

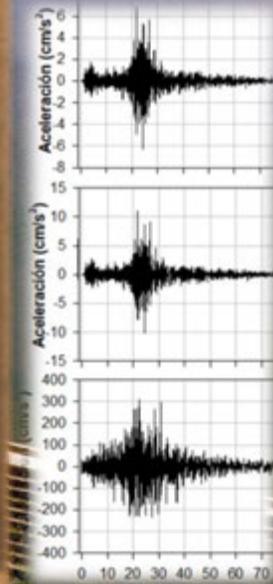
IMPACTO DE LOS SISMOS EN LA SEGURIDAD DE PRESAS



Organización
de las Naciones Unidas
para la Educación,
la Ciencia y la Cultura



Centro Regional de Seguridad Hidráulica
Bajo los auspicios de UNESCO



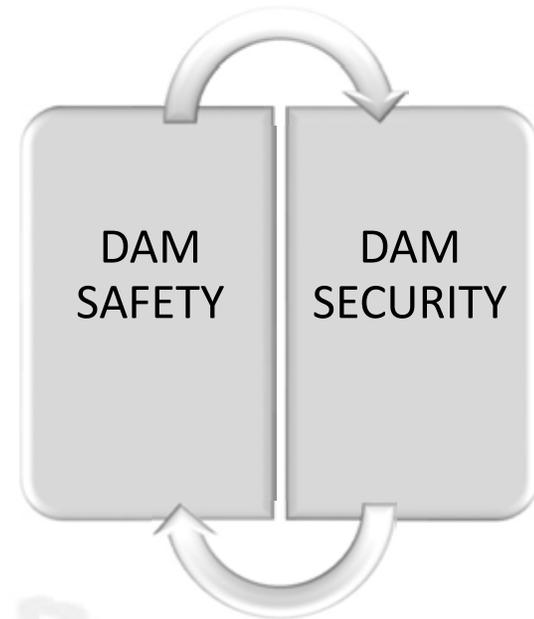
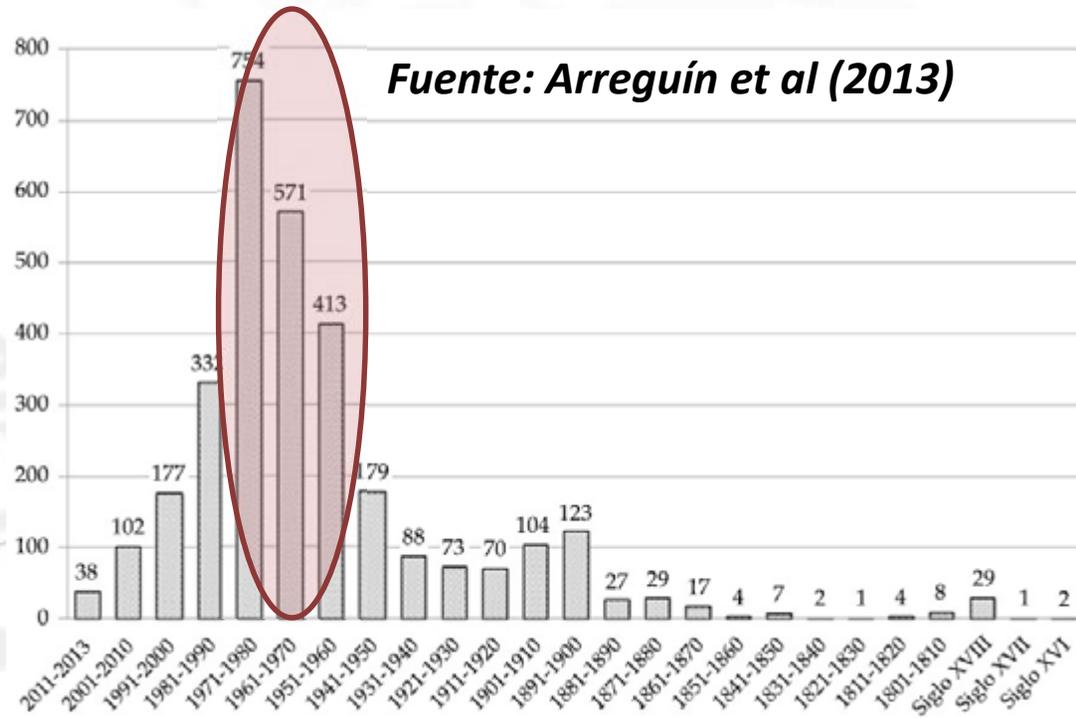
WEBINAR

Darío Espinoza

Julio del 2020

SEGURIDAD DE PRESAS

Conjunto de actividades necesarias para asegurar la integridad de presas existentes y la viabilidad de presas nuevas, de tal forma que representen riesgos aceptables a la población, ambiente y a las propiedades.



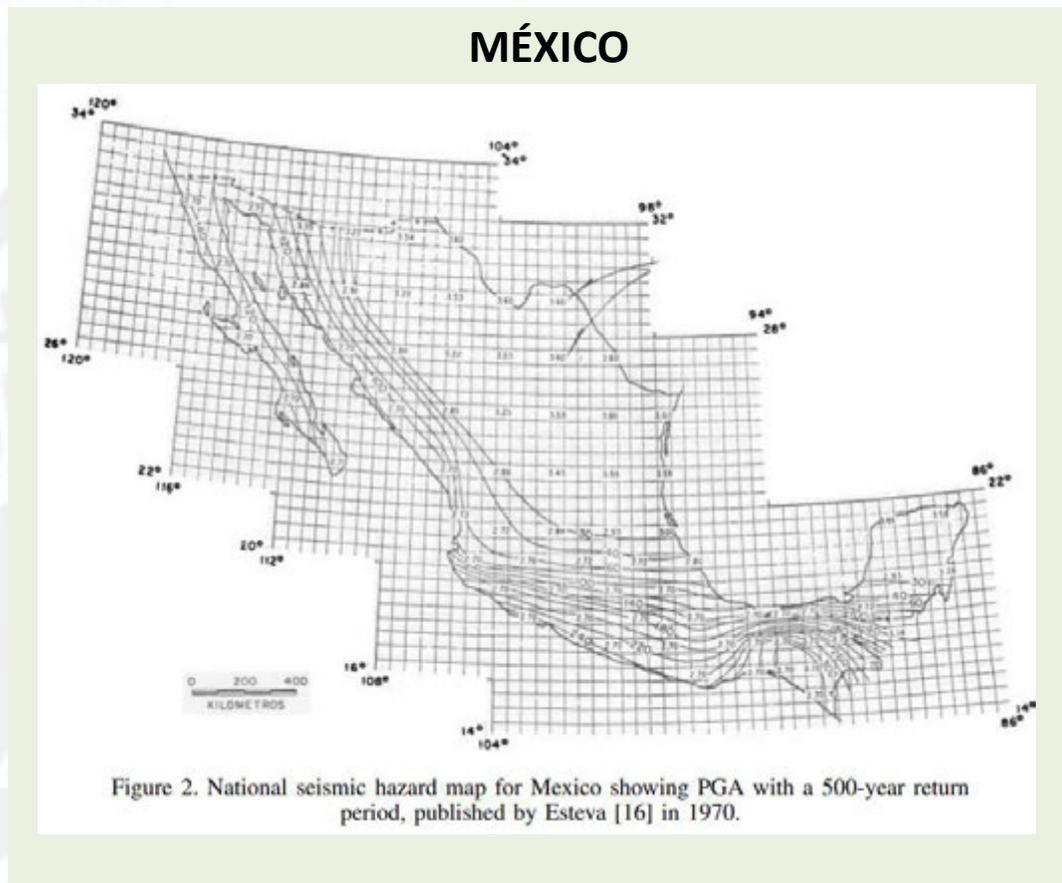
AMENAZA SÍSMICA EN LOS AÑOS 70

Boletín 27. ICOLD (1975)

