成果報告書の概要

【令和４年度】

【事業費：5,602千円　国費：　5,602千円】【事業主体名：スターツＣＡＭ株式会社】

住宅建築技術国際展開支援事業（うち事業環境整備）「トルコ共和国における都市型免震技術の国際展開とその技術者育成支援」

１．事業の目的

本事業の目的は、トルコ共和国において下記２点を実現することである。
①「都市型免震技術＊」の国際展開における課題の明確化及び人材育成を通じたトルコ企業との共同連携による設計手法の確立と実際的なワークフローの改良策定
②「都市型免震技術＊」を適用したパイロットプロジェクトに繋げるための技術者育成研修会の実施
令和５年度中にはパイロットプロジェクトの実設計を開始することを想定しており、パイロットプロジェクトの実現に向けて、「想定地震の設定」、「トルコ式設計法」及び「モデル建物の試設計」を研修内容に追加することで、パイロットプロジェクトでの計画を想定した内容での研修を実施する。
そのために、トルコ側企業群（トルコ設計事務所、トルコPC会社）（以下、「トルコ側企業群」という。）及びチームジャパン（地震・地盤関連：応用地質、地震計測：応用地震計測、免震装置メーカー：ブリヂストン・日鉄エンジニアリング等）（以下、「チームジャパン」という。）と共同して、研修資料を作成する。
研修対象者には、技術者以外の建物の構造種別（免震か非免震か）の決定権者に近い人（不動産関係会社勤務者、建築設計者、建設会社幹部等）（以下「技術者以外の研修対象者」という。）も含める。

２．事業の必要性

［1］地震大国トルコの免震需要
　トルコ共和国は日本と同様に地震の多い国で、地震による被害も頻発している。1999年コジャエリ大地震で約17,000人もの犠牲者を出した。トルコ政府も地震対策の施策を打ち出し、現在では、トルコ国内の地震危険地域内にある100床以上の病院施設に免震構造を義務化し、需要が急速に拡大している。これまで100棟程度（推計）の免震建物が建設され、病院施設や大型の施設には比較的新しい技術が採用されているが、日本の免震技術が十分に採用されていない現状がある。

［2］都市型免震技術の必要性
　トルコ共和国では、まだ中小規模のオフィスや共同住宅等には免震構造が採用されているとは言えない。トルコ国民の生命を守る「質の高いインフラ」として採用されるためには、日本で行われている比較的低廉で汎用性の高い免震技術を、今後提供することが必要である。
　トルコで採用されている免震装置の多くは曲面すべり支承型(FPS)であるが、これは郊外にある中層で塔状比が小さい建物に適しているものの、都市部でのタワー型の建物や狭小な敷地には適さない事が多い。トルコの免震構造の技術者はまだ数が少なく、特にイスタンブール市街地の多くの建物を免震化するための都市型免震技術を利用できる技術者は少ない。今後のトルコの都市部の開発が急速に進んでいる状況を鑑みると、都市型免震技術は広くトルコ国内に展開するのに相応しい技術であると言える。

［3］技術移転の課題解消するスターツの免震技術
　スターツでは、1995年の阪神淡路大震災以降、低廉で汎用性の高い免震構造技術や特許を含む独自工法の開発、維持管理点検の手法確立など、免震建設における広範な分野で高度なノウハウを構築してきた。2012年以降、トルコ共和国への免震技術移転について可能性を検証してきており、ある程度の課題が存在することが確認できた。
　また、2015年度の既往調査においても、技術移転の複数の課題が挙げられている。これらの課題を長年の経験に裏づけられた免震構造技術の観点から再検証し、本事業において課題解決の方策を提示する。
［4］技術者育成が必要不可欠
　都市型免震技術をトルコに展開するためには、下記２点が必要不可欠である。
①　技術移転の課題を克服する方法を検証し、実務的なプログラムと包括的な実施フローを策定すること。
②　都市型免震技術を理解し、有用性を確認した上で、これを習得できる技術者の育成研修を実行すること（特に若手技術者の育成が有効）。

３．事業内容

PhaseⅠ：研修内容の改善及び本研修に参加するトルコ人受講者等の選定
【研修内容の改善】
・昨年度までの研修内容について、トルコ人技術者と意見交換を行い、今年度の研修内容の改善のための検討等を行う。
・研修内容には、パイロットプロジェクトの実現に向けて「想定地震の設定」、「トルコ式設計法」及び「モデル建物の試設計」を追加した。
※上記の３つの内容は、研修プログラムのポイントの中の③「設計手法」に追加することとなる。
・トルコ側企業群及びチームジャパンと共同して、上記の研修内容を研修に組み込む。
・昨年度の事業において、都市型免震の研修プログラムのポイントを７つ設定しており、今年度の研修においてもこれらのポイントを重点に資料作成を行った。
（①「概要・事例・原則」、②「基準・指針」、③「設計手法」、④「免震装置」、⑤「施工技術」、⑥「維持管理」、⑦「価値・普及」）
・建物の維持管理・FMにおいて重要な技術である「免震装置」の交換工事における研修ビデオを作成した。
【受講者等の選定】
・トルコ人ネットワーク（トルコ免震協会、大学准教授、昨年度研修参加者等）を通じて、研修対象技術者の募集を行った
・技術者以外の研修対象者についても昨年同様に募集を行った。
PhaseⅡ：リモートによる技術者育成研修の実施を令和５年２月半ばに予定していたが、令和５年２月６日に発生した「トルコ・シリア大地震」により、現地の震災被害状況を鑑み、研修を開催することが適切ではないと判断した。急遽、リモート研修は中止としたが、替わりに作成した研修資料を研修参加予定者に送付した。また、研修そのものの開催がないのと、その研修後のフィードバックが無いため、本事業の成果報告会の替わりに、イスタンブール工科大学のSutcu先生に参加いただいた「トルコ・シリア大地震報告＆意見交換会」を開催した。地震後１か月以上が経った３月１０日時点の現地の被害状況や震源エリアに建つ６棟の免震建物の効果の報告をしていただいた。また、報告の後、関係者による、現時点での震災の振り返りの重要点や早急な支援等のポイントに加え、パイロットプロジェクトに向けての短期、中期的な重点事項について、それぞれの立場から、非常に有用なご意見をいただいた。令和３年度から実施してきた研修セミナーに参加した企業から具体的な免震プロジェクトについての問い合わせも来ており、今回の意見交換会を踏まえて、また今年度の研修資料作成を協働した「チームジャパン各企業」と情報共有、協力し合いながら進めていくこととする。
以下に「トルコ・シリア大地震報告＆意見交換会」の参加者を示す。
　国土交通省・住宅局総務課国際室　　望月 克信 課長補佐
　福岡大学　高山 峯夫　教授
　東京工業大学　笠井 和彦　特任教授
　日本免震構造協会　可児 長英 フェロー
　イスタンブール工科大学　准教授　Dr. Fatih Sutcu（ファティス・スッチュ）
　㈱ブリヂストン　室田 伸夫統括部長（免震構造協会副会長）、鮫島 祐介
　前田建設工業㈱成瀬 忠室長、Taner ATICI（タネル・アトゥジュ）, Country Manager
　応用地質㈱　甲斐田康弘部長Tonguc BINER（ビネル・トングチュ） Chief
　川金コアテック㈱　荒川 玄、Tolga Onal,（トルガ　オナル） Project Coordinator
　スターツコーポレーション㈱　関戸 博高特別顧問
　スターツCAM㈱　中西 力執行役員　、　谷 槙一朗
PhaseⅢ：研修資料送付後、トルコ・シリア大地震報告＆意見交換会開催後の検証
・来年度以降に開催予定の研修に向けて、研修内容等を考察し検証した。
・また、パイロットプロジェクトの実設計を開始するために、研修での意見交換等を検証し、パイロットプロジェクトの実現に向けた検討を行った。
・研修実施後の検証を踏まえて日本国内向けの本事業に関するセミナーに向けた準備を行った。
PhaseⅣ：調査・研修結果の広報等
・国土交通省や国内の学識有識者（東京工業大学・福岡大学等）や免震関連企業（ブリヂストン・川金コアテック等）が参画したセミナーを主催して、研修結果及び今後のパイロットプロジェクトの実施に関する報告・意見交換を実施する。
・調査・研修結果をスターツホームページやプレスリリースを通じて広報を行う。
・研修参加者とは、SNS等を通じて都市型免震技術に関するノウハウの提供を行うなど、情報交換を継続的に実施する。
・トルコでの免震技術関連の人脈ネットワークを今後も広げる。
（建設系政府要人、大学関係者、免震協会、構造設計者、建設会社、不動産会社、建築設計事務所等）

４．実施体制

「スターツＣＡＭ（株）免制震構造研究所」、「スターツＣＡＭ（株）国際建設事業部」、スターツＣＡＭ（株）設計本部」、「（株）スターツ総合研究所」、「スターツコーポレーション（株）」、及びスターツＣＡＭ（株）関連大学、関連企業とで実施した。

５．トルコ・シリア大地震報告＆意見交換会（２０２３年３月１０日（金））

国土交通省/住宅建築技術国際展開支援事業プログラム
トルコ・シリア大地震報告＆意見交換会

日時：　2023年３月１０日（金）16:00~17:40　（※日本時間）
会場：　リモートにて開催
主催：　国土交通省、スターツCAM（株）
使用言語：　日本語

司会：　スターツCAM

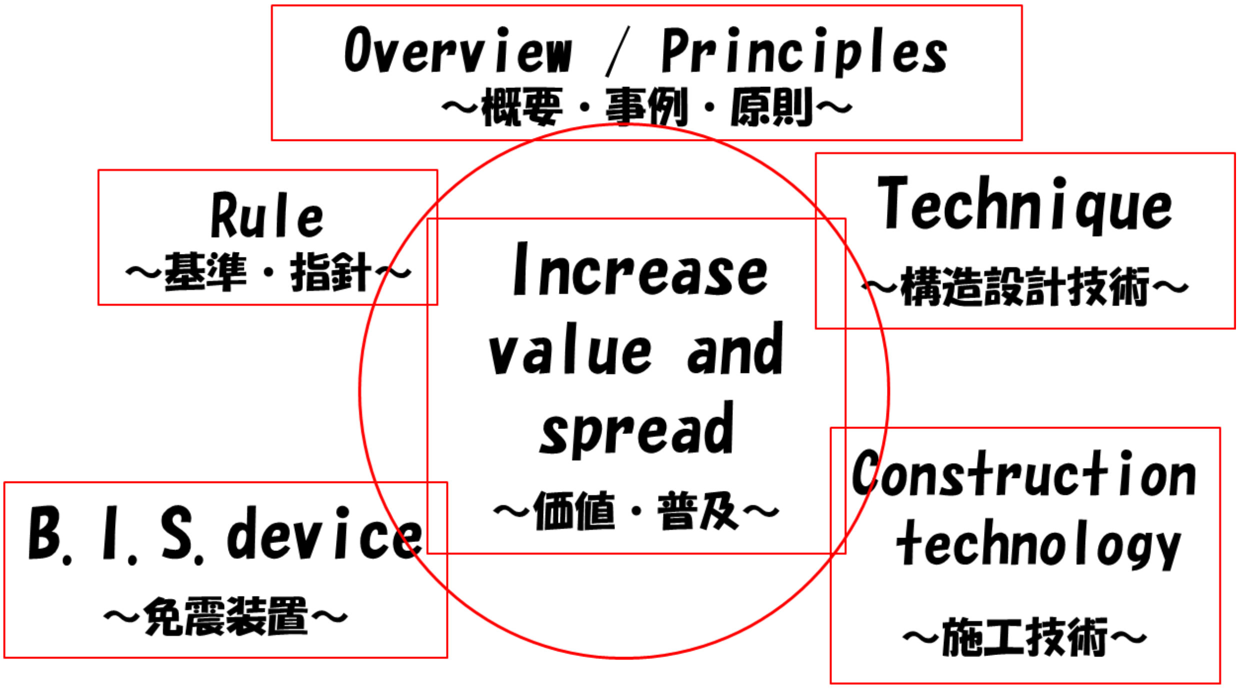
時間			プログラム	講演者
開始	終了	時間	内容	
16:00	16:05	5分	はじめに	スターツCAM㈱/スターツ免制震構造研究所 執行役員　中西　力
16:05	16:08	3分	開会の御挨拶	国土交通省住宅局総務課国際室 課長補佐　望月　克信
16:08	16:33	25分	トルコ・シリア大地震の現状報告	Dr. Fatih Sutcu（スターツ事務所より参加） イスタンブール工科大学　土木工学部　准教授
16:33	17:38	65分	参加者メンバーによる意見交換会	参加者メンバー：以下参照 【司会】スターツCAM㈱/スターツ免制震構造研究所 執行役員　中西　力
17:38	17:40	2分	最後に	スターツCAM㈱/スターツ免制震構造研究所 執行役員　中西　力
-	-	-	意見交換会：参加メンバー	
-	-	-	国土交通省・住宅局総務課国際室　　望月 克信課長補佐 福岡大学　高山 峯夫　教授 東京工業大学　笠井 和彦　特任教授　　※１６：２０よりご参加されます。 日本免震構造協会　可児 長英 フェロー	
-	-	-	イスタンブール工科大学　土木工学部　准教授　Dr. Fatih Sutcu（ファティス・スッチュ）	
-	-	-	㈱ブリヂストン　室田 伸夫統括部長（免震構造協会副会長）、鮫島 祐介 前田建設工業㈱　成瀬 忠室長　、　Taner ATICI（タネル・アトゥジュ），Country Manager 応用地質㈱　　井出 修執行役員　、甲斐田　康弘部長　、Tonguc BINER（ビネル　トングチュ），Chief 川金コアテック㈱　荒川 玄　、　Tolga Onal,（トルガ　オナル）Project Coordinator	
-	-	-		
-	-	-	スターツコーポレーション㈱　関戸 博高特別顧問　※１６：１５よりご参加されます。 スターツCAM㈱　中西 力執行役員　、　谷 槙 朗	

６．事業効果

●成果及び効果①「研修を通じた幅広い免震技術者の広がり」
（成果）トルコの環境都市計画省高官やトルコの建設系技術者等に対して、都市型免震の技術特性に関する理解促進を図る。また、免震技術展開の課題の一つである技術者不足を解消するために技術者の育成を図ることができる。研修講師を委託することにより、トルコ人技術の育成にも繋がり、日本式都市型免震の理解が深まる。
（効果）　　　トルコ国内で都市型免震の特性について理解できる構造技術者が増えることで、都市型免震の免震関連技術の展開が容易になる。高いレベルのトルコ人技術者がトルコ共和国における免震普及の更なるけん引役を担う。

●成果及び効果②「パイロットプロジェクトの実現に向けた足掛かり」
（成果）　　　研修対象者に、技術者以外の建物の構造種別（免震か非免震か）の決定権者に近い人（不動産関係会社勤務者、建築設計者、建設会社幹部等）を含め、研修内容にパイロットプロジェクトの実現を見据えた内容を含めることで、パイロットプロジェクトの具体的案件を通じたやり取りが生まれる。令和５年度中に開始する予定のパイロットプロジェクトの実設計に向けた、足掛かりとする。
（効果）日本式都市型免震の特性や優位性を把握することができ、国際展開するための更なるPR材料を有することができる。パイロットプロジェクトの構造計画及びコスト検討を通じて現在のトルコの免震技術における課題とその解決方法が明確化される。

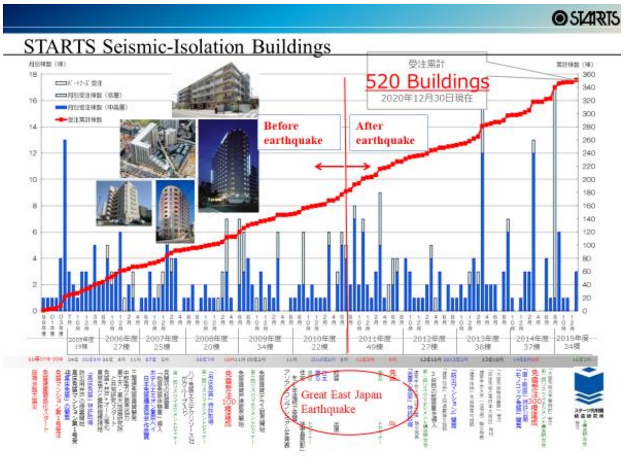
7.免震技術研修の7つのポイント



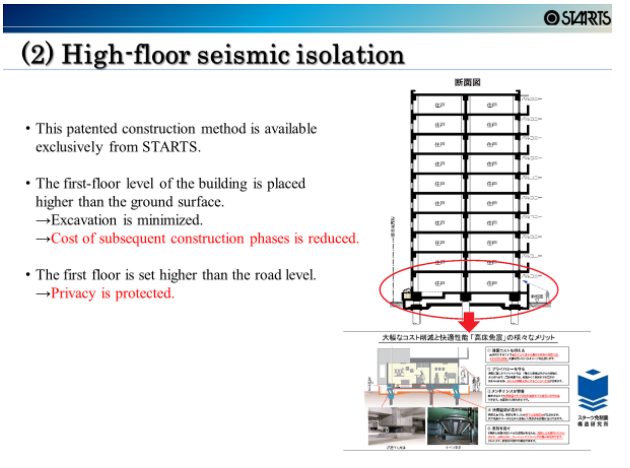
8.研修時使用スライド(抜粋)

