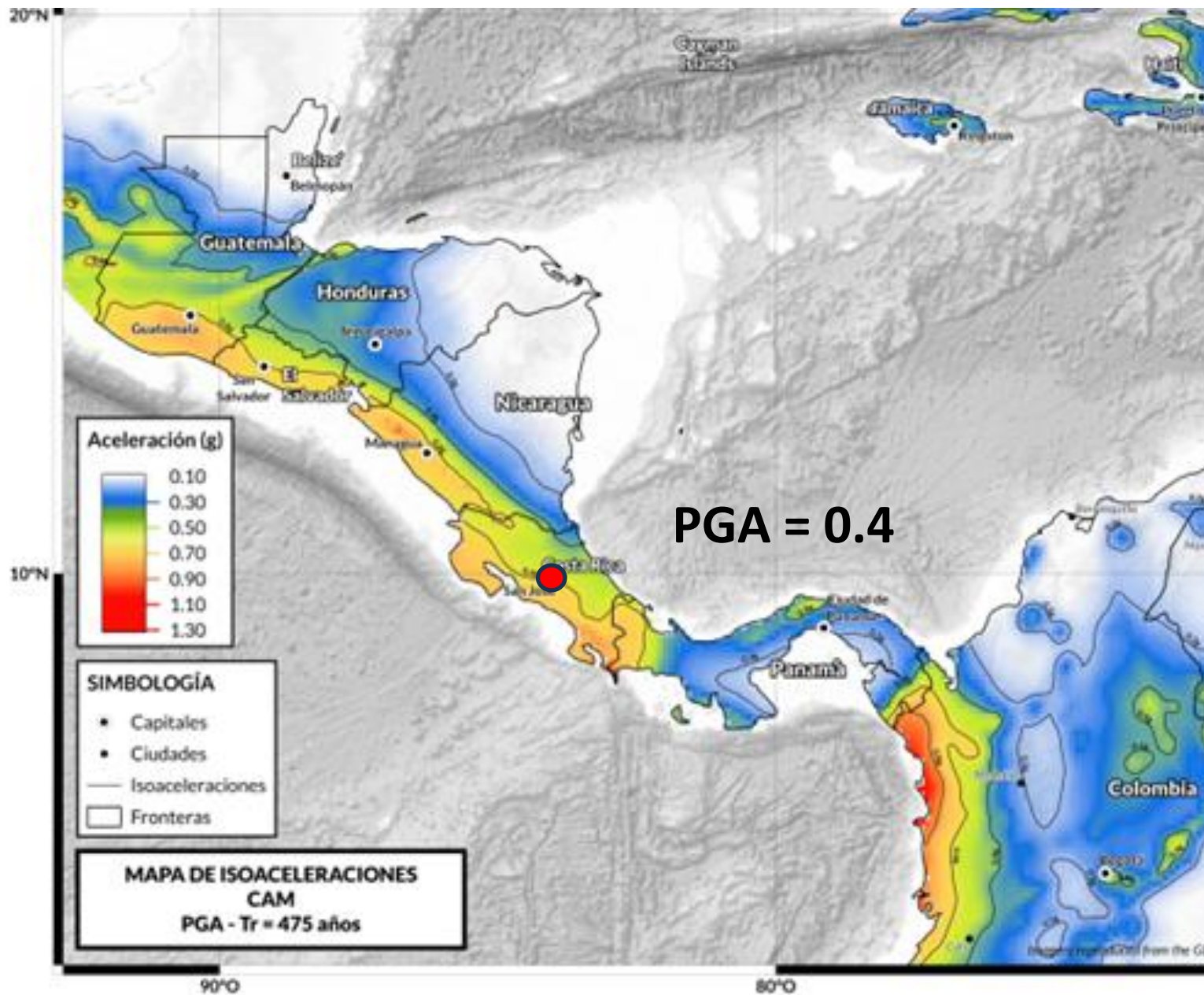
$$R = 4.0$$

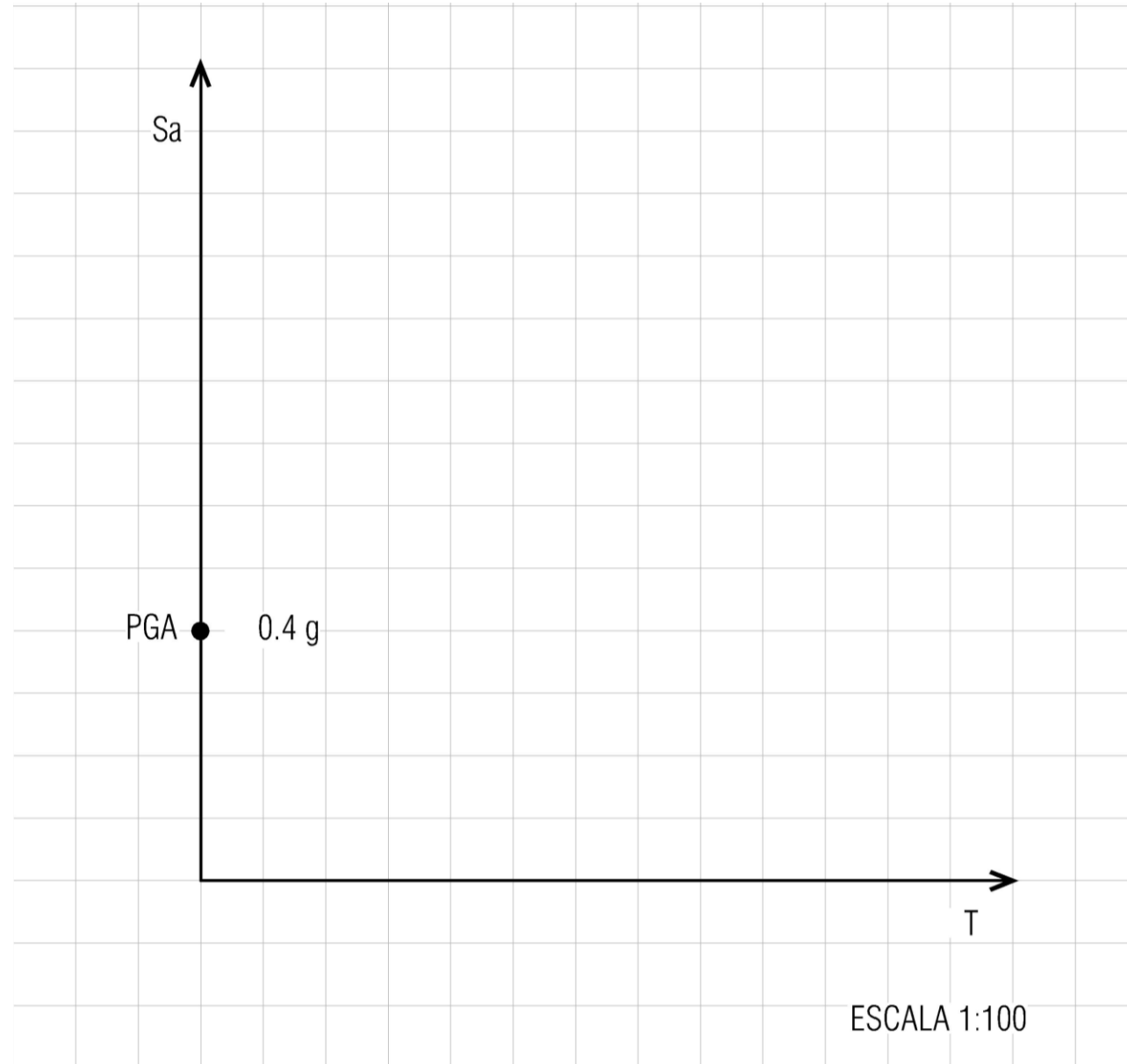
Ductilidad

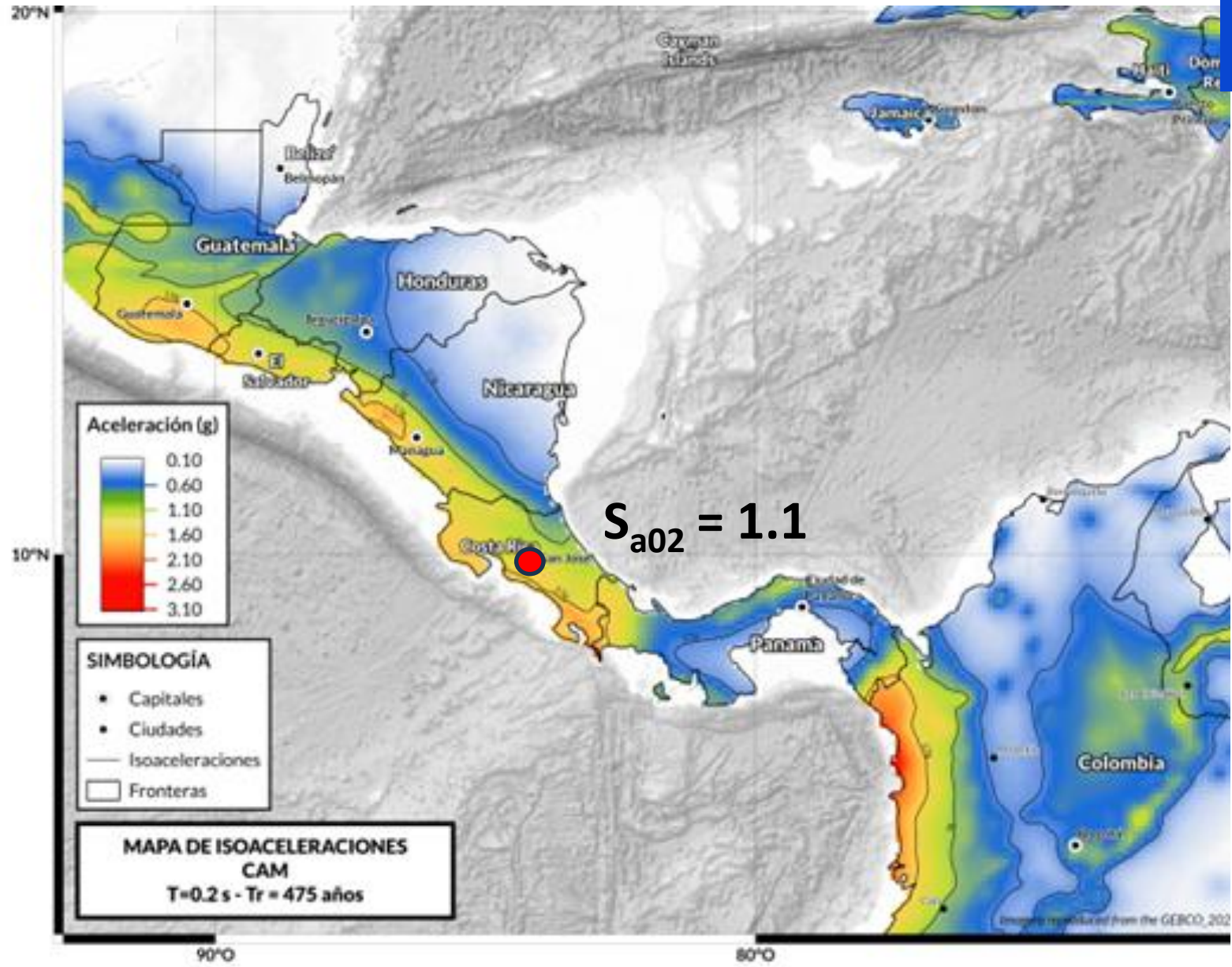
$$\mu = 2.0$$

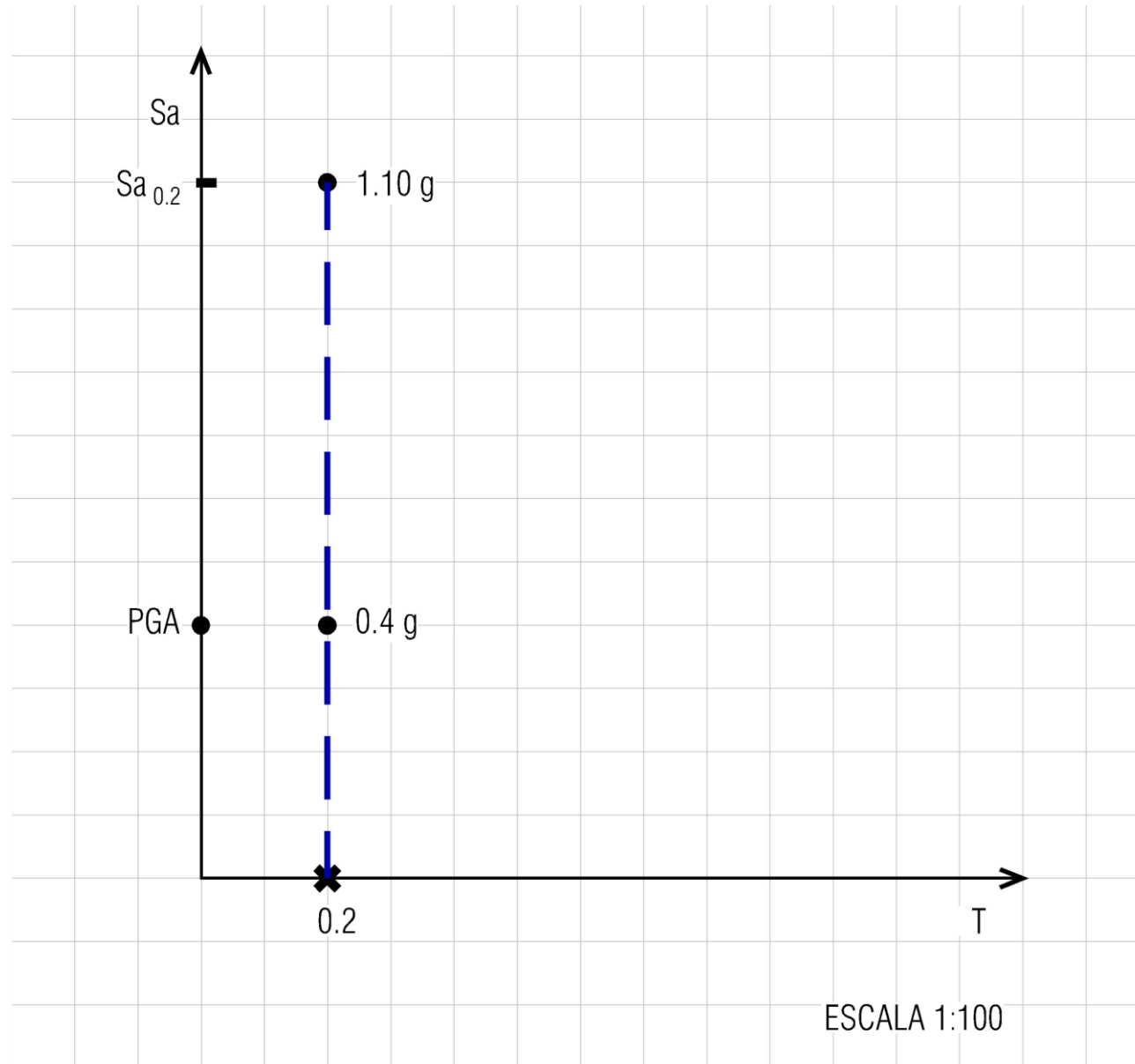
Sobrerresistencia

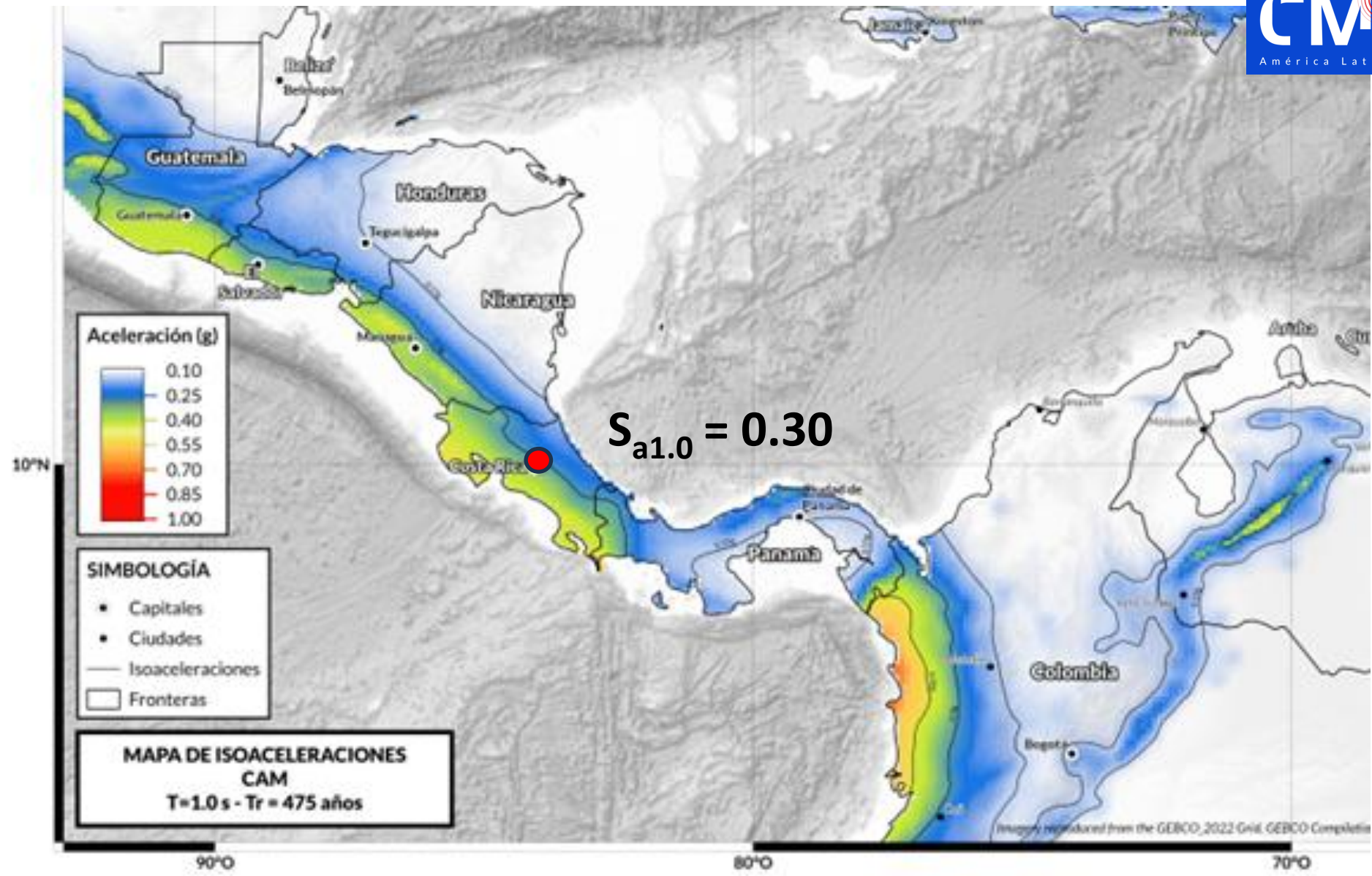
$$SR = 2.0$$

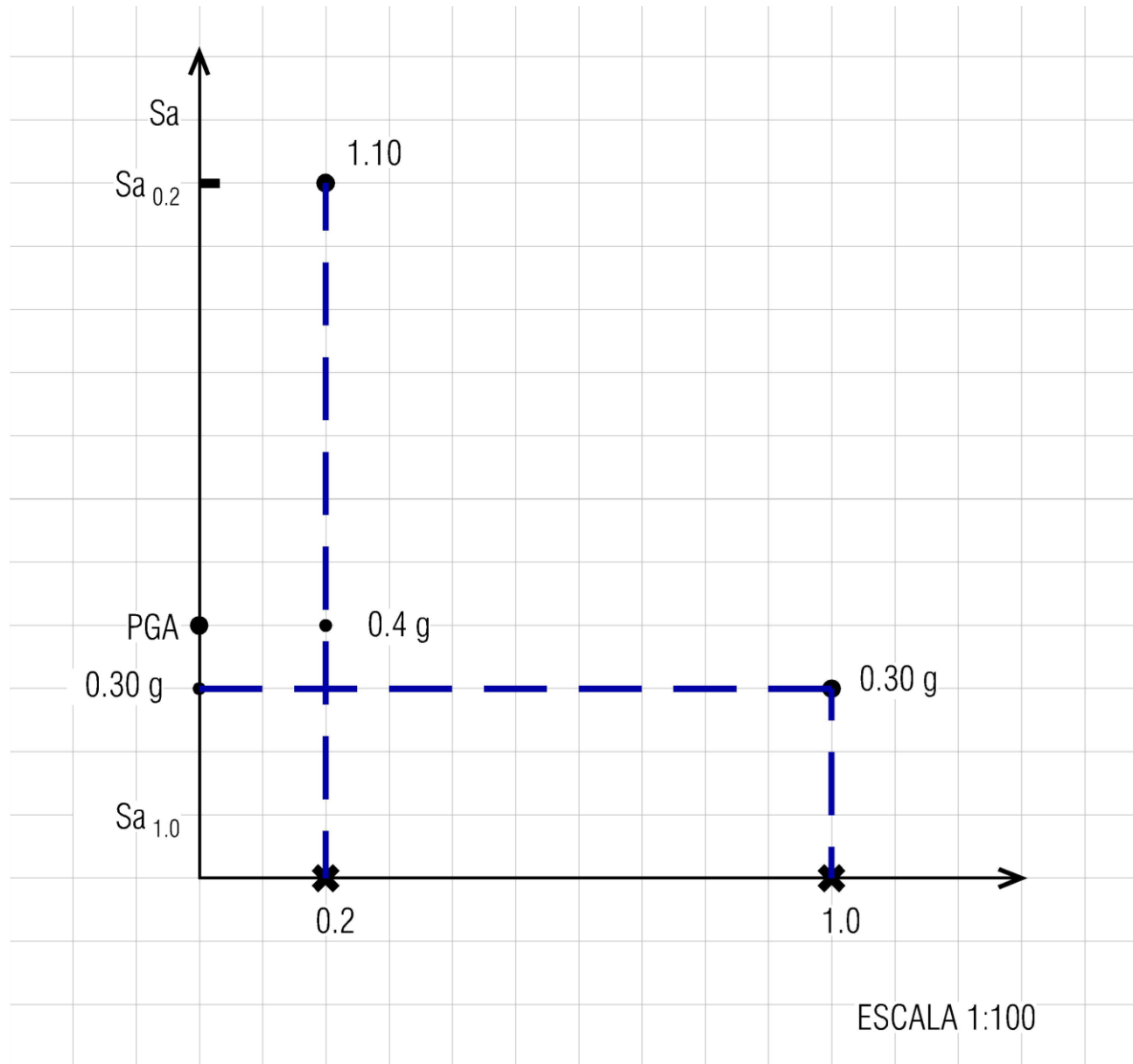


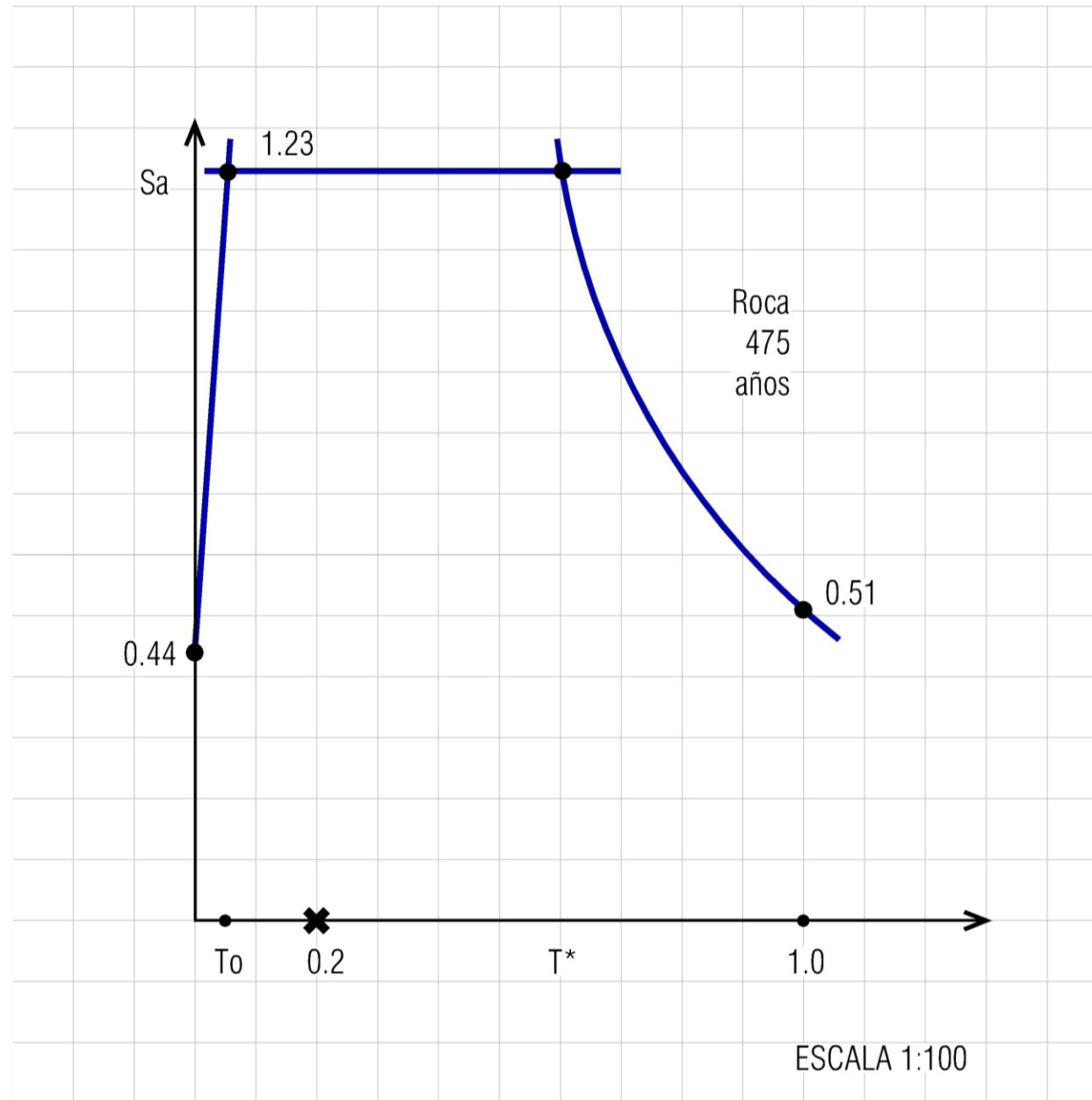












**Table 20.3-1 Site Classification**

Site Class	$\bar{v}_s$	$\bar{N}$ or $\bar{N}_{ch}$	$\bar{s}_u$
A. Hard rock	>5,000 ft/s	NA	NA
B. Rock	2,500 to 5,000 ft/s	NA	NA
C. Very dense soil and soft rock	1,200 to 2,500 ft/s	>50 blows/ft	>2,000 lb/ft <sup>2</sup>
D. Stiff soil	600 to 1,200 ft/s	15 to 50 blows/ft	1,000 to 2,000 lb/ft <sup>2</sup>
E. Soft clay soil	<600 ft/s	<15 blows/ft	<1,000 lb/ft <sup>2</sup>
	Any profile with more than 10 ft of soil that has the following characteristics:		
	— Plasticity index $PI > 20$ ,		
	— Moisture content $w \geq 40\%$ ,		
	— Undrained shear strength $\bar{s}_u < 500$ lb/ft <sup>2</sup>		
F. Soils requiring site response analysis in accordance with Section 21.1	See Section <a href="#">20.3.1</a>		