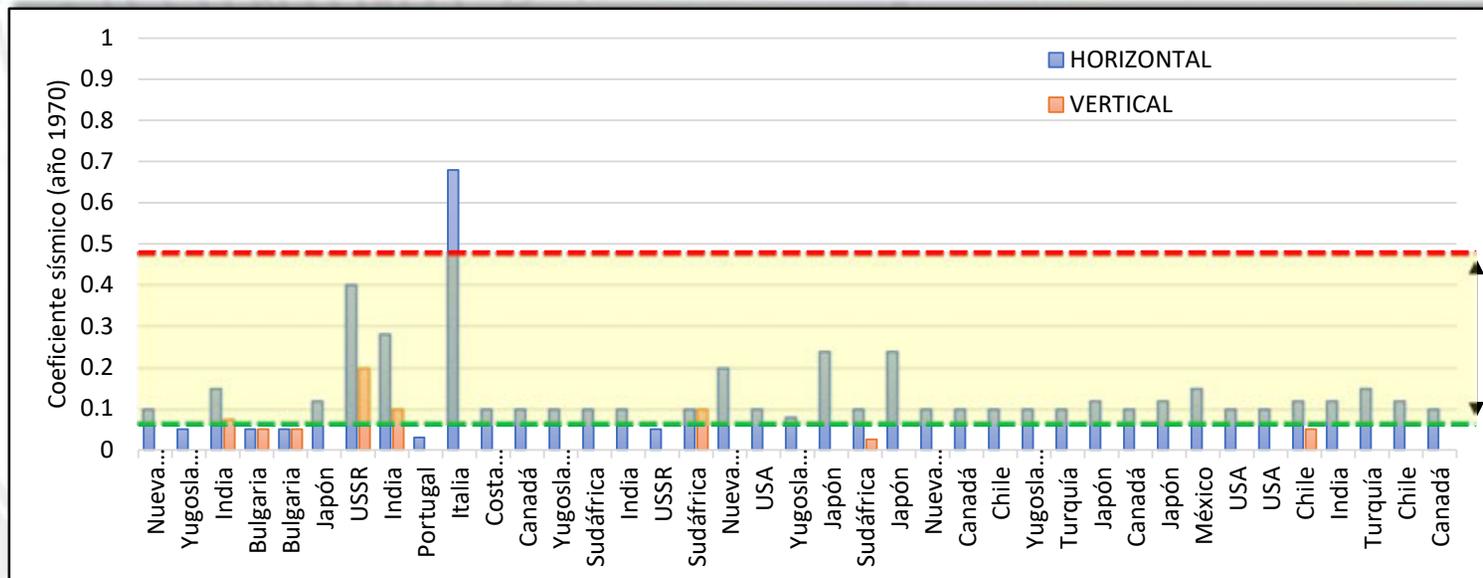
URSS	Design seismic intensity, degree	7	8	9
	Seismic coefficients, K_e	0.025	0.05	0.1

Region	Types of dam	
	Concrete Rockfill dam	Earthfill dam
Tohoku regions (Prefectures : Aomori, Iwate, Akita, Yamagata and Fukushima), Kanto, Chubu, Kinki Regions and Southern Shikoku	0.12-0.20	0.15-0.25
Hokkaido, Tohoku (Miyagi Pref.) Hokuriku, Chugoku, Northern Shikoku and Kyushu.	0.10-0.15	0.12-0.20

EUA	Sismicidad	Coeficiente sísmico
	Severa y moderada	0.10
	Menor	0.05

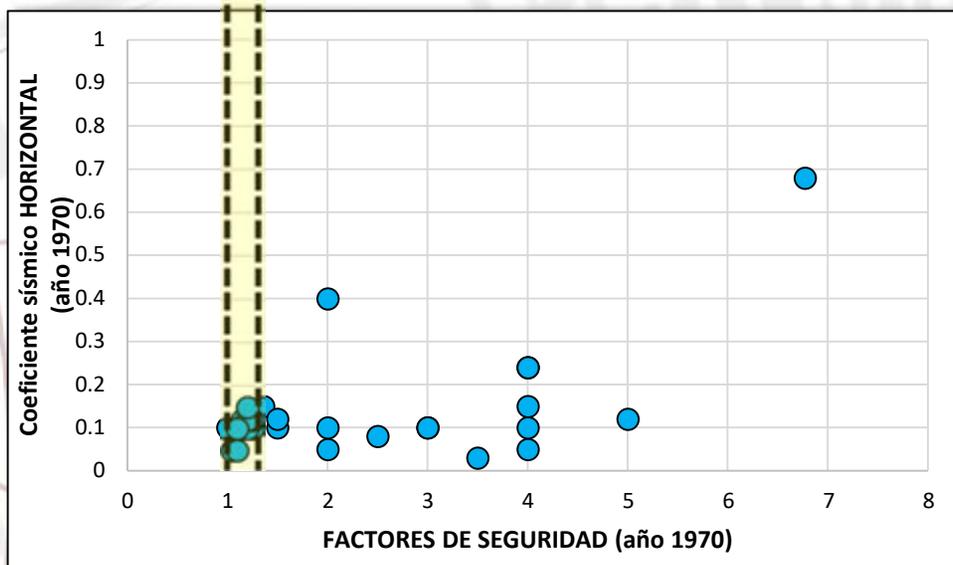


EVOLUCIÓN DE CRITERIOS DE DISEÑO SÍSMICO

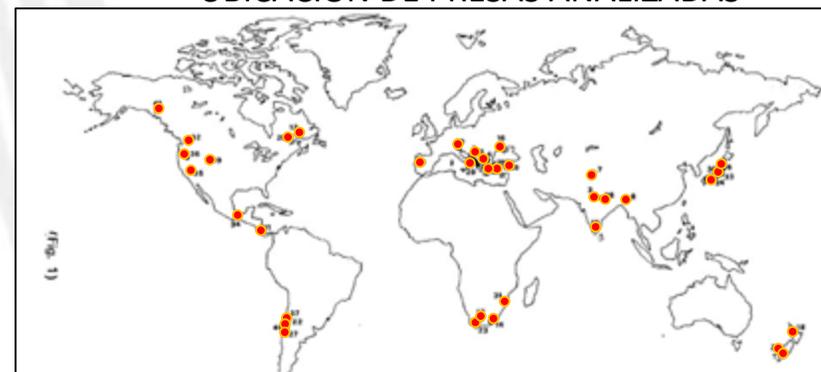


Coeficientes sísmicos aplicables a México (PRODISIS, CFE)

← Factores de seguridad permisibles ante carga extrema (CFE, USBR, USACE) en la actualidad.