Lecture ①:「免震の概要 (withスターツの免震の取り組み)」

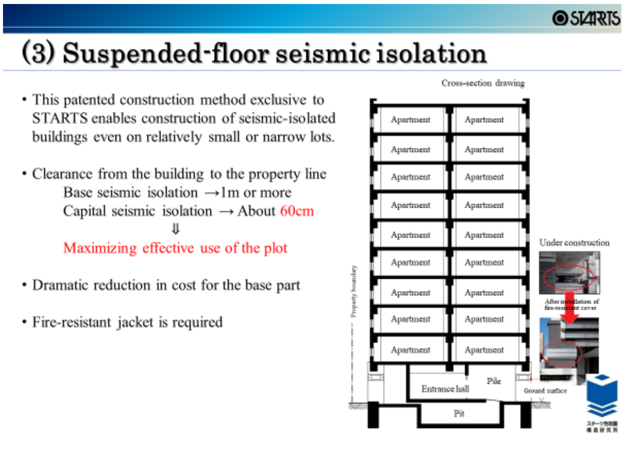
スターツの免震受注棟数と免震への25年の歩み



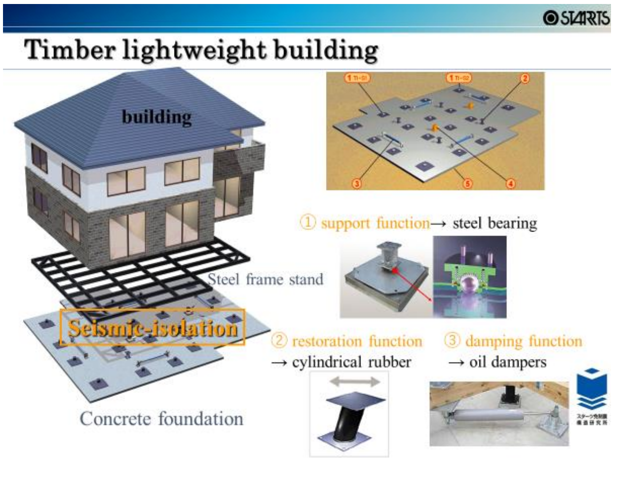
高床免震



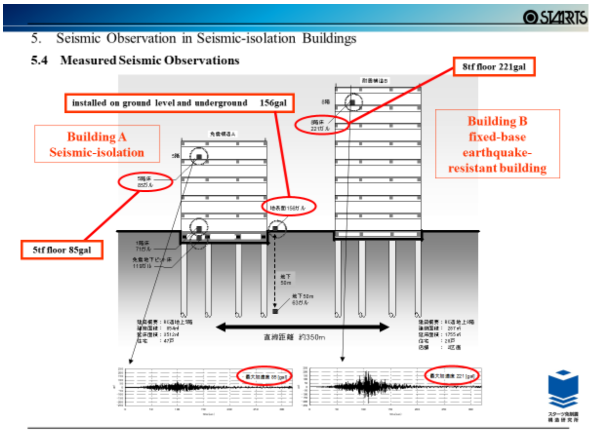
吊床免震



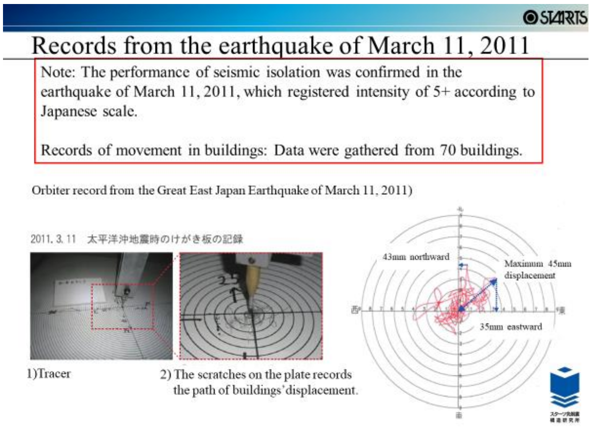
木造軽量建物も免震化可能



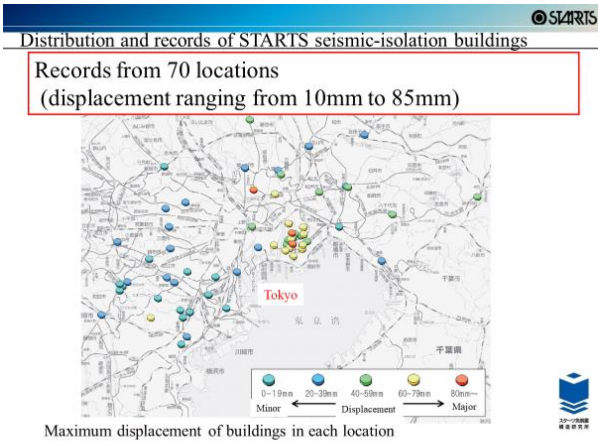
免震建物と耐震建物の地震観測データ差



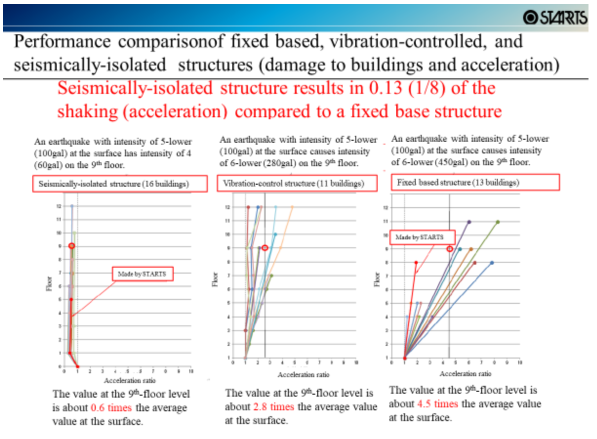
3.11の地震の記録



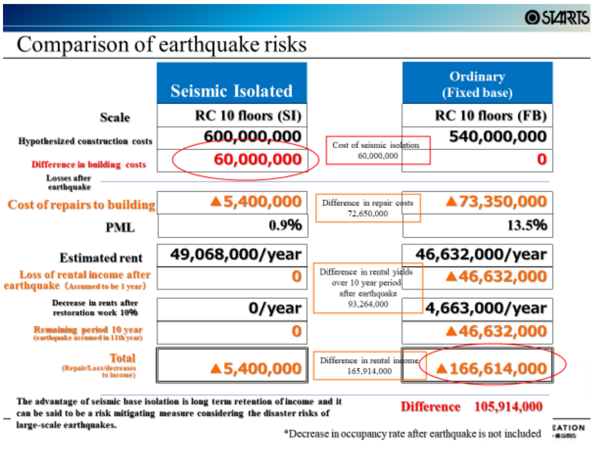
3.11スターツ免震建物分布と変位の記録



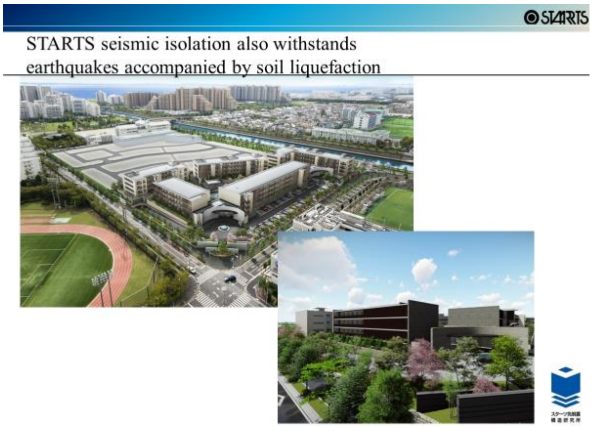
免震・制震・耐震の性能比較



免震建物と一般建物の地震リスクを数値化(コスト)

