## Shaking Table Tests on The Seismic Performance of Bridge Abutments with EPS And Soil Reinforcements in The Backfill



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## **Introduction**

Previous large earthquakes reported numerous damage cases on bridge abutments such as residual lateral displacements of abutment body and relative settlements at backfill-abutment wall interface. These damages disrupted normal traffic operation and hence posed a threat to post-earthquake rehabilitation and economic activities.

In light of it, this study focuses on different soil reinforcement methods in the backfill in order to determine the optimal aseismic countermeasure layout that is both effective and practically applicable on site.

## Previous research

Expanded Polystyrene (EPS), geogrids and soil nails are three main types of soil reinforcement methods adopted in the field. Previous research focused on the combined use of these reinforcements for existing structures, but the effects of different geometries or material properties of reinforcements were not fully studied. This study hence investigated how EPS stiffness and nail length/diameter affect overall structure seismic performance. Specifically, EPS of lower stiffness and through-out soil nails penetrating from the top of abutment body to subsoil layer were adopted.





Tohoku earthquake (2011)

Kumamoto earthquake (2016)

FPS of lower stiffness



nails

## Experimental models

Experimental models	0	raharra -	naiis
Scale: 1:20 one end: attached to abutment top via hinges the other end: with rollers on a supporting	Static load Supporting frame Abutment Bac	kfill Soil foundation	Lead ingots 0.39kPa Rubber bands Scale: 1:20; Material: Aluminum Weight: 48.7kg; Volume: 0.0194m <sup>3</sup> Unit weight: 25.1kN/m <sup>3</sup> → simulate semenande acimia resenance ac
frame→facilitates girder sliding under seismic input.	Shaking table Shaking direction		comparable seismic responses as prototype
Experimental cases	Results & Discussion	I	Through-out
5 out of the 12 cases were selected for parametric study purpose. Seismi performance of the abutment mode was evaluated against parameter shown in the figure circled.	C 14 suppressed tilting	Through-out + ordinary EPS Through- out + softer EPS 1. 1. Addition 1 profound r in soil force 1 0.4 1	eduction
			1446036
	0 500 Base acceleration	1000 <sup>0</sup>	Base acceleration (gal)
Through- out nail	Relative settlemen of backfill	a (gal) 1. <u>Through-out nail</u> 1. <u>Through-o</u>	
Through- out nail	Base acceleration	a (gal) 1. <u>Through-out nail</u> 1. <u>Intrough-out nail</u>	Base acceleration (gal) Through-out hrough-out + ordinary EPS 2. No further reduction despite softer EPS Addition of EPS, improve settlement (EPS uplifting) 1000 1500
Through- out nail	Base acceleration	a (gal) 1. <u>Through-out nail</u> alone not enough in inhibiting settlement 1. <u>Through-out nail</u> alone not enough in inhibiting settlement 5. Shortened 0 500 Base acceleration	Base acceleration (gal) Through-out hrough-out + ordinary EPS 2. No further reduction despite softer EPS 3. Addition of EPS , improve settlement (EPS uplifting) 1000 1500 (gal)
Through-out + softer EPS Softer EPS Through-out + softer EPS Through-out + ordinary EPS Conclusions (1) To confirm benefit of through-out type nails (2) To verify length	Base acceleration	a (gal) 1. <u>Through-out nail</u> 1. <u>Intrough-out nail</u>	Base acceleration (gal) Through-out Through-out + 2. No further reduction despite softer EPS 3. Addition of EPS, improve settlement (EPS uplifting) 1000 1500 (gal) Merits:
Through- out nail Through-out + softer EPS Softer EPS Through-out + ordinary EPS Conclusions ① To confirm benefit of through-out type nails ② To verify length effect ③ To investigate → Relative s	Base acceleration	a (gal) 1. <u>Through-out nail</u> alone not enough in inhibiting settlement 1. <u>Through-out nail</u> alone not enough in inhibiting settlement 5. Shortened 0 500 Base acceleration	Base acceleration (gal) Through-out Through-out + acceleration (gal) Through-out + 2. No further reduction despite softer EPS 3. Addition of EPS, improve settlement (EPS uplifting) 1000 1500 (gal) Merits: - consistent and continuous tensile force (nail) - better attenuation of
Through-out nail       Through-out + softer EPS         Through-out reprint of through-out type nails       Through-out + ordinary EPS         ① To confirm benefit of through-out type nails       Tilting and displacer         ② To verify length effect       Imadequate - Deep nail         ③ To investigate benefit of EPS backfill       Imadequate - Soil force         ④ To check stiffness       Soil force	Base acceleration	a (gal) 1. <u>Through-out nail</u> 1. <u>Through-out nail</u> 1. <u>Inrough-out nail</u> 1. <u>Inrough-o</u>	Base acceleration (gal) Through-out hrough-out + 2. No further reduction despite softer EPS 3. Addition of EPS, improve settlement (EPS uplifting) 1000 1500 (gal) Merits: ✓ consistent and continuous tensile force (nail) ↓ batter attoruction of