UBICACIÓN DE PRESAS ANALIZADAS



Información de 41 presas analizadas en el boletín 27 de la ICOLD (1975).

CRITERIOS ACTUALES DE DISEÑO SÍSMICO

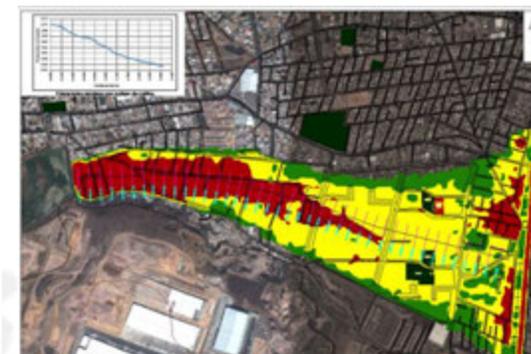
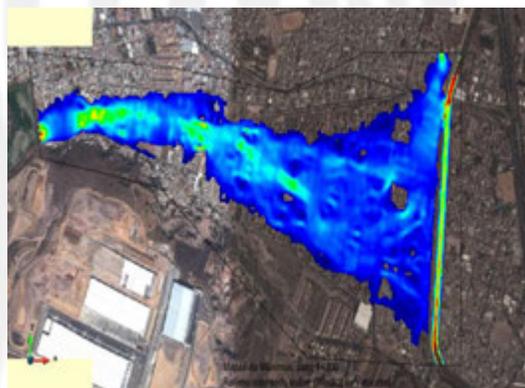
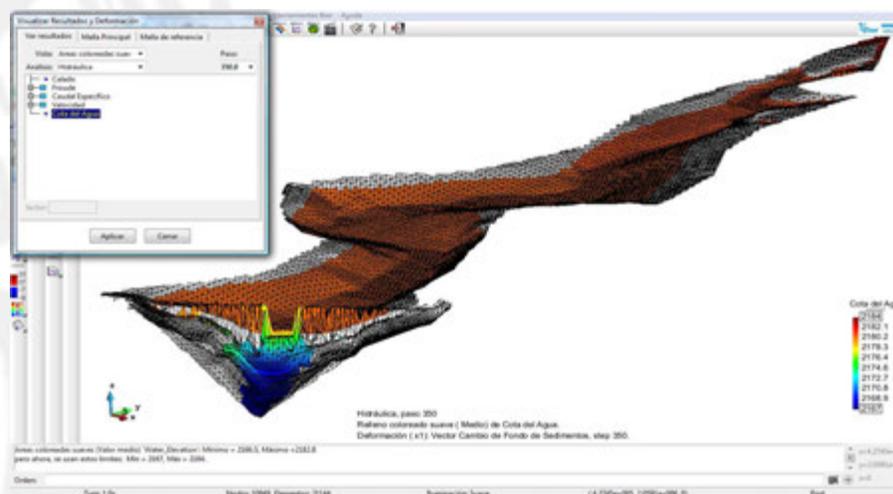
CONSECUENCIAS	SISMO DE DISEÑO
Altas o extremas	Pr=1/10,000
Moderadas	Pr=1/3,000
Bajas	Pr=1/1,000

CHOIX DES PARAMÈTRES SISMIQUES POUR GRANDS BARRAGES
Recommandations

SELECTING SEISMIC PARAMETERS FOR LARGE DAMS
Guidelines

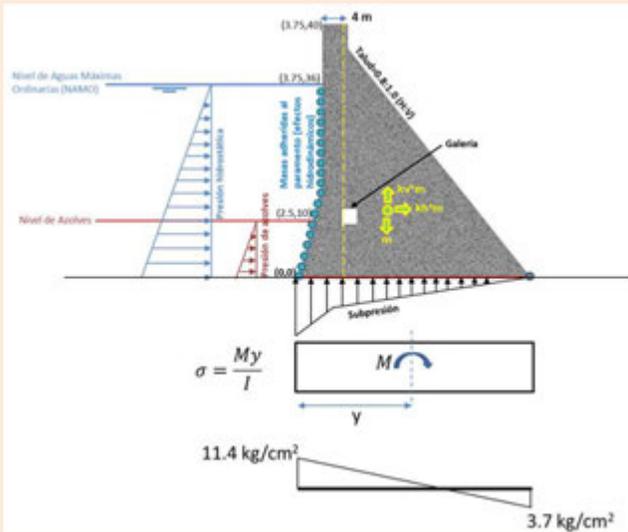
Bulletin 148



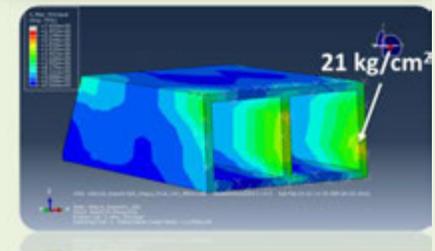
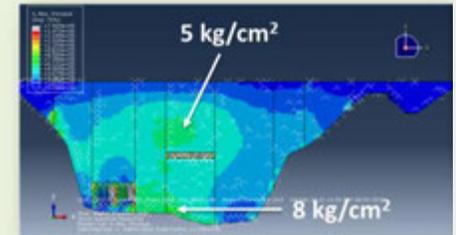
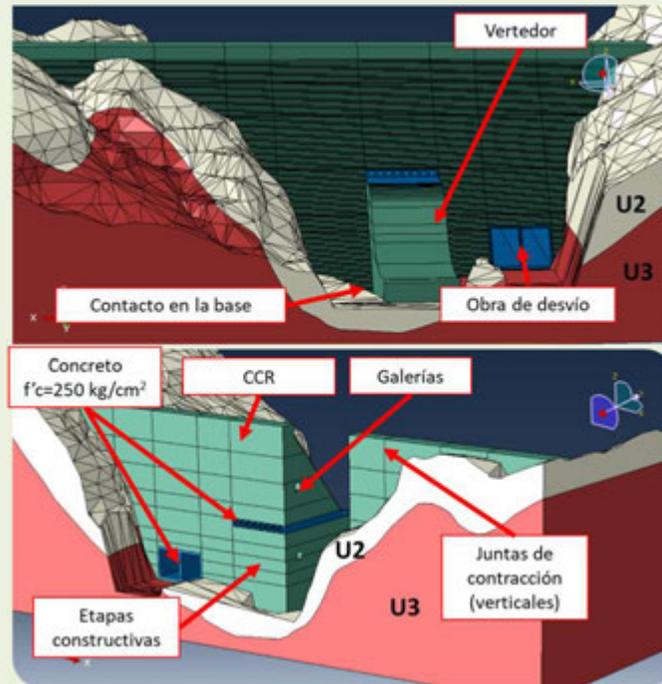