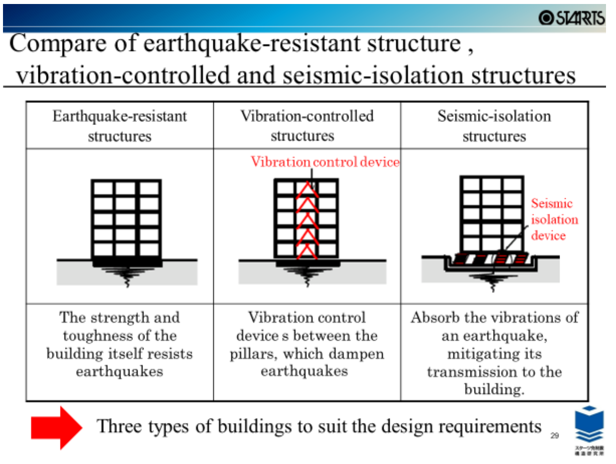


液状化対策をした免震プロジェクト

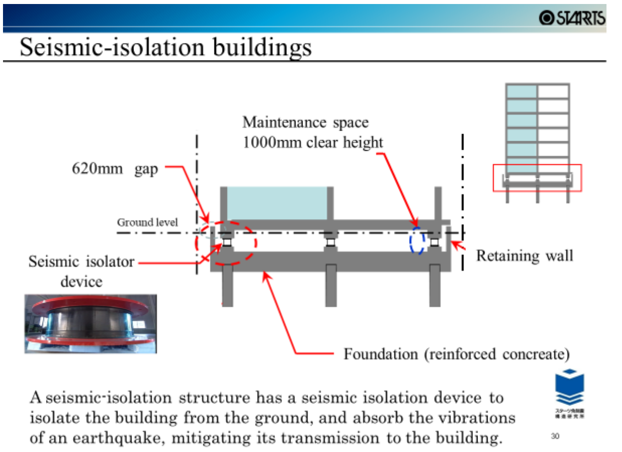


Lecture②:「免震構造とは」

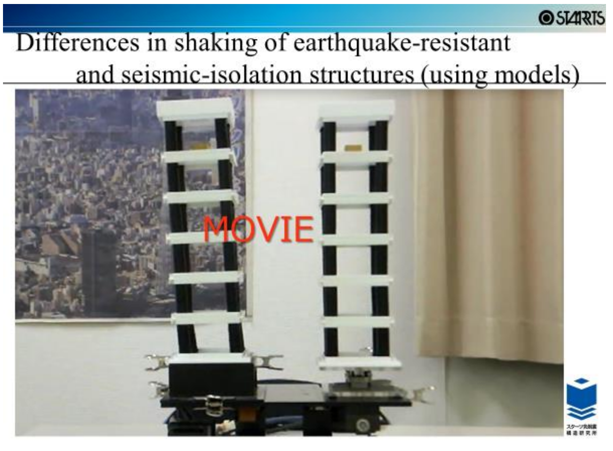
耐震・制震・免震の比較



免震建物

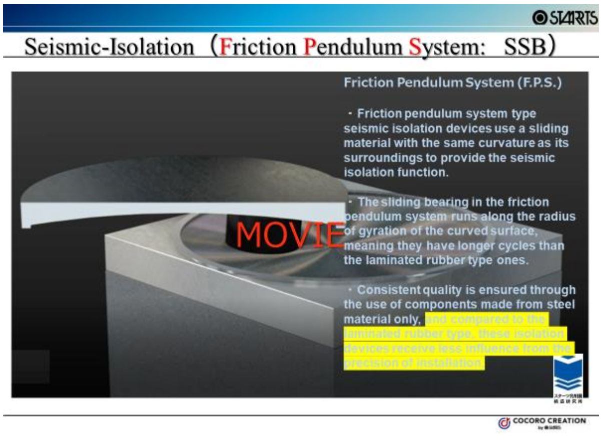


構造模型による免震と耐震の揺れ方の比較

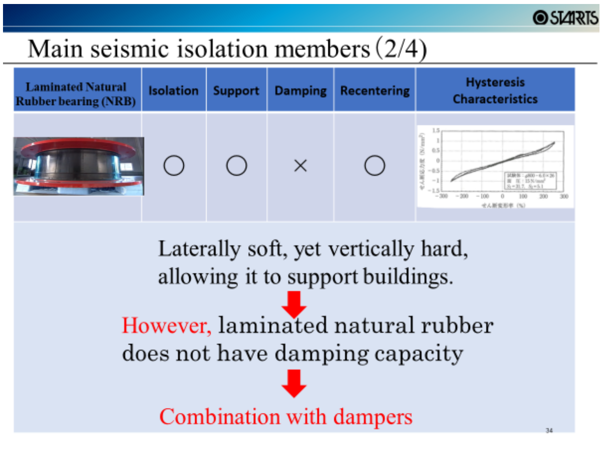


動画記録（免震と耐震）

免震装置（FSP）動画

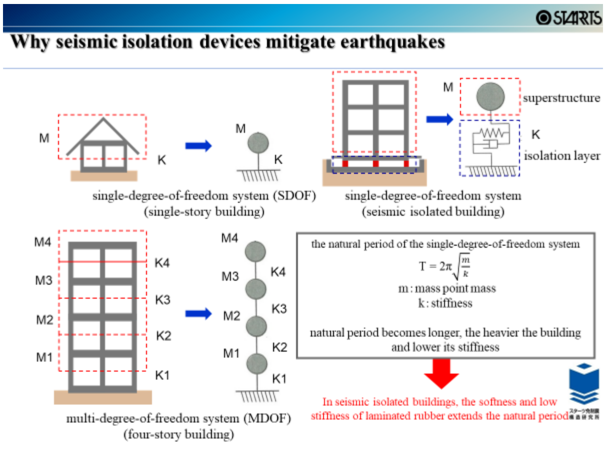


代表的な免震装置（天然ゴム系積層ゴム）

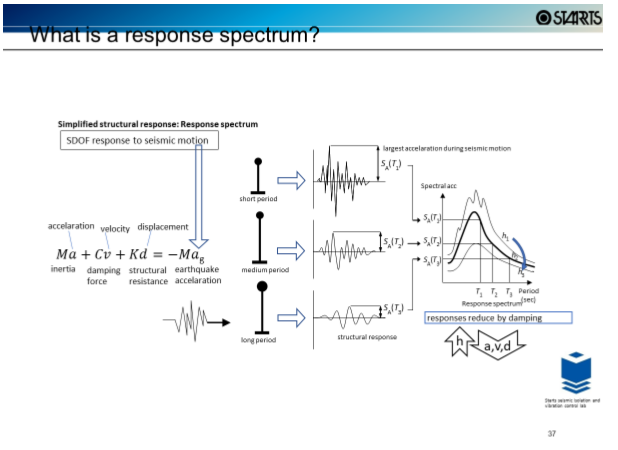


Lecture ③:「免震建物の構造設計」

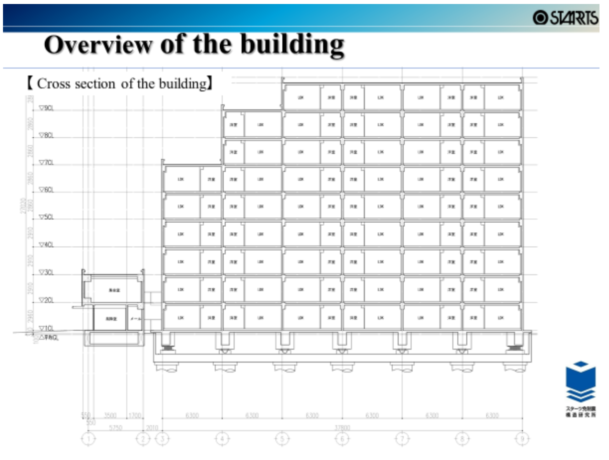
なぜ免震装置を付けると応答が減少するのか-1



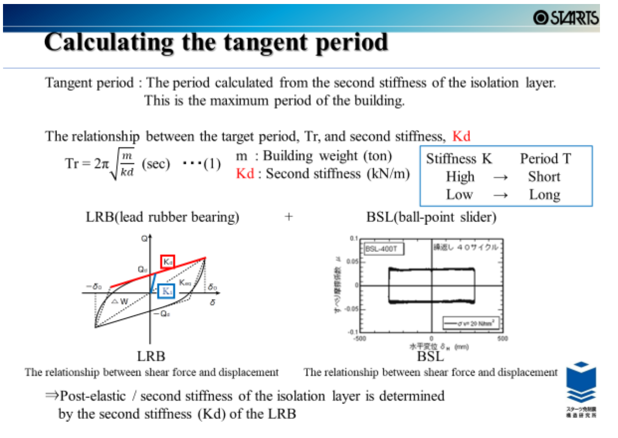
なぜ免震装置を付けると応答が減少するのか-2



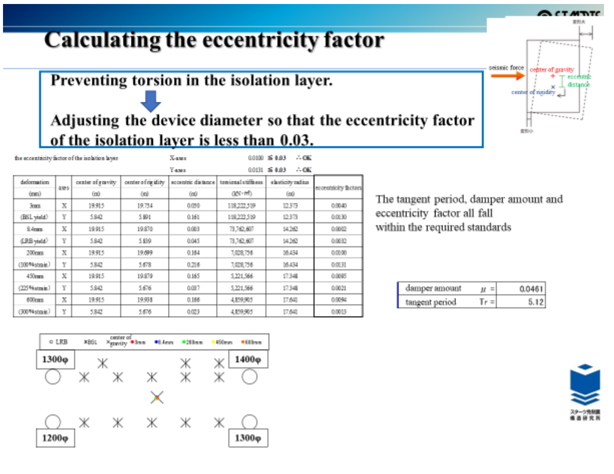
免震建物の構造設計フロー



接線周期の算定

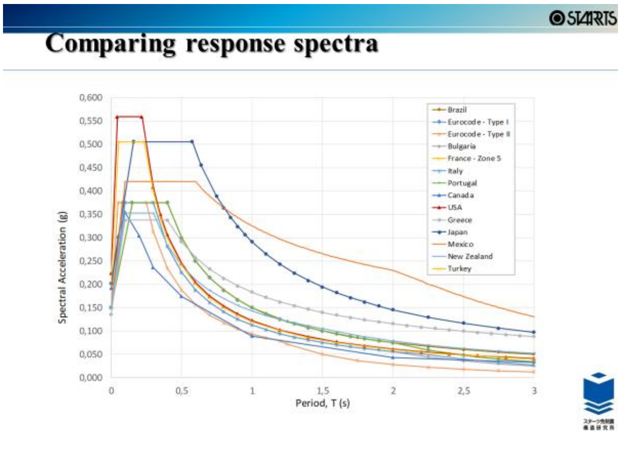


偏心率の算定



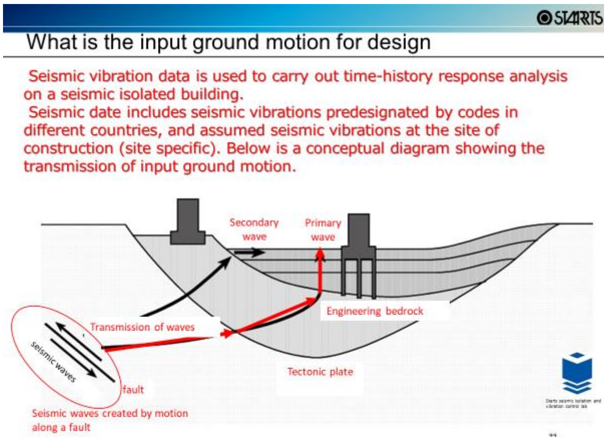
deformation (mm)	axes	center of gravity (m)	center of rigidity (m)	eccentric distance (m)	torsional stiffness (kN・m²)	elasticity radius (m)	eccentricity factors
3mm	X	19.915	19.754	0.050	118,222,519	12.373	0.0040
(BSL yield)	Y	5.842	5.891	0.161	118,222,519	12.373	0.0130
8.4mm	X	19.915	19.870	0.003	73,742,607	14.262	0.0002
(LRB yield)	Y	5.842	5.839	0.045	73,742,607	14.262	0.0032
200mm	X	19.915	19.699	0.164	7,028,756	16.434	0.0100
(100%strain)	Y	5.842	5.678	0.216	7,028,756	16.434	0.0131
450mm	X	19.915	19.879	0.165	5,221,566	17.348	0.0095
(225%strain)	Y	5.842	5.676	0.037	5,221,566	17.348	0.0021
600mm	X	19.915	19.938	0.166	4,859,905	17.641	0.0094
(300%strain)	Y	5.842	5.676	0.023	4,859,905	17.641	0.0013

海外の応答スペクトルの比較

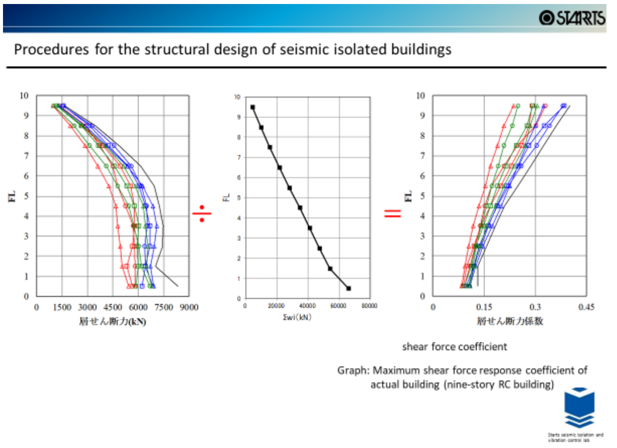


Lecture ④:「免震建物の地震応答解析」

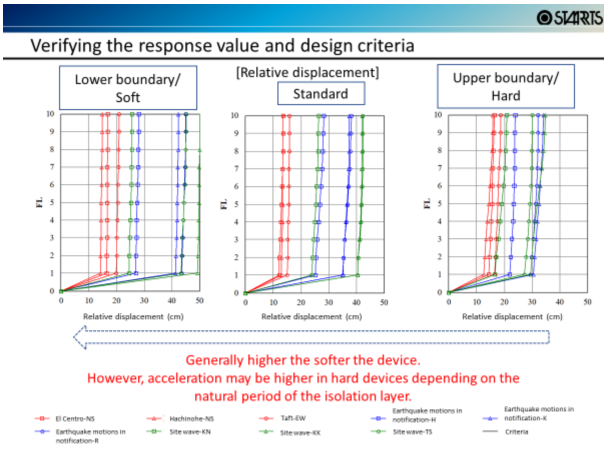
設計用入力地震動の選定【地震動の伝搬】



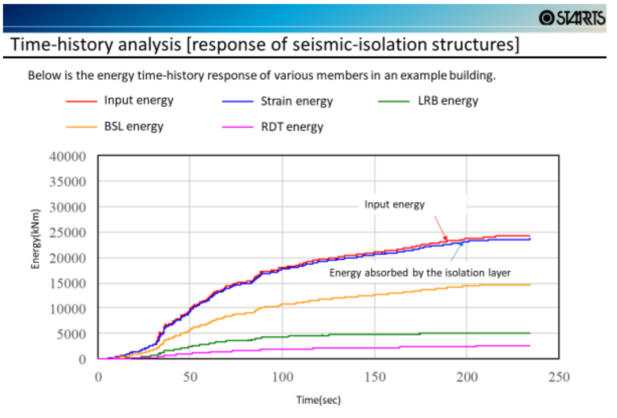
設計用層せんだん力係数の設定



応答値と設計クライテリアの確認

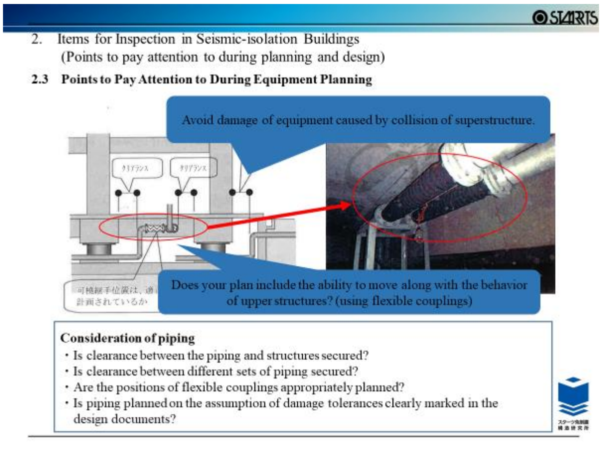


時刻応答解析【免震構造の応答】

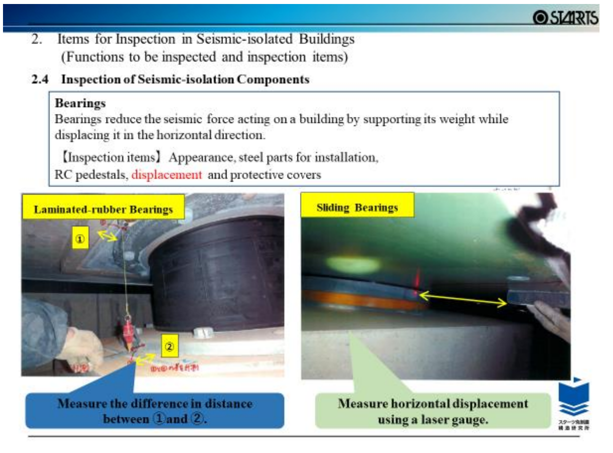


Lecture⑤:「維持管理・点検」

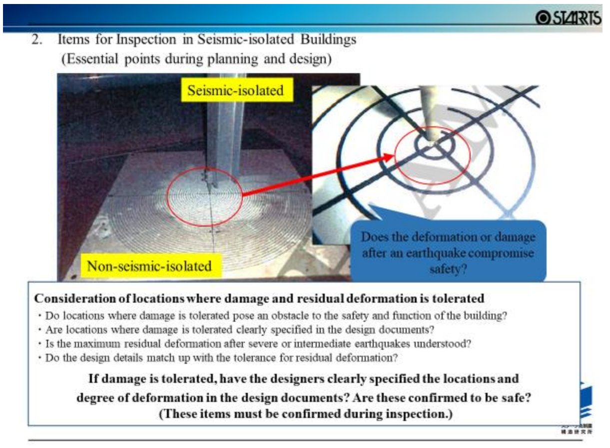
設備計画時に気を付けるべき点



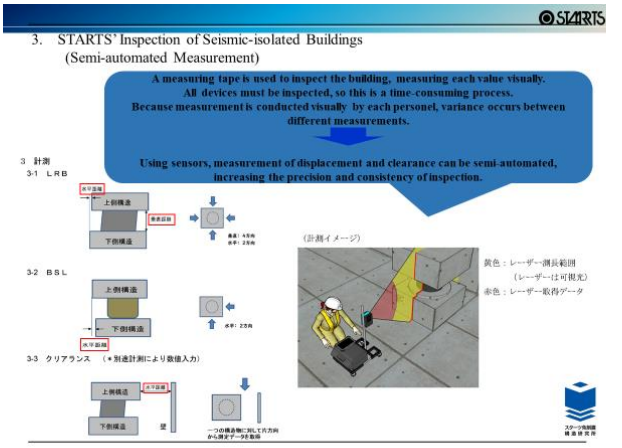
免震部材の点検項目



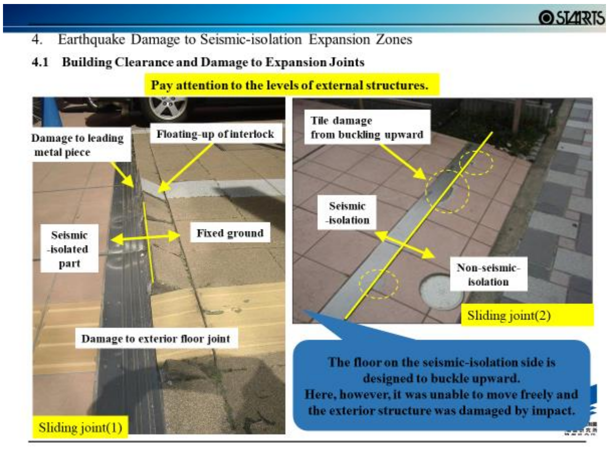
地震後の残留変形の確認



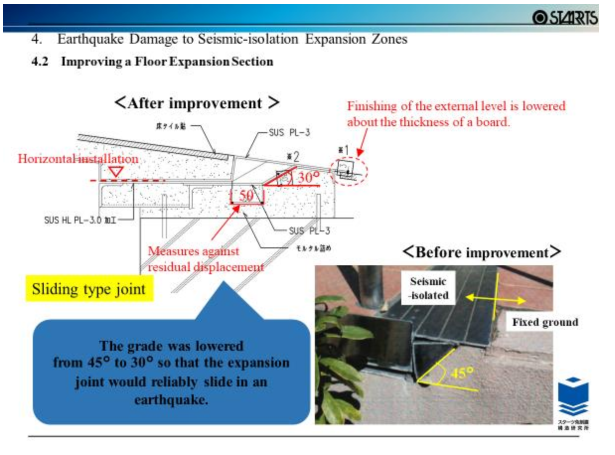
スターツの免震建物点検（半自動計測）



免震エキスパンションジョイントの地震被害-1



免震エキスパンションジョイントの地震被害-2



◆ブリヂストン

An Introduction to Bridgestone's Practice of Seismic Isolation Bearings in Turkey

Seismic Isolation and Vibration Control Products Development Department
Bridgestone Corporation

March. 16th, 2023

BRIDGESTONE
Solutions for your journey

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1. A Study of SI system design for Turkish residential buildings

BRIDGESTONE
Solutions for your journey

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1. A Study of SI system design for Turkish residential buildings

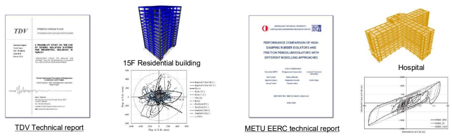
- Activity in Turkey: Joint research with Turkish Expert

Meetings/ Lectures, and Joint research

✓ Study on new Turkish seismic design code
✓ Information exchange of recent topics in both countries
✓ Discussion on Future direction of SI technologies in Turkey and Japan

◆ Bridgestone R&D Activities with Academia in Turkey

Project / Topics	Partners	Outcome
1. A Feasibility Study on the Use of Seismic Isolation Systems for Residential Buildings in Turkey (2018-2020)	• Turkish Earthquake Foundation (TDV) • Istanbul Technical University	• TDV Technical report • Journal paper (Soil Dyn. E.E) • Conference (17WCSI, 6ICEES)
2. Performance Comparison of High-Damping Rubber Isolators and Friction Pendulum Isolators with Different Modelling Approaches (2018-2020)	• Middle East Technical University (METU-SISMOLAB) • Istanbul Technical University	• METU-EERI Technical report • Conference (16WCSI, 17WCSI)



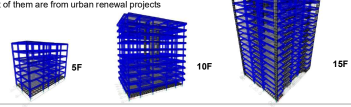
TDV Technical report

METU EERC technical report

A demonstration of design of seismic isolation system ～following Turkish code～

Turkish Earthquake Foundation & Bridgestone Corporation Joint Project
A Feasibility Study on the Use of Seismic Isolation Systems for Residential Buildings in Turkey (2018-2019)

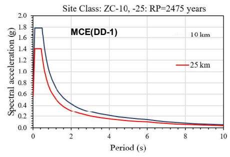
✓ Real residential buildings were selected from database of TDV
✓ Construction period is 2000-2015
✓ Most of them are from urban renewal projects



Construction period	2000-2015		
Construction material	Reinforced Concrete		
Structural system	Frame & Frame + Shear wall		
Number of story	5	10	15
Seismic weight	16789 kN	58582 kN	88926 kN

・Target fault : North Anatolian Fault
・Site distance from fault : **10** and **25** km (site 1, and 2)
・Site class (Soil condition) : C (very dense soil and soft rock)

(Cited from Wikipedia)



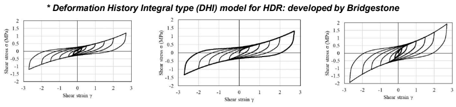
Location	Distance (km)	S_1 in (g)	
		2475 yrs.: MCE (DD1)	475 yrs.: DBE (DD2)
Site 1	10	0.854	0.503
Site 2	25	0.612	0.353