*Note:* For SI: 1 ft = 0.3048 m; 1 ft/s = 0.3048 m/s; 1 lb/ft<sup>2</sup> = 0.0479 kN/m<sup>2</sup>.

**Table 11.4-1 Short-Period Site Coefficient,  $F_a$**

**Mapped Risk-Targeted Maximum Considered Earthquake ( $MCE_R$ ) Spectral  
 Response Acceleration Parameter at Short Period**

<b>Site Class</b>	<b><math>S_S \leq 0.25</math></b>	<b><math>S_S = 0.5</math></b>	<b><math>S_S = 0.75</math></b>	<b><math>S_S = 1.0</math></b>	<b><math>S_S = 1.25</math></b>	<b><math>S_S \geq 1.5</math></b>
A	0.8	0.8	0.8	0.8	0.8	0.8
B	0.9	0.9	0.9	0.9	0.9	0.9
C	1.3	1.3	1.2	1.2	1.2	1.2
D	1.6	1.4	1.2	1.1	1.0	1.0
E	2.4	1.7	1.3	See	See	See
				Section 11.4.8	Section 11.4.8	Section 11.4.8
F	See	See	See	See	See	See
	Section 11.4.8	Section 11.4.8	Section 11.4.8	Section 11.4.8	Section 11.4.8	Section 11.4.8

Note: Use straight-line interpolation for intermediate values of  $S_S$ .

**Table 11.4-2 Long-Period Site Coefficient,  $F_v$**

Mapped Risk-Targeted Maximum Considered Earthquake ( $MCE_R$ ) Spectral Response Acceleration Parameter at 1-s Period						
Site Class	$S_1 \leq 0.1$	$S_1 = 0.2$	$S_1 = 0.3$	$S_1 = 0.4$	$S_1 = 0.5$	$S_1 \geq 0.6$
A	0.8	0.8	0.8	0.8	0.8	0.8