MÉTODOS ACTUALES DE ANÁLISIS SÍSMICO

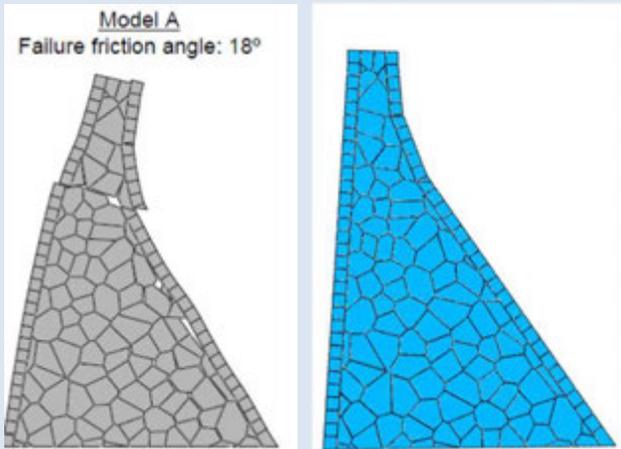
MODELOS DE CUERPO RÍGIDO



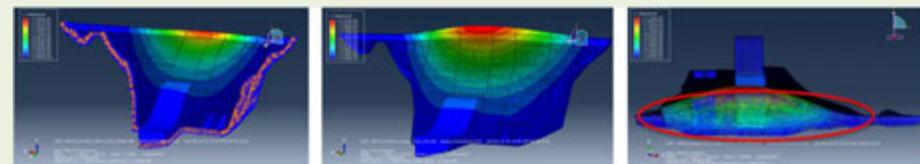
MODELOS DE ELEMENTOS FINITOS



MODELOS DE ELEMENTOS DISCRETOS



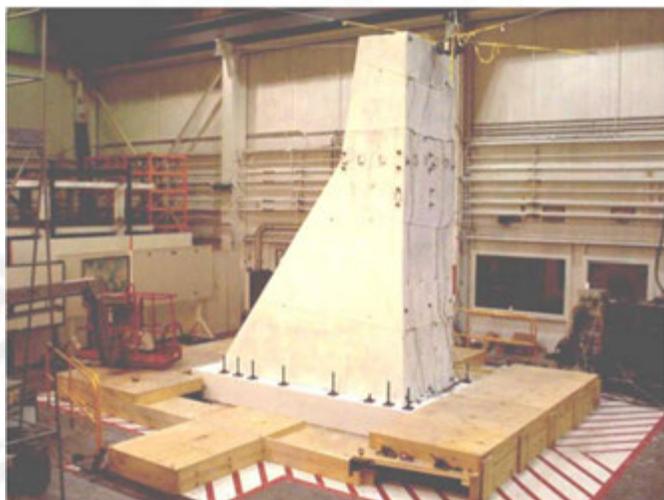
Bretas (2014)



Modo	Periodo Base Rígida (Segundos)	Periodo Base U2 y U3 (segundos)	Periodo Base U2 y U3 Interacción vaso (segundos)
1 (fundamental)	0.223	0.243	0.260
2	0.158	0.175	0.191
3	0.121	0.133	0.162
4	0.111	0.126	0.149
5	0.109	0.116	0.132

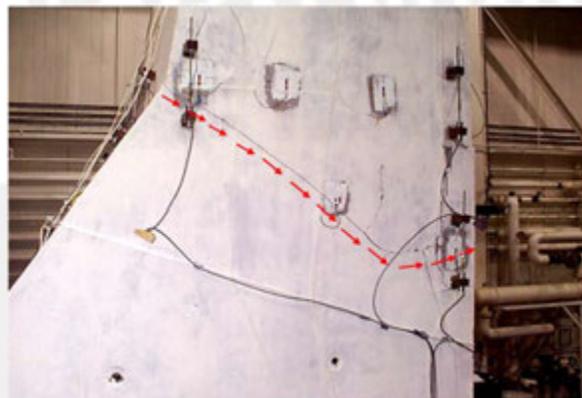
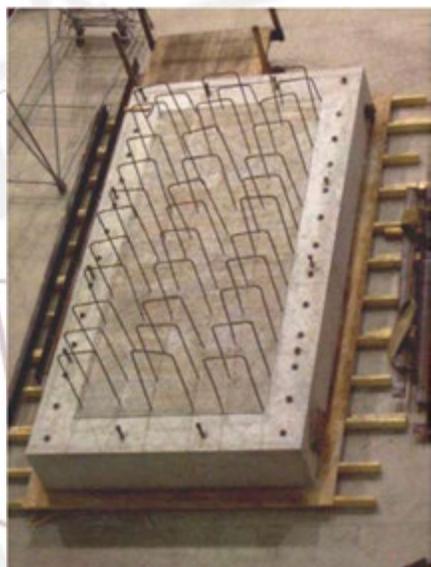
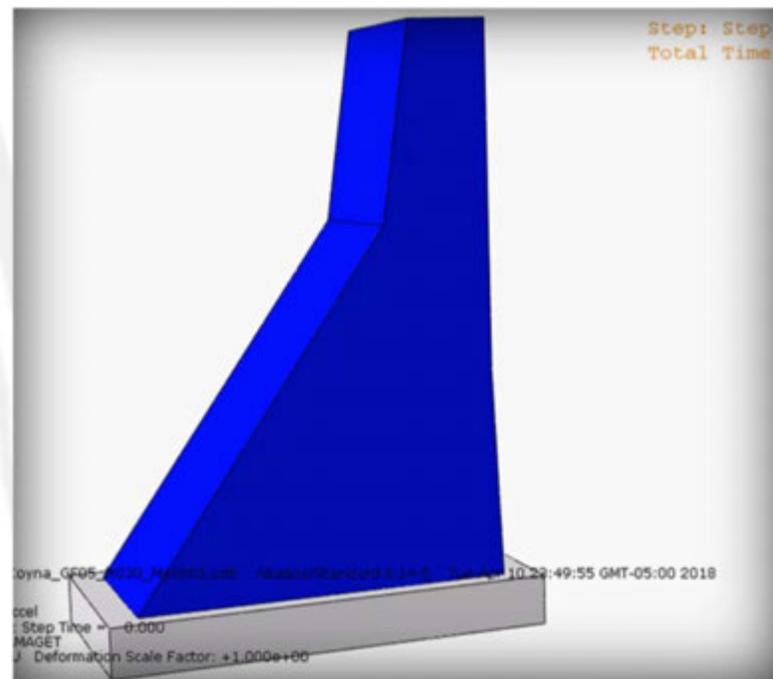
MÉTODOS ACTUALES DE ANÁLISIS SÍSMICO

Seismic Testing of a 1/20 Scale Model of Koyna Dam. USACE (2001)