Performance modification λ factors for effective stiffness and damping ratio of HDR

	Compound		Effective stiffness K_{eff}	Equiv. damp. ratio H_{eq}
Soft material for 5F build. →	**X0.4S**	Upper bound	1.52	0.94
		Lower bound	0.90	0.90
Hardt material for 10, 15F build. →	**X0.6R**	Upper bound	1.45	0.94
		Lower bound	0.90	0.90

Hysteresis curves of numerical model in the case of nominal, upper, and lower bound

**** Deformation History Integral type (DHI) model for HDR: developed by Bridgestone***



Lower bound　Nominal　Upper bound

An example of hysteresis curves of HDR – X0.6R at nominal, lower, and upper bound

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◆ **Design Target**

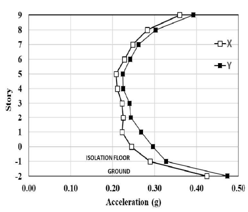
Items	Seismic level	Isolator prop.	Target
Base share Vb/W	475yrs.(DBE)	Upper b.	≦20%:
Isolator disp.	2475yrs.(MCE)	Lower b.	≦270% and satisfy UPD

*NOTE: UPD= Ulimate Property Diagram

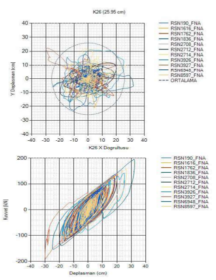
Do not comply to Turkish code

◆ **Analysis results**

Build.type	Dist.(km)	Vb/W (%)	Max.disp.(cm)
5F	10	21.25	49.59
	25	9.74	25.4
10F	10	18.27	49.12
	25	8.97	25.95
15F	10	17.18	47.31
	25	9.38	29.7



Maximum floor response acceleration of 10 Storey building at 10km dist. under MCE, 1995 Kobe (Takatori)



Orbit of gravity center and hysteresis loop of an element isolator of 10 Storey building at 25km dist. under MCE

◆ Stability check of isolators at D_{TM} with UPD (ISO22762)

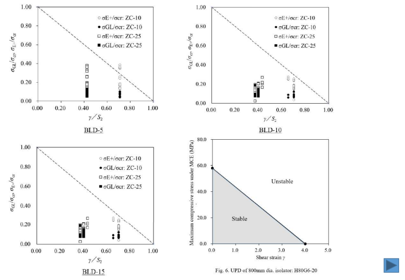
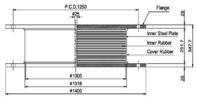


Fig. 13. Relationship of σ_{GL}/σ_{cr}, σ_{E+}/σ_{cr}, and γ/S_2 under MCE for each building

Full Scale Isolator Test
- Based on test protocol specified in Turkish Building Code 2018

◆ Test specimen and test machine

HDR-Φ1000, compound:X0.6R
Thicker rubber for low compressive stress



Outer (inner) dia.	1000 (25) (mm)
Unit rubber thks.(mm)	9.7(mm)
Shim plate thks. (mm)	4.4
Number of r.layers	21
Total rubber height (mm)	203.7
First s.factor S_1	25.1
Second s.factor S_2	4.91

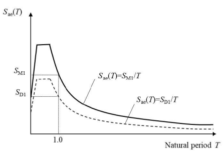
Biaxial Testing System (BATS) in NCREE, Tainan testing center, Taiwan

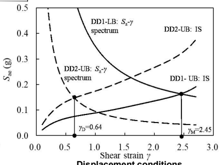
Vertical Force	Comp. 60(MN), Tens. 8(MN)
Horizontal Force	+/- 3.9 (MN)
Horizontal Stroke	+/-1200 (mm)
Horizontal Velocity	+/- 1.0 (m/s)

◆ Definition of prototype testing condition

- S_{M1}=0.8g : at MCE (DD-1) level
- S_{D1}=S_{M1}/1.6 =0.5g : at DBE (DD-2) level

* S_{M1}: Assumed by Bridgestone from project information during 2017-2018





Loading conditions

$1.4G+1.6Q$	8.08MN
$G+0.5Q$	4.94MN
$1.2G+0.5Q\pm E_d$	11.4MN / 0.217MN
$1.2G+Q\pm E_d$	12.1MN/ 0.861MN
$0.9W\pm E_d$	9.50MN/-1.73MN

Displacement conditions

$D_D = H_R \times \gamma_D$	128mm
$D_{TD} = D_D \times 1.1$	141mm
$D_M = H_R \times \gamma_M$	490mm (241%)
$D_{TM} = D_M \times 1.1$	540mm (265%)

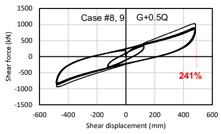
Test Conditions: protocols

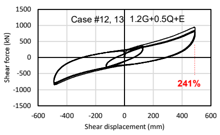
T_D: period at DBE, T_M: period at MCE

Specimen	Test No.	Vertical Load or displacement		Horizontal displacement		Number of cycles	Test period (sec)	
Specimen #1	1	1.4G +1.6Q	8,080kN	0	0	-	-	180 s.
	2	G + 0.5Q	4,940kN	wind drift	25mm	20	T_D	1.9sec
	3	G + 0.5Q	4,940kN	$0.25D_D$	32mm	3	T_D	1.9sec
				$0.50D_D$	64mm	3	T_D	1.9sec
				$1.00D_D$	128mm	3	T_D	1.9sec
				$1.00D_M$	490mm	3	T_M	3.5sec
	4	1.2G + 0.5Q ± E_d	11,460kN	$0.25D_D$	32mm	3	T_D	1.9sec
				$0.50D_D$	64mm	3	T_D	1.9sec
				$1.00D_D$	128mm	3	T_D	1.9sec
				$1.00D_M$	490mm	3	T_M	3.5sec
	5	0.9G ± E_d	9,500kN	$0.25D_D$	32mm	3	T_D	1.9sec
				$0.50D_D$	64mm	3	T_D	1.9sec
				$1.00D_D$	128mm	3	T_D	1.9sec
				$1.00D_M$	490mm	3	T_M	3.5sec
	6	G + 0.5Q	4,940kN	$1.00D_{TM}$	540mm	3	T_M	3.5sec
	7	G + 0.5Q	4,940kN	$1.00D_{TD}$	141mm	10	T_M	3.5sec
Specimen #2	8	1.2G +Q ± E_d	12,090kN	$1.00D_{TM}$	540mm	1/2	-	108sec (tri)
	9	0.9G ± E_d	0kN	$1.00D_{TM}$	540mm	1/2	-	108sec (tri)
	10	uplift disp.	10mm	$1.00D_{TM}$	540mm	1/2	-	108sec (tri)

◆ Compression and shear test: +/-D_D, D_M under G+0.5Q, 1.2G+0.5Q+E

① test # 8, 9 [σ= 6.3MPa, δ=+/- 128mm, T=1.9s], [σ=6.3MPa, δ=+/- 490mm, T=3.5s]
② test # 12, 13 [σ=14.6MPa, δ=+/- 128mm, T=1.9s], [σ=6.3MPa, δ=+/- 490mm, T=3.5s]

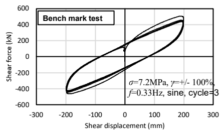


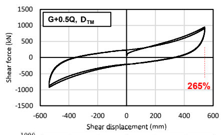


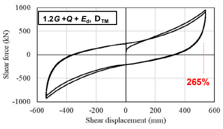
Test #	cycle	Keff	Keff/ave.	Heq	Heq/ave.
8	1	2.50	1.023	20.03	1.025
	2	2.43	0.995	19.40	0.992
	3	2.40	0.982	19.21	0.983
	ave.	2.44		19.55	
9	1	1.80	1.049	18.47	1.019
	2	1.70	0.990	18.07	0.997
	3	1.65	0.961	17.85	0.985
	ave.	1.72		18.13	

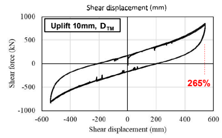
Test #	cycle	Keff	Keff/ave.	Heq	Heq/ave.
12	1	2.18	1.027	25.22	1.026
	2	2.12	0.998	24.27	0.987
	3	2.07	0.975	24.26	0.987
	ave.	2.12		24.58	
13	1	1.56	0.992	20.2	1.014
	2	1.51	0.960	19.81	0.995
	3	1.65	1.049	19.74	0.991
	ave.	1.57		19.92	

◆ Ultimate property test: +/-D_{TM} under G+0.5Q, 1.2G+0.5Q+E, Uplift 10mm









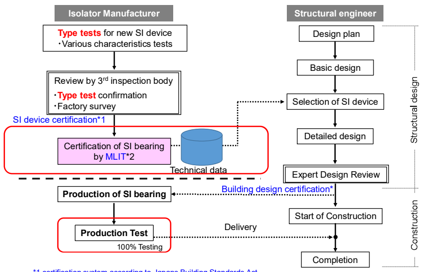
◆ **Conclusions of the R&D project**

- The results demonstrated the effectiveness of the SI system for all building at both locations.
- The differences in the seismic response of structures by other type of SI devices were not significant.
- Full scale HDR was designed, manufactured and dynamically tested according to test protocol specified in TBSC2018. Test results indicated adequacy of isolator design and sufficient performance.
- The applicability of SI system with HDR for residential buildings in Turkey was indicated.

2. Design and testing of seismic isolation bearings

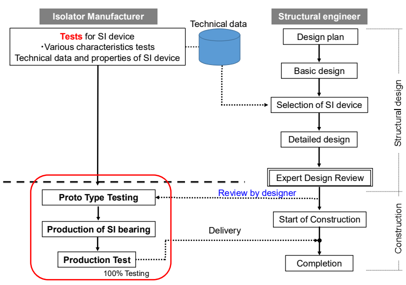
2. Design and testing of seismic isolation bearings

◆ Design flow of SI Building in Japan (certification system)



*1 certification system according to Japans Building Standards Act
*2 MLIT: Ministry of Land, Infrastructure, Information, and Transportation

◆ Design flow of SI Building in Turkey (Proto type testing system)



◆ Type test in categorized by full scale and scaled model in Bridgestone

Full scale testing	Scaled-model testing
1. *Loading conditions:*	
• Quasi-static : f=0.005～0.02Hz • Specimen : Φ600～Φ1800mm	• Dynamic : f=0.1～1.0Hz • Specimen : Φ160～Φ400mm
2. *Measurement item:*	
• Nominal performance • Ultimate property (including uplift) • Shear strain dependence • Compressive stress dependence Correction factor for quasi-static to dynamic cond.	• Nominal performance • Ultimate property • Shear strain dependence • Compressive stress dependence • **Repeated loading dependence** • **Frequency dependence** • **Temperature dependence** • **Aging, Creep**

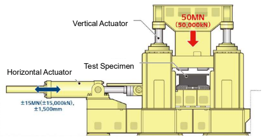
Correction of the results from quasi-static to dynamic condition (=isolation period)

◆ Large scale testing machine for full scale isolator (for production test and R&D)

• Bridgestone 50000kN compression and shear testing machine (Quasi-static)

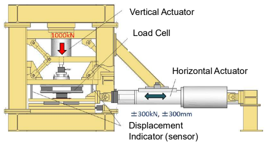
<Compressive Loading Capacity>
• Vertical Load : +50MN/ -10MN
• Displacement Capacity: +1000mm

<Horizontal Loading Capacity>
• Shear Load : +/-10MN
• Displacement Capacity: +/-1500mm



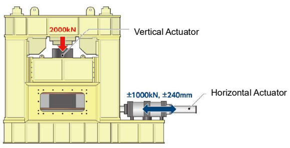
◆ Dynamic testing machine for scaled model isolators (Φ150~400)

Bridgestone 1000kN an 2000kN **dynamic** testing machine (for scaled model test)



<Compressive Loading Capacity>
• Vertical Load: +1000kN / -300kN
• Displacement Capacity: +/-100mm
• Maximum Velocity: 31.4 mm/sec

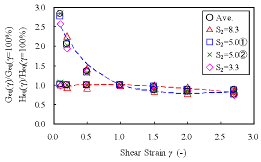
<Horizontal Loading Capacity>
• Shear load: +/- 300kN
• Displacement Capacity: +/-300mm
• Maximum Velocity: 628 mm/sec



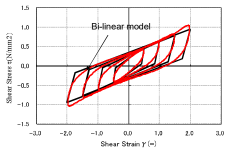
<Compressive Loading Capacity>
Vertical Load: +2000kN
Displacement Capacity: +/-300mm
Maximum Velocity: 13.8 mm/sec

<Horizontal Loading Capacity>
Shear load: +/- 1000kN
Displacement Capacity: +/-240mm
Maximum Velocity: 1200 mm/sec

◆ Shear strain dependence



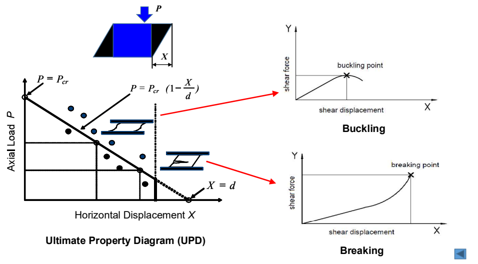
Non-linear relationship of shear properties and shear strain of HDR



Hysteresis curve and bi-linear model of HDR

An example of shear strain dependence test of high-damping rubber bearings

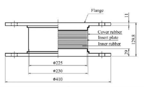
◆ Ultimate properties - Buckling and Breaking

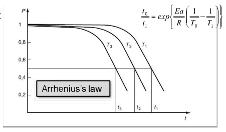


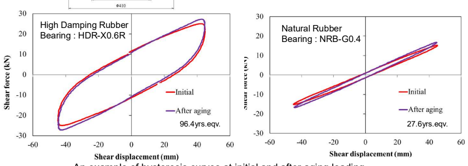
Ultimate Property Diagram (UPD)

◆ Aging ー Heat accelerated aging test

Ex.) 85℃×33days ≒ 96.4yrs. for HDR-X06R
27.6yrs. for NRB-G4

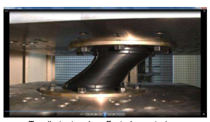




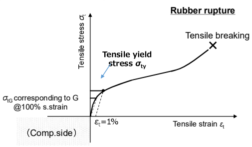


An example of hysteresis curves at initial and after-aging loading

◆ Behavior of seismic isolation bearing under uplift loading



Tensile test under offset-shear strain



Practice in Japan

• **Micro voids** generate under excessive tensile load (Tensile yield strength of rubber)
• **Allowable tensile stress** (=yield stress) is defined by type test results
Maximum tensile yield stress (max. 1.0 MPa (N/mm²))

Practice in other countries (Turkey, USA, etc)

• **Stability (no breaking) shall be verified by prototype testing**

Appendix

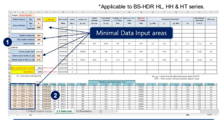
SIB Specification Selection Program (an MS EXCEL based program)

Dashboard Interface:

Allow user to make preliminary spec selection more efficiently from BS SIB specification catalogue* in a single interface dashboard.

- ✓ Require limited input cells only.
  (Minimize the required input by running background calculation / verification)
- ✓ Single sheet dashboard view for easy assess / spec refinement.
- ✓ Able to perform quick selection / spec refinement for different SIB spec combinations.
  i.e: rubber compound, thickness & diameter.

*Applicable to BS-HDR HL, HH & HT series.

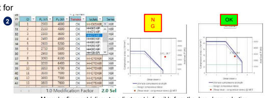


Simplified Sheet & Dashboard Design

1

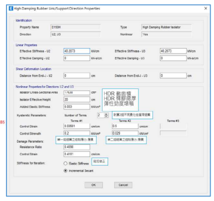
Rubber compound	X4S
Total rubber thickness	200
Isolator Series	HH

Rubber diameter for each column is determined automatically based on nominal column load.



Manual refinement / diameter adjustment is feasible from the drop-down selection.

- ETABS/SAP2000 Friendly:
- The parameter of the selected isolators could be easily exported as reference for structural engineers to model the isolator link element in ETABS/SAP2000.



