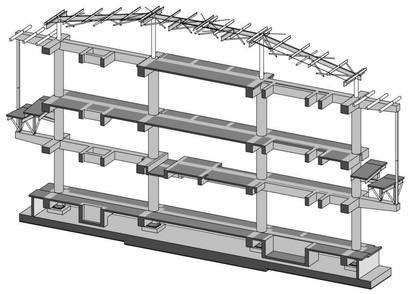
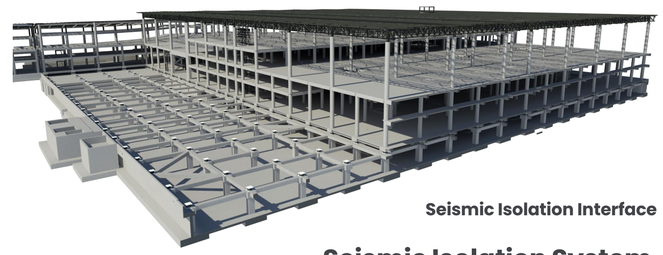
GLOBAL DESIGN AND INNOVATION AWARD ASSISi NEW JORGE CHAVEZ INTERNATIONAL AIRPORT | LIMA - PERÚ

Terminal Architecture

- Incorporates Base Isolation system, ensureing continuous operation after major ground motion.
- Capacity of 37.7MM pax/year: 267,500m².
- Reinforced concrete frames and steel roof structure.
- Main Processor Building: structure between 2 and 5 stories.
- 3 Boarding Buildings: International, Swing y Domestic.
- Seismic isolation on first floor base.



Swing Pier - Transverse Section



Seismic Isolation Interface

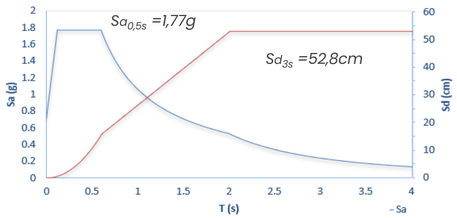
Structural design codes

- Peruvian Codes E.031, E.060, E.090

Seismic design general considerations

- Seismic demand: $MCE_{iso\_struct} = 1.5 \times MCE_{conventional}$
- R_b=1 (elastic) and R_s=2
- Time-history analysis for design
- Property modification factors (upper and lower bounds)

Seismic Design Spectrum



Lima

Structural system of seismic isolated buildings

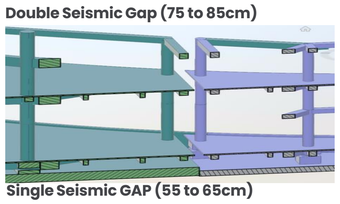
Substructure:

- Special RC moment frames (1 basement story)

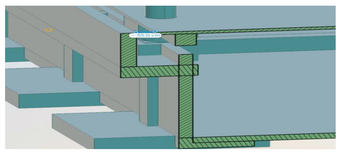
Superstructure:

- Special RC moment Frames for all stories (2 to 4)
- Steel wide flange beams and trusses for the roof structure

Double Seismic Gap (75 to 85cm)



Single Seismic GAP (55 to 65cm)