B	0.8	0.8	0.8	0.8	0.8	0.8
C	1.5	1.5	1.5	1.5	1.5	1.4
D	2.4	2.2 <sup>a</sup>	2.0 <sup>a</sup>	1.9 <sup>a</sup>	1.8 <sup>a</sup>	1.7 <sup>a</sup>
E	4.2	See	See	See	See	See
		Section <a href="#">11.4.8</a>	Section <a href="#">11.4.8</a>	Section <a href="#">11.4.8</a>	Section <a href="#">11.4.8</a>	Section <a href="#">11.4.8</a>
F	See	See	See	See	See	See
	Section <a href="#">11.4.8</a>	Section <a href="#">11.4.8</a>	Section <a href="#">11.4.8</a>	Section <a href="#">11.4.8</a>	Section <a href="#">11.4.8</a>	Section <a href="#">11.4.8</a>

Note: Use straight-line interpolation for intermediate values of  $S_1$ .

<sup>a</sup>Also, see requirements for site-specific ground motions in Section 11.4.8.

**TABLE 11.8-1 Site Coefficient  $F_{PGA}$**

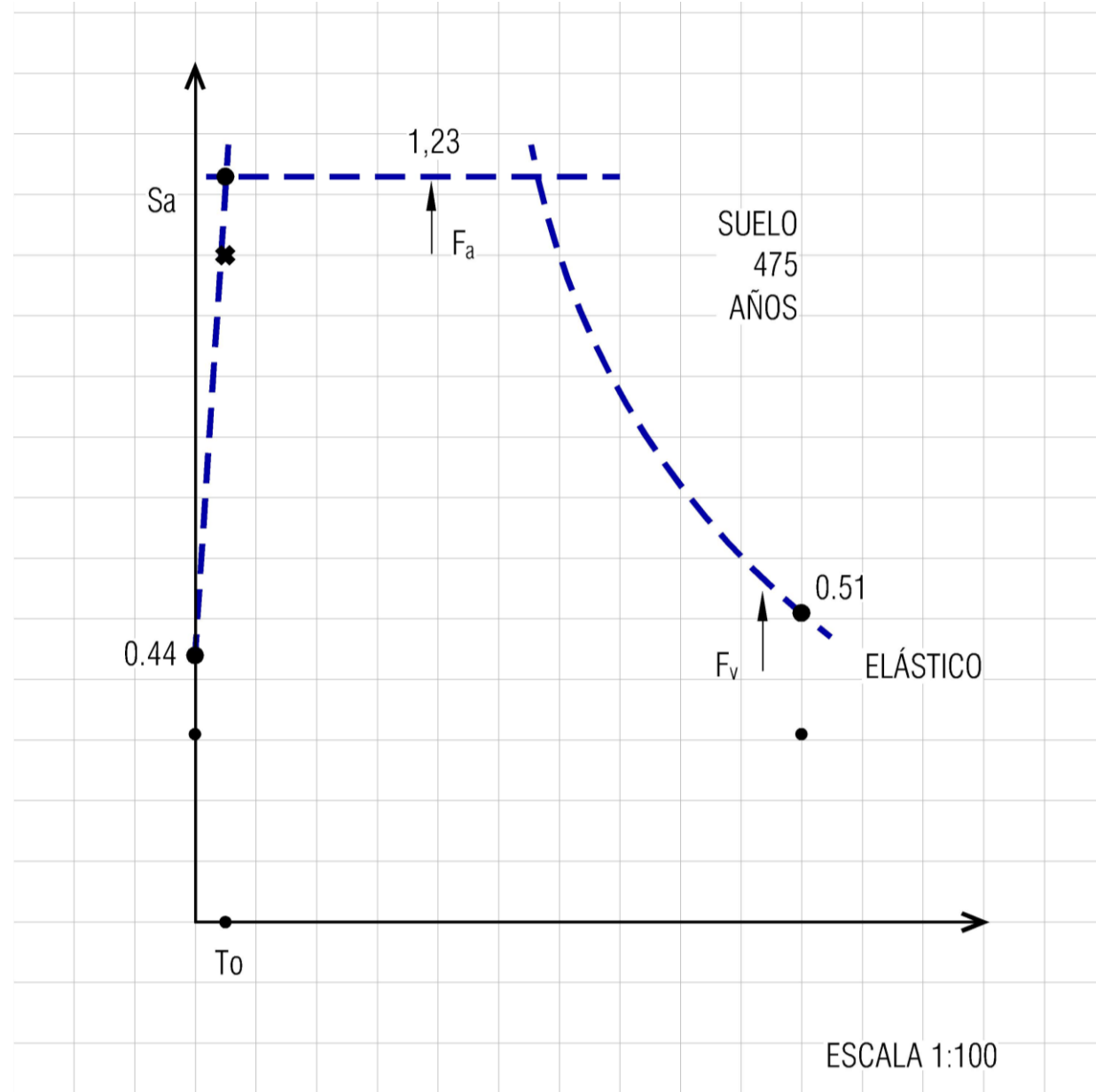
Mapped Maximum Considered Geometric Mean ( $MCE_G$ ) Peak Ground Acceleration, PGA						
Site Class	$PGA \leq 0.1$	$PGA = 0.2$	$PGA = 0.3$	$PGA = 0.4$	$PGA = 0.5$	$PGA \geq 0.6$
A	0.8	0.8	0.8	0.8	0.8	0.8
B	0.9	0.9	0.9	0.9	0.9	0.9
C	1.3	1.2	1.2	1.2	1.2	1.2
D	1.6	1.4	1.3	1.2	1.1	1.1
E	2.4	1.9	1.6	1.4	1.2	1.1
F	See Section <a href="#">11.4.8</a>					