Parameters for high damping rubber bearing link element in ETABS/SAP2000

Project :

Isolator	Tr (mm)	A (mm^2)	Nominal Keff (N/mm^2)	Upper Bound Keff (N/mm^2)	Lower Bound Keff (N/mm^2)
Max Response Displacement (mm)			500.00	400.00	550.00
HT090X6R					
HT095X6R					
HT100X6R					
HT110X6R	251.6	947956	1743.2	2559.2	1615.7
HT120X6R	248.0	1128598	2098.2	3077.5	1947.6
HT130X6R	252.3	1324947	2431.4	3570.2	2252.9
HT140X6R	247.0	1536062	2864.5	4200.4	2660.2
HT150X6R	250.0	1763828	3259.2	4782.9	3022.7
HT160X6R	249.6	2005593	3710.4	5444.6	3441.7

*Result from ETABS

			X0.6R nominal	X0.6R upper	X0.6R lower	X0.4S nominal	X0.4S upper	X0.4S lower
Added Elastic Stiffness		Ga (MPa)	0.5257	0.8136	0.5262	0.2	0.322	0.198
Terms #1	Control strain	γ-1	0.03591	0.03591	0.03591	0.03591	0.03591	0.03591
	Control strength	τ-1 (MPa)	2.468	3.364	1.999	1.150	1.643	0.9315
Terms #2	Control strain	γ-2	0.5	0.5	0.5	0.3	0.3	0.3
	Control strength	τ-2 (MPa)	0.3564	0.4858	0.2887	0.320	0.457	0.259
Resistance Ratio		θ	0.4598	0.4598	0.4598	0.5	0.5	0.5
Control Strain		γd	0.4181	0.4181	0.4181	2.5	2.5	2.5

応用地質

Site Investigation & Seismic Motion Verification

OYO Corporation
International Project Office, Business Promotion Headquarters
Tonguc BINER (Mr.)

2023

2月6日未明にトルコ南東部で発生した大地震により、お亡くなりになられた方々のご冥福をお祈り申し上げますとともに、被災された皆様に心よりお見舞い申し上げます。

6 ŞUBAT SABAHININ ERKEN SAATLERİNDE TÜRKİYE'NIN GÜNEYDOĞU BÖLGESİNDE MEYDANA GELEN BÜYÜK DEPREMDEN DOLAYI ÜZÜNTÜLERİMİZİ BELİRTİR, HAYATINI KAYBEDENLERE BAŞSAGLIGI, YARALANANLARA ACIL ŞIFALAR DILERIZ.

Contents

1. Company Profile

Four Business Segments OYO Corporation

Since its establishment in 1957, OYO Corporation **has been providing comprehensive** solutions to various sectors related to ground.
Recently, we have been actively providing various site investigation and evaluation techniques, particularly in the four business segments of "Natural Resources and Energy", "Maintenance, Management, and Renovation of Infrastructure", "Environment", and "Natural Disaster Prevention and Mitigation". Additionally, we are committed to providing even better solutions that address the challenges faced by our clients, communities, and society, by contributing to the realization of the SDGs and Digital Transformation technologies.

Disaster Prevention & Mitigation

This page shows some of the lists and locations of major earthquake Disaster Prevention & Mitigation projects, which OYO has been undertaking.

Country	Project	Period
All World	Information Collection and Analysis for Promoting Investment in Earthquake Disaster Prevention for Urban Resilience in High Risk Countries	2008-2022
Turkmenistan	Planning and Instalation of Earthquake Monitoring System	2017-2022
Ecuador	Making City Earthquake and Tsunami Resilient	2017-2021
El salvador	Capacity Building for Seismic Evaluation and Seismic Retrofitting of Buildings in the Metropolitan Area	2021-2025
Bangladesh	Promotion of Building Safety Enhancement for Disaster Risk Reduction	2014-2022
Armenia	Improvement of Enlightenment in Crisis Communication and Disaster Risk Management	2010-2022
Iran	Earthquake Disaster Mitigation Planning, and 72 hours after the Earthquake Emergency Response plan	2002-2015
Turkey	**Istanbul Micro Zoning and Capacity Building and Disaster Risk Management Education**	**2006-2014**
Bhutan	Capacity Building for Reinforcement of Slope Failure Countermeasure along Roads	2014-2023
India	Disaster Prevention Planning in Mountain Areas	2017-2022
Honduras	Capacity Building for Landslide Protection in the Metropolitan Area	2015-2022

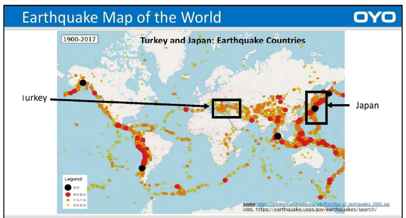
Japan

Estimated Large-scale Earthquakes in Japan (Ongoing Projects)
Nankai Trough Earthquake
Tokyo Inland Earthquakes
Trench-type Earthquakes in the Vicinity of the Japan and Chishima Trenches
Trench-type Earthquakes occurring along the Sagami Trough

This list shows our significant earthquake disaster prevention projects that OYO has undertaken. Our participation in various projects worldwide, particularly through ODA, has made a significant contribution to global earthquake disaster prevention efforts. Our experiences includes micro zoning in Istanbul, and I will show some of the Istanbul microzoning projects as examples in this document. In Japan, we are conducting earthquake damage simulations based on scenario earthquakes, including the Nankai Trough Earthquake, Tokyo Inland Earthquakes, earthquakes in the subduction zone along the Japan Trench, the Chishima Trenches, and the Sagami Trough, which are considered the highest risk earthquakes.

2. Introduction

Earthquake Map of the World



This map, compiled by the United States Geological Survey (USGS), plots major earthquakes that have occurred around the world from 1900 to 2017. Magnitude 7 to 8 earthquakes are represented in orange, magnitude 8 to 9 in red, and magnitude 9 and greater in black. These large earthquakes follow a linear pattern that coincides with the boundaries of tectonic plates. Although Turkey does not experienced earthquakes greater than magnitude 8, Japan and Turkey are highlighted within a black box, indicating that both countries are prone to earthquakes. In Japan, oceanic plates such as the Pacific Plate and the Philippine Sea Plate are subducting towards continental plates like the North American Plate and the Eurasian Plate at a rate of several centimeters per year. This movement results in high levels of strain, leading to large earthquakes. In Japan, currently, there is an increasing probability of Nankai Trough Earthquake, Tokyo Inland Earthquakes. Thus, measures to mitigate damage from these seismic motions and tsunamis are necessary. In Turkey, the fault is located at the boundary between the Arabian and other blocks. Historically, a lot of earthquakes are occurring around this fault. Additionally, from the historical earthquakes occurred around the Anatolian Fault, we can say that there is probability of an earthquake near to Istanbul.

Earthquakes Pictures from Turkey and Japan

- During "The 2023 Turkey–Syria Earthquake" & "The 1995 Southern Hyogo Prefecture Earthquake" ⇒ **a lot of buildings are collapsed**
- After "The 1995 Southern Hyogo Prefecture Earthquake" ⇒ **building standards were thoroughly reviewed and improved in Japan**
- During "The 2011 off the Pacific coast of Tohoku Earthquake" ⇒ **only a few buildings collapsed, but the accompanying tsunami resulted in extensive damage**

On the left, we have the collapsed buildings in Turkey–Syria Earthquake. In the center, we see the result of The Southern Hyogo Prefecture Earthquake, after a magnitude 6.9 earthquake that struck Kobe City, Japan in January 1995. On the right, we see some Japanese cities after the magnitude 9.1, the 2011 off the Pacific coast of Tohoku Earthquake that occurred in March 2011. Turkey has many brick buildings and historical structures that are vulnerable to major earthquakes, often resulting in extensively damaged and collapsed buildings. Japan has a higher proportion of wooden houses, as well as many tall reinforced concrete and steel-framed buildings in urban areas. Following the 1995 earthquake in Kobe, seismic resistance standards in Japan were revised, resulting in the construction of buildings with superior resistance to ground shaking using seismic reinforcement, seismic isolation, and vibration control technologies. Buildings and structures can suffer damage when the ground in which they are located experiences seismic activity. To ensure earthquake resistance, vibration isolation, and vibration control, the design of these structures is based on predictions of the level of ground shaking they may encounter in the future. As a result, the 2011 Tohoku earthquake caused minimal damage from collapsed buildings, although the resulting tsunami caused extensive damage that exceeded expectations. Overall, improving the seismic resistance of individual buildings will increase the resilience of cities, which in turn will support the resilience of the nation.

How the earthquake propagates through the ground?

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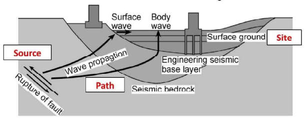
✓ Ground motion = [Source]*[Path]*[Site] : consisted of 3 key factors
- Source : Mechanism of a seismic fault
- Path : Wave propagation path effect e.g., energy attenuation etc.
- Site : Effect of a sedimentation at surface ground



Seismic waves travel from the bedrock through the engineering seismic base layer and sedimentary layers before reaching the surface of the earth. These waves are generated by the rupture of faults, which is examined as the source parameter of an earthquake. Path parameters, describe how seismic waves propagate through the ground, including the attenuation characteristics of seismic energy. Site parameters refer to the physical properties and amplification characteristics of the ground near a specific location, such as the depth of the engineering basement, the thickness of the sedimentary layer, and other relevant factors.

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3. Site

Site Parameters

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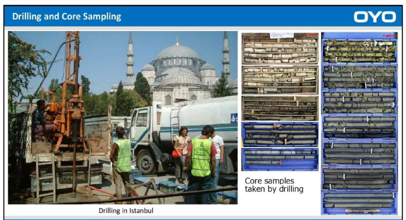
- Understanding the ground structure directly beneath a construction site is crucial ⇒ particularly in regard to the S-wave velocity structure
- S-wave velocity structure （S-wave velocity ∝ the square root of rigidity）
  - strongly weathered layer： Vs200 (m/s)
  - weakly weathered layer： Vs200-350 (m/s)
  - engineering seismic base layer： Vs300-700 (m/s)
  - seismic bedrock： Vs3000 (m/s)
- Survey Method
  - Standard Penetration Test (N value), core sampling, laboratory test
  - PS logging (downhole method, suspension method)
  - Seismic survey (refraction method, reflection method, surface wave method, microtremor survey (3D microtremor array survey))

When determining characteristics of site parameters, it is crucial to understand the S-wave velocity structure directly beneath the site where a building or other structure will be constructed. The S-wave velocity is correlated with the ground's rigidity, with higher velocities indicating more solid ground. Along with S-wave velocity, it's crucial to comprehend the accretionary distribution. Basement rocks are exposed on the surface in some areas, the seismic basement can be deeper in many other locations. To calculate ground motion, it's necessary to model the propagation and amplification characteristics of the seismic and engineering bases, respectively, as well as the surface ground. Survey methods to determine the S-wave velocity structure are chosen based on regional characteristics and a combination of different methods. Estimation of data from core samples taken from boreholes and laboratory tests are also widely used methods. Additionally, a geophysical method called seismic survey, which uses PS logging, is commonly used.

Drilling and Core Sampling

OYO



This photo shows the drillings and core samples collected in Istanbul. Drilling is the most basic method for investigating geological features. Core samples obtained by drillings can be analyzed for physical and geotechnical properties. By inserting logging tools into the drillholes, many geophysical properties , such as P and S wave velocities, densities, resistivity, and others, can be obtained. Core samples are tested in the laboratory to get the physical and chemical properties of soils and rocks, such as porosity, permeability, and mineral composition.

Site investigation：PS Logging

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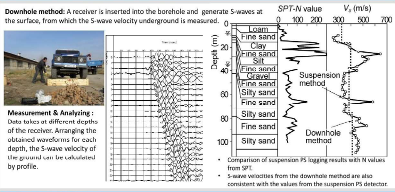
Downhole method: A receiver is inserted into the borehole and generate S-waves at the surface, from which the S-wave velocity underground is measured.



Measurement & Analyzing : Data takes at different depths of the receiver. Arranging the obtained waveforms for each depth, the S-wave velocity of the ground can be calculated by profile.

- Comparison of suspension PS logging results with N values from SPT.
- S-wave velocities from the downhole method are also consistent with the values from the suspension PS detector.

Downhole Method: By a seismic source it generates S-wave on the surface, which are shown in the picture. After geophone lowered into the borehole, and the S-waves generated on the surface are recorded, as shown in the center of the figure. By arranging obtained waveforms as shown in the center of the figure, the propagation speed of S-waves can be calculated. The S-wave velocity structure of the ground is then understood by analyzing this data.

Suspension PS Logging: By suspended small seismic source and a pair of receivers in the borehole, S-waves are generated and recorded. From recorded waveforms the S-wave velocity at each depth can be calculated, as shown on the right. The left part of the figure on the right shows the N value obtained by SPT. There is a good correlation between the Vs from suspension PS logging and N value, as shown in the figure. Suspension PS logging can be conducted using the borehole to efficiently determine S-wave velocities at each depth.

Site Investigation : Surface wave exploration

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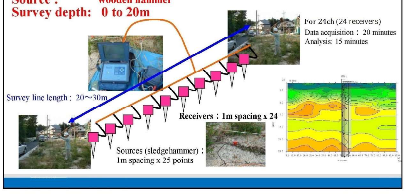
Source : wooden hammer
Survey depth: 0 to 20m



Surface wave exploration is a widely used as non-destructive method for determining the S-wave velocity structure of the ground. This method is less susceptible to ambient vibration noise than common refraction and reflection methods, and it can be used in urban areas during the daytime when cars are passing by, as illustrated in the photo. In the example figure, geophones (receivers) are placed at equal intervals of 1m on the surface and connected to a data acquisition device. A 2-dimensional cross-sectional view of the shallow part of ground down to about 20m can be obtained, as shown in the figure on the right. For analysis at greater depths, a seismic source larger than the "Kakeya" should be used, and the receiver spacing should be widened. The data acquisition device shown in the photo is a product of our company, McSeis SX. This device include the analyzing program that automatically performs analysis and generates results on site when the measurement is completed.

*Kakeya:wooden hammer

Site Investigation : 3D Microtremor Array exploration

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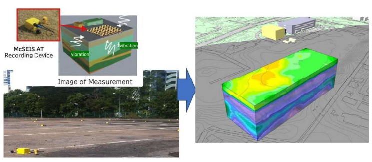
- This is method to understand the structure of the ground in three dimensions using various vibrations of the ground (traffic, waves, etc.)



The seismic refraction method, the seismic reflection method , and the surface wave exploration techniques require an active seismic source, whereas microtremor exploration utilizes naturally occurring ground motion (micro tremor). The sources of the vibrations in microtremor exploration are waves, vibrations induced by trains and cars, and wind-induced vibrations of trees. We analyze the vibrations as they propagate through the ground. These vibrations are recorded on a small device, along with precise timing using GPS. OYO's product, the "McSEIS-AT" recording device, shown in the photo, integrates a battery, recording device, and GPS synchronization device into a single unit, facilitating measurement-taking. Measurements only require a few dozen minutes to complete. The 3D microtremor array exploration employs multiple recording devices in an area to determine the 3D S-wave velocity structure of the ground. This is an excellent method for studying earthquake effects. By extending the measurement range, the deep structure of the ground can be characterized, and this method can also be used to investigate the seismic bedrock.

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4. Path

Setting Path Parameters

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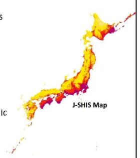
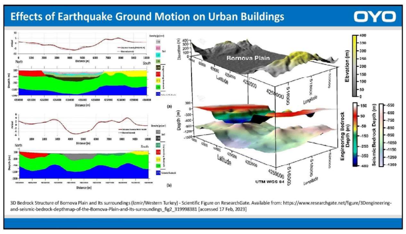
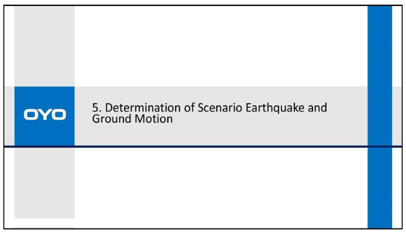
- **Important Parameters**
  - Depth of the Seismic Bedrock (geometry)
  - Distance to the Epicenter: short-period waves are highly attenuated against travel distance, while long-period waves can travel far without attenuation
- **Government Agency Public Disclosure of Data**
  - TURKEY：AFAD Turkey Earthquake Risk Map （https://tdth.afad.gov.tr）
  - JAPAN： National Research Institute for Earth Science and Disaster Resilience J-SHIS Map （https://www.j-shis.bosai.go.jp/map/?lang=en）
- **Methods of exploration of deep ground structures**
  - Seismic surveys (Seismic refraction method, Seismic reflection method, Microtremor array exploration)
  - Micro-gravity survey, etc.