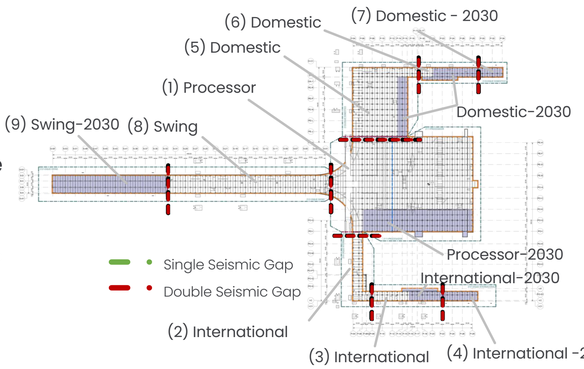


9 Independent seismic isolated structures

8 Types of LRB

1,077 LRB Seismic isolators

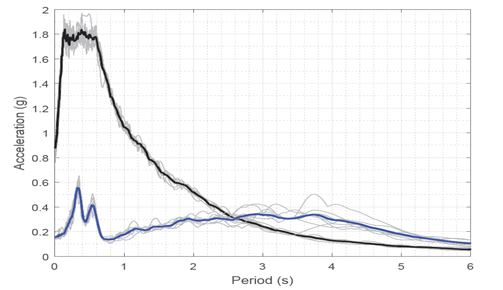
27 Friction sliders



Seismic Isolation System

- LRB + Frictional sliders
- Property modification factors
  - Postyield stiffness: $\lambda_{\min(LB)} = 0.8$ and $\lambda_{\max(UB)} = 1.3$
  - Lead yield force: $\lambda_{\min(LB)} = 0.8$ and $\lambda_{\max(UB)} = 1.5$
- Shrinkage deformations calculated according to ACI 209
- LRB Design procedure according to E.031
- Nonlinear axial force-deformation constitutive relationship

Parameter	Units	Range of values within buildings
SIS RESPONSE PARAMETERS		
Isolated modal period of vibration	s	3.42 to 4.11
Total maximum displacement of isolation system	cm	40.6 to 52.2
Compression loads	MN	3.4 to 21.04
Tension loads	MN	0 to 0.94
Flexural rotation	Rad	0.0010 to 0.0074
Damping ratio	%	14.6 to 21.2
STRUCTURE RESPONSE PARAMETERS		
Elastic base shear (at SIS)	% of Ws	11.2 to 13.9
Story drifts (elastic)	%	0.11 to 0.49 (limit: 0.5)
Accelerations at different stories	g	0.11 to 0.46
Accelerations at the steel roof	g	0.28 to 0.56



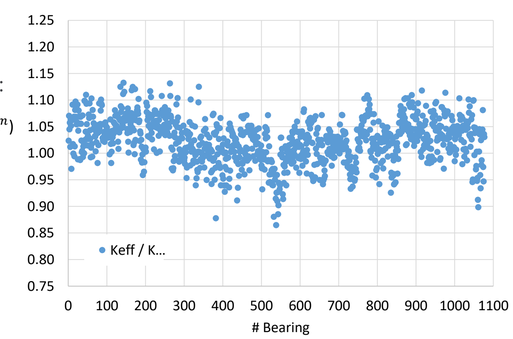
Mean acceleration response spectrum of ground motions

Mean acceleration response spectrum of the seismic isolated slab (Processor building)

QUALITY CONTROL TESTING

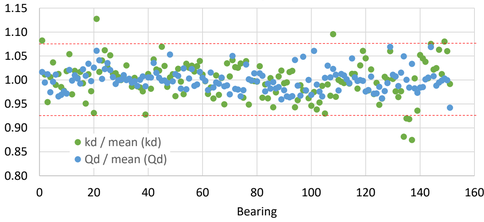
- 100% of the production units tested according to ASCE 7-16 and E.031.
- Units tested with 4 cycles at 0.67 D_M and vert. load $(D+0.5L)_{mean}$.
- Compliance for ASCE7-16 and E.031 requirements.
- Total mechanical properties (average of all) lie within $\pm\lambda_{spec}$ (ASCE 7-16) or $\pm 10\%$ (E.031) versus nom. properties

Verification of Total Properties



- **Manufacturing variability** (λ_{spec})

Statistical analysis of Production Tests data of RBs (similar characteristics of previous project



$$\lambda^{kd}_{max,spec} = \lambda^{Qd}_{max,spec} = 1.075$$

$$\lambda^{kd}_{min,spec} = \lambda^{Qd}_{min,spec} = 0.925$$

95% of samples contained between 1.075 and 0.925:

- **Test related effects:** Dynamic tests of similar RBs from previous projects (λ_{test})