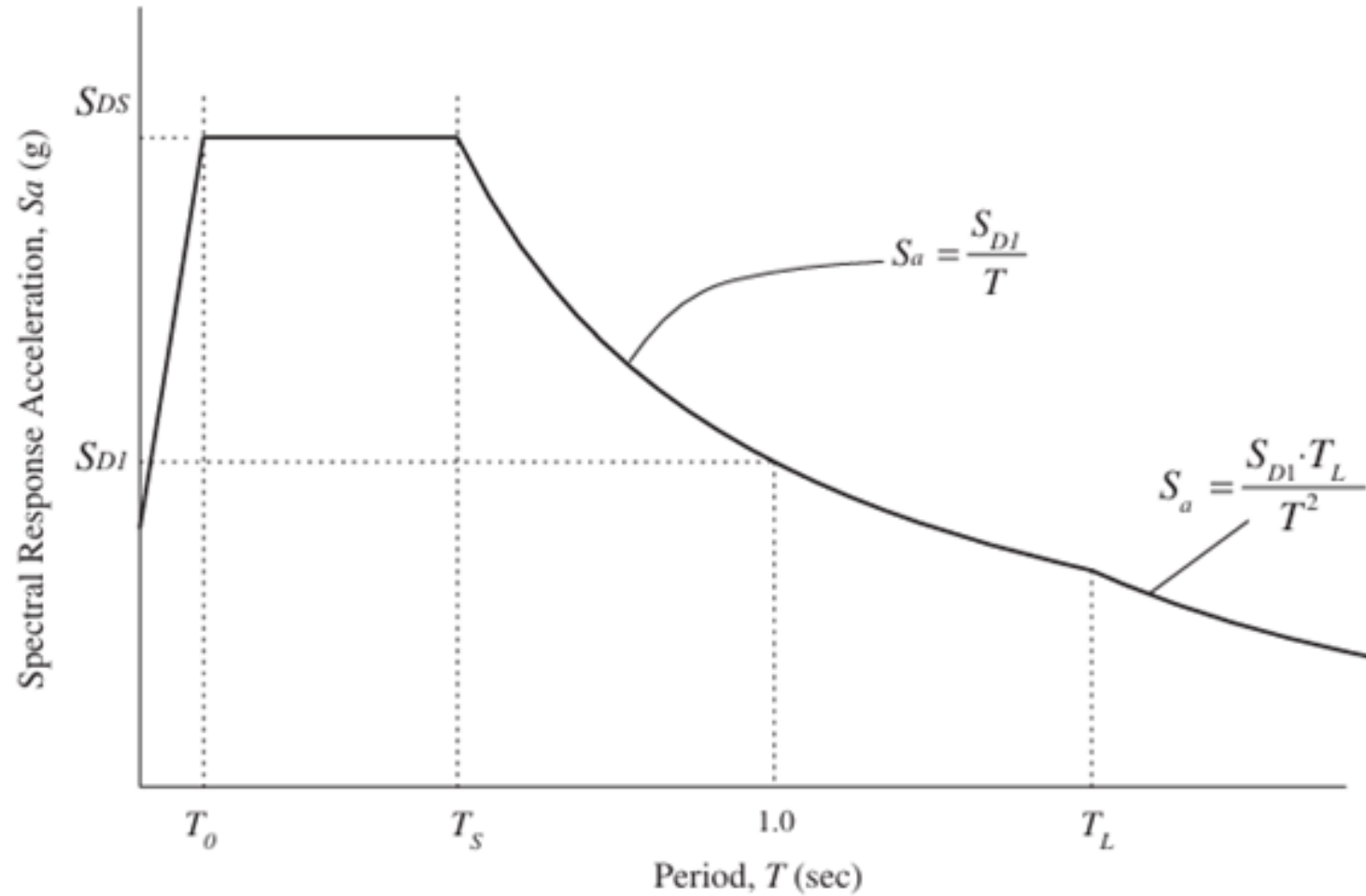
Note: Use straight-line interpolation for intermediate values of PGA.