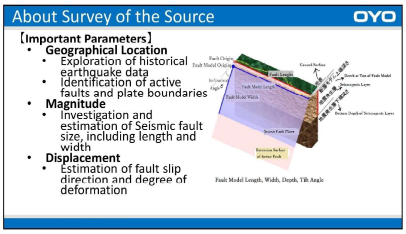


Seismic waves tend to be more intense closer to the hypocenter and attenuate as the distance increases. Short-period waves, such as body waves, decay more rapidly than long-period ones, which can travel several seconds to several tens of seconds and reach cities far from the epicenter. If the period matches the intrinsic period of a high-rise building, the building will be significantly and slowly shaken, which is a new concern for urban disaster prevention. To understand the path of seismic wave propagation, it is necessary to study the general state of the ground in the section from the hypocenter to the site. National and local governments often conduct extensive subsurface structure investigations as part of their projects. For instance, in Japan, National Research Institute for Earth Science and Disaster Resilience has created a deep subsurface structure model that is available on its Seismic Hazard Station (J-SHIS) website, where users can also access seismic hazard maps for Japan. Borehole surveys and seismic surveys are common methods used to investigate deep subsurface structures. Other geophysical methods, such as gravity surveys, electromagnetic surveys, and remote sensing, are also used for deep subsurface structural investigations.



This figure displays the outcomes of a survey conducted by "EREN PAMUK" et al. in 2018, which investigated the engineering and seismic basement of the Bornova Plain in western Turkey. To create 2D and 3D ground models, the researchers employed a combination with surface wave method and micro-gravity surveys. The results indicate that the central section of the Bornova Plain has an inclined engineered basement, located at a depth of 200 to 400 meters, and a seismic basement situated beneath it at a depth of 550 to 1350 meters, as depicted in the figure. In the event of an earthquake on the North Anatolian Fault, seismic waves would travel through the seismic basement (illustrated in blue) and generate ground surface vibrations via the engineering basement and sedimentary layers.





Earthquakes are among the most unpredictable natural disasters, making it crucial to be well-prepared for their occurrence. Below is a description of the steps and procedures required to anticipate earthquakes.

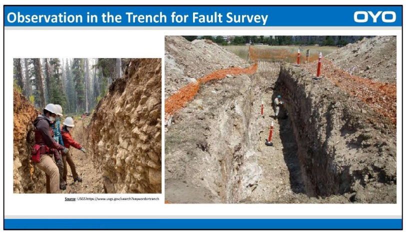
1.Identify areas where earthquakes are likely to occur based on past earthquake history and fault location. This includes regions where earthquakes frequently happen and those with active faults.

2.Estimate the expected size of the fault that is likely to rupture by determining the length (L) and width (W) of the source fault. This information is essential in predicting the intensity of shaking during an earthquake.

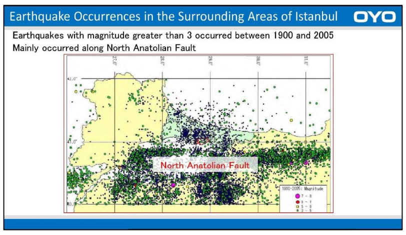
3.Estimate the total seismic moment (M0). This is an indicator of the earthquake's magnitude and is calculated by multiplying the fault area and the average stress. This information is necessary in predicting the earthquake's size.

4.Estimate the average stress drop (Δσc) in the source area. This is crucial in determining the deformation of the ground during an earthquake and evaluating the seismic resistance of buildings.

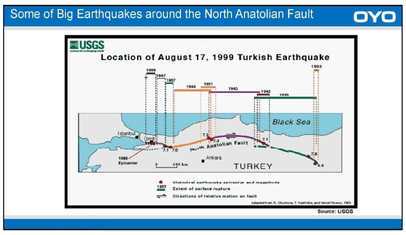
These are the steps and procedures required to anticipate an earthquake. Based on this information, it is vital to take measures to prepare for earthquakes, including constructing earthquake-resistant buildings, stockpiling emergency supplies, and securing evacuation sites.



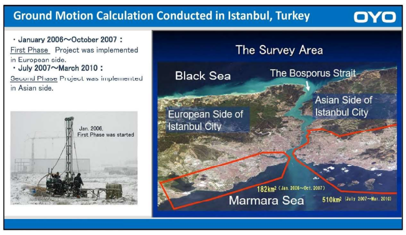
The image on the right depicts a trench survey that we carried out. In this region, where the fault is visible near the surface of the ground, we excavated a depth of nearly 5 meters to observe the fault and geological conditions. Observation in the trench can provide valuable information about the fault's history and behavior, which can help in understanding the potential risk of future seismic activity in the area. It is an important method used in fault survey and plays a critical role in engineering projects that involve building structures in areas prone to earthquakes. Observation in the trench is a method used during fault surveys to observe and study the geological layers exposed in a trench. It allows geologists to visualize the fault's structure and the rock layers involved. During the trench excavation, geologists can examine the fault zone for the type of fault and its relationship with the surrounding rock layers. They can also identify evidence of fault activity such as fault breccias, gouge, and slickensides.



This figure illustrates earthquakes that along the North Anatolian Fault zone from 1900 to 2005. The first step in conducting a "presumed earthquake investigation" is to identify all the previous seismic activities which are occurred around the presumed area and to identify their distribution. This involves gathering information on historical earthquakes in the area and analyzing their patterns.

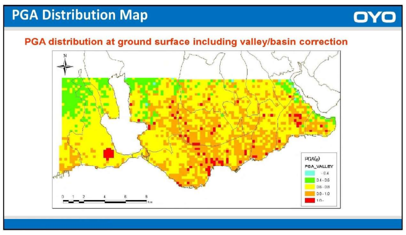


On the preceding page, it is explained that numerous earthquakes has occurred along the North Anatolian Fault. Specifically, a magnitude 6.8 earthquake occurred on the eastern side in 1992, and another earthquake occurred in the central side in 1943.
In the future, there is a risk of an earthquake near to Istanbul.



OYO conducted a micro-zonation projects in Istanbul in two phases. The first phase, which took place on the European side, was conducted from January 2006 to October 2007. The second phase, which was carried out on the Asian side, took place between July 2007 and March 2010. We calculated the ground motion and established the seismic hazard zoning.

The survey area on the European side was 182 square kilometers, while the survey area on the Asian side was 509 square kilometers. Following site investigations, we prepared a map of the ground shaking hazard, as shown in the bottom right.
The results of these studies can be accessed on the website of the Istanbul Metropolitan Municipality:
https://depremzemin.ibb.istanbul/calismalarimiz/tamamlanmis-calismalar/istanbul-ili-mikrobolgeleme-projeleri/
To learn details about the micro zoning results, please click on the link above.



PGA stands for Peak Ground Acceleration, which is a measure of the maximum acceleration that the ground experiences during an earthquake. It is an important parameter used in seismic hazard analysis and earthquake engineering. During an earthquake, the ground experiences various types of motion, including shaking, rolling, and vertical movement. The amount of acceleration that the ground experiences depends on several factors, such as the magnitude and depth of the earthquake, the distance from the earthquake source, and the characteristics of the local soil and rock. At the ground surface, the PGA distribution is affected by the distance from the earthquake source and the local geology. Generally, the closer the site is to the earthquake source, the higher the PGA is likely to be. The local geology can also have a significant impact on the PGA distribution, as softer soils tend to amplify the seismic waves, leading to higher acceleration values. In practice, the PGA distribution at the ground surface is typically characterized using probabilistic seismic hazard analysis (PSHA) techniques, which consider the likelihood of different earthquake scenarios and their associated ground motions. This information is used to inform building codes and other seismic safety measures, as it can help engineers and policymakers to design structures that can withstand the expected ground motions during earthquakes.

6. Our Suggestion

Our Suggestion

"Aggressive investment in Disaster Risk Reduction(DRR), including the construction of resilient buildings, can support SUSTAINABLE DEVELOPMENT"

Every "$1" investment into Disaster Mitigation contributes "$6" benefit

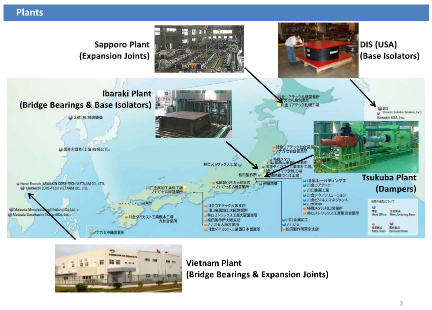
Disaster Risk Reduction (DRR) is a set of activities aimed at minimizing the potential negative impact of natural disasters. Firstly, it helps to protect human life and reduce the economic losses caused by disasters, which can have a significant impact on local communities and entire economies. By investing in DRR, countries can reduce the frequency and severity of natural disasters and minimize their impact on people's livelihoods. For example, the construction of resilient buildings and infrastructure requires skilled labor and materials, which can generate employment opportunities and stimulate local economies. In addition, DRR investments can promote innovation and the development of new technologies, which can drive economic growth in the long term. One of the most compelling arguments in favor of investing in DRR is the significant return on investment it can generate. Studies have shown that every dollar invested in disaster mitigation can benefit up to six dollars in future disaster-related costs. This is because investing in DRR can help to prevent or mitigate the impact of disasters, which reduces the need for expensive post-disaster recovery and reconstruction efforts. Aggressive investment in DRR is an essential component of sustainable development. By protecting human life, reducing economic losses, creating economic opportunities, promoting innovation, and generating a high return on investment, DRR can help to build more resilient and sustainable communities and economies.

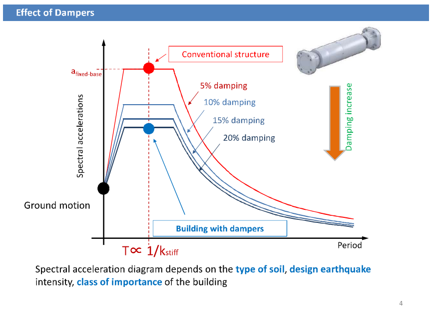
THANK YOU VERY MUCH

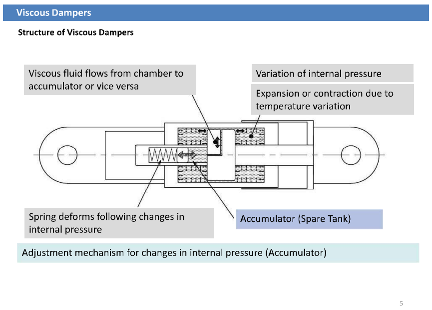
川金コアテック

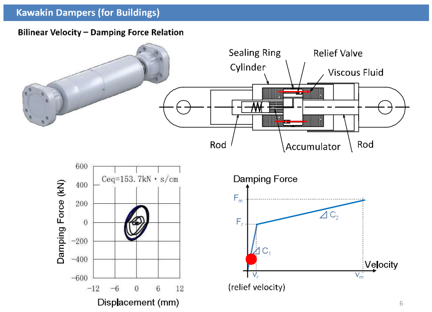

Kawakin
Kawakin Earthquake Protection Devices
Seismic Isolation &
Vibration Control
Seismic Isolation and Earthquake
Resistant Technology
Promotion Seminar in Turkey
27 February 2023
Kawakin

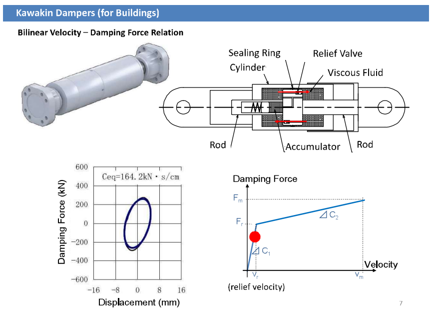

Kawakin
2

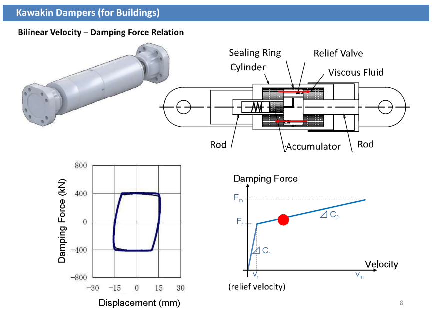

Plants
Sapporo Plant
(Expansion Joints)
DIS (USA)
(Base Isolators)
Ibaraki Plant
(Bridge Bearings & Base Isolators)
Tsukuba Plant
(Dampers)
Vietnam Plant
(Bridge Bearings & Expansion Joints)
3

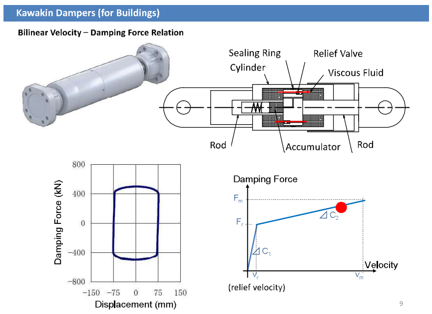

Effect of Dampers
Conventional structure
5% damping
10% damping
15% damping
20% damping
Damping increase
Spectral accelerations
Ground motion
Building with dampers
Period
T∝ 1/kstiff
Spectral acceleration diagram depends on the type of soil, design earthquake intensity, class of importance of the building
4


Viscous Dampers
Structure of Viscous Dampers
Viscous fluid flows from chamber to accumulator or vice versa
Variation of internal pressure
Expansion or contraction due to temperature variation
Spring deforms following changes in internal pressure
Accumulator (Spare Tank)
Adjustment mechanism for changes in internal pressure (Accumulator)
5


Kawakin Dampers (for Buildings)
Bilinear Velocity – Damping Force Relation
Sealing Ring
Cylinder
Relief Valve
Viscous Fluid
Rod
Accumulator
Rod
Ceq=153.7kN・s/cm
Damping Force (kN)
Displacement (mm)
Damping Force
Velocity
(relief velocity)
6

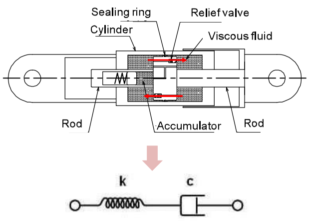

Kawakin Dampers (for Buildings)
Bilinear Velocity – Damping Force Relation
Sealing Ring
Cylinder
Relief Valve
Viscous Fluid
Rod
Accumulator
Rod
Ceq=164.2kN・s/cm
Damping Force (kN)
Displacement (mm)
Damping Force
Velocity
(relief velocity)
7


Kawakin Dampers (for Buildings)
Bilinear Velocity – Damping Force Relation
Sealing Ring
Cylinder
Relief Valve
Viscous Fluid
Rod
Accumulator
Rod
Damping Force (kN)
Displacement (mm)
Damping Force
Velocity
(relief velocity)
8


Kawakin Dampers (for Buildings)
Bilinear Velocity – Damping Force Relation
Sealing Ring
Cylinder
Relief Valve
Viscous Fluid
Rod
Accumulator
Rod
Damping Force (kN)
Displacement (mm)
Damping Force
Velocity
(relief velocity)
9