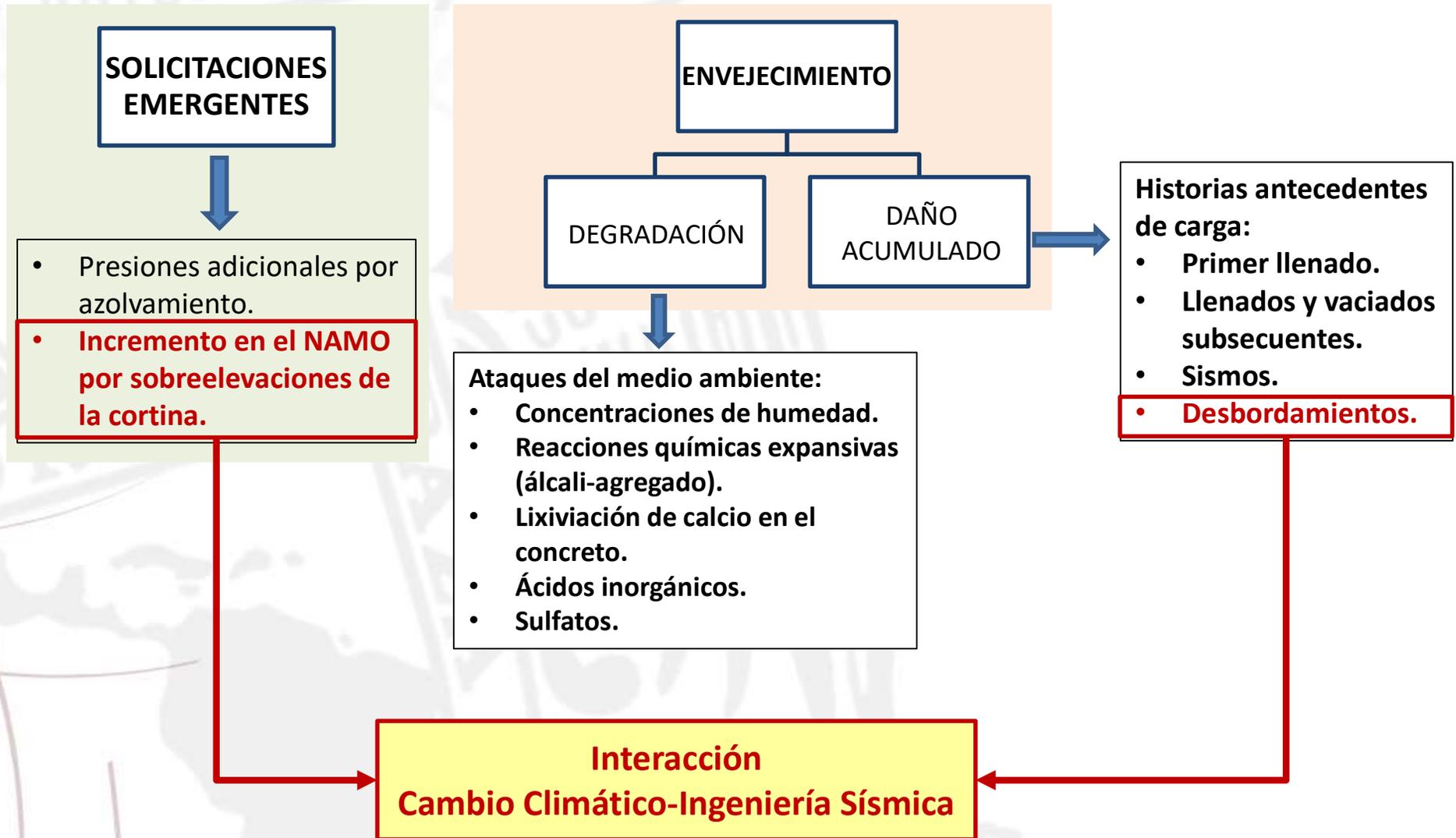


MODELO NUMÉRICO 2
 $f_t = 0.30f'_c = 0.30 (1.07 \text{ MPa}) = 0.32 \text{ MPa}$
 $G_f = 5 \text{ N/m}$

Inicio de grieta=1.1 s



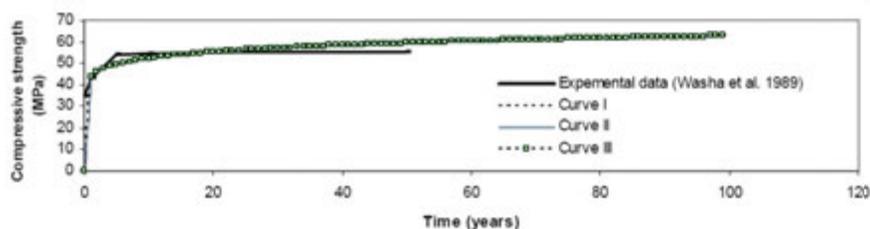
FACTORES QUE MODIFICAN EL COMPORTAMIENTO SÍSMICO DE CORTINAS EXISTENTES



PROPIEDADES DEL CONCRETO Y EVOLUCIÓN EN EL TIEMPO

INCREMENTO DE LA RESISTENCIA DEL CONCRETO CON EL TIEMPO

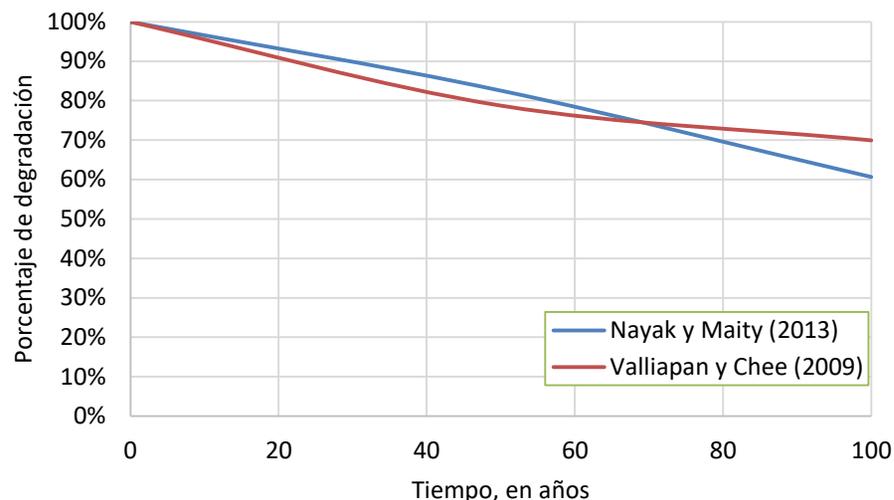
FIFTY-YEAR PROPERTIES OF CONCRETE MADE IN 1937
ACI Materials Journal, July-Aug 1989, Vol. 86, No. 4, pp 367-371:



$$f'c = 43.47t^{0.08}$$

donde t es el tiempo, en años.