$$S_{DS} = F_a S_s \quad (11.4-1)$$

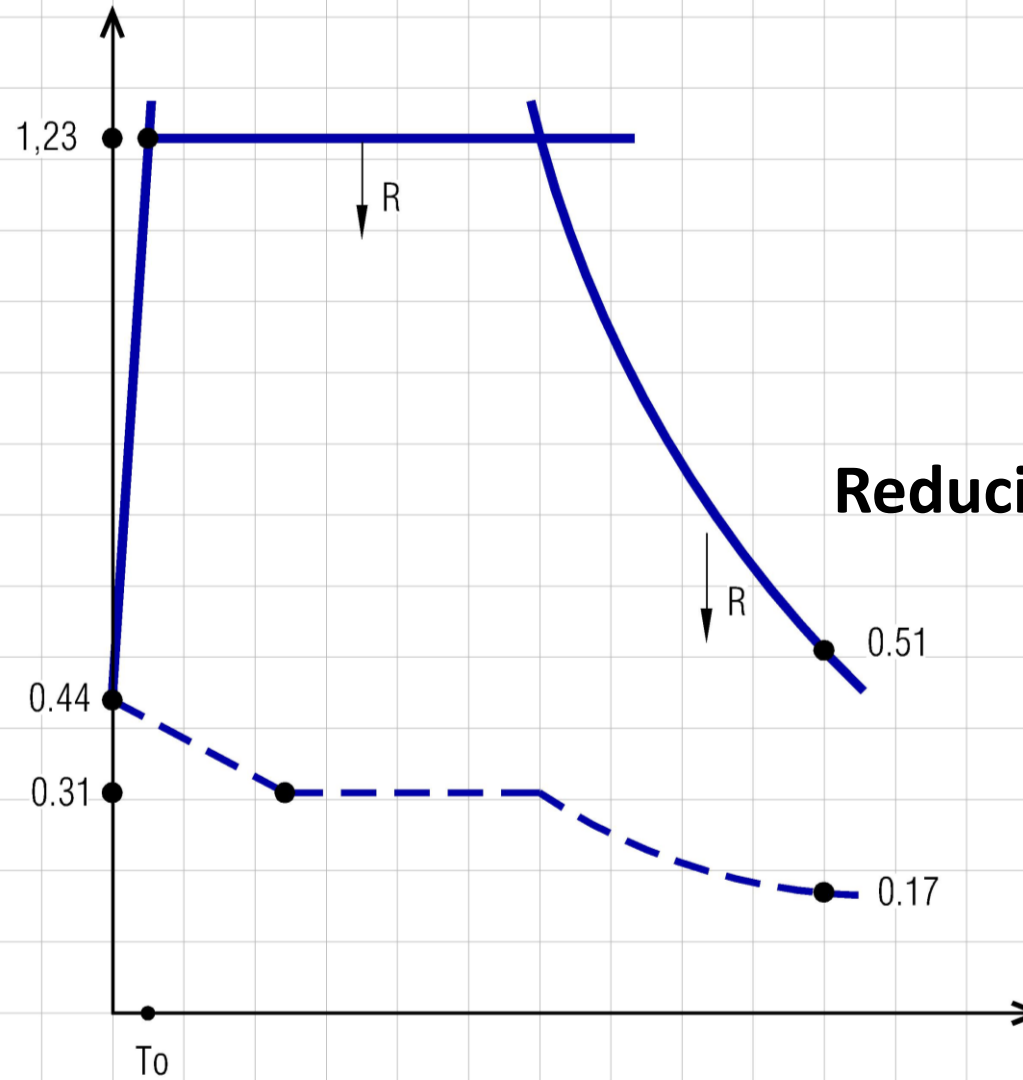
$$S_{D1} = F_v S_1 \quad (11.4-2)$$

$$T_0 = 0,2 (S_{D1}/S_{DS}) \quad (11.4-7)$$



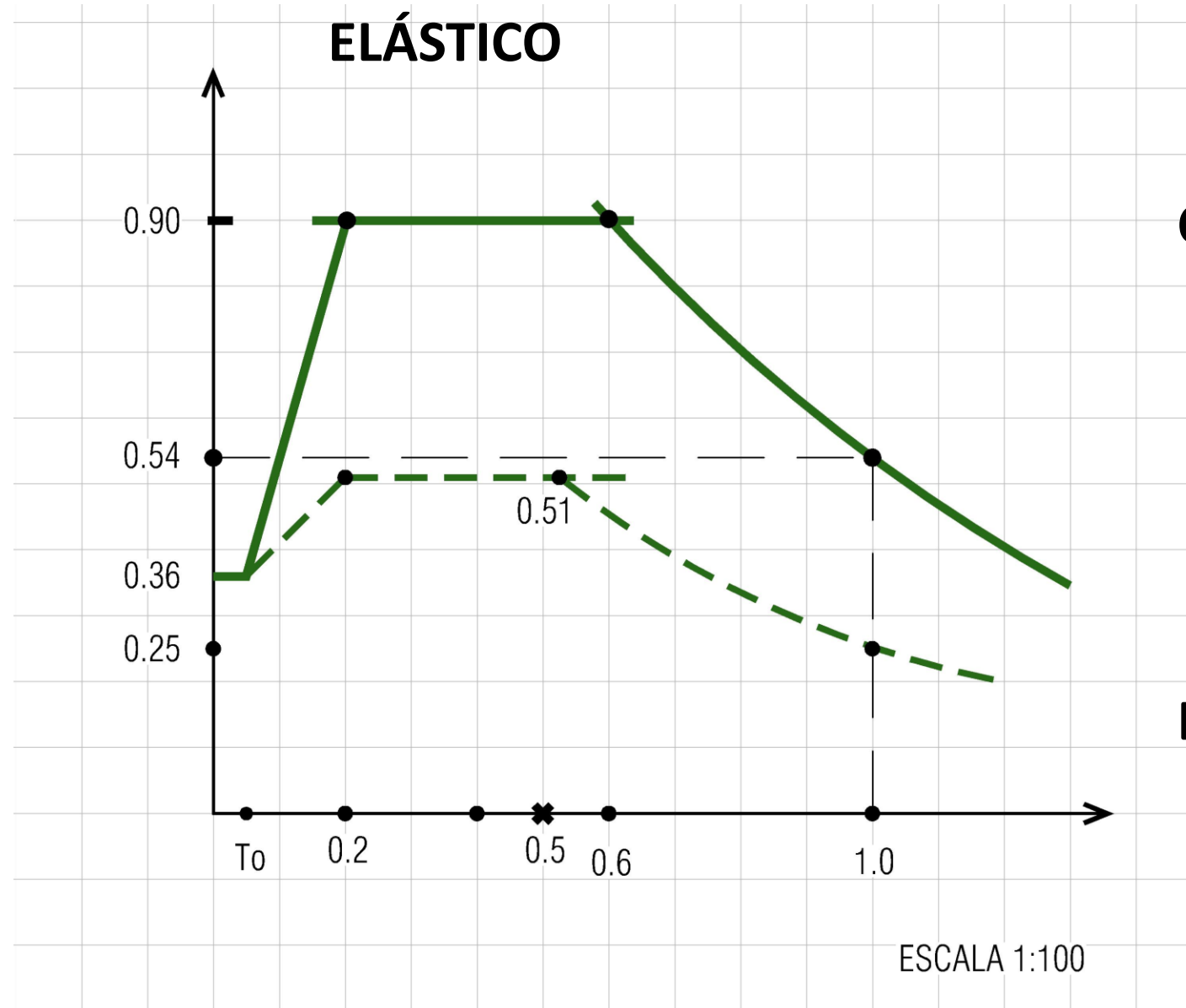


**FIGURE 11.4-1 Design Response Spectrum**



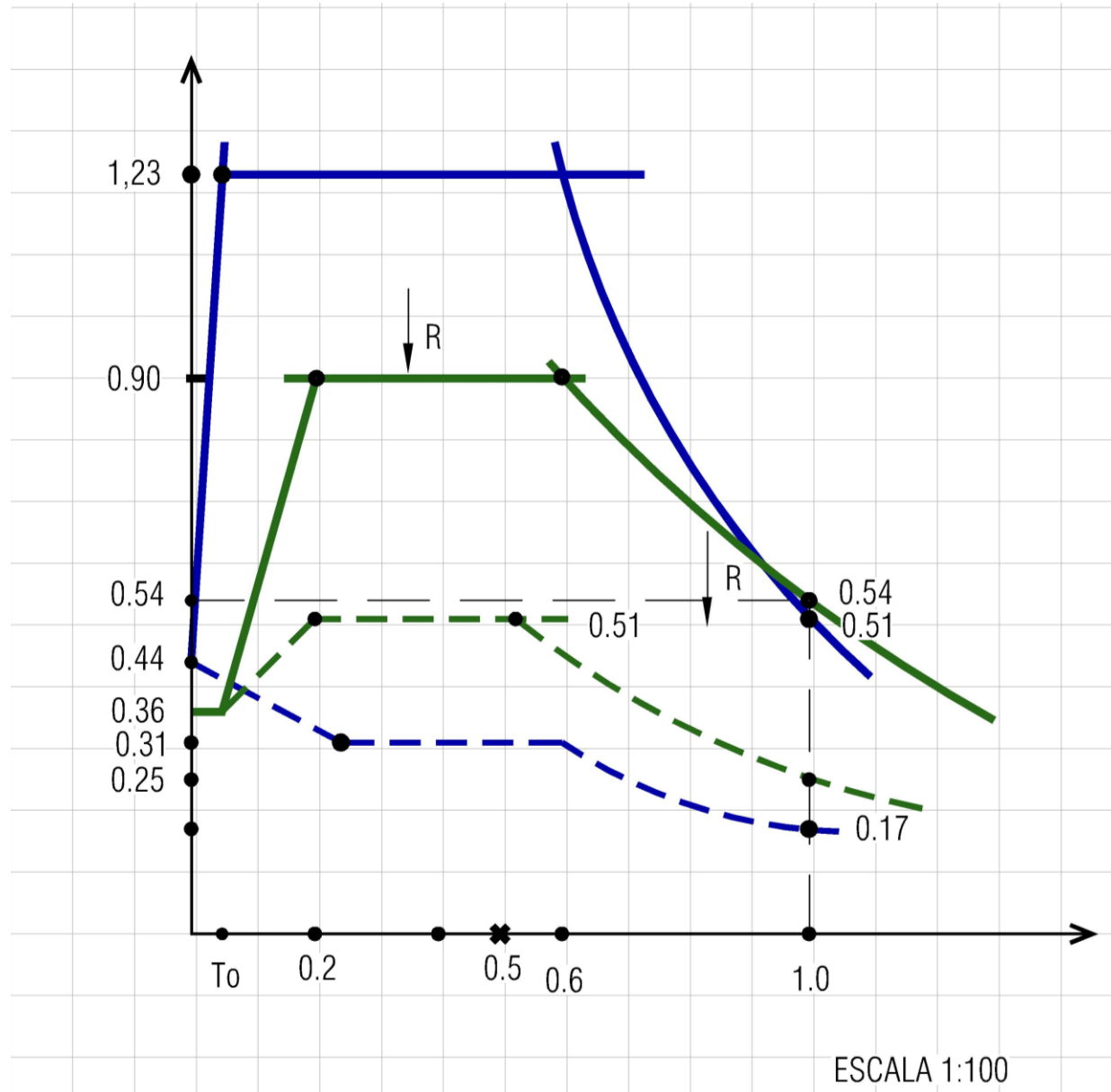
**Reducido por  $\mu$  y por  $\Omega$**