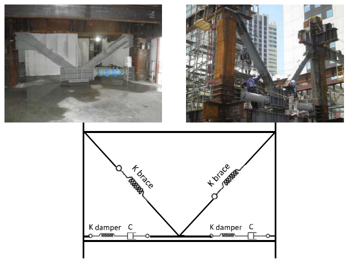
Modelling of Viscous Damper

Maxwell Model



Modelling of Viscous Damper Configuration

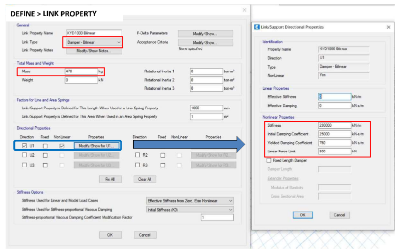
Chevron Brace Configuration



Modelling of Viscous Damper

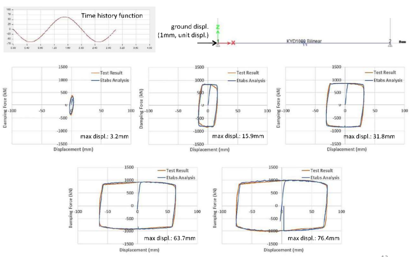
Input in ETABS

DEFINE > LINK PROPERTY



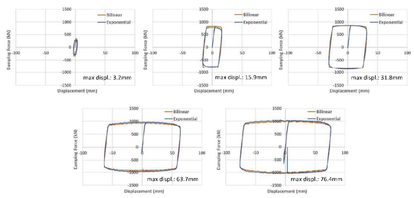
Modelling of Viscous Damper

Bilinear Model

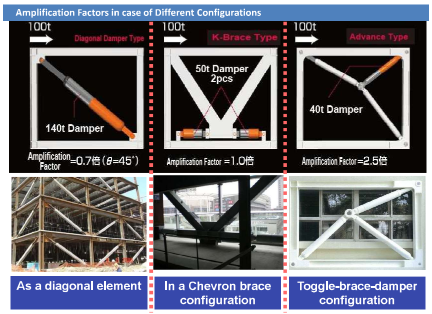


Modelling of Viscous Damper

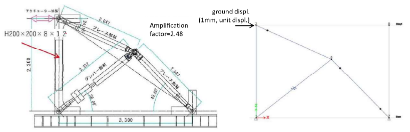
Bilinear Model vs. Exponential Model

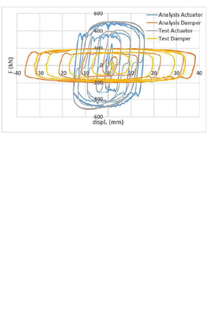


Amplification Factors in case of Different Configurations



Toggle Brace Damper Configuration

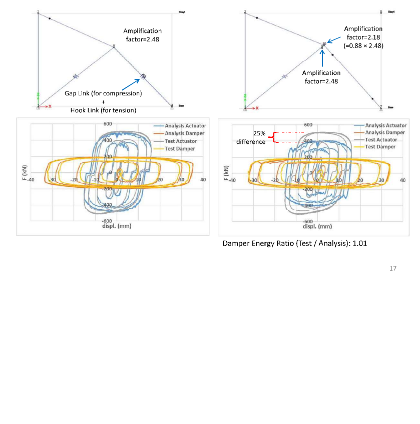




Damper Energy Ratio (Test / Analysis): 0.84

(analysis overestimates the damper performance around 15%)

Toggle Brace Damper Configuration



Damper Energy Ratio (Test / Analysis): 1.01

Design Flow in Vibration Control

Building Designer

① Provides:

- Performance criteria
- FEM model (ETABS) with complete seismic analysis results or
- Drawings, seismic weights, non-linear pushover analysis results, response spectrum, earthquake ground motion

③

- Inputs the modeling parameters of the dampers in the building structural model (SAP, MIDAS, ETABS,...).
- Carries out a **Time History Analysis (THA)**.
- Design the damper system: quantities, sizes, locations, etc.. that meets the chosen performance criteria

Manufacturer

② Provides:

- Preliminary design of the damper system using **Lump Mass Model**.
- Provides types, sizes, quantities, modeling parameters, and rough budgetary price & schedule.

④ Support:

Results interpretation, tolerances & design flow, technical doubts, etc..

Provides:

- Construction details, final quotation & delivery schedule.

Internal Preliminary Design Flow

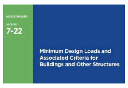
Preliminary design is performed internally in case of a demand from the client

Information from the designer
(building info., seismicity, performance criteria)

↓

Simplified preliminary design
(response spectrum analysis)

based on ASCE 7
etc.

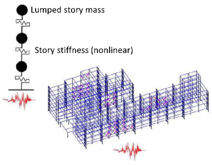


↓

Design using Lumped Mass Model
(nonlinear)
(time history analysis)

↓

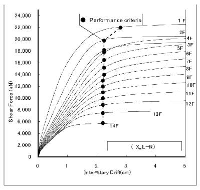
Design using 3D model (nonlinear)
(time history analysis)



Lumped Mass Model

- **Fast approximation** of the quantity of dampers needed per story
- Not suitable to verify the locations of the damper within each story

Lumped Mass Model



Results from Nonlinear Pushover Analysis

Building Examples with Viscous Dampers (Retrofit)

Government Buildings

Residential Buildings

Building Examples with Viscous Dampers (Retrofit)

Factory Buildings

Building Examples with Viscous Dampers (New Construction)

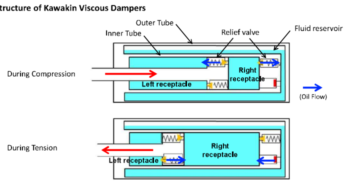
Office Buildings

Viscous Dampers for Seismic Isolation

- Works at **high velocity** with relatively **low pressure**
- **Low temperature** dependency
- **Compact** for a **large stroke**
- **Basically maintenance free** (Regular inspection required)

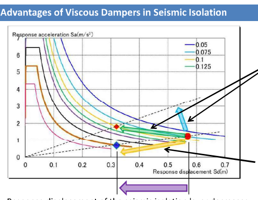
Viscous Dampers for Seismic Isolation

Structure of Kawakin Viscous Dampers



- **Single rod structure** : to make it more compact for a larger stroke
- **Fluid reservoir** between inner and outer tube to adapt volume to temperature variation. Presence of air in this reservoir implies horizontal installation only (diagonal or vertical not possible).

Advantages of Viscous Dampers in Seismic Isolation



Adding damping to the seismic isolation layer using a rigid device shortens the natural period of the seismic isolation layer and increases the shear force acting on the upper building.
The seismic isolation effect decreases.

By adding damping to the seismic isolation layer using a viscous damper that does not have rigidity, the displacement of the seismic isolation layer can be reduced while reducing the shear force on the upper building.

Response displacement of the seismic isolation layer decreases

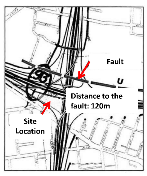
▪ It is possible to reduce the response displacement while keeping the natural period long without increasing the shear force (acceleration) acting on the upper layers
→ No need to increase the member cross section oft he upper stories. Since only damping is added, there is little design rework.

▪If rigid devices (LRB, steel dampers, etc.) are added to reduce the displacement, the shear forces acting on the upper stories increase, the natural period shortens, and the seismic isolation effect decreases.

Advantages of Oil Dampers in Seismic Isolation

Projects in Close Proximity to Active Faults

Example building is prone to high-velocity pulse effects (near-field effects)

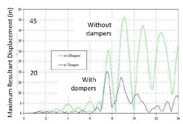


L.A. Regional Transportation Management Center

Number of floors: 5

Floor area: 8,175m²

Target performance:
Immediate occupancy after an MCE

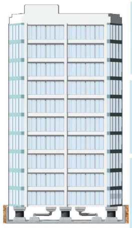


Using dampers: (max displ.) 100 cm ⟶ 60 cm

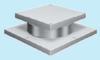
Ref: Design of a Seismic Isolation System with Supplemental Viscous Damping for a Near-Fault Essential Services Facility, Hussain and Al Satari, The 14th World Conference on Earthquake Engineering, 2008, China

Combination in Seismic Isolation

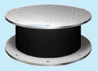
Flat Sliders can be used in combination with rubber bearings and viscous dampers for an economical solution



Flat Sliders



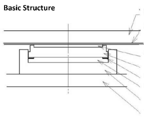
Rubber Bearings & Lead Rubber Bearings



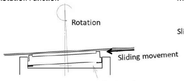
Viscous Dampers for Seismic Isolation

Flat Sliders

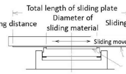
Basic Structure



Rotation Function



Movement Function



Building Example with Seismic Isolation Damper

School Building

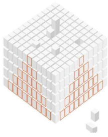
Capacity:	750kN
Stroke:	±700mm
Number of Dampers:	20

Kawakin

Kawakin

Thank You for Your Attention!

前田建設



GK GLOBAL | Maeda Corporation
GKMC İnşaat ve Danışmanlık A.Ş.

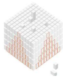
MaSTER FRAME® Method

STRUCTURAL (SEISMIC) RETROFITTING FROM OUTSIDE OF BUILDING WITH EXTERNAL RC FRAMES

NARUSE TADASHI /TANER ATICI / HASAN ŞAHİN
GKMC İNŞAAT VE DANIŞMANLIK A.Ş.

15.03.2023

CONTENTS



ABOUT GKMC

- GKMC Construction and Consultancy Inc., is established in Turkey in 2014.
- Maeda Corporation is the principal shareholder (50%)
- GKMC recently focuses on transferring innovative and novel seismic retrofitting solutions to Turkey that are developed in Japan.

  Localization and dissimination of innovative retrofitting solutions in Turkey is our main objective at the moment.

WHY EXTERNAL RETROFIT ?

The most common retrofitting method in Turkey : Shear-walls, jacketing etc.



WHY EXTERNAL RETROFIT ?

Issues:

- Occupancy is interrupted.
- Long construction period.
- Loss of space/area
- Excessive architectural repair
- Less view and sunlight
- Too many anchoring works. Damage to structural system.
- Environmental and social impact(dust, noise, vibration, relocation of habitants etc)
- Indirect costs when occupants are moved out (rent, relocation etc.)

Too many anchoring work even a single shear-wall is added.

What is MaSTER FRAME® Method ?

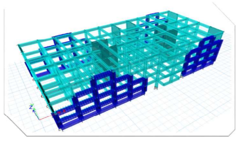
MaSTER FRAME® is an innovative structural retrofitting method that is developed in Japan after conducting long R&D studies.

Developed by,

Maeda Corporation
Sanko-Techno
Toyo Construction
Exterior
Retrofit

MaSTER FRAME

Pilot Project with MaSTER FRAME® in a Public School in Turkey



MaSTER FRAME® Method

While the occupancy of building continues, structural retrofitting is possible by adding outer RC frames to existing structural system (columns and beams) of buildings.

Also, in suitable structures, it has advantages over conventional retrofitting methods in terms of **construction time and cost.**

A Public University in Japan

MaSTER FRAME® Method

It is also possible to retrofit cantilevered buildings with corridor or balcony with MaSTER FRAME® by adding additional slabs, such as dwellings.

MaSTER FRAME® Method

Suitable Structures
- RC Structure
- Frame Structure
- Preferably minumum 12 MPa Concrete Strength
- Regular Structures

- Schools
- Hospitals
- Dwellings
- Offices, Dorms
- Small-mid Ind. Plants

A Public School in Japan

MaSTER FRAME® Method

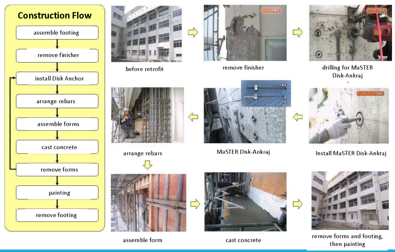
MaSTER FRAME is suitable for hybrid solutions by combining it with other structural retrofitting methods such as energy dissipation devices (damper, BRB), steel braces etc.

A Public Building in Turkey

MaSTER FRAME® Method

MaSTER Disk-Ankraj® is a special post-install type bonded anchor developed initially for MaSTER FRAME®

Construction of MaSTER FRAME®



Advantages of MaSTER FRAME® Method

- **No Need To Enter The Building**
  Construction can be performed while the occupancy of building continues in suitable buildings **(no interruption)**
- **Cost-Competitive**
  The method is **cost-competitive** compared to conventional (shear-wall etc) retrofitting methods. Also, **indirect costs** related to relocaton is avoided.
- **Shorter Construction Time**
  Construction period is expected to be shorter compared to conventional (shear-wall etc) retrofit method. With precast RC members, construction time can be further decreased
- **Less Social and Environmental Impact**
  Due to special MaSTER Disk-Ankraj® chipping is omitted; dust, noise and vibration is minimized. Social impact is reduced since relocation is not needed.

Advantages of MaSTER FRAME® Method

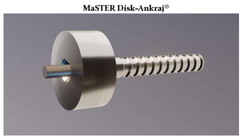
- **No Space Loss**
  Since the frames are attcached externally, no space is lost inside the building
- **No Excessive Architectural & Mechanical Repair**
  Architectural and mechanical repair is limited to only frame area.
- **Fine View and Sunlight**
  MF has a fine view and sunlight is not blocked.
- **Minimum Damage to Structural System**
  Since the number of onachoring works drops dramatically, damage to structural system is minimized.
- **No Maintenance Required**
  Rust-proof and maintenance free due to frames.

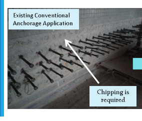
What is MaSTER Disk-Ankraj® ?

MaSTER Disk-Ankraj® is a special and patented post-install type bonded anchor developed initially for MaSTER FRAME®

- ✓ High Shear Strength
- ✓ Less number of anchor application
- ✓ Less noise, dust, vibration
- ✓ High performance in low-strength concretes (8,12,16,20 MPa)

MaSTER Disk-Ankraj®

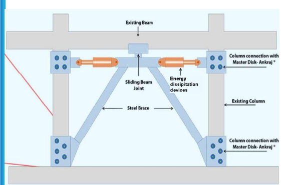




Alternative Usage of MaSTER Disk-Ankraj®

Apart from MaSTER FRAME Method, MaSTER Disk-Ankraj® is also used as a fastening element in the assembly of the various retrofitting members.

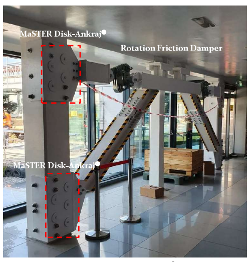
Especially where effective transfer of shear force is required, MaSTER Disk-Ankraj® provides secure connections by shorter embedment length and less number of anchor installations



Alternative Usage of MaSTER Disk-Ankraj®

Advantages :

- ✓ High shear strength
- ✓ High residual pull-out strength
- ✓ Less number of anchor application
- ✓ Less embedment depth, 160~ mm.
- ✓ Minimum damage on structural system (existing column and beam)
- ✓ Less dust, noise and vibration



Application of MaSTER Disk-Ankraj® as a fastener with retrofitting member where high shear force is transferred.

Localization and Certificate

İTÜ | İTÜ NOVA Teknoloji Transfer Ofisi | YDM Lab | TUBITAK | EMEK PREFABRİK

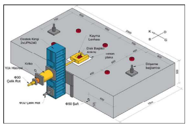
- **Technical**
  1. Task-Force (İTÜ-EEDMI)
  2. Pilot Project
  3. DA Performance Tests (İTÜ)
  4. Design Guideline (İTÜ-EEDMI)
  5. Fire Resistance Test (TSE)

  (items 1–4:) **by Asst. Prof. Fatih Sütçü**

- **Legal**
  1. Intellectual Property (Patent, Industrial Design, Trademark etc)
  2. National Technical Certificate (UTO Certificate)
  3. G Mark (Under application stage)

Performance of MaSTER Disk-Ankraj®

Shear Strength Test Set-Up
İstanbul Technical University
Structural and Earthquake Engineering Laboratuary

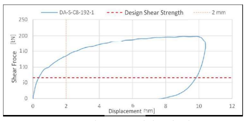


Concrete Class: C8, C12, C16 and C20

Performance of MaSTER Disk-Ankraj®

The high shear strength of MaSTER Disk-Ankraj® has been confirmed by extensive tests carried out by Asst. Prof. Fatih Sütçü, in Istanbul Technical University, Structural and Earthquake Engineering Laboratuary.

Disk-Ankraj® has a high shear strength even in low-strength concretes.

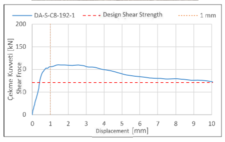


Concrete strength 7.96 MPa, embedment length 192 mm.
ITÜ Structural and Earthquake Engineering Laboratuary

Performance of MaSTER Disk-Ankraj®

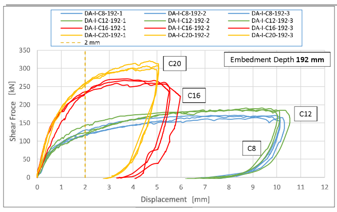
Pull-out tests are conducted after shear tests.

MaSTER Disk-Ankraj® has a very high residual pull-out strength even after a total shear failure.



İstanbul Technical University
Structural and Earthquake Engineering Laboratuary

Shear Force and Displacement Correlation in Different Concrete Strengths



DESIGN OF A PUBLIC SCHOOL WITH MaSTER FRAME®

PILOT PROJECT

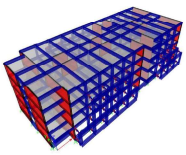
PILOT PROJECT WITH MaSTER FRAME®

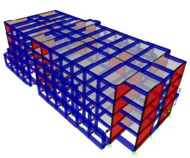
A public school in Istanbul is retrofitted by both conventional and MaSTER FRAME Method to compare.