DEGRADACIÓN DE LA RESISTENCIA DEL CONCRETO CON EL TIEMPO



$$d_m = (1 - \phi)^{t/T}$$

$$\phi = \phi_0 + \phi_c + \phi_m$$

Porosidad inicial

Porosidad química por condiciones agresivas

Porosidad por acciones mecánicas

COMPORTAMIENTO SÍSMICO CON DEGRADACIÓN DEL CONCRETO

Transient Analysis of Aged concrete dam-foundation coupled system. Burman (2012)

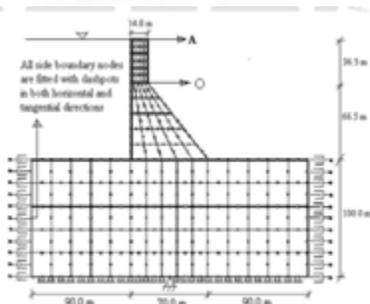
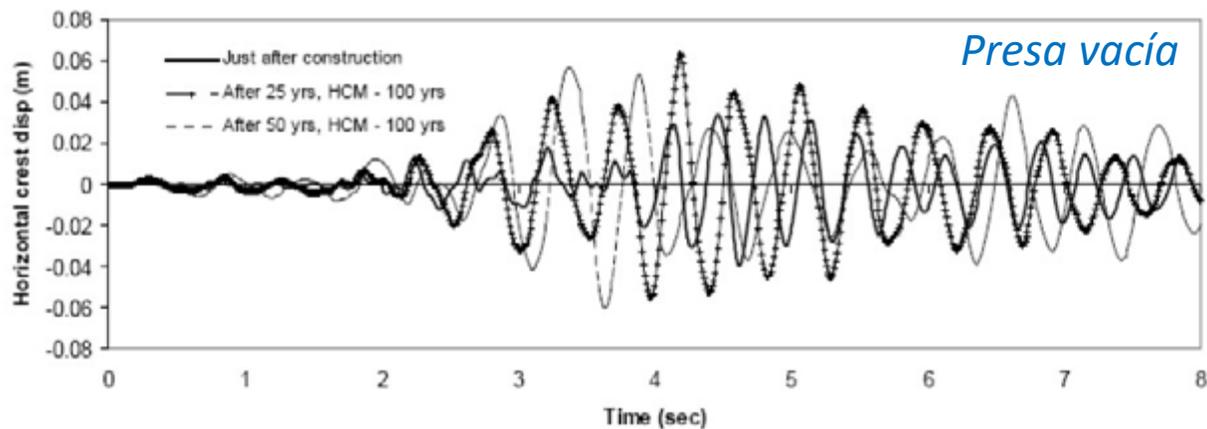
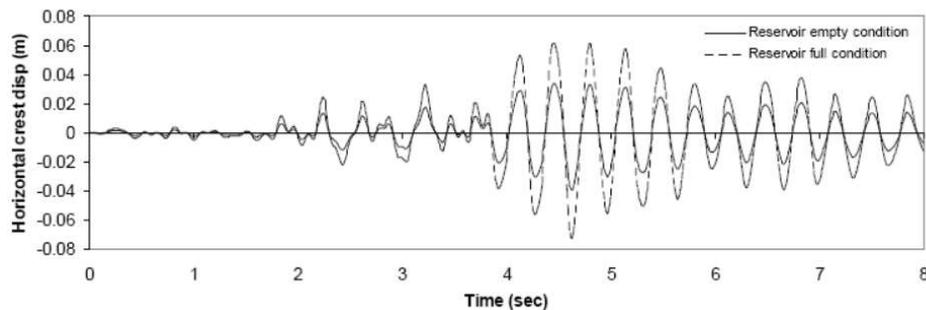


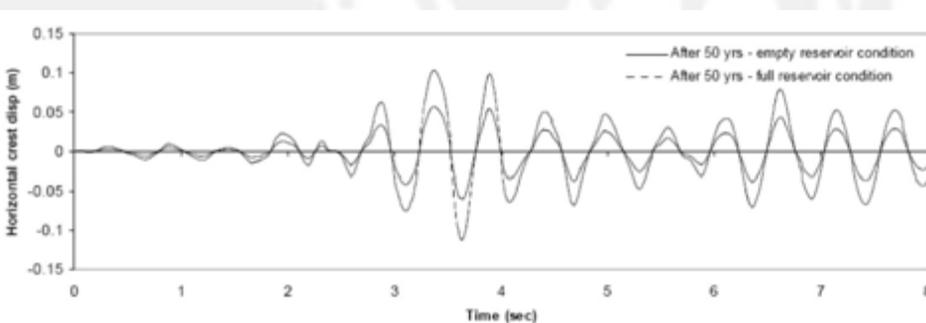
Fig. 4.47 The geometry and boundary condition of the Koyna dam-foundation system



Efectos hidrodinámicos.



Propiedades de diseño



Propiedades degradadas a 50 años

RETOS EN EL ANÁLISIS SÍSMICO DE PRESAS

NECESIDAD DE INSTRUMENTACIÓN. VARIACIÓN ESPACIAL DE LA EXCITACIÓN SÍSMICA



Figure 1: View of Karun III dam.

Figure 2: Location of accelerometer installed on Karun III dam and stream component of November 20, 2007 earthquake.

Table 1: PGA of the recorded ground motions and their occurring time for the earthquake of November 20, 2007.

Recorded stations	Stream comp.		Cross stream comp.		Vertical comp.	
	PGA (cm/s ²)	Time of PGA	PGA (cm/s ²)	Time of PGA	PGA (cm/s ²)	Time of PGA
S1	45	12.72	57	12.74	26	12.72
S2	57	12.76	62	12.74	23	12.73
S3	31	13.01	41	12.76	40	12.87
S6	43	12.82	47	12.82	32	12.81
S11	72	12.82	75	13.03	50	12.92
S15	71	12.85	74	12.85	28	12.81

Spatial variation input effects on seismic response of arch dams "M. Sohrabi-Gilani, M. Ghaemian (2012)