ESCALA 1:100



**CSCR**

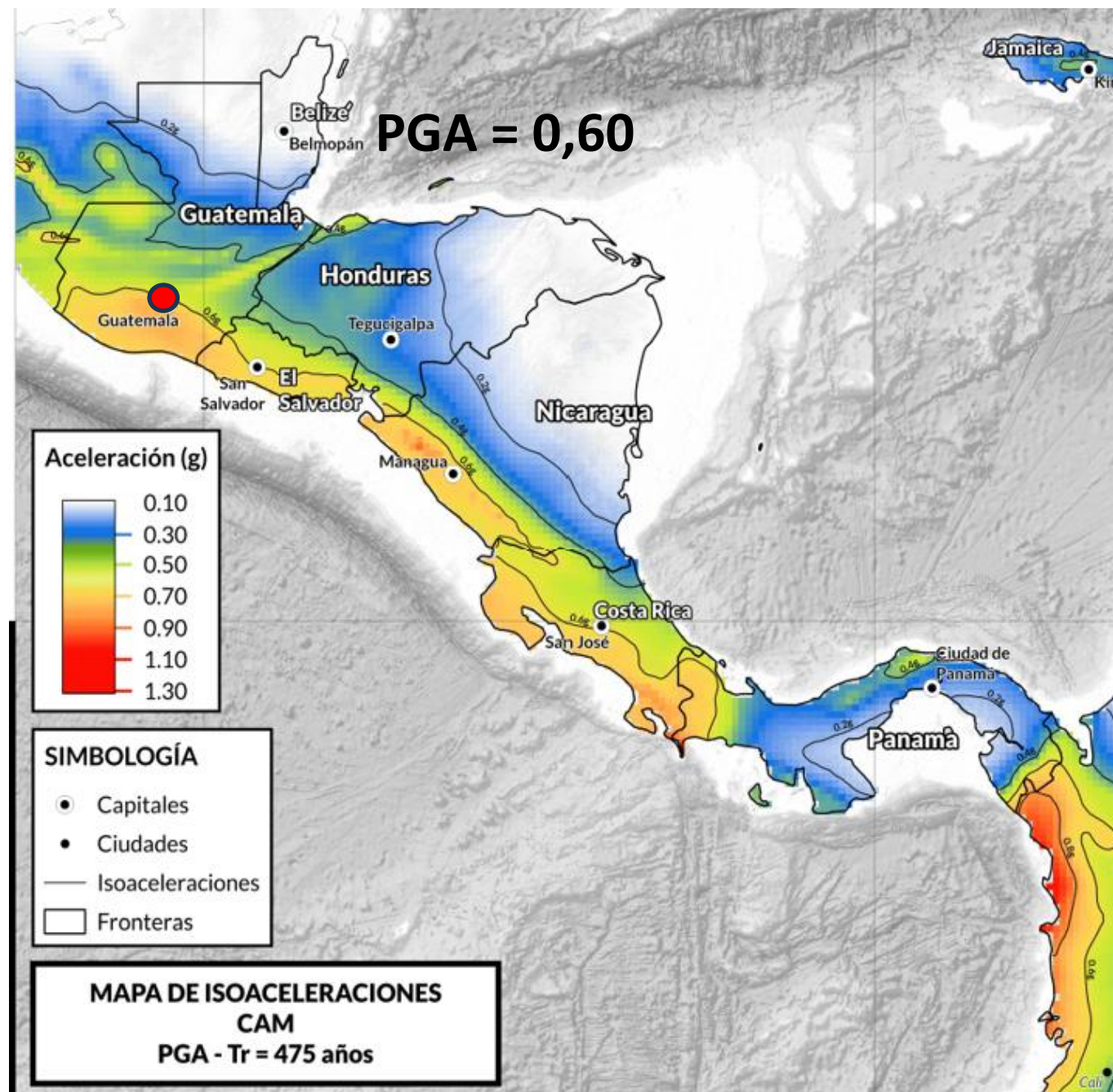
**Ductilidad 2**

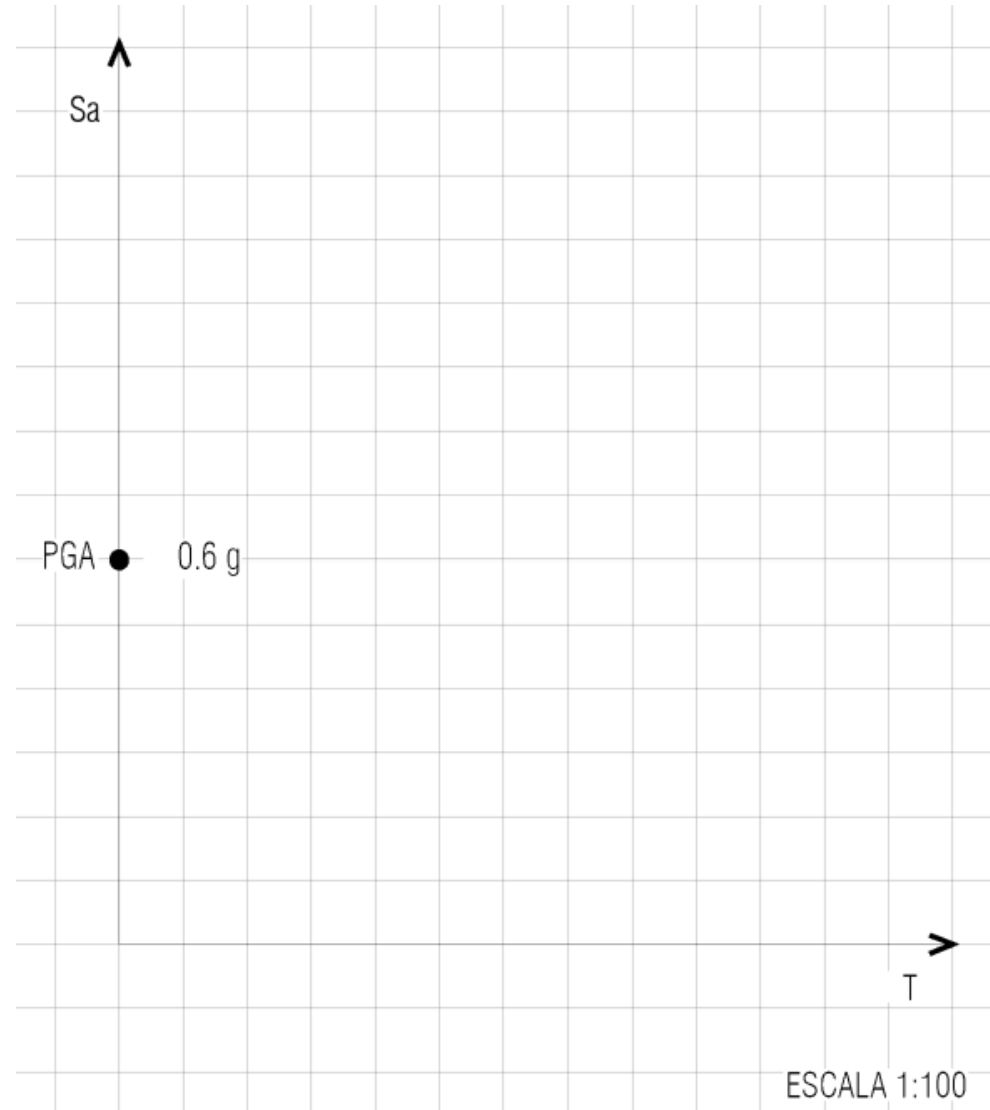


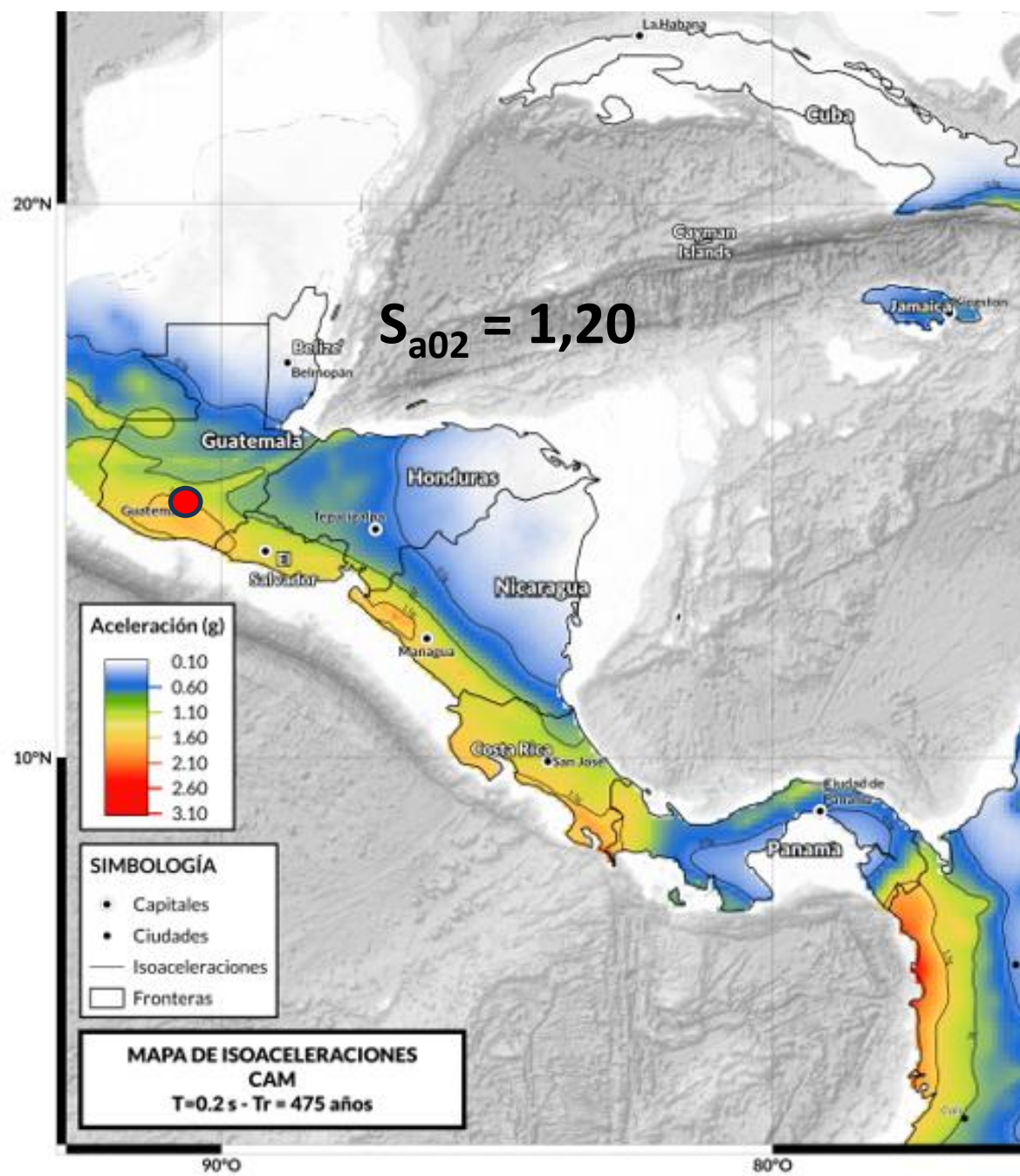
Al espectro reducido al CSCR se le aplica luego una reducción de 2 para dar un valor de  $S_a=0.26$  que es equivalente a un 20% menor al valor de  $S_a=0.31$  obtenido con el mapa del CMS.

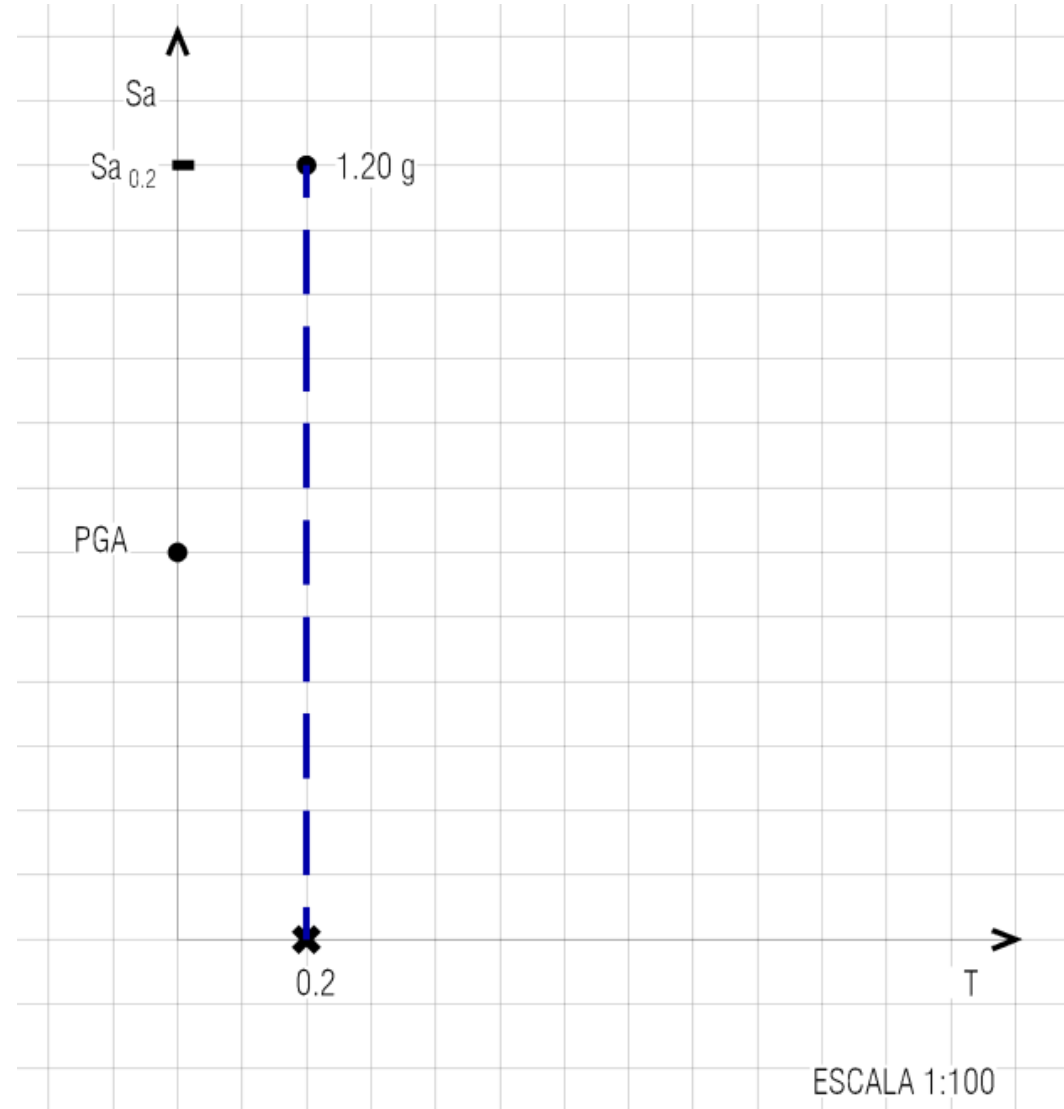
Estos valores desde el punto de vista de diseño pueden ser o no ser importantes.