Number of Floors	:	GF+3NF	Nr. of Classroomss	:	33
Number of Students	:	1203	Total Area	:	3400 m²
Structural System	:	Reinforced Concrete	Concrete	:	15.4 MPa ~ 24.7 MPa
			Reinforcement		S420
Construction Year	:	1995	Corrosion	:	Does not Exist
PGA (DD1)	:	0.582g	PGA (DD3)	:	0.140g
Soil Class	:	ZB	All. Bearing Pressure	:	1.70 kg/cm²
Liquefaction	:	Does not Exist	Subgrade Modulus	:	2500 t/m³
Method of Retrofit	:	Additional MaSTER FRAME System			

PILOT PROJECT WITH MaSTER FRAME®

3D View of Building Model with MaSTER FRAME





COST COMPARISON

PILOT PROJECT IN ISTANBUL – A Public School

MaSTER FRAME Method costs less than conventional methods, and construction time is expected to be shorter.

	Conventional (Adding Walls)	MaSTER FRAME® Method	
Work	**Cost**	**Cost**	**Difference**
Static Works	31.64%	69.66%	38.02%
Architectural Works	30.10%	16.17%	-13.93%
Electrical&Mechanical Works	38.26%	2.06%	-36.20%
TOTAL	**100.00%**	**87.89%**	**-12.11%**

	Conventional (Adding Walls etc)	MaSTER FRAME® Method
TOTAL RETROFIT COST	100.00%	87.89%
CONSTRUCTION TIME (MONTH)	6-8	3-4
RETROFIT COST VS RECONSTRUCTION COST	**22.5%**	**19.8%**

Business Model/Approach of GKMC

- Our main purpose is **providing an alternative retrofitting solution** for Turkish society from Japan, an experienced country in seismic retrofitting.
- GKMC or Maeda does not intend to involve in engineering or construction works. MF/DA are expected to be **designed and executed by local Turkish companies.**
- Turkish companies will benefit most from our current business model. Neither GKMC nor Maeda is competitor to local companies.
- GKMC will solely provide MaSTER Disk-Ankraj and will possess humble revenue.
- We would like to create a shared value, promote an innovation ecosystem in Turkey

More business opportunities for Turkish companies

REFERENCE PROJECTS in TURKEY

Total Projects in Turkey

Current business development of MaSTER FRAME® and MaSTER Disk-Ankraj®

- Total 12 projects in Turkey since the first application (2020-2021)
- Under design stage : 6 Projects
  Design completed : 3 Projects
- Under construction : 1 Project
  Construction completed : 2 Projects

Our solution is widely known and recognized by the key players in the market.

Project 1 - Design Work Completed

A public building. Hybrid solution with MaSTER FRAME.
Design work is completed. Under construction tender stage.

Pictures : Courtesy of Promer Engineering and Consultancy Inc.,

Project 2 - Construction Completed

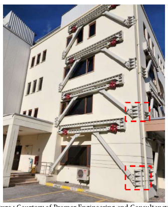
The first application in Turkey.

International food factory.

Over 2.000 DA is applied as a fastener with rotation friction dampers.

Project 3 - Construction Completed

Second application in Turkey.
International food factory.



Picture : Courtesy of Promer Engineering and Consultancy Inc.,

CONTACT

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Oruçreis Mah., Tekstilkent Cad., Koza Plaza,
A Blok, Kat:32, 34235 Esenler/İstanbul

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Office : +90-212-4672901
Email : tatici@gkmc.com.tr
Web : http://www.gkmc.com.tr

Webinar

HP/Web-Site

GK GLOBAL | Maeda Corporation
GKMC Inşaat ve Danışmanlık A.Ş.

黒沢建設

JCCME

PRODUCTION OF PC MEMBER IN TURKEY FOR LARGE SCALE WAREHOUSE CONSTRUCTION IN JAPAN

JAPAN - TURKEY COLLABORATION

Birol DOYRANLI
ALACALI Cons.
October 11, 2022

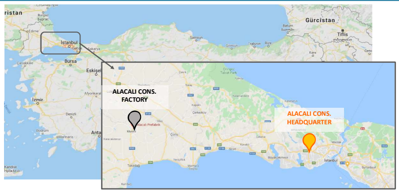
KUROSAWA CONSTRUCTION CO.,LTD. ALACALI

JCCME

Interscontinental journey of a Warehouse construction from Turkey to Japan

JCCME

Location of Head Office and Production Facility



JCCME

Layout plan of Production Facility

JCCME

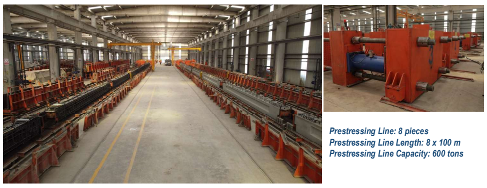
PRODUCTION FACILITY

The construction of the facility was completed within 3 months.
First Trial production : December 11, 2019
Kurosawa-Alacalı contract date : January 31, 2020
First Production : September, 2020

Indoor Area: 8000 m2
Stock Area: 14.000 m2
Number of Employees : 226 (18 White Collar Employee)

JCCME

PRODUCTION FACILITY



Prestressing Line: 8 pieces
Prestressing Line Length: 8 x 100 m
Prestressing Line Capacity: 600 tons

JCCME

PRODUCTION FACILITY

30 pieces of 0.6' strands stretching technique at the same time

BARRIER FOR LINES – SAFETY FIRST

Safety barriers on all lines

JCCME

PRODUCTION FACILITY

Capacity (Monthly)

Concrete : 5000 m3 (C60)

Reinforcement: 1018 tons

Number of Mixers: 3

JCCME

PRODUCTION FACILITY

AGGREGATE NO.1	AGGREGATE NO.2	0-5mm NATURAL SAND
CAPACITY : 1000 m³	CAPACITY : 1000 m³	CAPACITY : 1000 m³

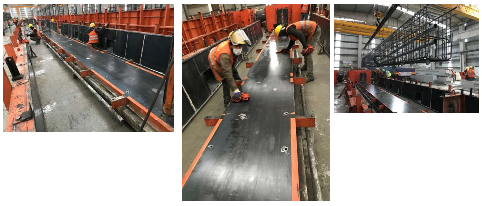
REBAR PREPARATION

Rebar Preparation Area: 2000 m2
3 mm tolerance on prepared iron

JIS Certified rebar and ropes were supplied from Japan.

In new productions that will start in 2023, JIS certified rebar and strands will be supplied from Turkey.

MOLD PREPARATION



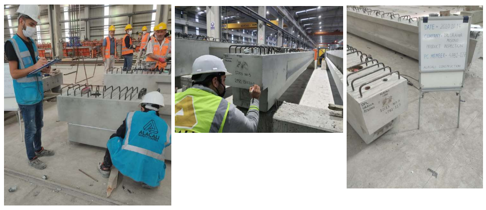
REBAR CONTROL

CONCRETE POURING - CONTROLS

CURİNG

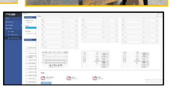
Fully automatic Curing system

MAKING FINAL CONTROLS - RECORDING



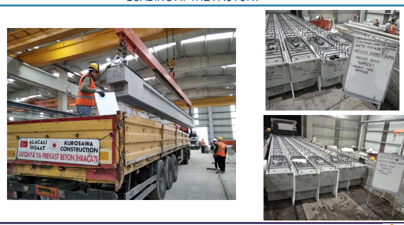
QUALITY CONTROL

Controlling the equipment with the virtual reality system developed by KUROSAWA
Fault Tolerance: 5 mm
All stages of quality control are recorded with the LOGO software system.

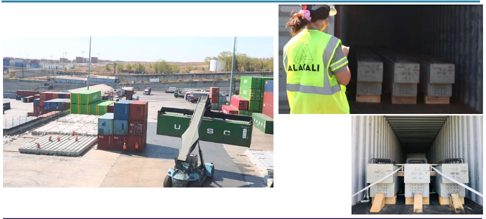


FINAL CONTROL and CLEANING

LOADING AT THE FACTORY



LOADING and LASHING AT THE PORT

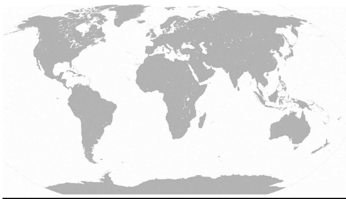


LOADING and LASHING AT THE PORT

UNLOADING AT YOKOHAMA PORT

INSTALLATION

Interscontinental journey of a Warehouse construction from Turkey to Japan



FINAL

ESR – Yokohama Sachiura Distribution Centre 1
Time of Completion : January, 2022
4 storeys , base-isolation – GFA 196.000 m2
Clear Height: 6.5 m – 5.5 m - Floor Loading : 2 ton/m2 – 1.5 ton/m2

JAPAN - TURKEY COLLABORATION

KUROSAWA CONSTRUCTION CO.,LTD. ALACALI

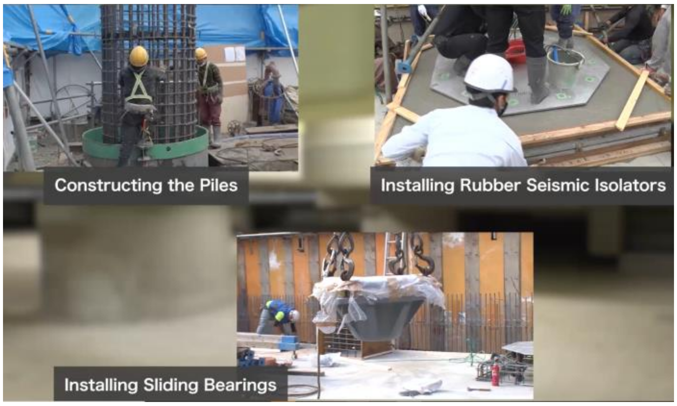
Thank you very much for your attention

Special Thanks to
Founder and owner of KUROSAWA
Ryohei KUROSAWA

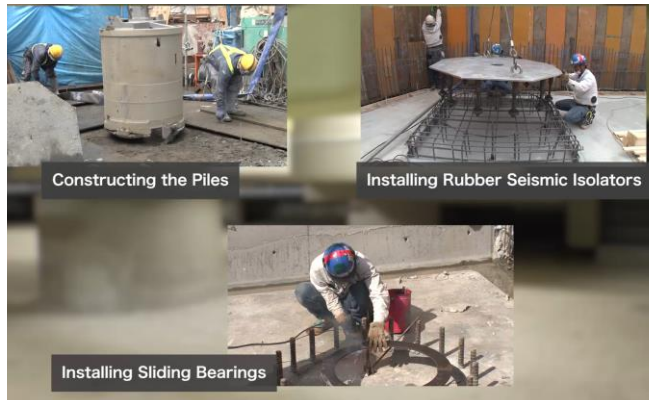
P.E. of JP Kei HIRAI
Assistant Professor Fatih SÜTÇÜ

Video ①:「施工手順ビデオ」(杭、免震装置)

杭、2種類の免震装置の施工状況(1)

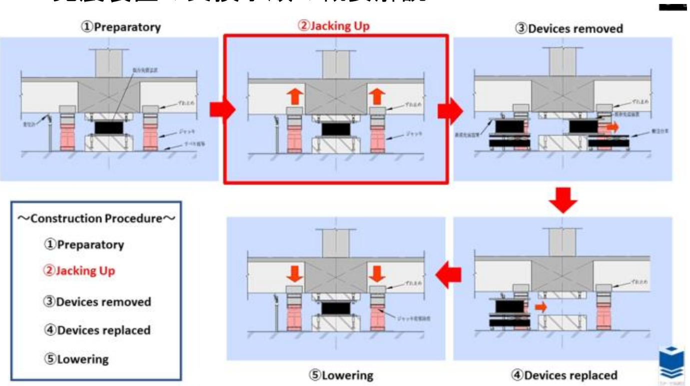


杭、2種類の免震装置の施工状況(2)



Video ②:「免震装置」の交換工事」

免震装置の交換手順の概要解説

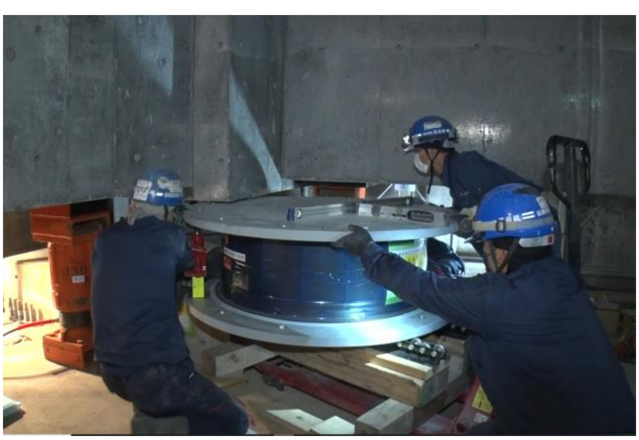


新規免震装置の搬入状況

ジャッキアップの状況

旧免震装置の取り出し

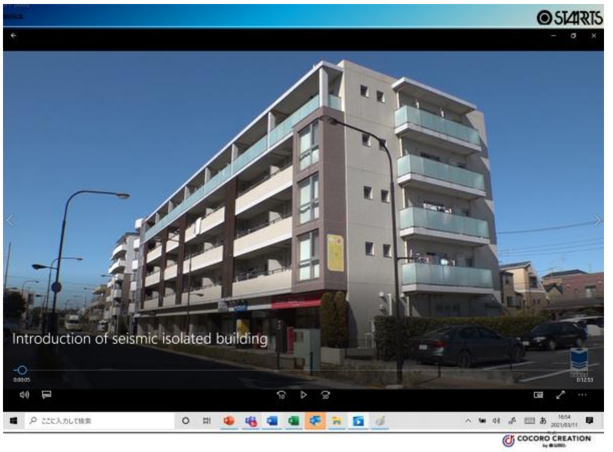
新規免震装置の設置



新規免震装置の固定ボルトの締め付け

Lecture⑥:「Video ②:「実免震建物紹介」

免震建物紹介（動画）



免震装置周囲の説明

Video ③:　免震レトロフィットの施工手順

免震レトロフィットの事例紹介

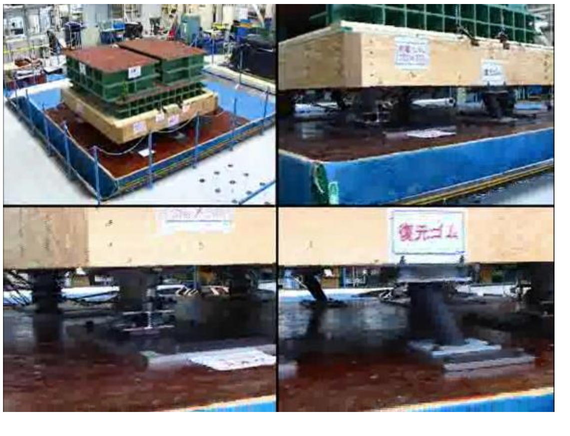
免震レトロフィットの施工手順の動画

Video ④:「振動実験（E-ディフェンス）」

実大建物の振動実験動画

Video ⑤:「振動実験（木造免震用建物）」

木造（軽量）建物用免震の振動実験動画



9.今後の展望

□人材育成<継続＞（研修のブラッシュアップ）

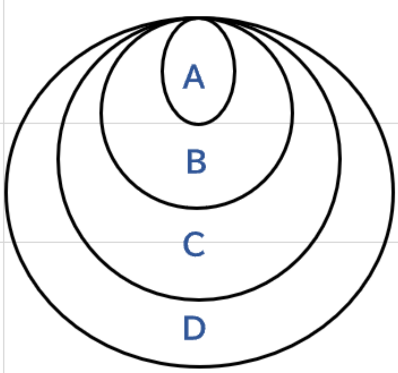
□設計手法の確立（日本式の適用へ）

□発注者への働きかけ（免震の良さを伝える）

【参考】
免震普及のポイントは、下記のA～Dのいづれの事業展開でも良いので、一刻も早く「都市型免震免震構造建物（地震計付き）」を竣工させ次の大地震に備え、免震普及の種をまいておくことであると考える。

将来の事業展開の展望
※今回の事業内容ではない

A	都市型免震技術のコンサルタント事業展開
B	都市型免震技術の構造設計事業展開
C	日本製の免震装置販売事業展開
D	都市型免震技術の建築施工事業展開



Japan – Turkey

Lecture of Seismic-Isolation Technology

Produced by STARTS CAM
Supported by MLIT