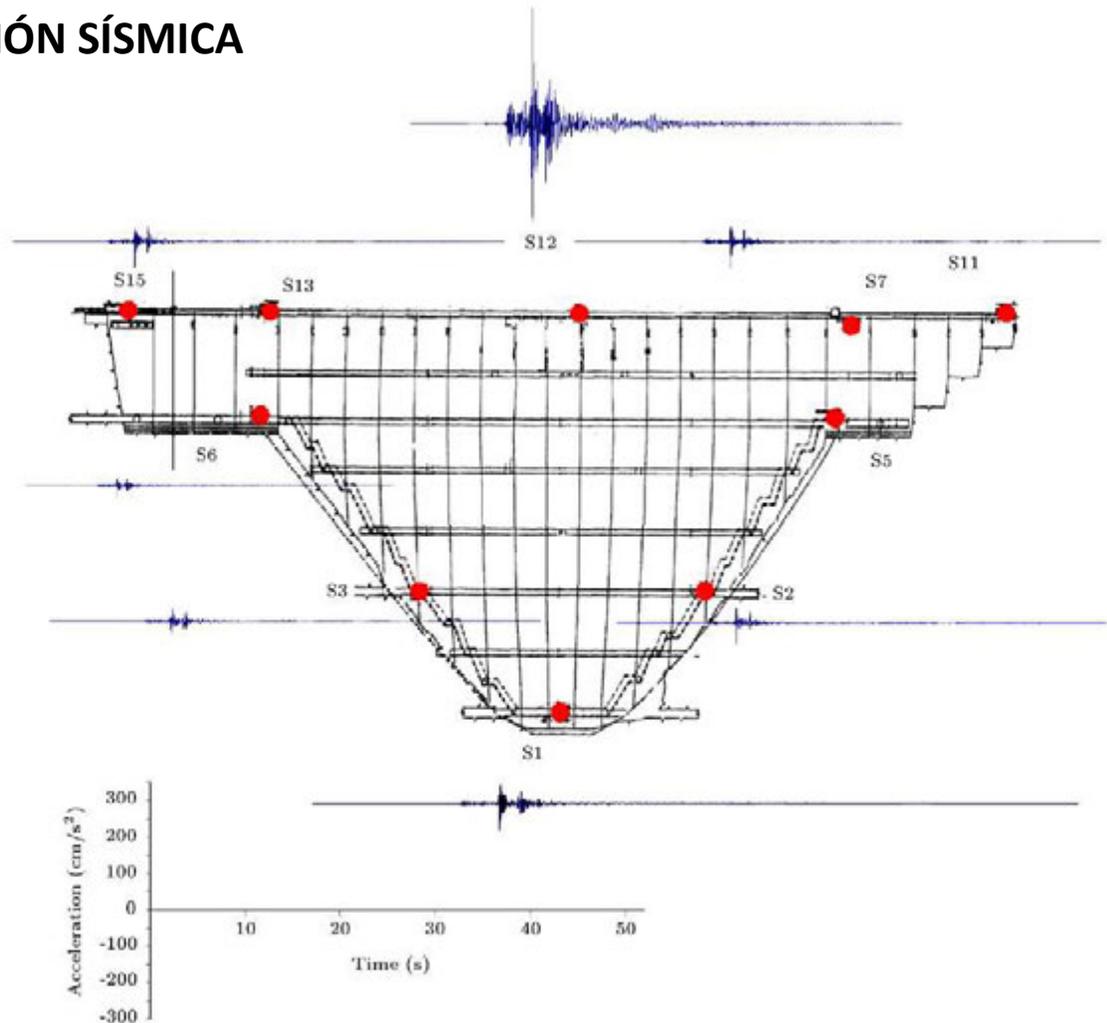


Figure 2: Location of accelerometer installed on Karun III dam and stream component of November 20, 2007 earthquake.

RETOS Y OPORTUNIDADES EN EL ANÁLISIS SÍSMICO DE PRESAS

NECESIDAD DE INSTRUMENTACIÓN.

VARIACIÓN ESPACIAL DE LA EXCITACIÓN SÍSMICA

Modelo de elementos finitos con asignación de los registros de aceleración en su ubicación correspondiente.

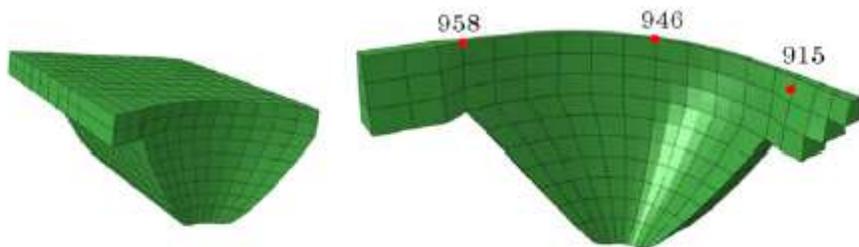


Figure 5: Finite element model of Karun III dam body and its reservoir.

Spatial variation input effects on seismic response of arch dams “M. Sohrabi-Gilani, M. Ghaemian (2012)”

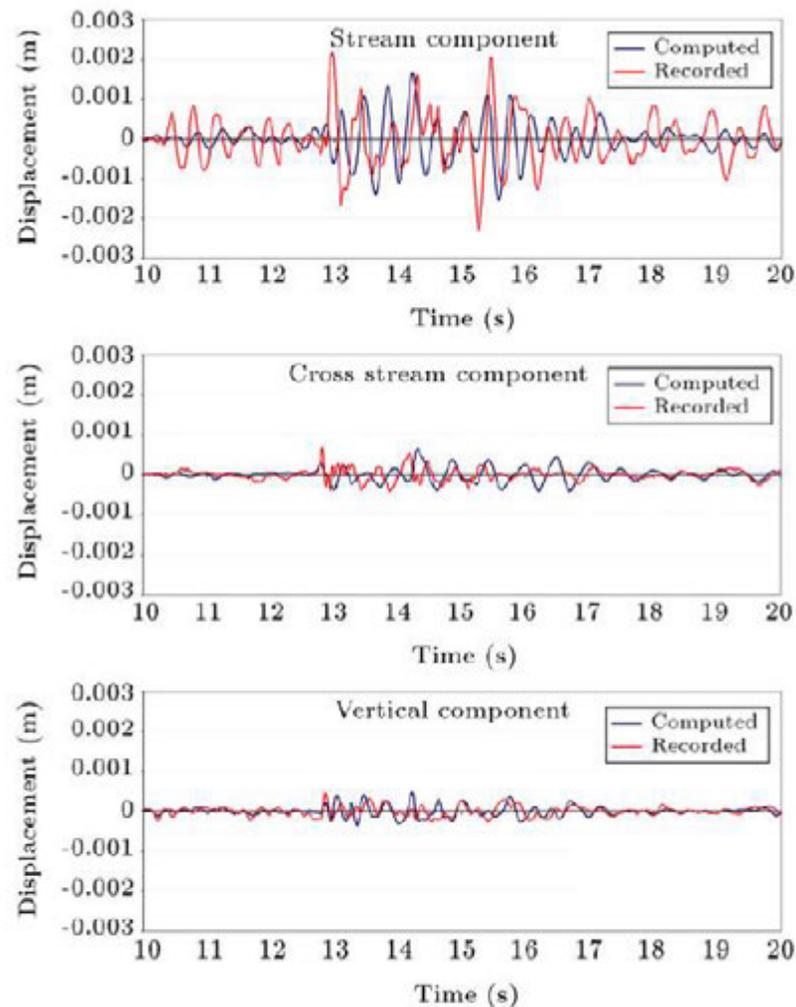


Figure 6: Recorded and computed displacements in stream, cross stream and vertical direction at crest (station 12).