Compliance with Quality Manufacturer λ values according to ASCE 7 and E.031

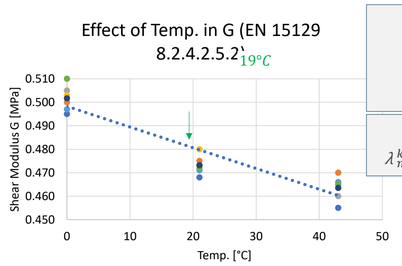
$$\lambda^{kd}_{min} = (1 + (0{,}75 \cdot (\lambda^{k_d}_{a,min} \cdot \lambda^{k_d}_{t,min} - 1))) \cdot \lambda^{k_d}_{test,min} \cdot \lambda^{kd}_{spec,min} = \mathbf{0.868} > 0.8 \checkmark$$

$$\lambda^{kd}_{max} = (1 + (0{,}75 \cdot (\lambda^{k_d}_{a,max} \cdot \lambda^{k_d}_{t,max} - 1))) \cdot \lambda^{k_d}_{test,max} \cdot \lambda^{kd}_{spec,max} = \mathbf{1.269} < 1.3 \checkmark$$

$$\lambda^{Qd}_{min} = (1 + (0{,}75 \cdot (\lambda^{Q_d}_{a,min} \cdot \lambda^{Q_d}_{t,min} - 1))) \cdot \lambda^{Q_d}_{test,min} \cdot \lambda^{Qd}_{spec,min} = \mathbf{0.858} > 0.8 \checkmark$$

$$\lambda^{Qd}_{max} = (1 + (0{,}75 \cdot (\lambda^{Q_d}_{a,max} \cdot \lambda^{Q_d}_{t,max} - 1))) \cdot \lambda^{Q_d}_{test,max} \cdot \lambda^{Qd}_{spec,max} = \mathbf{1.399} < 1.5 \checkmark$$

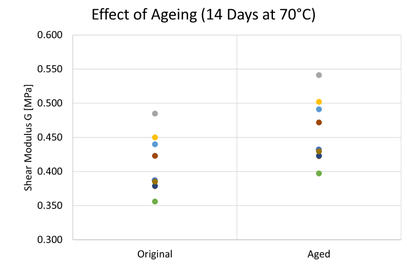
- **Ageing and environmental effects:** Test of rubber samples (λ^{kd}_{ae})



$$\lambda^{kd}_{min,t} = \frac{G_{19°C}}{G_{28°C}} = 0.987$$

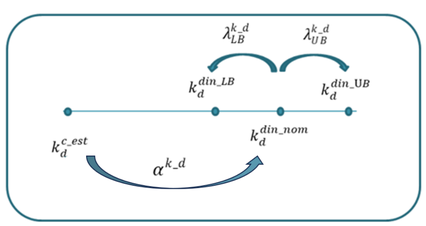
$$\lambda^{kd}_{max,t} = \frac{G_{10°C}}{G_{19°C}} = 1.013$$

$$\lambda^{kd}_{max,a} = \frac{\sum \frac{G_{aged,i}}{G_{original,i}}}{n} = 1.116$$



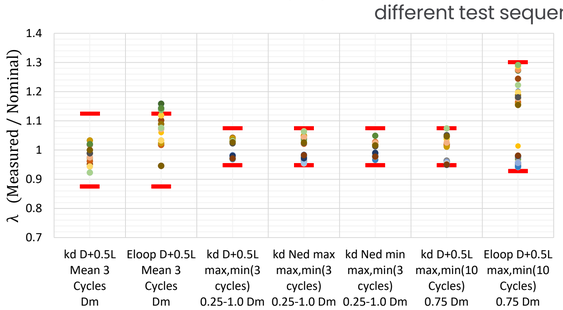
PROTOTYPE TESTING

- Reduced scale prototypes tested dynamically (0.27 Hz) and quasi-statically (0.01 Hz). Full-scale prototypes tested quasi-statically (0.01 Hz).
- α factors (ratio between mechanical properties at both frequencies) obtained to incorporate rate of loading effects into the full-scale quasi-static test results.



Dynamic reduced-scale test example (AS6R)

- **Full-scale prototypes (2 per type) tested according to ASCE 7-16**, section 17.8.2 considering the envelope of vertical loads, displacements and SF of the different SIS design results.
- Compliance for ASCE7-16 and E.031 requirements was verified.
- Verification of mechanical properties within λ factor limits for different test sequences:



Effective Stiffness:

$$\lambda_{spec,min} < mean\,(K^{Exp}_{eff} / K^{nom}_{eff}) = \mathbf{1.0237} < \lambda_{spec,max}$$

Damping Ratio:

$$\lambda_{spec,min} < mean\,(\xi^{Exp} / \xi^{nom}) = \mathbf{1.0382} < \lambda_{spec,max}$$