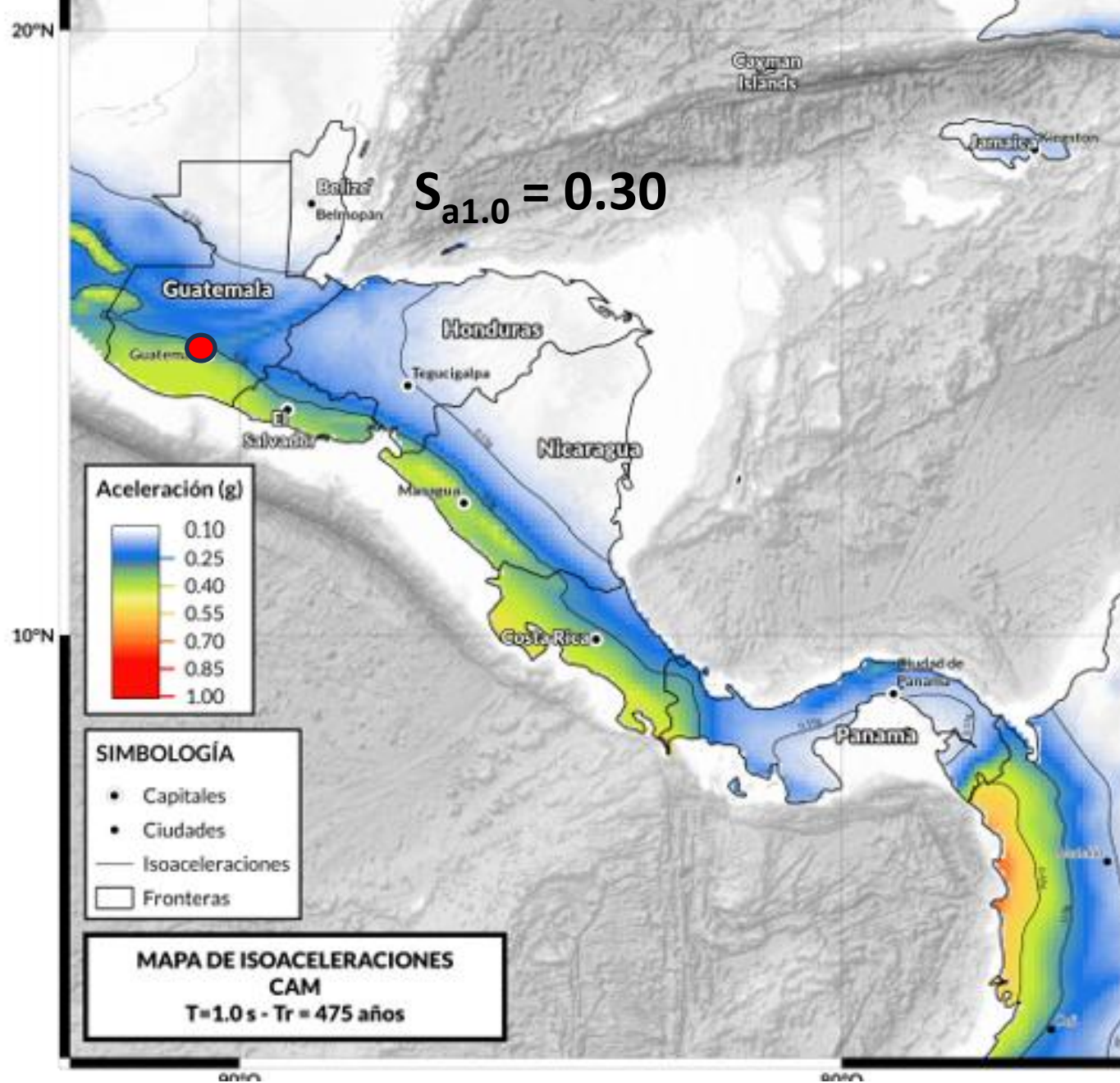
# Ejemplo adicional ciudad de Guatemala

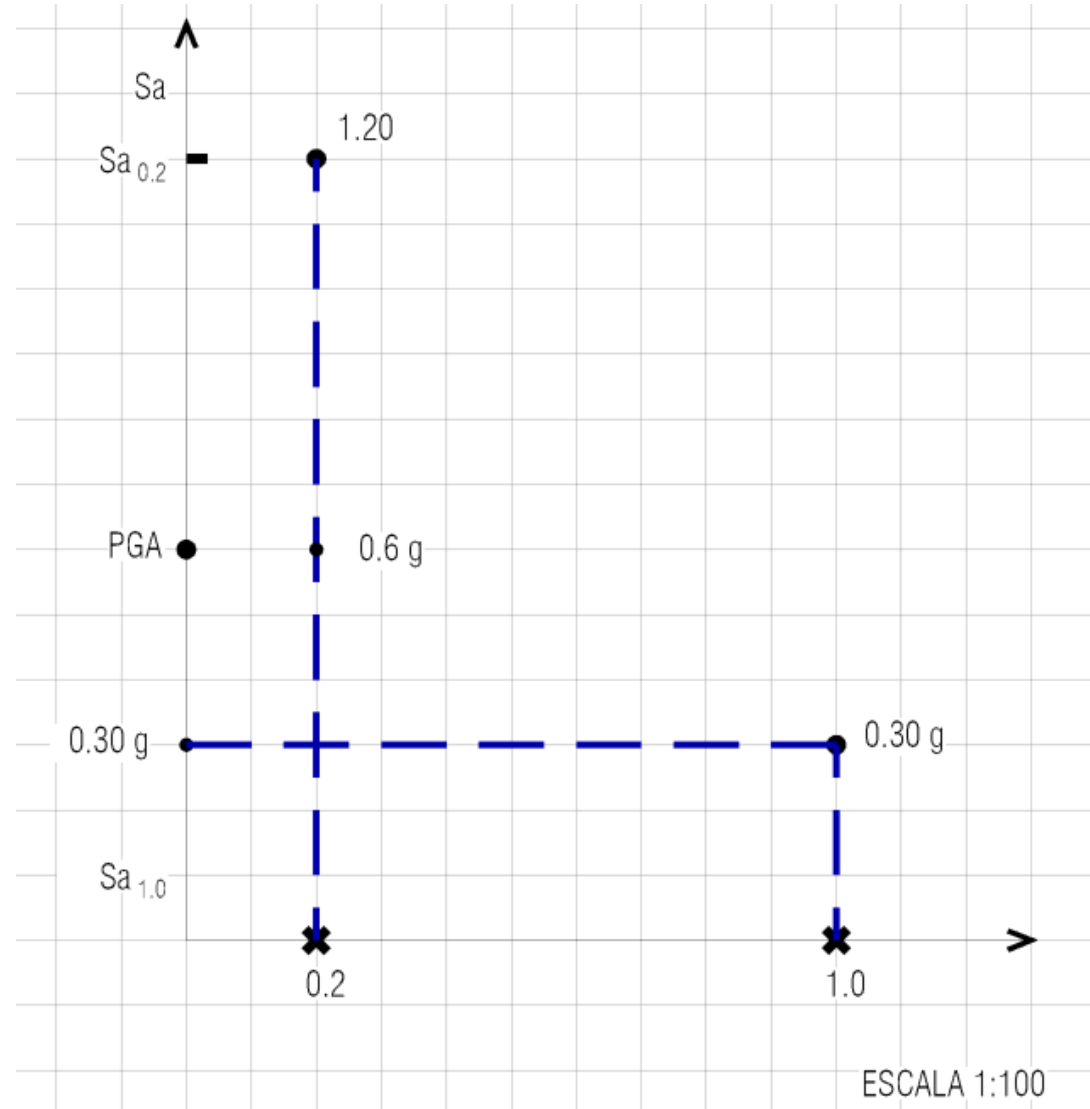


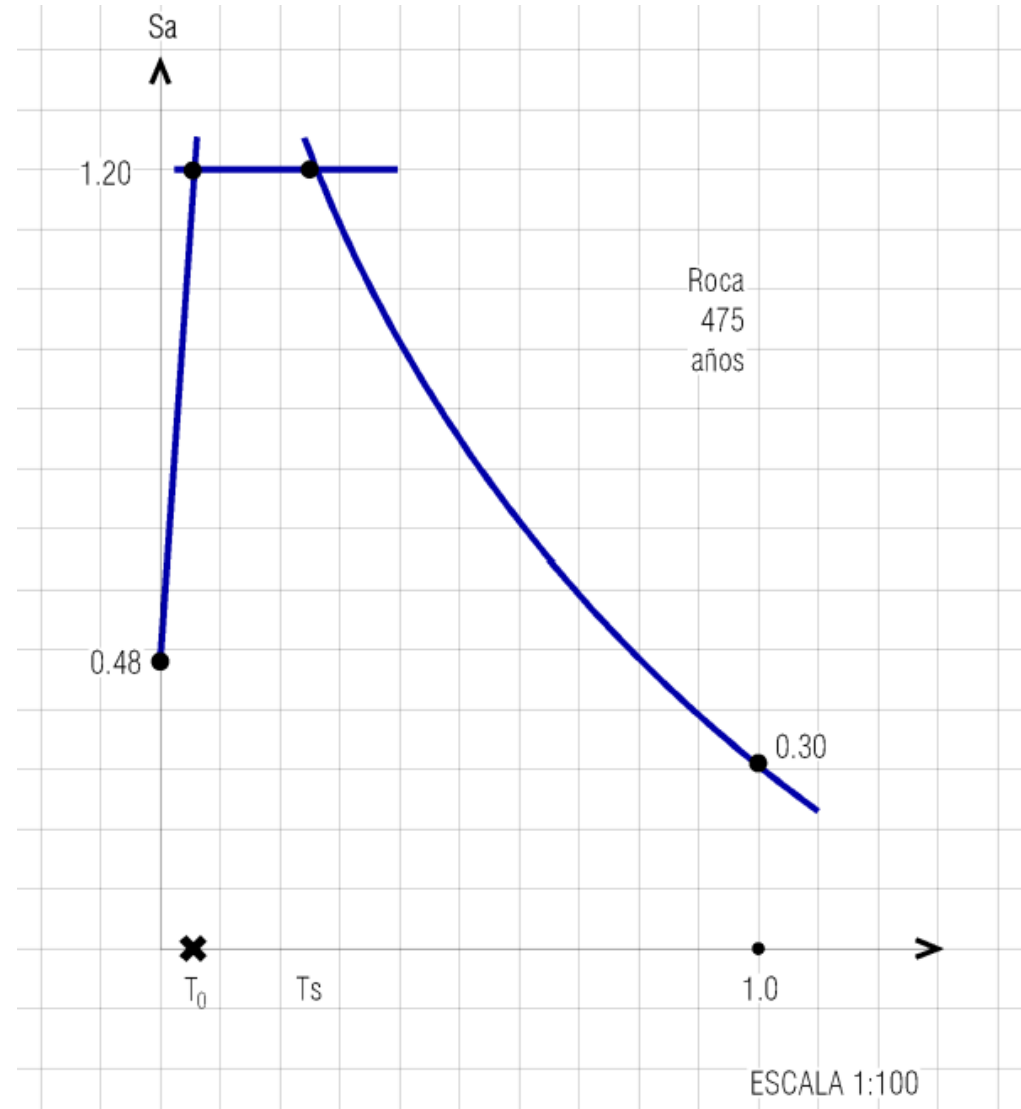












**Table 20.3-1 Site Classification**

Site Class	$\bar{v}_s$	$\bar{N}$ or $\bar{N}_{ch}$	$\bar{s}_u$
A. Hard rock	>5,000 ft/s	NA	NA
B. Rock	2,500 to 5,000 ft/s	NA	NA
C. Very dense soil and soft rock	1,200 to 2,500 ft/s	>50 blows/ft	>2,000 lb/ft <sup>2</sup>
D. Stiff soil	600 to 1,200 ft/s	15 to 50 blows/ft	1,000 to 2,000 lb/ft <sup>2</sup>
E. Soft clay soil	<600 ft/s	<15 blows/ft	<1,000 lb/ft <sup>2</sup>
	Any profile with more than 10 ft of soil that has the following characteristics:		
	<ul style="list-style-type: none"> <li>— Plasticity index <math>PI &gt; 20</math>,</li> <li>— Moisture content <math>w \geq 40\%</math>,</li> <li>— Undrained shear strength <math>\bar{s}_u &lt; 500</math> lb/ft<sup>2</sup></li> </ul>		
F. Soils requiring site response analysis in accordance with Section 21.1	See Section 20.3.1		

Note: For SI: 1 ft = 0.3048 m; 1 ft/s = 0.3048 m/s; 1 lb/ft<sup>2</sup> = 0.0479 kN/m<sup>2</sup>.

**Table 11.4-1 Short-Period Site Coefficient,  $F_a$**

Mapped Risk-Targeted Maximum Considered Earthquake (MCE <sub>R</sub> ) Spectral Response Acceleration Parameter at Short Period						
Site Class	$S_S \leq 0.25$	$S_S = 0.5$	$S_S = 0.75$	$S_S = 1.0$	$S_S = 1.25$	$S_S \geq 1.5$
A	0.8	0.8	0.8	0.8	0.8	0.8
B	0.9	0.9	0.9	0.9	0.9	0.9
C	1.3	1.3	1.2	1.2	1.2	1.2
D	1.6	1.4	1.2	1.1	1.0	1.0
E	2.4	1.7	1.3	See Section 11.4.8	See Section 11.4.8	See Section 11.4.8
F	See Section 11.4.8	See Section 11.4.8	See Section 11.4.8	See Section 11.4.8	See Section 11.4.8	See Section 11.4.8

$$F_a = 1, 2$$

Note: Use straight-line interpolation for intermediate values of  $S_S$ .

**Table 11.4-2 Long-Period Site Coefficient,  $F_v$**

**Mapped Risk-Targeted Maximum Considered Earthquake (MCE<sub>R</sub>) Spectral Response Acceleration Parameter at 1-s Period**

Site Class	$S_1 \leq 0.1$	$S_1 = 0.2$	$S_1 = 0.3$	$S_1 = 0.4$	$S_1 = 0.5$	$S_1 \geq 0.6$
A	0.8	0.8	0.8	0.8	0.8	0.8
B	0.8	0.8	0.8	0.8	0.8	0.8
C	1.5	1.5	1.5	1.5	1.5	1.4
D	2.4	2.2 <sup>a</sup>	2.0 <sup>a</sup>	1.9 <sup>a</sup>	1.8 <sup>a</sup>	1.7 <sup>a</sup>
E	4.2	See	See	See	See	See
		Section 11.4.8	Section 11.4.8	Section 11.4.8	Section 11.4.8	Section 11.4.8
F	See	See	See	See	See	See
	Section 11.4.8	Section 11.4.8	Section 11.4.8	Section 11.4.8	Section 11.4.8	Section 11.4.8

$$F_v = 1,5$$

Note: Use straight-line interpolation for intermediate values of  $S_1$ .

<sup>a</sup>Also, see requirements for site-specific ground motions in Section 11.4.8.