RETOS Y OPORTUNIDADES EN EL ANÁLISIS SÍSMICO DE PRESAS

HERRAMIENTAS PARA DETECCIÓN DE DAÑOS. *Otra vez, necesidad de instrumentación..*

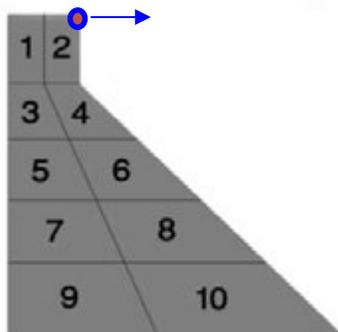


Figure 5. Dividing the Dam into Ten Zones to Detect the Location of the Damage

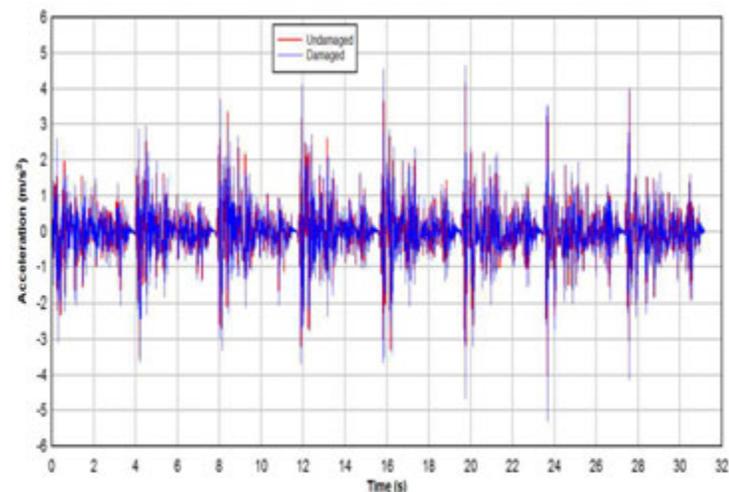


Figure 7. The Acceleration of the Damaged and Undamaged Structure

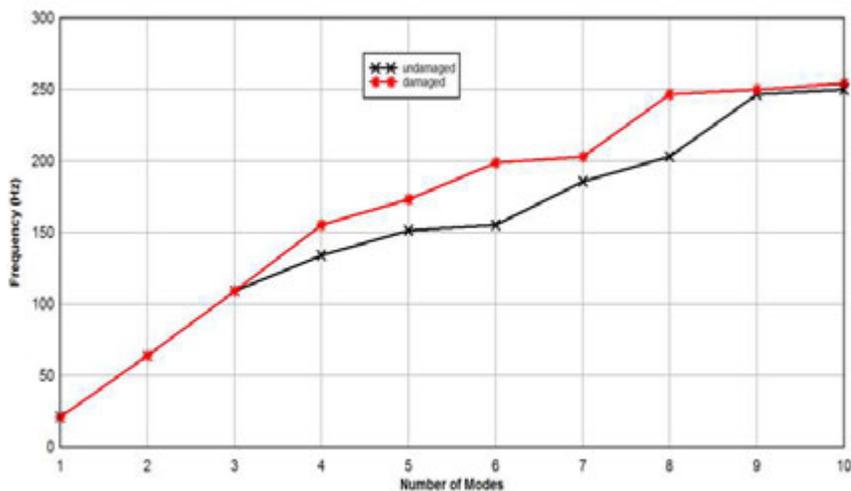
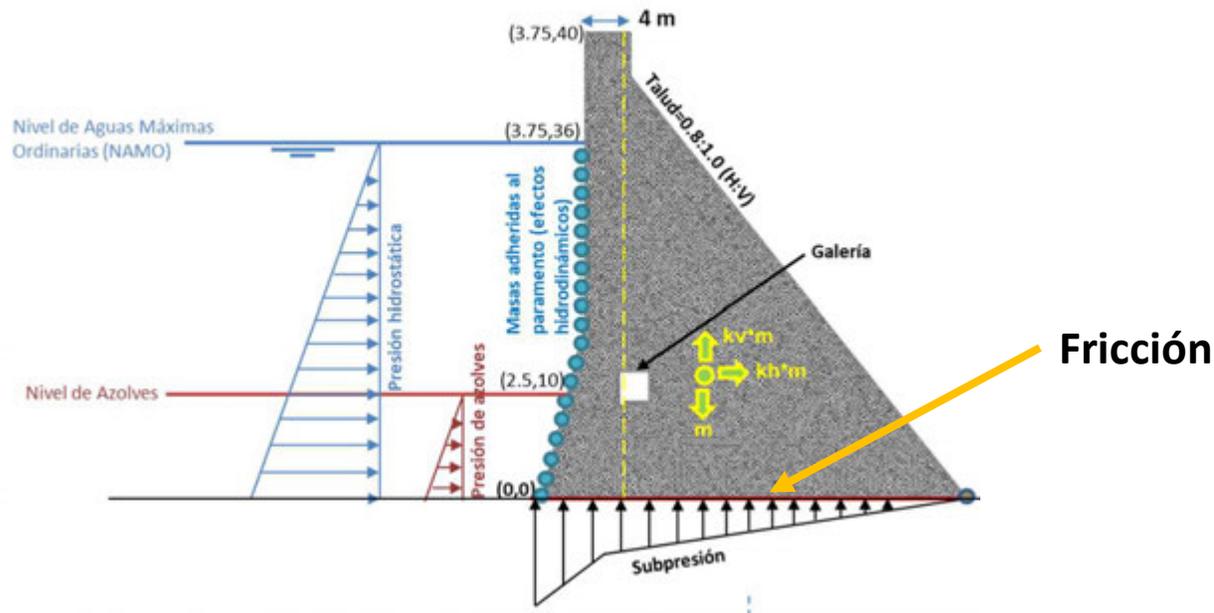


Figure 9. The Difference in Frequency as a Measure of Damage

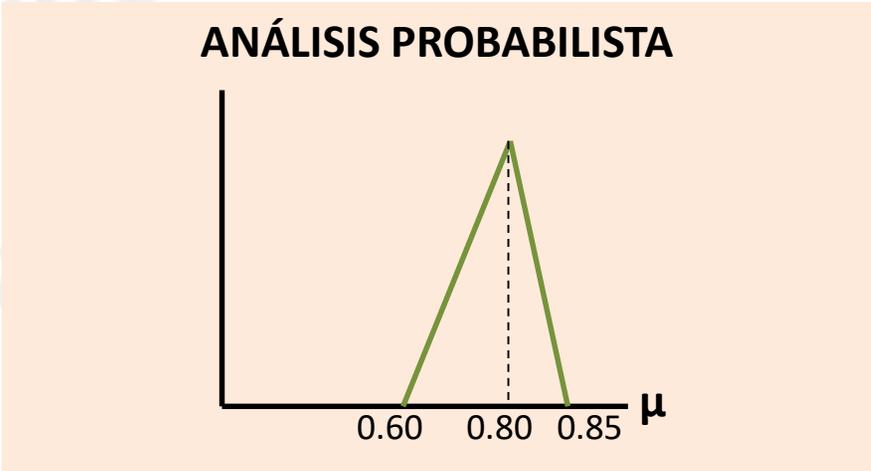
Damage detection of concrete gravity dams using Hilbert-Huang method. Esmailzadeh et al (2018)

RETOS Y OPORTUNIDADES EN EL ANÁLISIS SÍSMICO DE PRESAS

Aplicación de técnicas de confiabilidad estructural en presas.



ANÁLISIS DETERMINISTA
 $\mu=0.8$ (Coeficiente de fricción)





MUCHAS GRACIAS!

Darío Espinoza
Correo electrónico: espinfig@hotmail.com