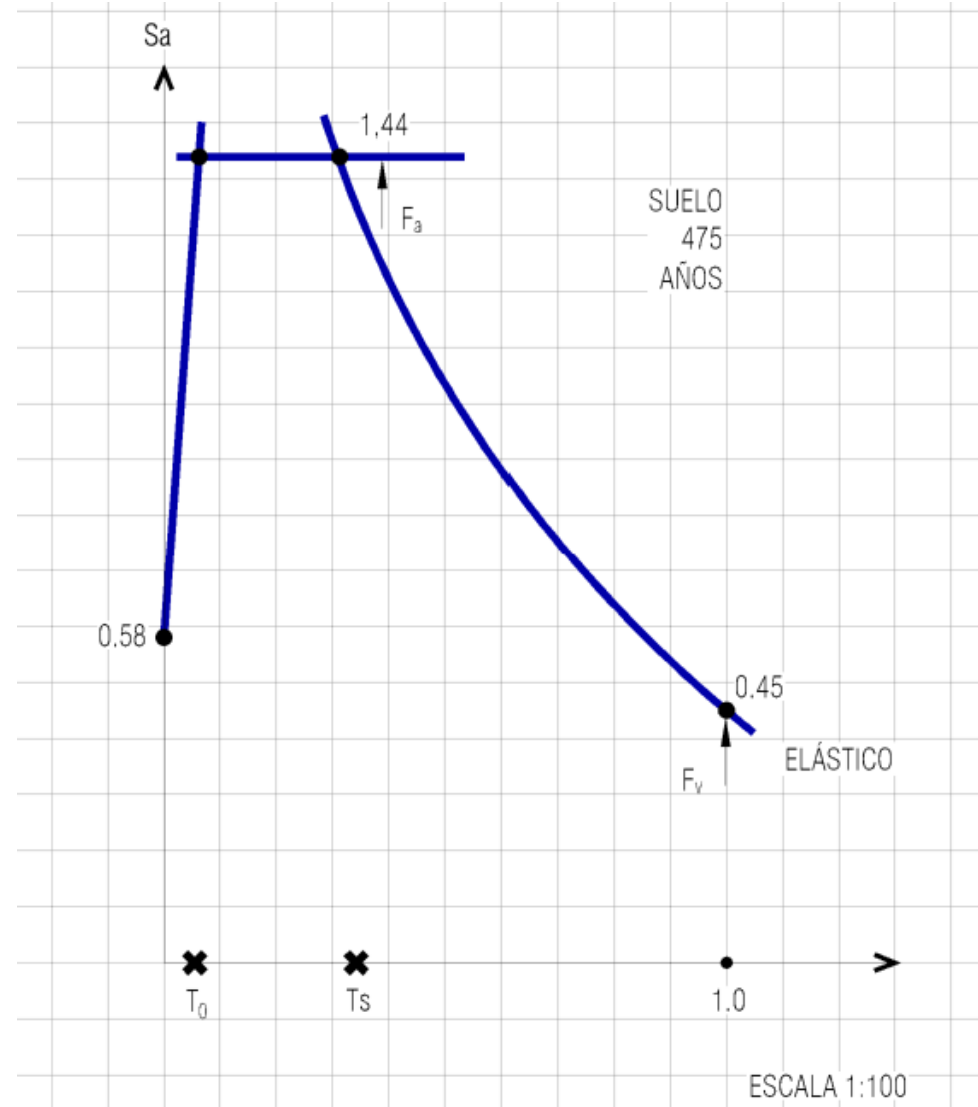
**TABLE 11.8-1 Site Coefficient  $F_{PGA}$**

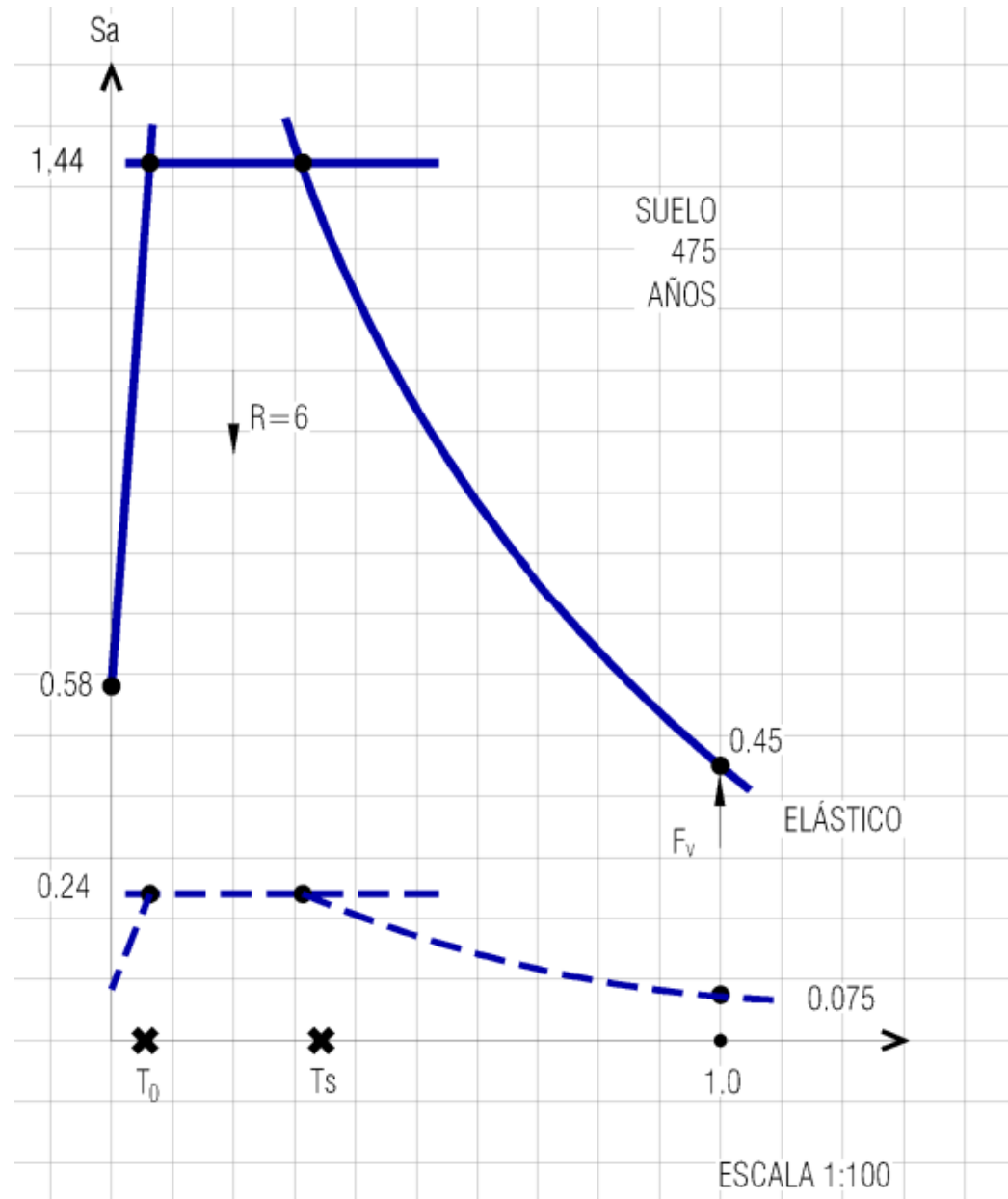
**Mapped Maximum Considered Geometric Mean ( $MCE_G$ ) Peak Ground  
Acceleration, PGA**

Site Class	PGA $\leq$ 0.1	PGA = 0.2	PGA = 0.3	PGA = 0.4	PGA = 0.5	PGA $\geq$ 0.6
A	0.8	0.8	0.8	0.8	0.8	0.8
B	0.9	0.9	0.9	0.9	0.9	0.9
C	1.3	1.2	1.2	1.2	1.2	1.2
D	1.6	1.4	1.3	1.2	1.1	1.1
E	2.4	1.9	1.6	1.4	1.2	1.1
F	See Section 11.4.8					

$F_{PGA} = 1, 2$

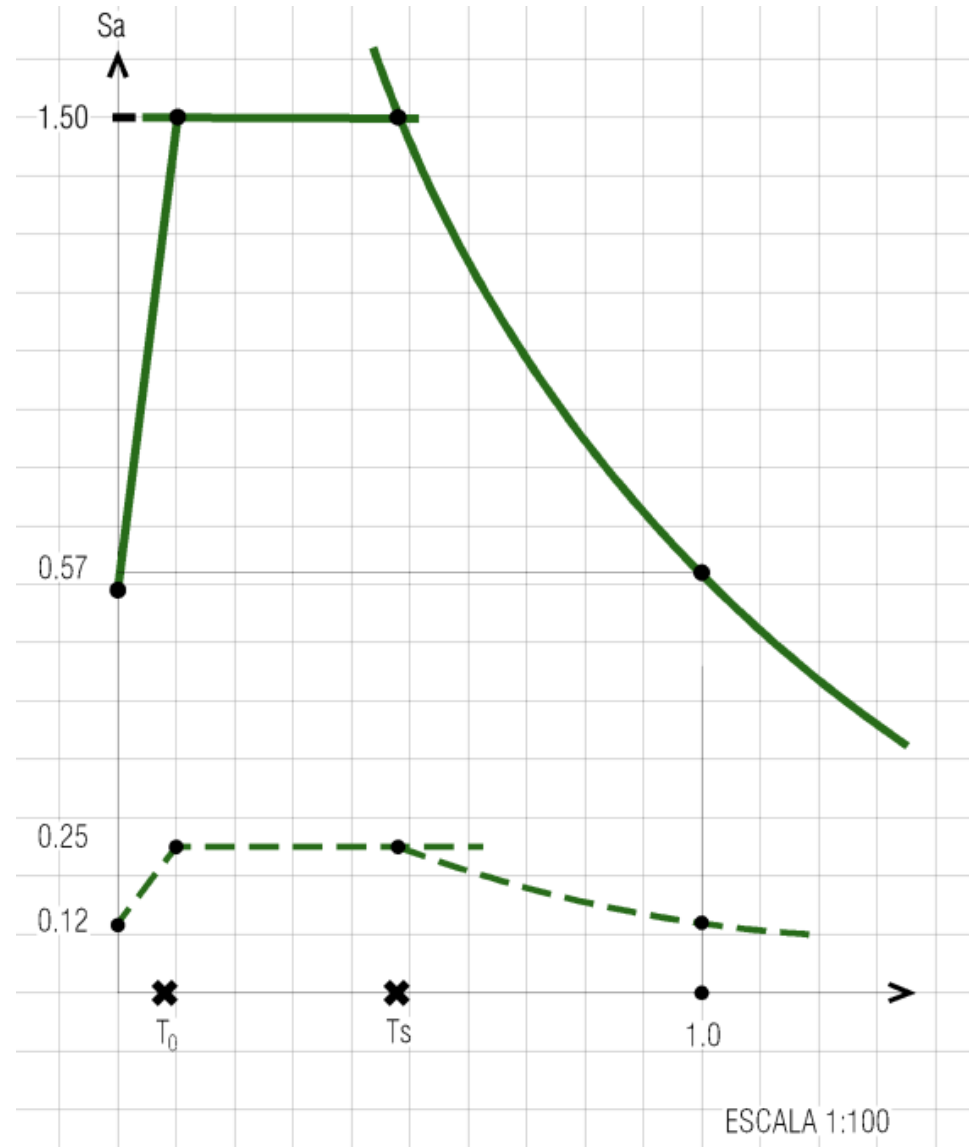
Note: Use straight-line interpolation for intermediate values of PGA.





**Reducido por  $R$**

# ELÁSTICO



**NSE**

**R=6**





[www.codigomodelosismico.org](http://www.codigomodelosismico.org)

Gracias por su atención